Database Developer Guide

Amazon Redshift

Amazon Redshift: Database Developer Guide

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Amazon Redshift will no longer support the creation of new Python UDFs starting November 1, 2025. If you would like to use Python UDFs, create the UDFs prior to that date. Existing Python UDFs will continue to function as normal. For more information, see the blog post .

Introduction to Amazon Redshift

Welcome to the *Amazon Redshift Database Developer Guide*. This guide focuses on helping you understand how to use Amazon Redshift to create and manage a data warehouse. If you work with databases as a designer, software developer, or administrator, this guide gives you the information you need to design, build, query, and maintain your data warehouse.

Amazon Redshift is a fully managed, petabyte-scale data warehouse service in the cloud. Amazon Redshift Serverless lets you access and analyze data without the usual configurations of a provisioned data warehouse. Resources are automatically provisioned and data warehouse capacity is intelligently scaled to deliver fast performance for even the most demanding and unpredictable workloads. You don't incur charges when the data warehouse is idle, so you only pay for what you use. Regardless of the size of the dataset, you can load data and start querying right away in the Amazon Redshift query editor v2 or in your favorite business intelligence (BI) tool. Enjoy the best price performance and familiar SQL features in an easy-to-use, zero administration environment.

Topics

- Prerequisites for using Amazon Redshift
- Amazon Redshift architecture
- Sample database

Prerequisites for using Amazon Redshift

This topic describes prerequisites you need to use Amazon Redshift.

Before you use this guide, you should read Get started with Redshift Serverless data warehouses, which goes over how to complete the following tasks.

- Create a data warehouse with Amazon Redshift Serverless.
- Loading in sample data with Amazon Redshift query editor v2
- Loading in data from Amazon S3.

You should also know how to use your SQL client and should have a fundamental understanding of the SQL language.

Amazon Redshift architecture

This topic helps you understand the components that make up Amazon Redshift.

An Amazon Redshift data warehouse is an enterprise-class relational database query and management system.

Amazon Redshift supports client connections with many types of applications, including business intelligence (BI), reporting, data, and analytics tools.

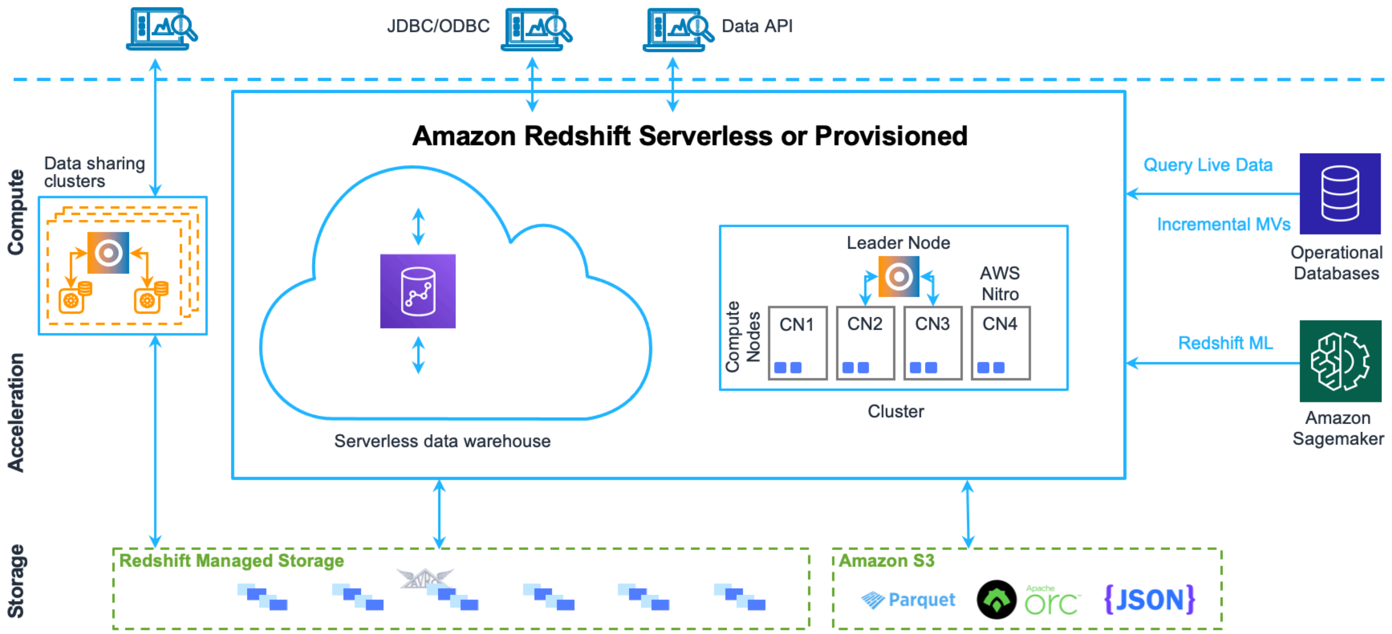
When you run analytic queries, you are retrieving, comparing, and evaluating large amounts of data in multiple-stage operations to produce a final result.

Amazon Redshift achieves efficient storage and optimum query performance through a combination of massively parallel processing, columnar data storage, and very efficient, targeted data compression encoding schemes. This section presents an introduction to the Amazon Redshift system architecture.

Topics

Data warehouse system architecture

This section explains the components that make up the Amazon Redshift data warehouse architecture, as shown in the following figure.



Client applications

Amazon Redshift integrates with various data loading and ETL (extract, transform, and load) tools and business intelligence (BI) reporting, data mining, and analytics tools. Amazon Redshift is based on open standard PostgreSQL, so most existing SQL client applications will work with only minimal changes. For information about important differences between Amazon Redshift SQL and PostgreSQL, see [Amazon Redshift and PostgreSQL](#).

Clusters

The core infrastructure component of an Amazon Redshift data warehouse is a *cluster*.

A cluster is composed of one or more *compute nodes*. If a cluster is provisioned with two or more compute nodes, an additional *leader node* coordinates the compute nodes and handles external communication. Your client application interacts directly only with the leader node. The compute nodes are transparent to external applications.

Leader node

The leader node manages communications with client programs and all communication with compute nodes. It parses and develops execution plans to carry out database operations, in particular, the series of steps necessary to obtain results for complex queries. Based on the execution plan, the leader node compiles code, distributes the compiled code to the compute nodes, and assigns a portion of the data to each compute node.

The leader node distributes SQL statements to the compute nodes only when a query references tables that are stored on the compute nodes. All other queries run exclusively on the leader node. Amazon Redshift is designed to implement certain SQL functions only on the leader node. A query that uses any of these functions will return an error if it references tables that reside on the compute nodes. For more information, see SQL functions supported on the leader node.

Compute nodes

The leader node compiles code for individual elements of the execution plan and assigns the code to individual compute nodes. The compute nodes run the compiled code and send intermediate results back to the leader node for final aggregation.

Each compute node has its own dedicated CPU and memory, which are determined by the node type. As your workload grows, you can increase the compute capacity of a cluster by increasing the number of nodes, upgrading the node type, or both.

Amazon Redshift provides several node types for your compute needs. For details of each node type, see Amazon Redshift clusters in the *Amazon Redshift Management Guide*.

Redshift Managed Storage

Data warehouse data is stored in a separate storage tier Redshift Managed Storage (RMS). RMS provides the ability to scale your storage to petabytes using Amazon S3 storage. RMS lets you scale and pay for computing and storage independently, so that you can size your cluster based only on your computing needs. It automatically uses high-performance SSD-based local storage as tier-1 cache. It also takes advantage of optimizations, such as data block temperature, data block age, and workload patterns to deliver high performance while scaling storage automatically to Amazon S3 when needed without requiring any action.

Node slices

A compute node is partitioned into slices. Each slice is allocated a portion of the node's memory and disk space, where it processes a portion of the workload assigned to the node. The leader node manages distributing data to the slices and apportions the workload for any queries or other database operations to the slices. The slices then work in parallel to complete the operation.

The number of slices per node is determined by the node size of the cluster. For more information about the number of slices for each node size, go to About clusters and nodes in the *Amazon Redshift Management Guide*.

When you create a table, you can optionally specify one column as the distribution key. When the table is loaded with data, the rows are distributed to the node slices according to the distribution key that is defined for a table. Choosing a good distribution key enables Amazon Redshift to use parallel processing to load data and run queries efficiently. For information about choosing a distribution key, see Choose the best distribution style.

Internal network

Amazon Redshift takes advantage of high-bandwidth connections, close proximity, and custom communication protocols to provide private, very high-speed network communication between the leader node and compute nodes. The compute nodes run on a separate, isolated network that client applications never access directly.

Databases

A cluster contains one or more databases. User data is stored on the compute nodes. Your SQL client communicates with the leader node, which in turn coordinates query run with the compute nodes.

Amazon Redshift is a relational database management system (RDBMS), so it is compatible with other RDBMS applications. Although it provides the same functionality as a typical RDBMS, including online transaction processing (OLTP) functions such as inserting and deleting data, Amazon Redshift is optimized for high-performance analysis and reporting of very large datasets.

Amazon Redshift is based on PostgreSQL. Amazon Redshift and PostgreSQL have a number of very important differences that you need to take into account as you design and develop your data warehouse applications. For information about how Amazon Redshift SQL differs from PostgreSQL, see Amazon Redshift and PostgreSQL.

Amazon Redshift Performance

This topic describes the Amazon Redshift components that drive performance. Understanding these components will help you tune performance and troubleshoot poor performance with Amazon Redshift.

Amazon Redshift achieves extremely fast query run by employing these performance features.

Topics

- Columnar data storage
- Data compression
- Query optimizer
- Result caching
- Compiled code

Massively parallel processing

Massively parallel processing (MPP) enables fast run of the most complex queries operating on large amounts of data. Multiple compute nodes handle all query processing leading up to final result aggregation, with each core of each node running the same compiled query segments on portions of the entire data.

Amazon Redshift distributes the rows of a table to the compute nodes so that the data can be processed in parallel. By selecting an appropriate distribution key for each table, you can optimize the distribution of data to balance the workload and minimize movement of data from node to node. For more information, see Choose the best distribution style.

Loading data from flat files takes advantage of parallel processing by spreading the workload across multiple nodes while simultaneously reading from multiple files. For more information about how to load data into tables, see Amazon Redshift best practices for loading data.

Columnar data storage

Columnar storage for database tables drastically reduces the overall disk I/O requirements and is an important factor in optimizing analytic query performance. For more information, see Columnar storage.

When columns are sorted appropriately, the query processor is able to rapidly filter out a large subset of data blocks. For more information, see Choose the best sort key.

Data compression

Data compression reduces storage requirements, thereby reducing disk I/O, which improves query performance. When you run a query, the compressed data is read into memory, then uncompressed during query run. Loading less data into memory enables Amazon Redshift to allocate more memory to analyzing the data. Because columnar storage stores similar data sequentially, Amazon

Redshift is able to apply adaptive compression encodings specifically tied to columnar data types. The best way to enable data compression on table columns is by allowing Amazon Redshift to apply optimal compression encodings when you load the table with data. To learn more about using automatic data compression, see Loading tables with automatic compression.

Query optimizer

The Amazon Redshift query run engine incorporates a query optimizer that is MPP-aware and also takes advantage of the columnar-oriented data storage. The Amazon Redshift query optimizer implements significant enhancements and extensions for processing complex analytic queries that often include multi-table joins, subqueries, and aggregation. To learn more about optimizing queries, see Query performance tuning.

Result caching

To reduce query runtime and improve system performance, Amazon Redshift caches the results of certain types of queries in memory on the leader node. When a user submits a query, Amazon Redshift checks the results cache for a valid, cached copy of the query results. If a match is found in the result cache, Amazon Redshift uses the cached results and doesn't run the query. Result caching is transparent to the user.

Result caching is turned on by default. To turn off result caching for the current session, set the enable_result_cache_for_session parameter to `off`.

Amazon Redshift uses cached results for a new query when all of the following are true:

- The user submitting the query has access permission to the objects used in the query.
- The table or views in the query haven't been modified.
- The query doesn't use a function that must be evaluated each time it's run, such as GETDATE.
- The query doesn't reference Amazon Redshift Spectrum external tables.
- Configuration parameters that might affect query results are unchanged.
- The query syntactically matches the cached query.

To maximize cache effectiveness and efficient use of resources, Amazon Redshift doesn't cache some large query result sets. Amazon Redshift determines whether to cache query results based on a number of factors. These factors include the number of entries in the cache and the instance type of your Amazon Redshift cluster.

To determine whether a query used the result cache, query the SVL_QLOG system view. If a query used the result cache, the source_query column returns the query ID of the source query. If result caching wasn't used, the source_query column value is NULL.

The following example shows that queries submitted by userid 104 and userid 102 use the result cache from queries run by userid 100.

```
select userid, query, elapsed, source_query from svl_qlog
where userid > 1
order by query desc;

userid | query  | elapsed  | source_query
-------+--------+----------+-------------
   104 | 629035 |       27 |       628919
   104 | 629034 |       60 |       628900
   104 | 629033 |       23 |       628891
   102 | 629017 |  1229393 |
   102 | 628942 |       28 |       628919
   102 | 628941 |       57 |       628900
   102 | 628940 |       26 |       628891
   100 | 628919 | 84295686 |
   100 | 628900 | 87015637 |
   100 | 628891 | 58808694 |
```

Compiled code

The leader node distributes fully optimized compiled code across all of the nodes of a cluster. Compiling the query decreases the overhead associated with an interpreter and therefore increases the runtime speed, especially for complex queries. The compiled code is cached and shared across sessions on the same cluster. As a result, future runs of the same query will be faster, often even with different parameters.

The query run engine compiles different code for the JDBC and ODBC connection protocols, so two clients using different protocols each incur the first-time cost of compiling the code. Clients that use the same protocol, however, benefit from sharing the cached code.

Columnar storage

This section describes columnar storage, which is the method Amazon Redshift uses to store tabular data efficiently.

Columnar storage for database tables is an important factor in optimizing analytic query performance, because it drastically reduces the overall disk I/O requirements. It reduces the amount of data you need to load from disk.

The following series of illustrations describe how columnar data storage implements efficiencies, and how that translates into efficiencies when retrieving data into memory.

This first illustration shows how records from database tables are typically stored into disk blocks by row.

SSN	Name	Age	Addr	City	St
101259797	SMITH	88	899 FIRST ST	JUNO	AL
892375862	CHIN	37	16137 MAIN ST	POMONA	CA
318370701	HANDU	12	42 JUNE ST	CHICAGO	IL

In a typical relational database table, each row contains field values for a single record. In row-wise database storage, data blocks store values sequentially for each consecutive column making up the entire row. If block size is smaller than the size of a record, storage for an entire record may take more than one block. If block size is larger than the size of a record, storage for an entire record may take less than one block, resulting in an inefficient use of disk space. In online transaction processing (OLTP) applications, most transactions involve frequently reading and writing all of the values for entire records, typically one record or a small number of records at a time. As a result, row-wise storage is optimal for OLTP databases.

The next illustration shows how with columnar storage, the values for each column are stored sequentially into disk blocks.

SSN	Name	Age	Addr	City	St
101259797	SMITH	88	899 FIRST ST	JUNO	AL
892375862	CHIN	37	16137 MAIN ST	POMONA	CA
318370701	HANDU	12	42 JUNE ST	CHICAGO	IL

Using columnar storage, each data block stores values of a single column for multiple rows. As records enter the system, Amazon Redshift transparently converts the data to columnar storage for each of the columns.

In this simplified example, using columnar storage, each data block holds column field values for as many as three times as many records as row-based storage. This means that reading the same number of column field values for the same number of records requires a third of the I/O operations compared to row-wise storage. In practice, using tables with very large numbers of columns and very large row counts, storage efficiency is even greater.

An added advantage is that, since each block holds the same type of data, block data can use a compression scheme selected specifically for the column data type, further reducing disk space and I/O. For more information about compression encodings based on data types, see [Compression encodings](#).

The savings in space for storing data on disk also carries over to retrieving and then storing that data in memory. Since many database operations only need to access or operate on one or a small number of columns at a time, you can save memory space by only retrieving blocks for columns you actually need for a query. Where OLTP transactions typically involve most or all of the columns in a row for a small number of records, data warehouse queries commonly read only a few columns for a very large number of rows. This means that reading the same number of column field values for the same number of rows requires a fraction of the I/O operations. It uses a fraction of the memory that would be required for processing row-wise blocks. In practice, using tables with very large numbers of columns and very large row counts, the efficiency gains are proportionally greater. For example, suppose a table contains 100 columns. A query that uses five columns will only need to read about five percent of the data contained in the table. This savings is repeated for possibly billions or even trillions of records for large databases. In contrast, a row-wise database would read the blocks that contain the 95 unneeded columns as well.

Typical database block sizes range from 2 KB to 32 KB. Amazon Redshift uses a block size of 1 MB, which is more efficient and further reduces the number of I/O requests needed to perform any database loading or other operations that are part of query run.

Workload management

This section describes workload management (WLM), which helps you understand how Amazon Redshift prepares and runs queries.

Amazon Redshift workload management (WLM) enables flexible management priorities within workloads so that short, fast-running queries don't get stuck in queues behind long-running queries. Amazon Redshift creates query queues at runtime according to *service classes*, which define the configuration parameters for various types of queues, including internal system queues and user-accessible queues. From a user perspective, a user-accessible service class and a queue are functionally equivalent. For consistency, this documentation uses the term *queue* to mean a user-accessible service class as well as a runtime queue.

Redshift offers automatic workload management, called **automatic WLM**, which is tuned to handle varying workloads and is the recommended default. With automatic WLM, Redshift determines resource utilization as queries arrive and dynamically determines whether to run them on the main cluster, on a concurrency scaling cluster, or to send each to a queue. (When queries are queued, automatic WLM prioritizes shorter-duration queries.) Automatic WLM maximizes total throughput and enables you to maintain efficient data-warehouse resources. You run workloads without having to be concerned with their size or how they're scheduled. Automatic WLM is the default for provisioned clusters. For more information, see Implementing automatic WLM.

Note

Amazon Redshift Serverless workgroups always use automatic WLM.

In times where a lot of queries or resource-intensive queries are running, workload management can scale to additional compute resources when workloads queue on local resources. Concurrency scaling with automatic WLM supports consistent performance for virtually unlimited concurrent users and queries.

Redshift provisioned clusters offer **manual WLM** if you need fine-grained manual optimization. Here, the customer manages resource allocation, query concurrency and queuing. When a query runs, WLM assigns the query to a queue according to the user's user group or by matching a query group that is listed in the queue configuration. This is configured with a query-group label that the user sets. For more information, see Implementing manual WLM.

Though Manual WLM can be fine tuned over time to match your workload patterns, in most cases we discourage its use because its static nature can make it more difficult for you to adapt to changing workloads through the course of a day or over an extended period. It requires more monitoring and ongoing tuning. In addition, Manual WLM in many cases doesn't use compute resources as efficiently as automatic WLM, such as for example if queues are set manually to limit memory allocated to them.

An important metric to measure the success of workload management configuration is system throughput, which in other words is how many queries are completed successfully. System throughput is measured in queries per second. For more information about system metrics, see Monitoring Amazon Redshift cluster performance.

The easiest way to manage your WLM configuration is by using the Amazon Redshift Management console. You can also use the Amazon Redshift command line interface (CLI) or the Amazon Redshift API. For more information about implementing and using workload management, see Implementing workload management.

Using Amazon Redshift with other services

This section describes how you can use other services as sources and destinations for Amazon Redshift data.

Amazon Redshift integrates with other AWS services to enable you to move, transform, and load your data quickly and reliably, using data security features.

S3

Amazon Simple Storage Service (Amazon S3) is a web service that stores data in the cloud. Amazon Redshift leverages parallel processing to read and load data from multiple data files stored in Amazon S3 buckets. For more information, see Loading data from Amazon S3.

You can also use parallel processing to export data from your Amazon Redshift data warehouse to multiple data files on Amazon S3. For more information, see Unloading data in Amazon Redshift.

DynamoDB

Amazon DynamoDB is a fully managed NoSQL database service. You can use the COPY command to load an Amazon Redshift table with data from a single Amazon DynamoDB table. For more information, see Loading data from an Amazon DynamoDB table.

SSH

You can use the COPY command in Amazon Redshift to load data from one or more remote hosts, such as Amazon EMR clusters, Amazon EC2 instances, or other computers. COPY connects to the remote hosts using SSH and runs commands on the remote hosts to generate data.

Amazon Redshift supports multiple simultaneous connections. The COPY command reads and loads the output from multiple host sources in parallel. For more information, see Loading data from remote hosts.

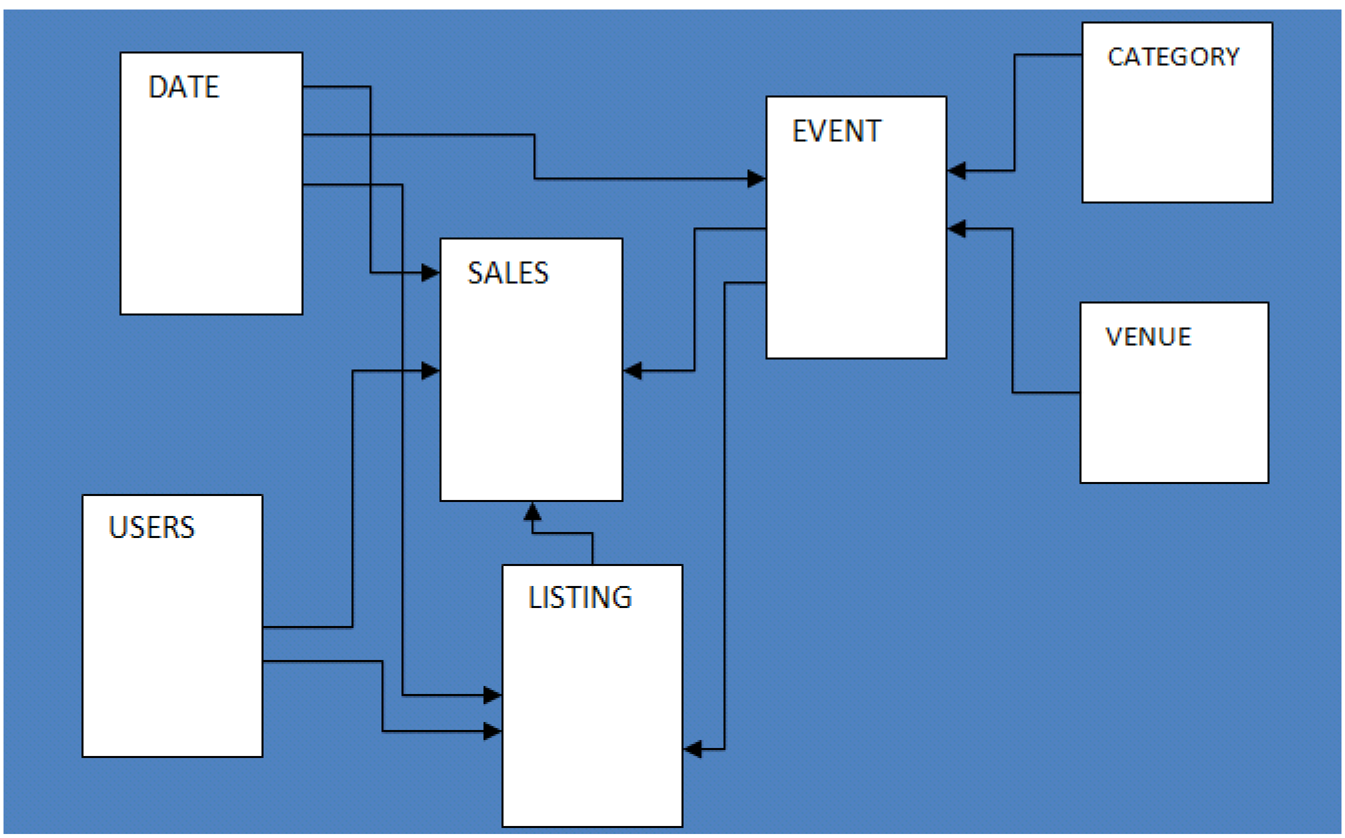
AWS DMS

You can migrate data to Amazon Redshift using AWS Database Migration Service. AWS DMS can migrate your data to and from most widely used commercial and open-source databases such as Oracle, PostgreSQL, Microsoft SQL Server, Amazon Redshift, Aurora DB cluster, DynamoDB, Amazon S3, MariaDB, and MySQL. For more information, see Using an Amazon Redshift database as a target for AWS Database Migration Service.

Sample database

This section describes TICKIT, a sample database that Amazon Redshift documentation examples use.

This small database consists of seven tables: two fact tables and five dimensions. You can load the TICKIT dataset by following the steps in Step 4: Load data from Amazon S3 to Amazon Redshift in the Amazon Redshift Getting Started Guide.



This sample database application helps analysts track sales activity for the fictional TICKIT web site, where users buy and sell tickets online for sporting events, shows, and concerts. In particular, analysts can identify ticket movement over time, success rates for sellers, and the best-selling events, venues, and seasons. Analysts can use this information to provide incentives to buyers and sellers who frequent the site, to attract new users, and to drive advertising and promotions.

For example, the following query finds the top five sellers in San Diego, based on the number of tickets sold in 2008:

```
select sellerid, username, (firstname ||' '|| lastname) as name,
city, sum(qtysold)
from sales, date, users
where sales.sellerid = users.userid
and sales.dateid = date.dateid
and year = 2008
and city = 'San Diego'
group by sellerid, username, name, city
order by 5 desc
limit 5;

sellerid | username |       name        |   city    | sum
----------+----------+-------------------+-----------+-----
49977 | JJK84WTE | Julie Hanson      | San Diego |  22
19750 | AAS23BDR | Charity Zimmerman | San Diego |  21
29069 | SVL81MEQ | Axel Grant        | San Diego |  17
43632 | VAG08HKW | Griffin Dodson    | San Diego |  16
36712 | RXT40MKU | Hiram Turner      | San Diego |  14
(5 rows)
```

The database used for the examples in this guide contains a small data set; the two fact tables each contain less than 200,000 rows, and the dimensions range from 11 rows in the CATEGORY table up to about 50,000 rows in the USERS table.

In particular, the database examples in this guide demonstrate the key features of Amazon Redshift table design:

- Data distribution
- Data sort
- Columnar compression

For information about the schemas of the tables in the TICKIT database, choose the following tabs:

CATEGORY table

Column name	Data type	Description
CATID	SMALLINT	Primary key, a unique ID value for each row. Each row represents a specific type of event for which tickets are bought and sold.
CATGROUP	VARCHAR(10)	Descriptive name for a group of events, such as **`Shows`** and **`Sports`**.
CATNAME	VARCHAR(10)	Short descriptive name for a type of event within a group, such as **`Opera`** and **`Musicals`**.
CATDESC	VARCHAR(50)	Longer descriptive name for the type of event, such as **`Musical theatre`**.

DATE table

Column name	Data type	Description
DATEID	SMALLINT	Primary key, a unique ID value for each row. Each row represents a day in the calendar year.
CALDATE	DATE	Calendar date, such as **`2008-06-24`** .
DAY	CHAR(3)	Day of week (short form), such as **`SA`**.
WEEK	SMALLINT	Week number, such as **`26`**.
MONTH	CHAR(5)	Month name (short form), such as **`JUN`**.
QTR	CHAR(5)	Quarter number (**`1`** through **`4`**).
YEAR	SMALLINT	Four-digit year (**`2008`**).

Column name	Data type	Description
HOLIDAY	BOOLEAN	Flag that denotes whether the day is a public holiday (U.S.).

EVENT table

Column name	Data type	Description
EVENTID	INTEGER	Primary key, a unique ID value for each row. Each row represents a separate event that takes place at a specific venue at a specific time.
VENUEID	SMALLINT	Foreign-key reference to the VENUE table.
CATID	SMALLINT	Foreign-key reference to the CATEGORY table.
DATEID	SMALLINT	Foreign-key reference to the DATE table.
EVENTNAME	VARCHAR(200)	Name of the event, such as **`Hamlet`** or **`La Traviata`**.
STARTTIME	TIMESTAMP	Full date and start time for the event, such as **`2008-10-10 19:30:00`** .

VENUE table

Column name	Data type	Description
VENUEID	SMALLINT	Primary key, a unique ID value for each row. Each row represents a specific venue where events take place.
VENUENAME	VARCHAR(100)	Exact name of the venue, such as **`Cleveland Browns Stadium`**.
VENUECITY	VARCHAR(30)	City name, such as **`Cleveland`** .

Column name	Data type	Description
VENUESTATE	CHAR(2)	Two-letter state or province abbreviation (United States and Canada), such as **OH**.
VENUESEATS	INTEGER	Maximum number of seats available at the venue, if known, such as **73200**. For demonstra tion purposes, this column contains some null values and zeroes.

USERS table

Column name	Data type	Description
USERID	INTEGER	Primary key, a unique ID value for each row. Each row represents a registered user (a buyer or seller or both) who has listed or bought tickets for at least one event.
USERNAME	CHAR(8)	An 8-character alphanumeric username, such as **PGL08LJI**.
FIRSTNAME	VARCHAR(30)	The user's first name, such as **Victor**.
LASTNAME	VARCHAR(30)	The user's last name, such as **Hernandez** .
CITY	VARCHAR(30)	The user's home city, such as **Naperville** .
STATE	CHAR(2)	The user's home state, such as **GA**.
EMAIL	VARCHAR(100)	The user's email address; this column contains random Latin values, such as **turpis@accumsanlaoreet.org** .
PHONE	CHAR(14)	The user's 14-character phone number, such as **(818) 765-4255**.

Column name	Data type	Description
LIKESPORTS, ...	BOOLEAN	A series of 10 different columns that identify the user's likes and dislikes with **`true`** and **`false`** values.

LISTING table

Column name	Data type	Description
LISTID	INTEGER	Primary key, a unique ID value for each row. Each row represents a listing of a batch of tickets for a specific event.
SELLERID	INTEGER	Foreign-key reference to the USERS table, identifyi ng the user who is selling the tickets.
EVENTID	INTEGER	Foreign-key reference to the EVENT table.
DATEID	SMALLINT	Foreign-key reference to the DATE table.
NUMTICKETS	SMALLINT	The number of tickets available for sale, such as **`2`** or **`20`**.
PRICEPERT ICKET	DECIMAL(8,2)	The fixed price of an individual ticket, such as **`27.00`** or **`206.00`**.
TOTALPRICE	DECIMAL(8,2)	The total price for this listing (NUMTICKETS*PRICEP ERTICKET).
LISTTIME	TIMESTAMP	The full date and time when the listing was posted, such as **`2008-03-18 07:19:35`** .

SALES table

Column name	Data type	Description
SALESID	INTEGER	Primary key, a unique ID value for each row. Each row represents a sale of one or more tickets for a specific event, as offered in a specific listing.
LISTID	INTEGER	Foreign-key reference to the LISTING table.
SELLERID	INTEGER	Foreign-key reference to the USERS table (the user who sold the tickets).
BUYERID	INTEGER	Foreign-key reference to the USERS table (the user who bought the tickets).
EVENTID	INTEGER	Foreign-key reference to the EVENT table.
DATEID	SMALLINT	Foreign-key reference to the DATE table.
QTYSOLD	SMALLINT	The number of tickets that were sold, from **1** to **8**. (A maximum of 8 tickets can be sold in a single transacti on.)
PRICEPAID	DECIMAL(8,2)	The total price paid for the tickets, such as **`75.00`** or **`488.00`**. The individual price of a ticket is PRICEPAID/ QTYSOLD.
COMMISSION	DECIMAL(8,2)	The 15% commission that the business collects from the sale, such as **`11.25`** or **`73.20`**. The seller receives 85% of the PRICEPAID value.
SALETIME	TIMESTAMP	The full date and time when the sale was completed, such as **`2008-05-24 06:21:47`** .

Amazon Redshift best practices

Following, you can find best practices for planning a proof of concept, designing tables, loading data into tables, and writing queries for Amazon Redshift, and also a discussion of working with Amazon Redshift Advisor.

Amazon Redshift is not the same as other SQL database systems. To fully realize the benefits of the Amazon Redshift architecture, you must specifically design, build, and load your tables to use massively parallel processing, columnar data storage, and columnar data compression. If your data loading and query execution times are longer than you expect, or longer than you want, you might be overlooking key information.

If you are an experienced SQL database developer, we strongly recommend that you review this topic before you begin developing your Amazon Redshift data warehouse.

If you are new to developing SQL databases, this topic is not the best place to start. We recommend that you begin by reading Run commands to define and use a database in your data warehouse in the *Amazon Redshift Getting Started Guide*, and trying the examples yourself.

In this topic, you can find an overview of the most important development principles, along with specific tips, examples, and best practices for implementing those principles. No single practice can apply to every application. Evaluate all of your options before finishing a database design. For more information, see Automatic table optimization, Loading data in Amazon Redshift, Query performance tuning, and the reference chapters.

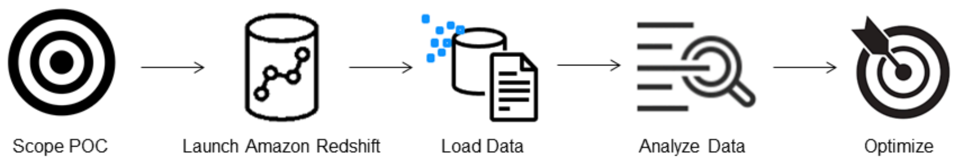
Topics

Conduct a proof of concept (POC) for Amazon Redshift

Amazon Redshift is a popular cloud data warehouse, which offers a fully managed cloud-based service that integrates with an organization's Amazon Simple Storage Service data lake, real-time streams, machine learning (ML) workflows, transactional workflows, and much more. The following sections guide you through the process of doing a proof of concept (POC) on Amazon Redshift. The information here helps you set goals for your POC, and takes advantage of tools that can automate the provisioning and configuration of services for your POC.

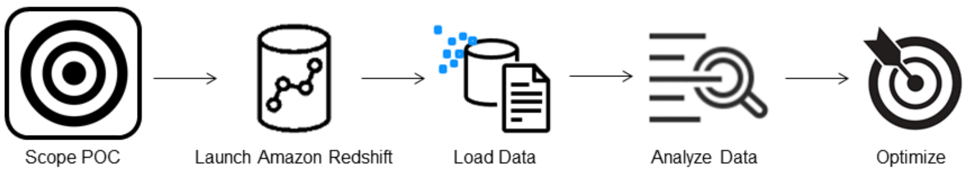
> **Note**
>
> For a copy of this information as a PDF, choose the link **Run your own Redshift POC** on the [Amazon Redshift resources](https://aws.amazon.com/redshift/resources/) page.

When doing a POC of Amazon Redshift, you test, prove out, and adopt features ranging from best-in-class security capabilities, elastic scaling, easy integration and ingestion, and flexible decentralized data architecture options.



Follow the these steps to conduct a successful POC.

Step 1: Scope your POC



When conducting a POC, you can either choose to use your own data, or you can choose to use benchmarking datasets. When you choose your own data you run your own queries against the data. With benchmarking data, sample queries are provided with the benchmark. See Use sample datasets for more details if you are not ready to conduct a POC with your own data just yet.

In general, we recommend using two weeks of data for an Amazon Redshift POC.

Start by doing the following:

1. **Identify your business and functional requirements,** then work backwards. Common examples are: faster performance, lower costs, test a new workload or feature, or comparison between Amazon Redshift and another data warehouse.
2. **Set specific targets** which become the success criteria for the POC. For example, from *faster performance*, come up with a list of the top five processes you wish to accelerate, and include the current run times along with your required run time. These can be reports, queries, ETL processes, data ingestion, or whatever your current pain points are.
3. **Identify the specific scope and artifacts** needed to run the tests. What datasets do you need to migrate or continuously ingest into Amazon Redshift, and what queries and processes are needed to run the tests to measure against the success criteria? There are two ways to do this:

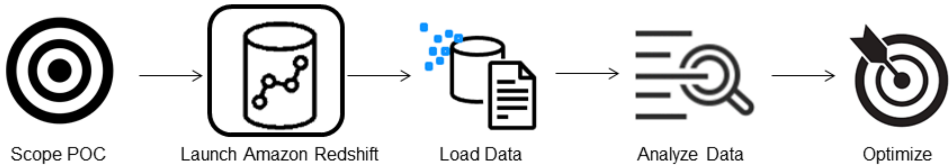
   Bring your own data

   - To test your own data, come up with the minimum viable list of data artifacts which is required to test for your success criteria. For example, if your current data warehouse has 200 tables, but the reports you want to test only need 20, your POC can be run faster by using only the smaller subset of tables.

   Use sample datasets

   - If you don't have your own datasets ready, you can still get started doing a POC on Amazon Redshift by using the industry-standard benchmark datasets such as TPC-DS or TPC-H and run sample benchmarking queries to harness the power of Amazon Redshift. These datasets can be accessed from within your Amazon Redshift data warehouse after it is created. For detailed instructions on how to access these datasets and sample queries, see Step 2: Launch Amazon Redshift.

Step 2: Launch Amazon Redshift



Amazon Redshift accelerates your time to insights with fast, easy, and secure cloud data warehousing at scale. You can start quickly by launching your warehouse on the Redshift Serverless console and get from data to insights in seconds. With Redshift Serverless, you can focus on delivering on your business outcomes without worrying about managing your data warehouse.

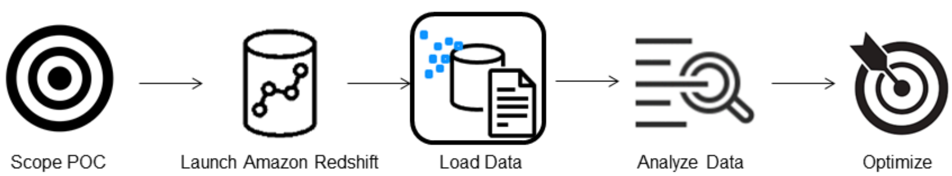
Set up Amazon Redshift Serverless

The first time you use Redshift Serverless, the console leads you through the steps required to launch your warehouse. You might also be eligible for a credit towards your Redshift Serverless usage in your account. For more information about choosing a free trial, see Amazon Redshift free trial. Follow the steps in the Creating a data warehouse with Redshift Serverless in the *Amazon Redshift Getting Started Guide* to create a data warehouse with Redshift Serverless. If you do not have a dataset that you would like to load, the guide also contains steps on how to load a sample data set.

If you have previously launched Redshift Serverless in your account, follow the steps in Creating a workgroup with a namespace in the *Amazon Redshift Management Guide*. After your warehouse is available, you can opt to load the sample data available in Amazon Redshift. For information about using Amazon Redshift query editor v2 to load data, see Loading sample data in the *Amazon Redshift Management Guide*.

If you are bringing your own data instead of loading the sample data set, see Step 3: Load your data.

Step 3: Load your data



After launching Redshift Serverless, the next step is to load your data for the POC. Whether you are uploading a simple CSV file, ingesting semi-structured data from S3, or streaming data directly, Amazon Redshift provides the flexibility to quickly and easily move the data into Amazon Redshift tables from the source.

Choose one of the following methods to load your data.

Upload a local file

For quick ingestion and analysis, you can use Amazon Redshift query editor v2 to easily load data files from your local desktop. It has the capability to process files in various formats such as CSV, JSON, AVRO, PARQUET, ORC, and more. To enable your users, as an administrator, to load data from a local desktop using query editor v2 you have to specify a common Amazon S3 bucket, and the user account must be configured with the proper permissions. You can follow Data load made easy and secure in Amazon Redshift using Query Editor V2 for step-by-step guidance.

Load an Amazon S3 file

To load data from an Amazon S3 bucket into Amazon Redshift, begin by using the COPY command, specifying the source Amazon S3 location and target Amazon Redshift table. Ensure that the IAM roles and permissions are properly configured to allow Amazon Redshift access to the designated Amazon S3 bucket. Follow Tutorial: Loading data from Amazon S3 for step-by-step guidance. You can also choose the **Load data** option in query editor v2 to directly load data from your S3 bucket.

Continuous data ingestion

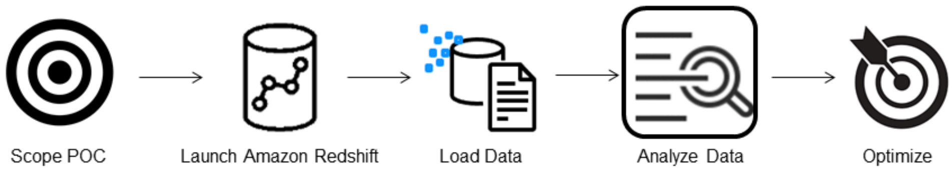
Autocopy (in preview) is an extension of the COPY command and automates continuous data loading from Amazon S3 buckets. When you create a copy job, Amazon Redshift detects when new Amazon S3 files are created in a specified path, and then loads them automatically without your intervention. Amazon Redshift keeps track of the loaded files to verify that they are loaded only one time. For instructions on how to create copy jobs, see COPY JOB

> **Note**
>
> Autocopy is currently in preview and supported only in provisioned clusters in specific AWS Regions. To create a preview cluster for autocopy, see Create an S3 event integration to automatically copy files from Amazon S3 buckets.

Load your streaming data

Streaming ingestion provides low-latency, high-speed ingestion of stream data from Amazon Kinesis Data Streams and Amazon Managed Streaming for Apache Kafka into Amazon Redshift. Amazon Redshift streaming ingestion uses a materialized view, which is updated directly from the stream utilizing auto refresh. The materialized view maps to the stream data source. You can perform filtering and aggregations on the stream data as part of the materialized view definition. For step-by-step guidance to load data from a stream, see Getting started with Amazon Kinesis Data Streams or an Getting started with Amazon Managed Streaming for Apache Kafka.

Step 4: Analyze your data



After creating your Redshift Serverless workgroup and namespace, and loading your data, you can immediately run queries by opening the **Query editor v2** from the navigation panel of the Redshift Serverless console. You can use query editor v2 to test query functionality or query performance against your own datasets.

Query using Amazon Redshift query editor v2

You can access query editor v2 from the Amazon Redshift console. See Simplify your data analysis with Amazon Redshift query editor v2 for a complete guide on how to configure, connect, and run queries with query editor v2.

Alternatively, if you want to run a load test as part of your POC, you can do this by the following steps to install and run Apache JMeter.

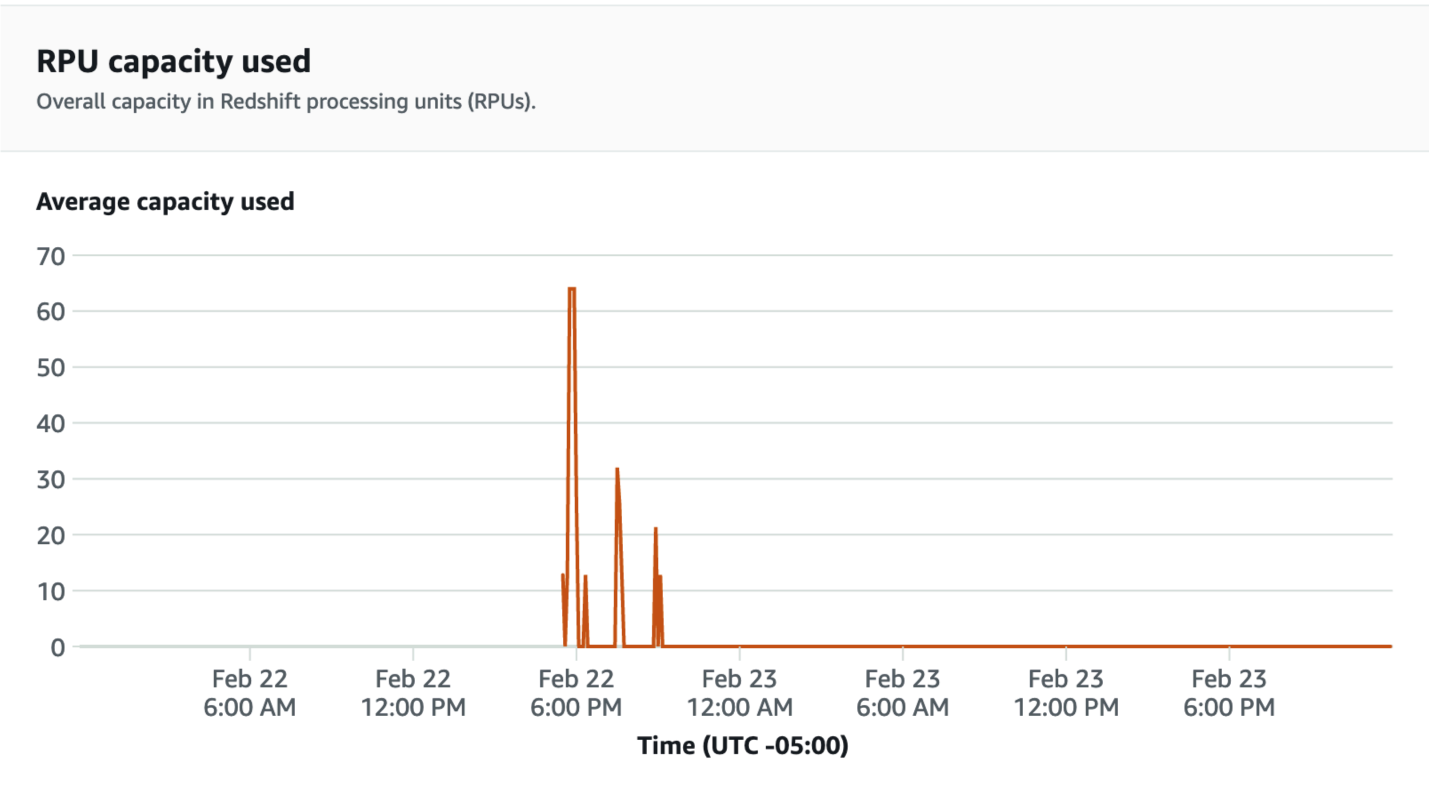
Run a load test using Apache JMeter

To perform a load test to simulate “N” users submitting queries concurrently to Amazon Redshift, you can use Apache JMeter, an open-source Java based tool.

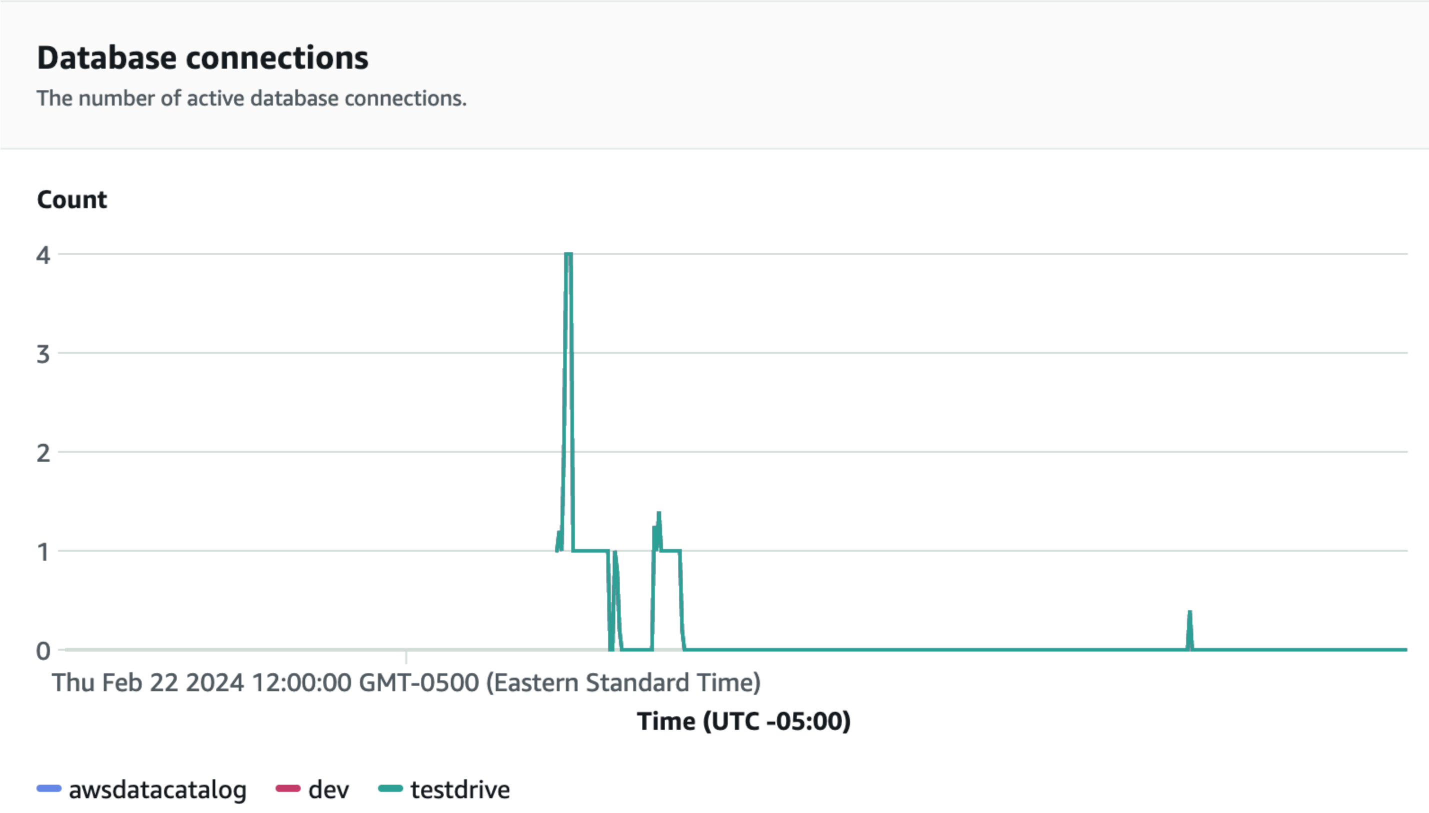
To install and configure Apache JMeter to run against your Redshift Serverless workgroup, follow the instructions in Automate Amazon Redshift load testing with the AWS Analytics Automation Toolkit. It uses the AWS Analytics Automation toolkit (AAA), an open source utility for dynamically deploying Redshift solutions, to automatically launch these resources. If you have loaded your own data into Amazon Redshift, be sure to perform the Step #5 – Customize SQL option, to make sure you supply the appropriate SQL statements you would like to test against your tables. Test each of these SQL statements one time using query editor v2 to make sure they run without errors.

After you complete customizing your SQL statements and finalizing your test plan, save and run your test plan against your Redshift Serverless workgroup. To monitor the progress of your test, open the Redshift Serverless console, navigate to **Query and database monitoring**, choose the **Query history** tab and view information about your queries.

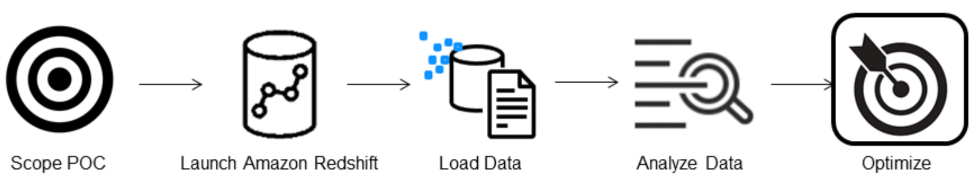
For performance metrics, choose the **Database performance** tab on the Redshift Serverless console, to monitor metrics such as **Database Connections** and **CPU utilization**. Here you can view a graph to monitor the RPU capacity used and observe how Redshift Serverless automatically scales to meet concurrent workload demands while the load test is running on your workgroup.



Database connections is another useful metric to monitor while running the load test to see how your workgroup is handling numerous concurrent connections at a given time to meet the increasing workload demands.



Step 5: Optimize



Amazon Redshift empowers tens of thousands of users to process exabytes of data every day and power their analytics workloads by offering a variety of configurations and features to support individual use cases. When choosing between these options, customers are looking for tools that help them determine the most optimal data warehouse configuration to support their Amazon Redshift workload.

Test drive

You can use Test Drive to automatically replay your existing workload on potential configurations and analyze the corresponding outputs to evaluate the optimal target to migrate your workload to.

See Find the best Amazon Redshift configuration for your workload using Redshift Test Drive for information about using Test Drive to evaluate different Amazon Redshift configurations.

Amazon Redshift best practices for designing tables

As you plan your database, certain key table design decisions heavily influence overall query performance. These design choices also have a significant effect on storage requirements, which in turn affects query performance by reducing the number of I/O operations and minimizing the memory required to process queries.

In this section, you can find a summary of the most important design decisions and best practices for optimizing query performance. Automatic table optimization provides more detailed explanations and examples of table design options.

Topics

Choose the best sort key

Amazon Redshift stores your data on disk in sorted order according to the sort key. The Amazon Redshift query optimizer uses sort order when it determines optimal query plans.

> **Note**
>
> When you use automatic table optimization, you don't need to choose the sort key of your table. For more information, see Automatic table optimization.

Some suggestions for the best approach follow:

- To have Amazon Redshift choose the appropriate sort order, specify `AUTO` for the sort key.

- If recent data is queried most frequently, specify the timestamp column as the leading column for the sort key.

  Queries are more efficient because they can skip entire blocks that fall outside the time range.
- If you do frequent range filtering or equality filtering on one column, specify that column as the sort key.

  Amazon Redshift can skip reading entire blocks of data for that column. It can do so because it tracks the minimum and maximum column values stored on each block and can skip blocks that don't apply to the predicate range.
- If you frequently join a table, specify the join column as both the sort key and the distribution key.

  Doing this enables the query optimizer to choose a sort merge join instead of a slower hash join. Because the data is already sorted on the join key, the query optimizer can bypass the sort phase of the sort merge join.

Choose the best distribution style

When you run a query, the query optimizer redistributes the rows to the compute nodes as needed to perform any joins and aggregations. The goal in selecting a table distribution style is to minimize the impact of the redistribution step by locating the data where it needs to be before the query is run.

> **Note**
>
> When you use automatic table optimization, you don't need to choose the distribution style of your table. For more information, see Automatic table optimization.

Some suggestions for the best approach follow:

1. Distribute the fact table and one dimension table on their common columns.

   Your fact table can have only one distribution key. Any tables that join on another key aren't collocated with the fact table. Choose one dimension to collocate based on how frequently it is joined and the size of the joining rows. Designate both the dimension table's primary key and the fact table's corresponding foreign key as the DISTKEY.

2. Choose the largest dimension based on the size of the filtered dataset.

   Only the rows that are used in the join must be distributed, so consider the size of the dataset after filtering, not the size of the table.
3. Choose a column with high cardinality in the filtered result set.

   If you distribute a sales table on a date column, for example, you should probably get fairly even data distribution, unless most of your sales are seasonal. However, if you commonly use a range-restricted predicate to filter for a narrow date period, most of the filtered rows occur on a limited set of slices and the query workload is skewed.
4. Change some dimension tables to use ALL distribution.

   If a dimension table cannot be collocated with the fact table or other important joining tables, you can improve query performance significantly by distributing the entire table to all of the nodes. Using ALL distribution multiplies storage space requirements and increases load times and maintenance operations, so you should weigh all factors before choosing ALL distribution.

To have Amazon Redshift choose the appropriate distribution style, specify `AUTO` for the distribution style.

For more information about choosing distribution styles, see Data distribution for query optimization.

Let COPY choose compression encodings

You can specify compression encodings when you create a table, but in most cases, automatic compression produces the best results.

ENCODE AUTO is the default for tables. When a table is set to ENCODE AUTO, Amazon Redshift automatically manages compression encoding for all columns in the table. For more information, see CREATE TABLE and ALTER TABLE.

The COPY command analyzes your data and applies compression encodings to an empty table automatically as part of the load operation.

Automatic compression balances overall performance when choosing compression encodings. Range-restricted scans might perform poorly if sort key columns are compressed much more highly than other columns in the same query. As a result, automatic compression chooses a less efficient compression encoding to keep the sort key columns balanced with other columns.

Suppose that your table's sort key is a date or timestamp and the table uses many large varchar columns. In this case, you might get better performance by not compressing the sort key column at all. Run the ANALYZE COMPRESSION command on the table, then use the encodings to create a new table, but leave out the compression encoding for the sort key.

There is a performance cost for automatic compression encoding, but only if the table is empty and does not already have compression encoding. For short-lived tables and tables that you create frequently, such as staging tables, load the table once with automatic compression or run the ANALYZE COMPRESSION command. Then use those encodings to create new tables. You can add the encodings to the CREATE TABLE statement, or use CREATE TABLE LIKE to create a new table with the same encoding.

For more information, see Loading tables with automatic compression.

Define primary key and foreign key constraints

Define primary key and foreign key constraints between tables wherever appropriate. Even though they are informational only, the query optimizer uses those constraints to generate more efficient query plans.

Do not define primary key and foreign key constraints unless your application enforces the constraints. Amazon Redshift does not enforce unique, primary-key, and foreign-key constraints.

See Table constraints for additional information about how Amazon Redshift uses constraints.

Use the smallest possible column size

Don't make it a practice to use the maximum column size for convenience.

Instead, consider the largest values you are likely to store in your columns and size them accordingly. For instance, a CHAR column for storing U.S. state and territory abbreviations used by the post office only needs to be CHAR(2).

Use date/time data types for date columns

Amazon Redshift stores DATE and TIMESTAMP data more efficiently than CHAR or VARCHAR, which results in better query performance. Use the DATE or TIMESTAMP data type, depending on the resolution you need, rather than a character type when storing date/time information. For more information, see Datetime types.

Amazon Redshift best practices for loading data

Loading very large datasets can take a long time and consume a lot of computing resources. How your data is loaded can also affect query performance. This section presents best practices for loading data efficiently using COPY commands, bulk inserts, and staging tables.

Topics

Learn how to load data with a tutorial

Tutorial: Loading data from Amazon S3 walks you beginning to end through the steps to upload data to an Amazon S3 bucket and then use the COPY command to load the data into your tables. The tutorial includes help with troubleshooting load errors and compares the performance difference between loading from a single file and loading from multiple files.

Use a COPY command to load data

The COPY command loads data in parallel from Amazon S3, Amazon EMR, Amazon DynamoDB, or multiple data sources on remote hosts. COPY loads large amounts of data much more efficiently than using INSERT statements, and stores the data more effectively as well.

For more information about using the COPY command, see Loading data from Amazon S3 and Loading data from an Amazon DynamoDB table.

Use a single COPY command to load from multiple files

Amazon Redshift can automatically load in parallel from multiple compressed data files. You can specify the files to be loaded by using an Amazon S3 object prefix or by using a manifest file.

However, if you use multiple concurrent COPY commands to load one table from multiple files, Amazon Redshift is forced to perform a serialized load. This type of load is much slower and requires a VACUUM process at the end if the table has a sort column defined. For more information about using COPY to load data in parallel, see Loading data from Amazon S3.

Loading data files

Source-data files come in different formats and use varying compression algorithms. When loading data with the COPY command, Amazon Redshift loads all of the files referenced by the Amazon S3 bucket prefix. (The prefix is a string of characters at the beginning of the object key name.) If the prefix refers to multiple files or files that can be split, Amazon Redshift loads the data in parallel, taking advantage of Amazon Redshift's MPP architecture. This divides the workload among the nodes in the cluster. In contrast, when you load data from a file that can't be split, Amazon Redshift is forced to perform a serialized load, which is much slower. The following sections describe the recommended way to load different file types into Amazon Redshift, depending on their format and compression.

Loading data from files that can be split

The following files can be automatically split when their data is loaded:

- an uncompressed CSV file
- a columnar file (Parquet/ORC)

Amazon Redshift automatically splits files 128MB or larger into chunks. Columnar files, specifically Parquet and ORC, aren't split if they're less than 128MB. Redshift makes use of slices working in parallel to load the data. This provides fast load performance.

Loading data from files that can't be split

File types such as JSON, or CSV, when compressed with other compression algorithms, such as GZIP, aren't automatically split. For these we recommend manually splitting the data into multiple smaller files that are close in size, from 1 MB to 1 GB after compression. Additionally, make the number of files a multiple of the number of slices in your cluster. For more information about how to split your data into multiple files and examples of loading data using COPY, see Loading data from Amazon S3.

Compressing your data files

When you want to compress large load files, we recommend that you use gzip, lzop, bzip2, or Zstandard to compress them and split the data into multiple smaller files.

Specify the GZIP, LZOP, BZIP2, or ZSTD option with the COPY command. This example loads the TIME table from a pipe-delimited lzop file.

```
copy time
from 's3://amzn-s3-demo-bucket/data/timerows.lzo'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
lzop
delimiter '|';
```

There are instances when you don't have to split uncompressed data files. For more information about splitting your data and examples of using COPY to load data, see Loading data from Amazon S3.

Verify data files before and after a load

Before you load data from Amazon S3, first verify that your Amazon S3 bucket contains all the correct files, and only those files. For more information, see Verifying that the correct files are present in your bucket.

After the load operation is complete, query the STL_LOAD_COMMITS system table to verify that the expected files were loaded. For more information, see Verifying that the data loaded correctly.

Use a multi-row insert

If a COPY command is not an option and you require SQL inserts, use a multi-row insert whenever possible. Data compression is inefficient when you add data only one row or a few rows at a time.

Multi-row inserts improve performance by batching up a series of inserts. The following example inserts three rows into a four-column table using a single INSERT statement. This is still a small insert, shown simply to illustrate the syntax of a multi-row insert.

```
insert into category_stage values
(default, default, default, default),
(20, default, 'Country', default),
(21, 'Concerts', 'Rock', default);
```

For more details and examples, see INSERT.

Use a bulk insert

Use a bulk insert operation with a SELECT clause for high-performance data insertion.

Use the INSERT and CREATE TABLE AS commands when you need to move data or a subset of data from one table into another.

For example, the following INSERT statement selects all of the rows from the CATEGORY table and inserts them into the CATEGORY_STAGE table.

```
insert into category_stage
(select * from category);
```

The following example creates CATEGORY_STAGE as a copy of CATEGORY and inserts all of the rows in CATEGORY into CATEGORY_STAGE.

```
create table category_stage as
select * from category;
```

Load data in sort key order

Load your data in sort key order to avoid needing to vacuum.

If each batch of new data follows the existing rows in your table, your data is properly stored in sort order, and you don't need to run a vacuum. You don't need to presort the rows in each load because COPY sorts each batch of incoming data as it loads.

For example, suppose that you load data every day based on the current day's activity. If your sort key is a timestamp column, your data is stored in sort order. This order occurs because the current day's data is always appended at the end of the previous day's data. For more information, see Load your data in sort key order. For more information about vacuum operations, see Vacuuming tables.

Load data in sequential blocks

If you need to add a large quantity of data, load the data in sequential blocks according to sort order to eliminate the need to vacuum.

For example, suppose that you need to load a table with events from January 2017 to December 2017. Assuming each month is in a single file, load the rows for January, then February, and so on. Your table is completely sorted when your load completes, and you don't need to run a vacuum. For more information, see Use time-series tables.

When loading very large datasets, the space required to sort might exceed the total available space. By loading data in smaller blocks, you use much less intermediate sort space during each load. In addition, loading smaller blocks make it easier to restart if the COPY fails and is rolled back.

Use time-series tables

If your data has a fixed retention period, you can organize your data as a sequence of time-series tables. In such a sequence, each table is identical but contains data for different time ranges.

You can easily remove old data simply by running a DROP TABLE command on the corresponding tables. This approach is much faster than running a large-scale DELETE process and saves you from having to run a subsequent VACUUM process to reclaim space. To hide the fact that the data is stored in different tables, you can create a UNION ALL view. When you delete old data, refine your UNION ALL view to remove the dropped tables. Similarly, as you load new time periods into new tables, add the new tables to the view. To signal the optimizer to skip the scan on tables that don't match the query filter, your view definition filters for the date range that corresponds to each table.

Avoid having too many tables in the UNION ALL view. Each additional table adds a small processing time to the query. Tables don't need to use the same time frame. For example, you might have tables for differing time periods, such as daily, monthly, and yearly.

If you use time-series tables with a timestamp column for the sort key, you effectively load your data in sort key order. Doing this eliminates the need to vacuum to re-sort the data. For more information, see Load your data in sort key order.

Schedule around maintenance windows

If a scheduled maintenance occurs while a query is running, the query is terminated and rolled back and you need to restart it. Schedule long-running operations, such as large data loads or VACUUM operation, to avoid maintenance windows. You can also minimize the risk, and make restarts easier when they are needed, by performing data loads in smaller increments and managing the size of your VACUUM operations. For more information, see Load data in sequential blocks and Vacuuming tables.

Amazon Redshift best practices for designing queries

To maximize query performance, follow these recommendations when creating queries:

- Design tables according to best practices to provide a solid foundation for query performance. For more information, see Amazon Redshift best practices for designing tables.
- Avoid using `select *`. Include only the columns you specifically need.
- Use a CASE conditional expression to perform complex aggregations instead of selecting from the same table multiple times.
- Don't use cross-joins unless absolutely necessary. These joins without a join condition result in the Cartesian product of two tables. Cross-joins are typically run as nested-loop joins, which are the slowest of the possible join types.
- Use subqueries in cases where one table in the query is used only for predicate conditions and the subquery returns a small number of rows (less than about 200). The following example uses a subquery to avoid joining the LISTING table.

```
select sum(sales.qtysold)
from sales
where salesid in (select listid from listing where listtime > '2008-12-26');
```

- Use predicates to restrict the dataset as much as possible.
- In the predicate, use the least expensive operators that you can. Comparison condition operators are preferable to LIKE operators. LIKE operators are still preferable to SIMILAR TO or POSIX operators.
- Avoid using functions in query predicates. Using them can drive up the cost of the query by requiring large numbers of rows to resolve the intermediate steps of the query.

- If possible, use a WHERE clause to restrict the dataset. The query planner can then use row order to help determine which records match the criteria, so it can skip scanning large numbers of disk blocks. Without this, the query execution engine must scan participating columns entirely.
- Add predicates to filter tables that participate in joins, even if the predicates apply the same filters. The query returns the same result set, but Amazon Redshift is able to filter the join tables before the scan step and can then efficiently skip scanning blocks from those tables. Redundant filters aren't needed if you filter on a column that's used in the join condition.

  For example, suppose that you want to join `SALES` and `LISTING` to find ticket sales for tickets listed after December, grouped by seller. Both tables are sorted by date. The following query joins the tables on their common key and filters for `listing.listtime` values greater than December 1.

  ```
  select listing.sellerid, sum(sales.qtysold)
  from sales, listing
  where sales.salesid = listing.listid
  and listing.listtime > '2008-12-01'
  group by 1 order by 1;
  ```

  The WHERE clause doesn't include a predicate for `sales.saletime`, so the execution engine is forced to scan the entire `SALES` table. If you know the filter would result in fewer rows participating in the join, then add that filter as well. The following example cuts execution time significantly.

  ```
  select listing.sellerid, sum(sales.qtysold)
  from sales, listing
  where sales.salesid = listing.listid
  and listing.listtime > '2008-12-01'
  and sales.saletime > '2008-12-01'
  group by 1 order by 1;
  ```
- Use sort keys in the GROUP BY clause so the query planner can use more efficient aggregation. A query might qualify for one-phase aggregation when its GROUP BY list contains only sort key columns, one of which is also the distribution key. The sort key columns in the GROUP BY list must include the first sort key, then other sort keys that you want to use in sort key order. For example, it is valid to use the first sort key, the first and second sort keys, the first, second, and third sort keys, and so on. It is not valid to use the first and third sort keys.

You can confirm the use of one-phase aggregation by running the EXPLAIN command and looking for `XN GroupAggregate` in the aggregation step of the query.

- If you use both GROUP BY and ORDER BY clauses, make sure that you put the columns in the same order in both. That is, use the approach just following.

```
group by a, b, c
order by a, b, c
```

Don't use the following approach.

```
group by b, c, a
order by a, b, c
```

Follow recommendations from Amazon Redshift Advisor

To help you improve the performance and decrease the operating costs for your Amazon Redshift cluster, Amazon Redshift Advisor offers you specific recommendations about changes to make. Advisor develops its customized recommendations by analyzing performance and usage metrics for your cluster. These tailored recommendations relate to operations and cluster settings. To help you prioritize your optimizations, Advisor ranks recommendations by order of impact.

Advisor bases its recommendations on observations regarding performance statistics or operations data. Advisor develops observations by running tests on your clusters to determine if a test value is within a specified range. If the test result is outside of that range, Advisor generates an observation for your cluster. At the same time, Advisor creates a recommendation about how to bring the observed value back into the best-practice range. Advisor only displays recommendations that should have a significant impact on performance and operations. When Advisor determines that a recommendation has been addressed, it removes it from your recommendation list.

For example, suppose that your data warehouse contains a large number of uncompressed table columns. In this case, you can save on cluster storage costs by rebuilding tables using the `ENCODE` parameter to specify column compression. In another example, suppose that Advisor observes that your cluster contains a significant amount of data in uncompressed table data. In this case, it provides you with the SQL code block to find the table columns that are candidates for compression and resources that describe how to compress those columns.

Amazon Redshift Regions where Advisor is supported

The Amazon Redshift Advisor feature is available only in the following AWS Regions:

- US East (N. Virginia) Region (us-east-1)
- US East (Ohio) Region (us-east-2)
- US West (N. California) Region (us-west-1)
- US West (Oregon) Region (us-west-2)
- Africa (Cape Town) Region (af-south-1)
- Asia Pacific (Hong Kong) Region (ap-east-1)
- Asia Pacific (Hyderabad) Region (ap-south-2)
- Asia Pacific (Jakarta) Region (ap-southeast-3)
- Asia Pacific (Melbourne) Region (ap-southeast-4)
- Asia Pacific (Malaysia) Region (ap-southeast-5)
- Asia Pacific (Mumbai) Region (ap-south-1)
- Asia Pacific (Osaka) Region (ap-northeast-3)
- Asia Pacific (Seoul) Region (ap-northeast-2)
- Asia Pacific (Singapore) Region (ap-southeast-1)
- Asia Pacific (Sydney) Region (ap-southeast-2)
- Asia Pacific (Tokyo) Region (ap-northeast-1)
- Canada (Central) Region (ca-central-1)
- Canada West (Calgary) Region (ca-west-1)
- China (Beijing) Region (cn-north-1)
- China (Ningxia) Region (cn-northwest-1)
- Europe (Frankfurt) Region (eu-central-1)
- Europe (Ireland) Region (eu-west-1)
- Europe (London) Region (eu-west-2)
- Europe (Milan) Region (eu-south-1)
- Europe (Paris) Region (eu-west-3)
- Europe (Spain) Region (eu-south-2)
- Europe (Stockholm) Region (eu-north-1)

- Europe (Zurich) Region (eu-central-2)
- Israel (Tel Aviv) Region (il-central-1)
- Middle East (Bahrain) Region (me-south-1)
- Middle East (UAE) Region (me-central-1)
- South America (São Paulo) Region (sa-east-1)

Topics

Viewing Amazon Redshift Advisor recommendations

You can access Amazon Redshift Advisor recommendations using the Amazon Redshift console, Amazon Redshift API, or AWS CLI. To access recommendations you must have permission `redshift:ListRecommendations` attached to your IAM role or identity.

Viewing Amazon Redshift Advisor recommendations on the Amazon Redshift provisioned console

You can view Amazon Redshift Advisor recommendations on the AWS Management Console.

To view Amazon Redshift Advisor recommendations for Amazon Redshift clusters on the console

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Advisor**.
3. Expand each recommendation to see more details. On this page, you can sort and group recommendations.

Viewing Amazon Redshift Advisor recommendations using Amazon Redshift API operations

You can list Amazon Redshift Advisor recommendations for Amazon Redshift clusters using the Amazon Redshift API. Typically, you develop and application in your programming language of your choice to call the `redshift:ListRecommendations` API using an AWS SDK. For more information, see ListRecommendations in the *Amazon Redshift API Reference*.

Viewing Amazon Redshift Advisor recommendations using AWS Command Line Interface operations

You can list Amazon Redshift Advisor recommendations for Amazon Redshift clusters using the AWS Command Line Interface. For more information, see list-recommendations in the *AWS CLI Command Reference*.

Amazon Redshift Advisor recommendations

Amazon Redshift Advisor offers recommendations about how to optimize your Amazon Redshift cluster to increase performance and save on operating costs. You can find explanations for each recommendation in the console, as described preceding. You can find further details on these recommendations in the following sections.

Topics

Compress Amazon S3 file objects loaded by COPY

The COPY command takes advantage of the massively parallel processing (MPP) architecture in Amazon Redshift to read and load data in parallel. It can read files from Amazon S3, DynamoDB tables, and text output from one or more remote hosts.

When loading large amounts of data, we strongly recommend using the COPY command to load compressed data files from S3. Compressing large datasets saves time uploading the files to Amazon S3. COPY can also speed up the load process by uncompressing the files as they are read.

Analysis

Long-running COPY commands that load large uncompressed datasets often have an opportunity for considerable performance improvement. The Advisor analysis identifies COPY commands that load large uncompressed datasets. In such a case, Advisor generates a recommendation to implement compression on the source files in Amazon S3.

Recommendation

Ensure that each COPY that loads a significant amount of data, or runs for a significant duration, ingests compressed data objects from Amazon S3. You can identify the COPY commands that load large uncompressed datasets from Amazon S3 by running the following SQL command as a superuser.

```
SELECT
    wq.userid, query, exec_start_time AS starttime, COUNT(*) num_files,
    ROUND(MAX(wq.total_exec_time/1000000.0),2) execution_secs,
    ROUND(SUM(transfer_size)/(1024.0*1024.0),2) total_mb,
    SUBSTRING(querytxt,1,60) copy_sql
FROM stl_s3client s
JOIN stl_query q USING (query)
JOIN stl_wlm_query wq USING (query)
WHERE s.userid>1 AND http_method = 'GET'
    AND POSITION('COPY ANALYZE' IN querytxt) = 0
    AND aborted = 0 AND final_state='Completed'
GROUP BY 1, 2, 3, 7
HAVING SUM(transfer_size) = SUM(data_size)
AND SUM(transfer_size)/(1024*1024) >= 5
ORDER BY 6 DESC, 5 DESC;
```

If the staged data remains in Amazon S3 after you load it, which is common in data lake architectures, storing this data in a compressed form can reduce your storage costs.

Implementation tips

- The ideal object size is 1–128 MB after compression.

- You can compress files with gzip, lzop, or bzip2 format.

Isolate multiple active databases

As a best practice, we recommend isolating databases in Amazon Redshift from one another. Queries run in a specific database and can't access data from any other database on the cluster. However, the queries that you run in all databases of a cluster share the same underlying cluster storage space and compute resources. When a single cluster contains multiple active databases, their workloads are usually unrelated.

Analysis

The Advisor analysis reviews all databases on the cluster for active workloads running at the same time. If there are active workloads running at the same time, Advisor generates a recommendation to consider migrating databases to separate Amazon Redshift clusters.

Recommendation

Consider moving each actively queried database to a separate dedicated cluster. Using a separate cluster can reduce resource contention and improve query performance. It can do so because it allows you to set the size for each cluster for the storage, cost, and performance needs of each workload. Also, unrelated workloads often benefit from different workload management configurations.

To identify which databases are actively used, you can run this SQL command as a superuser.

```
SELECT database,
  COUNT(*) as num_queries,
  AVG(DATEDIFF(sec,starttime,endtime)) avg_duration,
  MIN(starttime) as oldest_ts,
  MAX(endtime) as latest_ts
FROM stl_query
WHERE userid > 1
GROUP BY database;
```

Implementation tips

- Because a user must connect to each database specifically, and queries can only access a single database, moving databases to separate clusters has minimal impact for users.

- One option to move a database is to take the following steps:
  1. Temporarily restore a snapshot of the current cluster to a cluster of the same size.
  2. Delete all databases from the new cluster except the target database to be moved.
  3. Resize the cluster to an appropriate node type and count for the database's workload.

Reallocate workload management (WLM) memory

Amazon Redshift routes user queries to Implementing manual WLM for processing. Workload management (WLM) defines how those queries are routed to the queues. Amazon Redshift allocates each queue a portion of the cluster's available memory. A queue's memory is divided among the queue's query slots.

When a queue is configured with more slots than the workload requires, the memory allocated to these unused slots goes underutilized. Reducing the configured slots to match the peak workload requirements redistributes the underutilized memory to active slots, and can result in improved query performance.

Analysis

The Advisor analysis reviews workload concurrency requirements to identify query queues with unused slots. Advisor generates a recommendation to reduce the number of slots in a queue when it finds the following:

- A queue with slots that are completely inactive throughout the analysis.
- A queue with more than four slots that had at least two inactive slots throughout the analysis.

Recommendation

Reducing the configured slots to match peak workload requirements redistributes underutilized memory to active slots. Consider reducing the configured slot count for queues where the slots have never been fully used. To identify these queues, you can compare the peak hourly slot requirements for each queue by running the following SQL command as a superuser.

```
WITH
 generate_dt_series AS (select sysdate - (n * interval '5 second') as dt from (select
 row_number() over () as n from stl_scan limit 17280)),
 apex AS (
```

```
    SELECT iq.dt, iq.service_class, iq.num_query_tasks, count(iq.slot_count) as
 service_class_queries, sum(iq.slot_count) as service_class_slots
    FROM
        (select gds.dt, wq.service_class, wscc.num_query_tasks, wq.slot_count
        FROM stl_wlm_query wq
        JOIN stv_wlm_service_class_config wscc ON (wscc.service_class =
 wq.service_class AND wscc.service_class > 5)
        JOIN generate_dt_series gds ON (wq.service_class_start_time <= gds.dt AND
 wq.service_class_end_time > gds.dt)
        WHERE wq.userid > 1 AND wq.service_class > 5) iq
    GROUP BY iq.dt, iq.service_class, iq.num_query_tasks),
    maxes as (SELECT apex.service_class, trunc(apex.dt) as d, date_part(h,apex.dt) as
 dt_h, max(service_class_slots) max_service_class_slots
                    from apex group by apex.service_class, apex.dt,
 date_part(h,apex.dt))
SELECT apex.service_class - 5 AS queue, apex.service_class, apex.num_query_tasks AS
 max_wlm_concurrency, maxes.d AS day, maxes.dt_h || ':00 - ' || maxes.dt_h || ':59' as
 hour, MAX(apex.service_class_slots) as max_service_class_slots
FROM apex
JOIN maxes ON (apex.service_class = maxes.service_class AND apex.service_class_slots =
 maxes.max_service_class_slots)
GROUP BY  apex.service_class, apex.num_query_tasks, maxes.d, maxes.dt_h
ORDER BY apex.service_class, maxes.d, maxes.dt_h;
```

The `max_service_class_slots` column represents the maximum number of WLM query slots in the query queue for that hour. If underutilized queues exist, implement the slot reduction optimization by modifying a parameter group, as described in the *Amazon Redshift Management Guide.*

Implementation tips

- If your workload is highly variable in volume, make sure that the analysis captured a peak utilization period. If it didn't, run the preceding SQL repeatedly to monitor peak concurrency requirements.
- For more details on interpreting the query results from the preceding SQL code, see the wlm_apex_hourly.sql script on GitHub.

Skip compression analysis during COPY

When you load data into an empty table with compression encoding declared with the COPY command, Amazon Redshift applies storage compression. This optimization ensures that data in your cluster is stored efficiently even when loaded by end users. The analysis required to apply compression can require significant time.

Analysis

The Advisor analysis checks for COPY operations that were delayed by automatic compression analysis. The analysis determines the compression encodings by sampling the data while it's being loaded. This sampling is similar to that performed by the ANALYZE COMPRESSION command.

When you load data as part of a structured process, such as in an overnight extract, transform, load (ETL) batch, you can define the compression beforehand. You can also optimize your table definitions to skip this phase permanently without any negative impacts.

Recommendation

To improve COPY responsiveness by skipping the compression analysis phase, implement either of the following two options:

- Use the column `ENCODE` parameter when creating any tables that you load using the COPY command.
- Turn off compression altogether by supplying the `COMPUPDATE OFF` parameter in the COPY command.

The best solution is generally to use column encoding during table creation, because this approach also maintains the benefit of storing compressed data on disk. You can use the ANALYZE COMPRESSION command to suggest compression encodings, but you must recreate the table to apply these encodings. To automate this process, you can use the AWSColumnEncodingUtility, found on GitHub.

To identify recent COPY operations that triggered automatic compression analysis, run the following SQL command.

```
WITH xids AS (
  SELECT xid FROM stl_query WHERE userid>1 AND aborted=0
  AND querytxt = 'analyze compression phase 1' GROUP BY xid
```

```
    INTERSECT SELECT xid FROM stl_commit_stats WHERE node=-1)
SELECT a.userid, a.query, a.xid, a.starttime, b.complyze_sec,
    a.copy_sec, a.copy_sql
FROM (SELECT q.userid, q.query, q.xid, date_trunc('s',q.starttime)
    starttime, substring(querytxt,1,100) as copy_sql,
    ROUND(datediff(ms,starttime,endtime)::numeric / 1000.0, 2) copy_sec
    FROM stl_query q JOIN xids USING (xid)
    WHERE (querytxt ilike 'copy %from%' OR querytxt ilike '% copy %from%')
    AND querytxt not like 'COPY ANALYZE %') a
LEFT JOIN (SELECT xid,
    ROUND(sum(datediff(ms,starttime,endtime))::numeric / 1000.0,2) complyze_sec
    FROM stl_query q JOIN xids USING (xid)
    WHERE (querytxt like 'COPY ANALYZE %'
    OR querytxt like 'analyze compression phase %')
    GROUP BY xid ) b ON a.xid = b.xid
WHERE b.complyze_sec IS NOT NULL ORDER BY a.copy_sql, a.starttime;
```

Implementation tips

- Ensure that all tables of significant size created during your ETL processes (for example, staging tables and temporary tables) declare a compression encoding for all columns except the first sort key.
- Estimate the expected lifetime size of the table being loaded for each of the COPY commands identified by the SQL command preceding. If you are confident that the table will remain extremely small, turn off compression altogether with the `COMPUPDATE OFF` parameter. Otherwise, create the table with explicit compression before loading it with the COPY command.

Split Amazon S3 objects loaded by COPY

The COPY command takes advantage of the massively parallel processing (MPP) architecture in Amazon Redshift to read and load data from files on Amazon S3. The COPY command loads the data in parallel from multiple files, dividing the workload among the nodes in your cluster. To achieve optimal throughput, we strongly recommend that you divide your data into multiple files to take advantage of parallel processing.

Analysis

The Advisor analysis identifies COPY commands that load large datasets contained in a small number of files staged in Amazon S3. Long-running COPY commands that load large datasets from a few files often have an opportunity for considerable performance improvement. When Advisor identifies that these COPY commands are taking a significant amount of time, it creates a recommendation to increase parallelism by splitting the data into additional files in Amazon S3.

Recommendation

In this case, we recommend the following actions, listed in priority order:

1. Optimize COPY commands that load fewer files than the number of cluster nodes.
2. Optimize COPY commands that load fewer files than the number of cluster slices.
3. Optimize COPY commands where the number of files is not a multiple of the number of cluster slices.

Certain COPY commands load a significant amount of data or run for a significant duration. For these commands, we recommend that you load a number of data objects from Amazon S3 that is equivalent to a multiple of the number of slices in the cluster. To identify how many S3 objects each COPY command has loaded, run the following SQL code as a superuser.

```
SELECT
    query, COUNT(*) num_files,
    ROUND(MAX(wq.total_exec_time/1000000.0),2) execution_secs,
    ROUND(SUM(transfer_size)/(1024.0*1024.0),2) total_mb,
    SUBSTRING(querytxt,1,60) copy_sql
FROM stl_s3client s
JOIN stl_query q USING (query)
JOIN stl_wlm_query wq USING (query)
WHERE s.userid>1 AND http_method = 'GET'
    AND POSITION('COPY ANALYZE' IN querytxt) = 0
    AND aborted = 0 AND final_state='Completed'
GROUP BY query, querytxt
HAVING (SUM(transfer_size)/(1024*1024))/COUNT(*) >= 2
ORDER BY CASE
WHEN COUNT(*) < (SELECT max(node)+1 FROM stv_slices) THEN 1
WHEN COUNT(*) < (SELECT COUNT(*) FROM stv_slices WHERE node=0) THEN 2
ELSE 2+((COUNT(*) % (SELECT COUNT(*) FROM stv_slices))/(SELECT COUNT(*)::DECIMAL FROM
 stv_slices))
END, (SUM(transfer_size)/(1024.0*1024.0))/COUNT(*) DESC;
```

Implementation tips

- The number of slices in a node depends on the node size of the cluster. For more information about the number of slices in the various node types, see Clusters and Nodes in Amazon Redshift in the *Amazon Redshift Management Guide.*
- You can load multiple files by specifying a common prefix, or prefix key, for the set, or by explicitly listing the files in a manifest file. For more information about loading files, see Loading data from compressed and uncompressed files.
- Amazon Redshift doesn't take file size into account when dividing the workload. Split your load data files so that the files are about equal size, between 1 MB and 1 GB after compression.

Update table statistics

Amazon Redshift uses a cost-based query optimizer to choose the optimum execution plan for queries. The cost estimates are based on table statistics gathered using the ANALYZE command. When statistics are out of date or missing, the database might choose a less efficient plan for query execution, especially for complex queries. Maintaining current statistics helps complex queries run in the shortest possible time.

Analysis

The Advisor analysis tracks tables whose statistics are out-of-date or missing. It reviews table access metadata associated with complex queries. If tables that are frequently accessed with complex patterns are missing statistics, Advisor creates a **critical** recommendation to run ANALYZE. If tables that are frequently accessed with complex patterns have out-of-date statistics, Advisor creates a **suggested** recommendation to run ANALYZE.

Recommendation

Whenever table content changes significantly, update statistics with ANALYZE. We recommend running ANALYZE whenever a significant number of new data rows are loaded into an existing table with COPY or INSERT commands. We also recommend running ANALYZE whenever a significant number of rows are modified using UPDATE or DELETE commands. To identify tables with missing or out-of-date statistics, run the following SQL command as a superuser. The results are ordered from largest to smallest table.

To identify tables with missing or out-of-date statistics, run the following SQL command as a superuser. The results are ordered from largest to smallest table.

```
SELECT
   ti.schema||'.'||ti."table" tablename,
   ti.size table_size_mb,
   ti.stats_off statistics_accuracy
 FROM svv_table_info ti
 WHERE ti.stats_off > 5.00
 ORDER BY ti.size DESC;
```

Implementation tips

The default ANALYZE threshold is 10 percent. This default means that the ANALYZE command skips a given table if fewer than 10 percent of the table's rows have changed since the last ANALYZE. As a result, you might choose to issue ANALYZE commands at the end of each ETL process. Taking this approach means that ANALYZE is often skipped but also ensures that ANALYZE runs when needed.

ANALYZE statistics have the most impact for columns that are used in joins (for example, `JOIN tbl_a ON col_b`) or as predicates (for example, `WHERE col_b = 'xyz'`). By default, ANALYZE collects statistics for all columns in the table specified. If needed, you can reduce the time required to run ANALYZE by running ANALYZE only for the columns where it has the most impact. You can run the following SQL command to identify columns used as predicates. You can also let Amazon Redshift choose which columns to analyze by specifying `ANALYZE PREDICATE COLUMNS`.

```
WITH predicate_column_info as (
SELECT ns.nspname AS schema_name, c.relname AS table_name, a.attnum as col_num,
 a.attname as col_name,
        CASE
            WHEN 10002 = s.stakind1 THEN array_to_string(stavalues1, '||')
            WHEN 10002 = s.stakind2 THEN array_to_string(stavalues2, '||')
            WHEN 10002 = s.stakind3 THEN array_to_string(stavalues3, '||')
            WHEN 10002 = s.stakind4 THEN array_to_string(stavalues4, '||')
            ELSE NULL::varchar
        END AS pred_ts
   FROM pg_statistic s
   JOIN pg_class c ON c.oid = s.starelid
   JOIN pg_namespace ns ON c.relnamespace = ns.oid
   JOIN pg_attribute a ON c.oid = a.attrelid AND a.attnum = s.staattnum)
SELECT schema_name, table_name, col_num, col_name,
       pred_ts NOT LIKE '2000-01-01%' AS is_predicate,
```

```
       CASE WHEN pred_ts NOT LIKE '2000-01-01%' THEN (split_part(pred_ts,
 '||',1))::timestamp ELSE NULL::timestamp END as first_predicate_use,
       CASE WHEN pred_ts NOT LIKE '%||2000-01-01%' THEN (split_part(pred_ts,
 '||',2))::timestamp ELSE NULL::timestamp END as last_analyze
FROM predicate_column_info;
```

For more information, see Analyzing tables.

Enable short query acceleration

Short query acceleration (SQA) prioritizes selected short-running queries ahead of longer-running queries. SQA runs short-running queries in a dedicated space, so that SQA queries aren't forced to wait in queues behind longer queries. SQA only prioritizes queries that are short-running and are in a user-defined queue. With SQA, short-running queries begin running more quickly and users see results sooner.

If you turn on SQA, you can reduce or eliminate workload management (WLM) queues that are dedicated to running short queries. In addition, long-running queries don't need to contend with short queries for slots in a queue, so you can configure your WLM queues to use fewer query slots. When you use lower concurrency, query throughput is increased and overall system performance is improved for most workloads. For more information, see Short query acceleration.

Analysis

Advisor checks for workload patterns and reports the number of recent queries where SQA would reduce latency and the daily queue time for SQA-eligible queries.

Recommendation

Modify the WLM configuration to turn on SQA. Amazon Redshift uses a machine learning algorithm to analyze each eligible query. Predictions improve as SQA learns from your query patterns. For more information, see Configuring Workload Management.

When you turn on SQA, WLM sets the maximum runtime for short queries to dynamic by default. We recommend keeping the dynamic setting for SQA maximum runtime.

Implementation tips

To check whether SQA is turned on, run the following query. If the query returns a row, then SQA is turned on.

```
select * from stv_wlm_service_class_config
```

```
where service_class = 14;
```

For more information, see Monitoring SQA.

Alter distribution keys on tables

Amazon Redshift distributes table rows throughout the cluster according to the table distribution style. Tables with KEY distribution require a column as the distribution key (DISTKEY). A table row is assigned to a node slice of a cluster based on its DISTKEY column value.

An appropriate DISTKEY places a similar number of rows on each node slice and is frequently referenced in join conditions. An optimized join occurs when tables are joined on their DISTKEY columns, accelerating query performance.

Analysis

Advisor analyzes your cluster's workload to identify the most appropriate distribution key for the tables that can significantly benefit from a KEY distribution style.

Recommendation

Advisor provides ALTER TABLE statements that alter the DISTSTYLE and DISTKEY of a table based on its analysis. To realize a significant performance benefit, make sure to implement all SQL statements within a recommendation group.

Redistributing a large table with ALTER TABLE consumes cluster resources and requires temporary table locks at various times. Implement each recommendation group when other cluster workload is light. For more details on optimizing table distribution properties, see the Amazon Redshift Engineering's Advanced Table Design Playbook: Distribution Styles and Distribution Keys.

For more information about ALTER DISTSTYLE and DISTKEY, see ALTER TABLE.

> **Note**
>
> If you don't see a recommendation that doesn't necessarily mean that the current distribution styles are the most appropriate. Advisor doesn't provide recommendations when there isn't enough data or the expected benefit of redistribution is small.
> Advisor recommendations apply to a particular table and don't necessarily apply to a table that contains a column with the same name. Tables that share a column name can have different characteristics for those columns unless data inside the tables is the same.

> If you see recommendations for staging tables that are created or dropped by ETL jobs, modify your ETL processes to use the Advisor recommended distribution keys.

Alter sort keys on tables

Amazon Redshift sorts table rows according to the table sort key. The sorting of table rows is based on the sort key column values.

Sorting a table on an appropriate sort key can accelerate performance of queries, especially those with range-restricted predicates, by requiring fewer table blocks to be read from disk.

Analysis

Advisor analyzes your cluster's workload over several days to identify a beneficial sort key for your tables.

Recommendation

Advisor provides two groups of ALTER TABLE statements that alter the sort key of a table based on its analysis:

- Statements that alter a table that currently doesn't have a sort key to add a COMPOUND sort key.
- Statements that alter a sort key from INTERLEAVED to COMPOUND or no sort key.

  Using compound sort keys significantly reduces maintenance overhead. Tables with compound sort keys don't need the expensive VACUUM REINDEX operations that are necessary for interleaved sorts. In practice, compound sort keys are more effective than interleaved sort keys for the vast majority of Amazon Redshift workloads. However, if a table is small, it's more efficient not to have a sort key to avoid sort key storage overhead.

When sorting a large table with the ALTER TABLE, cluster resources are consumed and table locks are required at various times. Implement each recommendation when a cluster's workload is moderate. More details on optimizing table sort key configurations can be found in the Amazon Redshift Engineering's Advanced Table Design Playbook: Compound and Interleaved Sort Keys.

For more information about ALTER SORTKEY, see ALTER TABLE.

> **Note**
>
> If you don't see a recommendation for a table, that doesn't necessarily mean that the current configuration is the best. Advisor doesn't provide recommendations when there isn't enough data or the expected benefit of sorting is small.
> Advisor recommendations apply to a particular table and don’t necessarily apply to a table that contains a column with the same name and data type. Tables that share column names can have different recommendations based on the data in the tables and the workload.

Alter compression encodings on columns

Compression is a column-level operation that reduces the size of data when it's stored. Compression is used in Amazon Redshift to conserve storage space and improve query performance by reducing the amount of disk I/O. We recommend an optimal compression encoding for each column based on its data type and on query patterns. With optimal compression, queries can run more efficiently and the database can take up minimal storage space.

Analysis

Advisor performs analysis of your cluster's workload and database schema continually to identify the optimal compression encoding for each table column.

Recommendation

Advisor provides ALTER TABLE statements that change the compression encoding of particular columns, based on its analysis.

Changing column compression encodings with ALTER TABLE consumes cluster resources and requires table locks at various times. It's best to implement recommendations when the cluster workload is light.

For reference, ALTER TABLE examples shows several statements that change the encoding for a column.

> **Note**
>
> Advisor doesn't provide recommendations when there isn't enough data or the expected benefit of changing the encoding is small.

Data type recommendations

Amazon Redshift has a library of SQL data types for various use cases. These include integer types like `INT` and types to store characters, like `VARCHAR`. Redshift stores types in an optimized way to provide fast access and good query performance. Also, Redshift provides functions for specific types, which you can use to format or perform calculations on query results.

Analysis

Advisor performs analysis of your cluster's workload and database schema continually to identify columns that can benefit significantly from a data type change.

Recommendation

Advisor provides an `ALTER TABLE` statement that adds a new column with the suggested data type. An accompanying `UPDATE` statement copies data from the existing column to the new column. After you create the new column and load the data, change your queries and ingestion scripts to access the new column. Then leverage features and functions specialized to the new data type, found in SQL functions reference.

Copying existing data to the new column can take time. We recommend that you implement each advisor recommendation when the cluster’s workload is light. Reference the list of available data types at Data types.

Note that Advisor doesn't provide recommendations when there isn't enough data or the expected benefit of changing the data type is small.

Tutorials for Amazon Redshift

Follow the steps in these tutorials to learn about Amazon Redshift features:

Tutorial: Loading data from Amazon S3	In this tutorial, you walk through the process of loading data into your Amazon Redshift database tables from data files in an S3 bucket from beginning to end.
Tutorial: Querying nested data with Amazon Redshift Spectrum	In this tutorial, you use Redshift Spectrum to query nested data. Redshift Spectrum lets you query data in Parquet, ORC, JSON, or Ion file formats.
Tutorial: Configuring manual workload management (WLM) queues	In this tutorial, you configure Amazon Redshift to use manual workload management (WLM) queues. Amazon Redshift uses WLM queues to manage how resources are divided to run concurrent queries. You must configure Amazon Redshift to use manual WLM if you need to use multiple WLM WLM queues.
Tutorial: Using spatial SQL functions with Amazon Redshift	In this tutorial, you query data using spatial functions. You use spatial functions to query geometry and geography data.
Tutorials for Amazon Redshift ML	In these tutorials, you create and use machine learning models.
Tutorial: Creating roles and querying with RBAC	In this tutorial, you use role-based access control (RBAC) to create and use permissions in a database you create. With RBAC, you can create roles with specific permissions, such as read-only or read-write permissions. You can then assign these roles to users to grant them the specified permissions.

Automatic table optimization

Automatic table optimization is a self-tuning capability that automatically optimizes the design of tables by applying sort and distribution keys without the need for administrator intervention. By using automation to tune the design of tables, you can get started and get the fastest performance without investing time to manually tune and implement table optimizations.

Automatic table optimization continuously observes how queries interact with tables. It uses advanced artificial intelligence methods to choose sort and distribution keys to optimize performance for the cluster's workload. If Amazon Redshift determines that applying a key improves cluster performance, tables are automatically altered within hours from the time the cluster was created, with minimal impact to queries.

To take advantage of this automation, an Amazon Redshift administrator creates a new table, or alters an existing table to enable it to use automatic optimization. Existing tables with a distribution style or sort key of `AUTO` are already enabled for automation. When you run queries against those tables, Amazon Redshift determines if a sort key or distribution key will improve performance. If so, then Amazon Redshift automatically modifies the table without requiring administrator intervention. If a minimum number of queries are run, optimizations are applied within hours of the cluster being launched.

If Amazon Redshift determines that a distribution key improves the performance of queries, tables where distribution style is `AUTO` can have their distribution style changed to `KEY`.

Topics

Enabling, disabling, and monitoring automatic table optimization

By default, tables created without explicitly defining sort keys or distributions keys are set to AUTO. At the time of table creation, you can also explicitly set a sort or a distribution key manually. If you set the sort or distribution key, then the table is not automatically managed.

Enabling automatic table optimization

To enable an existing table to be automatically optimized, use the ALTER statement options to change the table to AUTO. You might choose to define automation for sort keys, but not for distribution keys (and vice versa). If you run an ALTER statement to convert a table to be an automated table, existing sort keys and distribution styles are preserved.

```
ALTER TABLE table_name ALTER SORTKEY AUTO;
```

```
ALTER TABLE table_name ALTER DISTSTYLE AUTO;
```

For more information, see ALTER TABLE.

Initially, a table has no distribution key or sort key. The distribution style is set to either EVEN or ALL depending on table size. As the table grows in size, Amazon Redshift applies the optimal distribution keys and sort keys. Optimizations are applied within hours after a minimum number of queries are run. When determining sort key optimizations, Amazon Redshift attempts to optimize the data blocks read from disk during a table scan. When determining distribution style optimizations, Amazon Redshift tries to optimize the number of bytes transferred between cluster nodes.

Removing automatic table optimization from a table

You can remove a table from automatic optimization. Removing a table from automation involves selecting a sort key or distribution style. To change distribution style, specify a specific distribution style.

```
ALTER TABLE table_name ALTER DISTSTYLE EVEN;
```

```
ALTER TABLE table_name ALTER DISTSTYLE ALL;
```

```
ALTER TABLE table_name ALTER DISTSTYLE KEY DISTKEY c1;
```

To change a sort key, you can define a sort key or choose none.

```
ALTER TABLE table_name ALTER SORTKEY(c1, c2);
```

```
ALTER TABLE table_name ALTER SORTKEY NONE;
```

Monitoring automatic table optimization

The system view `SVV_ALTER_TABLE_RECOMMENDATIONS` records the current Amazon Redshift Advisor recommendations for tables. This view shows recommendations for all tables, those that are defined for automatic optimization and those that aren't.

To view if a table is defined for automatic optimization, query the system view `SVV_TABLE_INFO`. Entries appear only for tables visible in the current session's database. Recommendations are inserted into the view twice per day starting within hours from the time the cluster was created. After a recommendation is available, it's started within an hour. After a recommendation has been applied (either by Amazon Redshift or by you), it no longer appears in the view.

The system view `SVL_AUTO_WORKER_ACTION` shows an audit log of all actions taken by Amazon Redshift, and the previous state of the table.

The system view `SVV_TABLE_INFO` lists all of the tables in the system, along with a column to indicate whether the sort key and distribution style of the table is set to `AUTO`.

For more information about these system views, see [System monitoring (provisioned only)](#).

Column compression to reduce the size of stored data

Compression is a column-level operation that reduces the size of data when it is stored. Compression conserves storage space and reduces the size of data that is read from storage, which reduces the amount of disk I/O and therefore improves query performance.

ENCODE AUTO is the default for tables. When a table is set to ENCODE AUTO, Amazon Redshift automatically manages compression encoding for all columns in the table. For more information, see [CREATE TABLE](#) and [ALTER TABLE](#).

However, if you specify compression encoding for any column in the table, the table is no longer set to ENCODE AUTO. Amazon Redshift no longer automatically manages compression encoding for all columns in the table.

You can apply a compression type, or *encoding*, to the columns in a table manually when you create the table. Or you can use the COPY command to analyze and apply compression automatically. For more information, see Let COPY choose compression encodings. For details about applying automatic compression, see Loading tables with automatic compression.

Note

We strongly recommend using the COPY command to apply automatic compression.

You might choose to apply compression encodings manually if the new table shares the same data characteristics as another table. Or you might do so if you discover in testing that the compression encodings applied during automatic compression are not the best fit for your data. If you choose to apply compression encodings manually, you can run the ANALYZE COMPRESSION command against an already populated table and use the results to choose compression encodings.

To apply compression manually, you specify compression encodings for individual columns as part of the CREATE TABLE statement. The syntax is as follows.

```
CREATE TABLE table_name (column_name
data_type ENCODE encoding-type)[, ...]
```

Here, *encoding-type* is taken from the keyword table in the following section.

For example, the following statement creates a two-column table, PRODUCT. When data is loaded into the table, the PRODUCT_ID column is not compressed, but the PRODUCT_NAME column is compressed, using the byte dictionary encoding (BYTEDICT).

```
create table product(
product_id int encode raw,
product_name char(20) encode bytedict);
```

You can specify the encoding for a column when it is added to a table using the ALTER TABLE command.

```
ALTER TABLE table-name ADD [ COLUMN ] column_name column_type ENCODE encoding-type
```

Topics

Compression encodings

A *compression encoding* specifies the type of compression that is applied to a column of data values as rows are added to a table.

ENCODE AUTO is the default for tables. When a table is set to ENCODE AUTO, Amazon Redshift automatically manages compression encoding for all columns in the table. For more information, see CREATE TABLE and ALTER TABLE.

However, if you specify compression encoding for any column in the table, the table is no longer set to ENCODE AUTO. Amazon Redshift no longer automatically manages compression encoding for all columns in the table.

When you use CREATE TABLE, ENCODE AUTO is disabled when you specify compression encoding for any column in the table. If ENCODE AUTO is disabled, Amazon Redshift automatically assigns compression encoding to columns for which you don't specify an ENCODE type as follows:

- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIMESTAMP, or TIMESTAMPTZ data types are assigned AZ64 compression.
- Columns that are defined as CHAR or VARCHAR data types are assigned LZO compression.

You can change a table's encoding after creating it by using ALTER TABLE. If you disable ENCODE AUTO using ALTER TABLE, Amazon Redshift no longer automatically manages compression encodings for your columns. All columns will keep the compression encoding types that they had when you disabled ENCODE AUTO until you change them or you enable ENCODE AUTO again.

Amazon Redshift supports the following compression encodings:

Raw

Raw encoding is the default encoding for columns that are designated as sort keys and columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types. With raw encoding, data is stored in raw, uncompressed form.

AZ64

AZ64 is a proprietary compression encoding algorithm designed by Amazon to achieve a high compression ratio and improved query processing. At its core, the AZ64 algorithm compresses smaller groups of data values and uses single instruction, multiple data (SIMD) instructions for parallel processing. Use AZ64 to achieve significant storage savings and high performance for numeric, date, and time data types.

You can use AZ64 as the compression encoding when defining columns using CREATE TABLE and ALTER TABLE statements with the following data types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- DATE
- TIMESTAMP
- TIMESTAMPTZ

Byte-dictionary

In byte dictionary encoding, a separate dictionary of unique values is created for each block of column values on disk. (An Amazon Redshift disk block occupies 1 MB.) The dictionary contains up to 256 one-byte values that are stored as indexes to the original data values. If more than 256 values are stored in a single block, the extra values are written into the block in raw, uncompressed form. The process repeats for each disk block.

This encoding is very effective on low cardinality string columns. This encoding is optimal when the data domain of a column is fewer than 256 unique values.

For columns with the string data type (CHAR and VARCHAR) encoded with BYTEDICT, Amazon Redshift performs vectorized scans and predicate evaluations that operate over compressed data directly. These scans use hardware-specific single instruction and multiple data (SIMD) instructions for parallel processing. This significantly speeds up the scanning of string columns. Byte-dictionary encoding is especially space-efficient if a CHAR/VARCHAR column holds long character strings.

Suppose that a table has a COUNTRY column with a CHAR(30) data type. As data is loaded, Amazon Redshift creates the dictionary and populates the COUNTRY column with the index value. The dictionary contains the indexed unique values, and the table itself contains only the one-byte subscripts of the corresponding values.

Note

Trailing blanks are stored for fixed-length character columns. Therefore, in a CHAR(30) column, every compressed value saves 29 bytes of storage when you use the byte-dictionary encoding.

The following table represents the dictionary for the COUNTRY column.

Unique data value	Dictionary index	Size (fixed length, 30 bytes per value)
England	0	30
United States of America	1	30
Venezuela	2	30
Sri Lanka	3	30
Argentina	4	30
Japan	5	30
Total		180

The following table represents the values in the COUNTRY column.

Original data value	Original size (fixed length, 30 bytes per value)	Compressed value (index)	New size (bytes)
England	30	0	1
England	30	0	1
United States of America	30	1	1
United States of America	30	1	1
Venezuela	30	2	1
Sri Lanka	30	3	1
Argentina	30	4	1
Japan	30	5	1
Sri Lanka	30	3	1
Argentina	30	4	1
Total	300		10

The total compressed size in this example is calculated as follows: 6 different entries are stored in the dictionary (6 * 30 = 180), and the table contains 10 1-byte compressed values, for a total of 190 bytes.

Delta

Delta encodings are very useful for date time columns.

Delta encoding compresses data by recording the difference between values that follow each other in the column. This difference is recorded in a separate dictionary for each block of column values on disk. (An Amazon Redshift disk block occupies 1 MB.) For example, suppose that the column contains 10 integers in sequence from 1 to 10. The first are stored as a 4-byte integer (plus a 1-byte flag). The next nine are each stored as a byte with the value 1, indicating that it is one greater than the previous value.

Delta encoding comes in two variations:

- DELTA records the differences as 1-byte values (8-bit integers)
- DELTA32K records differences as 2-byte values (16-bit integers)

If most of the values in the column could be compressed by using a single byte, the 1-byte variation is very effective. However, if the deltas are larger, this encoding, in the worst case, is somewhat less effective than storing the uncompressed data. Similar logic applies to the 16-bit version.

If the difference between two values exceeds the 1-byte range (DELTA) or 2-byte range (DELTA32K), the full original value is stored, with a leading 1-byte flag. The 1-byte range is from -127 to 127, and the 2-byte range is from -32K to 32K.

The following table shows how a delta encoding works for a numeric column.

Original data value	Original size (bytes)	Difference (delta)	Compressed value	Compressed size (bytes)
1	4		1	1+4 (flag + actual value)
5	4	4	4	1
50	4	45	45	1
200	4	150	150	1+4 (flag + actual value)
185	4	-15	-15	1
220	4	35	35	1
221	4	1	1	1
Totals	28			15

LZO

LZO encoding provides a very high compression ratio with good performance. LZO encoding works especially well for CHAR and VARCHAR columns that store very long character strings. They are especially good for free-form text, such as product descriptions, user comments, or JSON strings.

Mostly

Mostly encodings are useful when the data type for a column is larger than most of the stored values require. By specifying a mostly encoding for this type of column, you can compress the majority of the values in the column to a smaller standard storage size. The remaining values that cannot be compressed are stored in their raw form. For example, you can compress a 16-bit column, such as an INT2 column, to 8-bit storage.

In general, the mostly encodings work with the following data types:

- SMALLINT/INT2 (16-bit)
- INTEGER/INT (32-bit)
- BIGINT/INT8 (64-bit)
- DECIMAL/NUMERIC (64-bit)

Choose the appropriate variation of the mostly encoding to suit the size of the data type for the column. For example, apply MOSTLY8 to a column that is defined as a 16-bit integer column. Applying MOSTLY16 to a column with a 16-bit data type or MOSTLY32 to a column with a 32-bit data type is disallowed.

Mostly encodings might be less effective than no compression when a relatively high number of the values in the column can't be compressed. Before applying one of these encodings to a column, perform a check. *Most* of the values that you are going to load now (and are likely to load in the future) should fit into the ranges shown in the following table.

Encoding	Compressed storage size	Range of values that can be compressed (values outside the range are stored raw)
MOSTLY8	1 byte (8 bits)	-128 to 127
MOSTLY16	2 bytes (16 bits)	-32768 to 32767

Encoding	Compressed storage size	Range of values that can be compressed (values outside the range are stored raw)
MOSTLY32	4 bytes (32 bits)	-2147483648 to +2147483647

> **Note**
>
> For decimal values, ignore the decimal point to determine whether the value fits into the range. For example, 1,234.56 is treated as 123,456 and can be compressed in a MOSTLY32 column.

For example, the VENUEID column in the VENUE table is defined as a raw integer column, which means that its values consume 4 bytes of storage. However, the current range of values in the column is **`0`** to **`309`**. Therefore, recreating and reloading this table with MOSTLY16 encoding for VENUEID would reduce the storage of every value in that column to 2 bytes.

If the VENUEID values referenced in another table were mostly in the range of 0 to 127, it might make sense to encode that foreign-key column as MOSTLY8. Before making the choice, run several queries against the referencing table data to find out whether the values mostly fall into the 8-bit, 16-bit, or 32-bit range.

The following table shows compressed sizes for specific numeric values when the MOSTLY8, MOSTLY16, and MOSTLY32 encodings are used:

Original value	Original INT or BIGINT size (bytes)	MOSTLY8 compressed size (bytes)	MOSTLY16 compressed size (bytes)	MOSTLY32 compressed size (bytes)
1	4	1	2	4
10	4	1	2	4
100	4	1	2	4
1000	4	Same as raw data size	2	4

Original value	Original INT or BIGINT size (bytes)	MOSTLY8 compressed size (bytes)	MOSTLY16 compressed size (bytes)	MOSTLY32 compressed size (bytes)
10000	4		2	4
20000	4		2	4
40000	8		Same as raw data size	4
100000	8			4
2000000000	8			4

Run length

Run length encoding replaces a value that is repeated consecutively with a token that consists of the value and a count of the number of consecutive occurrences (the length of the run). A separate dictionary of unique values is created for each block of column values on disk. (An Amazon Redshift disk block occupies 1 MB.) This encoding is best suited to a table in which data values are often repeated consecutively, for example, when the table is sorted by those values.

For example, suppose that a column in a large dimension table has a predictably small domain, such as a COLOR column with fewer than 10 possible values. These values are likely to fall in long sequences throughout the table, even if the data is not sorted.

We don't recommend applying run length encoding on any column that is designated as a sort key. Range-restricted scans perform better when blocks contain similar numbers of rows. If sort key columns are compressed much more highly than other columns in the same query, range-restricted scans might perform poorly.

The following table uses the COLOR column example to show how the run length encoding works.

Original data value	Original size (bytes)	Compressed value (token)	Compressed size (bytes)
Blue	4	{2,Blue}	5

Original data value	Original size (bytes)	Compressed value (token)	Compressed size (bytes)
Blue	4		0
Green	5	{3,Green}	6
Green	5		0
Green	5		0
Blue	4	{1,Blue}	5
Yellow	6	{4,Yellow}	7
Yellow	6		0
Yellow	6		0
Yellow	6		0
Total	51		23

Text255 and Text32k

Text255 and text32k encodings are useful for compressing VARCHAR columns in which the same words recur often. A separate dictionary of unique words is created for each block of column values on disk. (An Amazon Redshift disk block occupies 1 MB.) The dictionary contains the first 245 unique words in the column. Those words are replaced on disk by a one-byte index value representing one of the 245 values, and any words that are not represented in the dictionary are stored uncompressed. The process repeats for each 1-MB disk block. If the indexed words occur frequently in the column, the column yields a high compression ratio.

For the text32k encoding, the principle is the same, but the dictionary for each block does not capture a specific number of words. Instead, the dictionary indexes each unique word it finds until the combined entries reach a length of 32K, minus some overhead. The index values are stored in two bytes.

For example, consider the VENUENAME column in the VENUE table. Words such as **`Arena`**, **`Center`**, and **`Theatre`** recur in this column and are likely to be among the first 245 words encountered in each block if text255 compression is applied. If so, this column benefits from compression. This is because every time those words appear, they occupy only 1 byte of storage (instead of 5, 6, or 7 bytes, respectively).

ZSTD

Zstandard (ZSTD) encoding provides a high compression ratio with very good performance across diverse datasets. ZSTD works especially well with CHAR and VARCHAR columns that store a wide range of long and short strings, such as product descriptions, user comments, logs, and JSON strings. Where some algorithms, such as Delta encoding or Mostly encoding, can potentially use more storage space than no compression, ZSTD is unlikely to increase disk usage.

ZSTD supports SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, and TIMESTAMPTZ data types.

The following table identifies the supported compression encodings and the data types that support the encoding.

Encoding type	Keyword in CREATE TABLE and ALTER TABLE	Data types
Raw (no compression)	RAW	All
AZ64	AZ64	SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIMESTAMP, TIMESTAMPTZ
Byte dictionary	BYTEDICT	SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ
Delta	DELTA DELTA32K	SMALLINT, INT, BIGINT, DATE, TIMESTAMP, DECIMAL INT, BIGINT, DATE, TIMESTAMP, DECIMAL

Encoding type	Keyword in CREATE TABLE and ALTER TABLE	Data types
LZO	LZO	SMALLINT, INTEGER, BIGINT, DECIMAL, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ, SUPER
Mostly*n*	MOSTLY8 MOSTLY16 MOSTLY32	SMALLINT, INT, BIGINT, DECIMAL INT, BIGINT, DECIMAL BIGINT, DECIMAL
Run-length	RUNLENGTH	SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ
Text	TEXT255 TEXT32K	VARCHAR only VARCHAR only
Zstandard	ZSTD	SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ, SUPER

Testing compression encodings

If you decide to manually specify column encodings, you might want to test different encodings with your data.

> **Note**
>
> We recommend that you use the COPY command to load data whenever possible, and allow the COPY command to choose the optimal encodings based on your data. Or you can use the ANALYZE COMPRESSION command to view the suggested encodings for existing

data. For details about applying automatic compression, see [Loading tables with automatic compression](#).

To perform a meaningful test of data compression, you must have a large number of rows. For this example, we create a table and insert rows by using a statement that selects from two tables; VENUE and LISTING. We leave out the WHERE clause that would normally join the two tables. The result is that *each* row in the VENUE table is joined to *all* of the rows in the LISTING table, for a total of over 32 million rows. This is known as a Cartesian join and normally is not recommended. However, for this purpose, it's a convenient method of creating many rows. If you have an existing table with data that you want to test, you can skip this step.

After we have a table with sample data, we create a table with seven columns. Each has a different compression encoding: raw, bytedict, lzo, run length, text255, text32k, and zstd. We populate each column with exactly the same data by running an INSERT command that selects the data from the first table.

To test compression encodings, do the following:

1. (Optional) First, use a Cartesian join to create a table with a large number of rows. Skip this step if you want to test an existing table.

```
create table cartesian_venue(
venueid smallint not null distkey sortkey,
venuename varchar(100),
venuecity varchar(30),
venuestate char(2),
venueseats integer);

insert into cartesian_venue
select venueid, venuename, venuecity, venuestate, venueseats
from venue, listing;
```

2. Next, create a table with the encodings that you want to compare.

```
create table encodingvenue (
venueraw varchar(100) encode raw,
venuebytedict varchar(100) encode bytedict,
venuelzo varchar(100) encode lzo,
venuerunlength varchar(100) encode runlength,
venuetext255 varchar(100) encode text255,
```

```
venuetext32k varchar(100) encode text32k,
venuezstd varchar(100) encode zstd);
```

3. Insert the same data into all of the columns using an INSERT statement with a SELECT clause.

```
insert into encodingvenue
select venuename as venueraw, venuename as venuebytedict, venuename as venuelzo,
 venuename as venuerunlength, venuename as  venuetext32k, venuename as  venuetext255,
 venuename as venuezstd
from cartesian_venue;
```

4. Verify the number of rows in the new table.

```
select count(*) from encodingvenue

  count
----------
 38884394
(1 row)
```

5. Query the STV_BLOCKLIST system table to compare the number of 1 MB disk blocks used by each column.

   The MAX aggregate function returns the highest block number for each column. The STV_BLOCKLIST table includes details for three system-generated columns. This example uses `col < 6` in the WHERE clause to exclude the system-generated columns.

```
select col, max(blocknum)
from stv_blocklist b, stv_tbl_perm p
where (b.tbl=p.id) and name ='encodingvenue'
and col < 7
group by name, col
order by col;
```

   The query returns the following results. The columns are numbered beginning with zero. Depending on how your cluster is configured, your result might have different numbers, but the relative sizes should be similar. You can see that BYTEDICT encoding on the second column produced the best results for this dataset. This approach has a compression ratio of better than 20:1. LZO and ZSTD encoding also produced excellent results. Different datasets produce different results, of course. When a column contains longer text strings, LZO often produces the best compression results.

```
 col | max
-----+-----
   0 | 203
   1 |  10
   2 |  22
   3 | 204
   4 |  56
   5 |  72
   6 |  20
(7 rows)
```

If you have data in an existing table, you can use the ANALYZE COMPRESSION command to view the suggested encodings for the table. For example, the following example shows the recommended encoding for a copy of the VENUE table, CARTESIAN_VENUE, that contains 38 million rows. Notice that ANALYZE COMPRESSION recommends LZO encoding for the VENUENAME column. ANALYZE COMPRESSION chooses optimal compression based on multiple factors, which include percent of reduction. In this specific case, BYTEDICT provides better compression, but LZO also produces greater than 90 percent compression.

```
analyze compression cartesian_venue;

Table           | Column     | Encoding | Est_reduction_pct
---------------+------------+----------+------------------
reallybigvenue | venueid    | lzo      | 97.54
reallybigvenue | venuename  | lzo      | 91.71
reallybigvenue | venuecity  | lzo      | 96.01
reallybigvenue | venuestate | lzo      | 97.68
reallybigvenue | venueseats | lzo      | 98.21
```

Example

The following example creates a CUSTOMER table that has columns with various data types. This CREATE TABLE statement shows one of many possible combinations of compression encodings for these columns.

```
create table customer(
custkey int encode delta,
custname varchar(30) encode raw,
gender varchar(7) encode text255,
```

```
address varchar(200) encode text255,
city varchar(30) encode text255,
state char(2) encode raw,
zipcode char(5) encode bytedict,
start_date date encode delta32k);
```

The following table shows the column encodings that were chosen for the CUSTOMER table and gives an explanation for the choices:

Column	Data type	Encoding	Explanation
CUSTKEY	int	delta	CUSTKEY consists of unique, consecutive integer values. Because the differences are one byte, DELTA is a good choice.
CUSTNAME	varchar(30)	raw	CUSTNAME has a large domain with few repeated values. Any compression encoding would probably be ineffective.
GENDER	varchar(7)	text255	GENDER is very small domain with many repeated values. Text255 works well with VARCHAR columns in which the same words recur.
ADDRESS	varchar(200)	text255	ADDRESS is a large domain, but contains many repeated

Column	Data type	Encoding	Explanation
			words, such as Street, Avenue, North, South, and so on. Text 255 and text 32k are useful for compressing VARCHAR columns in which the same words recur. The column length is short, so text255 is a good choice.
CITY	varchar(30)	text255	CITY is a large domain, with some repeated values. Certain city names are used much more commonly than others. Text255 is a good choice for the same reasons as ADDRESS.

Column	Data type	Encoding	Explanation
STATE	char(2)	raw	In the United States, STATE is a precise domain of 50 two-character values. Bytedict encoding would yield some compression, but because the column size is only two characters, compressi on might not be worth the overhead of uncompressing the data.
ZIPCODE	char(5)	bytedict	ZIPCODE is a known domain of fewer than 50,000 unique values. Certain zip codes occur much more commonly than others. Bytedict encoding is very effective when a column contains a limited number of unique values.
START_DATE	date	delta32k	Delta encodings are very useful for date time columns, especially if the rows are loaded in date order.

Data distribution for query optimization

When you load data into a table, Amazon Redshift distributes the rows of the table to each of the compute nodes according to the table's distribution style. When you run a query, the query optimizer redistributes the rows to the compute nodes as needed to perform any joins and aggregations. The goal in choosing a table distribution style is to minimize the impact of the redistribution step by locating the data where it must be before the query is run.

> **Note**
>
> This section will introduce you to the principles of data distribution in an Amazon Redshift database. We recommend that you create your tables with `DISTSTYLE AUTO`. If you do so, then Amazon Redshift uses automatic table optimization to choose the data distribution style. For more information, see Automatic table optimization. The rest of this section provides details about distribution styles.

Topics

Data distribution concepts

Some data distribution concepts for Amazon Redshift follow.

Nodes and slices

An Amazon Redshift cluster is a set of nodes. Each node in the cluster has its own operating system, dedicated memory, and dedicated disk storage. One node is the *leader node*, which manages the distribution of data and query processing tasks to the compute nodes. The *compute nodes* provide resources to do those tasks.

The disk storage for a compute node is divided into a number of *slices*. The number of slices per node depends on the node size of the cluster. The nodes all participate in running parallel queries, working on data that is distributed as evenly as possible across the slices. For more information about the number of slices that each node size has, see About clusters and nodes in the *Amazon Redshift Management Guide*.

Data redistribution

When you load data into a table, Amazon Redshift distributes the rows of the table to each of the node slices according to the table's distribution style. As part of a query plan, the optimizer determines where blocks of data must be located to best run the query. The data is then physically moved, or redistributed, while the query runs. Redistribution might involve either sending specific rows to nodes for joining or broadcasting an entire table to all of the nodes.

Data redistribution can account for a substantial portion of the cost of a query plan, and the network traffic it generates can affect other database operations and slow overall system performance. To the extent that you anticipate where best to locate data initially, you can minimize the impact of data redistribution.

Data distribution goals

When you load data into a table, Amazon Redshift distributes the table's rows to the compute nodes and slices according to the distribution style that you chose when you created the table. Data distribution has two primary goals:

- To distribute the workload uniformly among the nodes in the cluster. Uneven distribution, or data distribution skew, forces some nodes to do more work than others, which impairs query performance.
- To minimize data movement as a query runs. If the rows that participate in joins or aggregates are already collocated on the nodes with their joining rows in other tables, the optimizer doesn't need to redistribute as much data when queries run.

The distribution strategy that you choose for your database has important consequences for query performance, storage requirements, data loading, and maintenance. By choosing the best distribution style for each table, you can balance your data distribution and significantly improve overall system performance.

Distribution styles

When you create a table, you can designate one of the following distribution styles: AUTO, EVEN, KEY, or ALL.

If you don't specify a distribution style, Amazon Redshift uses AUTO distribution.

AUTO distribution

With AUTO distribution, Amazon Redshift assigns an optimal distribution style based on the size of the table data. For example, if AUTO distribution style is specified, Amazon Redshift initially assigns the ALL distribution style to a small table. When the table grows larger, Amazon Redshift might change the distribution style to KEY, choosing the primary key (or a column of the composite primary key) as the distribution key. If the table grows larger and none of the columns are suitable to be the distribution key, Amazon Redshift changes the distribution style to EVEN. The change in distribution style occurs in the background with minimal impact to user queries.

To view actions that Amazon Redshift automatically performed to alter a table distribution key, see SVL_AUTO_WORKER_ACTION. To view current recommendations regarding altering a table distribution key, see SVV_ALTER_TABLE_RECOMMENDATIONS.

To view the distribution style applied to a table, query the PG_CLASS_INFO system catalog view. For more information, see Viewing distribution styles. If you don't specify a distribution style with the CREATE TABLE statement, Amazon Redshift applies AUTO distribution.

EVEN distribution

The leader node distributes the rows across the slices in a round-robin fashion, regardless of the values in any particular column. EVEN distribution is appropriate when a table doesn't participate in joins. It's also appropriate when there isn't a clear choice between KEY distribution and ALL distribution.

KEY distribution

The rows are distributed according to the values in one column. The leader node places matching values on the same node slice. If you distribute a pair of tables on the joining keys, the leader node collocates the rows on the slices according to the values in the joining columns. This way, matching values from the common columns are physically stored together.

ALL distribution

A copy of the entire table is distributed to every node. Where EVEN distribution or KEY distribution place only a portion of a table's rows on each node, ALL distribution ensures that every row is collocated for every join that the table participates in.

ALL distribution multiplies the storage required by the number of nodes in the cluster, and so it takes much longer to load, update, or insert data into multiple tables. ALL distribution is appropriate only for relatively slow moving tables; that is, tables that are not updated frequently or extensively. Because the cost of redistributing small tables during a query is low, there isn't a significant benefit to define small dimension tables as DISTSTYLE ALL.

Note

After you have specified a distribution style for a column, Amazon Redshift handles data distribution at the cluster level. Amazon Redshift does not require or support the concept of partitioning data within database objects. You don't need to create table spaces or define partitioning schemes for tables.

In certain scenarios, you can change the distribution style of a table after it is created. For more information, see ALTER TABLE. For scenarios when you can't change the distribution style of a table after it's created, you can recreate the table and populate the new table with a deep copy. For more information, see Performing a deep copy

Viewing distribution styles

To view the distribution style of a table, query the PG_CLASS_INFO view or the SVV_TABLE_INFO view.

The RELEFFECTIVEDISTSTYLE column in PG_CLASS_INFO indicates the current distribution style for the table. If the table uses automatic distribution, RELEFFECTIVEDISTSTYLE is 10, 11, or 12, which indicates whether the effective distribution style is AUTO (ALL), AUTO (EVEN), or AUTO (KEY). If the table uses automatic distribution, the distribution style might initially show AUTO (ALL), then change to AUTO (EVEN) or AUTO (KEY) when the table grows.

The following table gives the distribution style for each value in RELEFFECTIVEDISTSTYLE column:

RELEFFECTIVEDISTSTYLE	Current distribution style
0	EVEN

RELEFFECTIVEDISTSTYLE	Current distribution style
1	KEY
8	ALL
10	AUTO (ALL)
11	AUTO (EVEN)
12	AUTO (KEY)

The DISTSTYLE column in SVV_TABLE_INFO indicates the current distribution style for the table. If the table uses automatic distribution, DISTSTYLE is AUTO (ALL), AUTO (EVEN), or AUTO (KEY).

The following example creates four tables using the three distribution styles and automatic distribution, then queries SVV_TABLE_INFO to view the distribution styles.

```
create table public.dist_key (col1 int)
diststyle key distkey (col1);

insert into public.dist_key values (1);

create table public.dist_even (col1 int)
diststyle even;

insert into public.dist_even values (1);

create table public.dist_all (col1 int)
diststyle all;

insert into public.dist_all values (1);

create table public.dist_auto (col1 int);

insert into public.dist_auto values (1);

select "schema", "table", diststyle from SVV_TABLE_INFO
where "table" like 'dist%';

        schema    |    table        | diststyle
```

```
 ------------+-----------------+------------
  public     | dist_key        | KEY(col1)
  public     | dist_even       | EVEN
  public     | dist_all        | ALL
  public     | dist_auto       | AUTO(ALL)
```

Evaluating query patterns

Choosing distribution styles is only one aspect of database design. Consider distribution styles within the context of the entire system, balancing distribution with other important factors such as cluster size, compression encoding methods, sort keys, and table constraints.

Test your system with data that is as close to real data as possible.

To make good choices for distribution styles, you must understand the query patterns for your Amazon Redshift application. Identify the most costly queries in your system and base your initial database design on the demands of those queries. Factors that determine the total cost of a query include how long the query takes to run and how much computing resources it consumes. Other factors that determine query cost are how often it is run, and how disruptive it is to other queries and database operations.

Identify the tables that are used by the most costly queries, and evaluate their role in query runtime. Consider how the tables are joined and aggregated.

Use the guidelines in this section to choose a distribution style for each table. When you have done so, create the tables and load them with data that is as close as possible to real data. Then test the tables for the types of queries that you expect to use. You can evaluate the query explain plans to identify tuning opportunities. Compare load times, storage space, and query runtimes to balance your system's overall requirements.

Designating distribution styles

The considerations and recommendations for designating distribution styles in this section use a star schema as an example. Your database design might be based on a star schema, some variant of a star schema, or an entirely different schema. Amazon Redshift is designed to work effectively with whatever schema design you choose. The principles in this section can be applied to any design schema.

1. **Specify the primary key and foreign keys for all your tables.**

Amazon Redshift does not enforce primary key and foreign key constraints, but the query optimizer uses them when it generates query plans. If you set primary keys and foreign keys, your application must maintain the validity of the keys.

2. **Distribute the fact table and its largest dimension table on their common columns.**

   Choose the largest dimension based on the size of dataset that participates in the most common join, not only the size of the table. If a table is commonly filtered, using a WHERE clause, only a portion of its rows participate in the join. Such a table has less impact on redistribution than a smaller table that contributes more data. Designate both the dimension table's primary key and the fact table's corresponding foreign key as DISTKEY. If multiple tables use the same distribution key, they are also collocated with the fact table. Your fact table can have only one distribution key. Any tables that join on another key isn't collocated with the fact table.

3. **Designate distribution keys for the other dimension tables.**

   Distribute the tables on their primary keys or their foreign keys, depending on how they most commonly join with other tables.

4. **Evaluate whether to change some of the dimension tables to use ALL distribution.**

   If a dimension table cannot be collocated with the fact table or other important joining tables, you can improve query performance significantly by distributing the entire table to all of the nodes. Using ALL distribution multiplies storage space requirements and increases load times and maintenance operations, so you should weigh all factors before choosing ALL distribution. The following section explains how to identify candidates for ALL distribution by evaluating the EXPLAIN plan.

5. **Use AUTO distribution for the remaining tables.**

   If a table is largely denormalized and does not participate in joins, or if you don't have a clear choice for another distribution style, use AUTO distribution.

To let Amazon Redshift choose the appropriate distribution style, don't explicitly specify a distribution style.

Evaluating the query plan

You can use query plans to identify candidates for optimizing the distribution style.

After making your initial design decisions, create your tables, load them with data, and test them. Use a test dataset that is as close as possible to the real data. Measure load times to use as a baseline for comparisons.

Evaluate queries that are representative of the most costly queries you expect to run, specifically queries that use joins and aggregations. Compare runtimes for various design options. When you compare runtimes, don't count the first time the query is run, because the first runtime includes the compilation time.

DS_DIST_NONE

No redistribution is required, because corresponding slices are collocated on the compute nodes. You typically have only one DS_DIST_NONE step, the join between the fact table and one dimension table.

DS_DIST_ALL_NONE

No redistribution is required, because the inner join table used DISTSTYLE ALL. The entire table is located on every node.

DS_DIST_INNER

The inner table is redistributed.

DS_DIST_OUTER

The outer table is redistributed.

DS_BCAST_INNER

A copy of the entire inner table is broadcast to all the compute nodes.

DS_DIST_ALL_INNER

The entire inner table is redistributed to a single slice because the outer table uses DISTSTYLE ALL.

DS_DIST_BOTH

Both tables are redistributed.

DS_DIST_ERR

When the table doesn't have a distribution style selected.

DS_DIST_NONE and DS_DIST_ALL_NONE are good. They indicate that no distribution was required for that step because all of the joins are collocated.

DS_DIST_INNER means that the step probably has a relatively high cost because the inner table is being redistributed to the nodes. DS_DIST_INNER indicates that the outer table is already properly distributed on the join key. Set the inner table's distribution key to the join key to convert this to DS_DIST_NONE. In some cases, distributing the inner table on the join key isn't possible because the outer table isn't distributed on the join key. If this is the case, evaluate whether to use ALL distribution for the inner table. If the table isn't updated frequently or extensively, and it's large enough to carry a high redistribution cost, change the distribution style to ALL and test again. ALL distribution causes increased load times, so when you retest, include the load time in your evaluation factors.

DS_DIST_ALL_INNER is not good. It means that the entire inner table is redistributed to a single slice because the outer table uses DISTSTYLE ALL, so that a copy of the entire outer table is located on each node. This results in inefficient serial runtime of the join on a single node, instead taking advantage of parallel runtime using all of the nodes. DISTSTYLE ALL is meant to be used only for the inner join table. Instead, specify a distribution key or use even distribution for the outer table.

DS_BCAST_INNER and DS_DIST_BOTH are not good. Usually these redistributions occur because the tables are not joined on their distribution keys. If the fact table does not already have a distribution key, specify the joining column as the distribution key for both tables. If the fact table already has a distribution key on another column, evaluate whether changing the distribution key to collocate this join improve overall performance. If changing the distribution key of the outer table isn't an optimal choice, you can achieve collocation by specifying DISTSTYLE ALL for the inner table.

The following example shows a portion of a query plan with DS_BCAST_INNER and DS_DIST_NONE labels.

```
->  XN Hash Join DS_BCAST_INNER  (cost=112.50..3272334142.59 rows=170771 width=84)
        Hash Cond: ("outer".venueid = "inner".venueid)
        ->  XN Hash Join DS_BCAST_INNER  (cost=109.98..3167290276.71 rows=172456
 width=47)
              Hash Cond: ("outer".eventid = "inner".eventid)
              ->  XN Merge Join DS_DIST_NONE  (cost=0.00..6286.47 rows=172456 width=30)
                    Merge Cond: ("outer".listid = "inner".listid)
                    ->  XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497
 width=14)
                    ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=24)
```

After changing the dimension tables to use DISTSTYLE ALL, the query plan for the same query shows DS_DIST_ALL_NONE in place of DS_BCAST_INNER. Also, there is a dramatic change in the relative cost for the join steps. The total cost is `14142.59` compared to `3272334142.59` in the previous query.

```
->  XN Hash Join DS_DIST_ALL_NONE  (cost=112.50..14142.59 rows=170771 width=84)
        Hash Cond: ("outer".venueid = "inner".venueid)
        ->  XN Hash Join DS_DIST_ALL_NONE  (cost=109.98..10276.71 rows=172456 width=47)
              Hash Cond: ("outer".eventid = "inner".eventid)
              ->  XN Merge Join DS_DIST_NONE  (cost=0.00..6286.47 rows=172456 width=30)
                    Merge Cond: ("outer".listid = "inner".listid)
                    ->  XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497
 width=14)
                    ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=24)
```

Query plan example

This example shows how to evaluate a query plan to find opportunities to optimize the distribution.

Run the following query with an EXPLAIN command to produce a query plan.

```
explain
select lastname, catname, venuename, venuecity, venuestate, eventname,
month, sum(pricepaid) as buyercost, max(totalprice) as maxtotalprice
from category join event on category.catid = event.catid
join venue on venue.venueid = event.venueid
join sales on sales.eventid = event.eventid
join listing on sales.listid = listing.listid
join date on sales.dateid = date.dateid
join users on users.userid = sales.buyerid
group by lastname, catname, venuename, venuecity, venuestate, eventname, month
having sum(pricepaid)>9999
order by catname, buyercost desc;
```

In the TICKIT database, SALES is a fact table and LISTING is its largest dimension. In order to collocate the tables, SALES is distributed on the LISTID, which is the foreign key for LISTING, and LISTING is distributed on its primary key, LISTID. The following example shows the CREATE TABLE commands for SALES and LISTING.

```
create table sales(
 salesid integer not null,
 listid integer not null distkey,
 sellerid integer not null,
 buyerid integer not null,
 eventid integer not null encode mostly16,
 dateid smallint not null,
 qtysold smallint not null encode mostly8,
 pricepaid decimal(8,2) encode delta32k,
 commission decimal(8,2) encode delta32k,
 saletime timestamp,
 primary key(salesid),
 foreign key(listid) references listing(listid),
 foreign key(sellerid) references users(userid),
 foreign key(buyerid) references users(userid),
 foreign key(dateid) references date(dateid))
        sortkey(listid,sellerid);

create table listing(
 listid integer not null distkey sortkey,
 sellerid integer not null,
 eventid integer not null encode mostly16,
 dateid smallint not null,
 numtickets smallint not null encode mostly8,
 priceperticket decimal(8,2) encode bytedict,
 totalprice decimal(8,2) encode mostly32,
 listtime timestamp,
 primary key(listid),
 foreign key(sellerid) references users(userid),
 foreign key(eventid) references event(eventid),
 foreign key(dateid) references date(dateid));
```

In the following query plan, the Merge Join step for the join on SALES and LISTING shows DS_DIST_NONE, which indicates that no redistribution is required for the step. However, moving up the query plan, the other inner joins show DS_BCAST_INNER, which indicates that the inner table is broadcast as part of the query execution. Because only one pair of tables can be collocated using key distribution, five tables must be rebroadcast.

```
QUERY PLAN
XN Merge  (cost=1015345167117.54..1015345167544.46 rows=1000 width=103)
  Merge Key: category.catname, sum(sales.pricepaid)
  ->  XN Network  (cost=1015345167117.54..1015345167544.46 rows=170771 width=103)
```

```
       Send to leader
       ->  XN Sort  (cost=1015345167117.54..1015345167544.46 rows=170771 width=103)
             Sort Key: category.catname, sum(sales.pricepaid)
             ->  XN HashAggregate  (cost=15345150568.37..15345152276.08 rows=170771 
width=103)
                   Filter: (sum(pricepaid) > 9999.00)
                    ->  XN Hash Join DS_BCAST_INNER  (cost=742.08..15345146299.10 
rows=170771 width=103)
                          Hash Cond: ("outer".catid = "inner".catid)
                          ->  XN Hash Join DS_BCAST_INNER 
(cost=741.94..15342942456.61 rows=170771 width=97)
                                Hash Cond: ("outer".dateid = "inner".dateid)
                                ->  XN Hash Join DS_BCAST_INNER 
(cost=737.38..15269938609.81 rows=170766 width=90)
                                      Hash Cond: ("outer".buyerid = "inner".userid)
                                      ->  XN Hash Join DS_BCAST_INNER 
(cost=112.50..3272334142.59 rows=170771 width=84)
                                            Hash Cond: ("outer".venueid = 
"inner".venueid)
                                            ->  XN Hash Join DS_BCAST_INNER 
(cost=109.98..3167290276.71 rows=172456 width=47)
                                                  Hash Cond: ("outer".eventid = 
"inner".eventid)
                                                  ->  XN Merge Join DS_DIST_NONE 
(cost=0.00..6286.47 rows=172456 width=30)
                                                        Merge Cond: ("outer".listid = 
"inner".listid)
                                                        ->  XN Seq Scan on listing 
(cost=0.00..1924.97 rows=192497 width=14)
                                                        ->  XN Seq Scan on sales 
(cost=0.00..1724.56 rows=172456 width=24)
                                                  ->  XN Hash  (cost=87.98..87.98 
rows=8798 width=25)
                                                        ->  XN Seq Scan on event 
(cost=0.00..87.98 rows=8798 width=25)
                                            ->  XN Hash  (cost=2.02..2.02 rows=202 
width=41)
                                                  ->  XN Seq Scan on venue 
(cost=0.00..2.02 rows=202 width=41)
                                      ->  XN Hash  (cost=499.90..499.90 rows=49990 
width=14)
                                            ->  XN Seq Scan on users 
(cost=0.00..499.90 rows=49990 width=14)
                                ->  XN Hash  (cost=3.65..3.65 rows=365 width=11)
```

```
                                        ->  XN Seq Scan on date  (cost=0.00..3.65
 rows=365 width=11)
                            ->  XN Hash  (cost=0.11..0.11 rows=11 width=10)
                                  ->  XN Seq Scan on category  (cost=0.00..0.11 rows=11
 width=10)
```

One solution is to alter the tables to have DISTSTYLE ALL.

```
ALTER TABLE users ALTER DISTSTYLE ALL;
ALTER TABLE venue ALTER DISTSTYLE ALL;
ALTER TABLE category ALTER DISTSTYLE ALL;
ALTER TABLE date ALTER DISTSTYLE ALL;
ALTER TABLE event ALTER DISTSTYLE ALL;
```

Run the same query with EXPLAIN again, and examine the new query plan. The joins now show DS_DIST_ALL_NONE, indicating that no redistribution is required because the data was distributed to every node using DISTSTYLE ALL.

```
QUERY PLAN
XN Merge  (cost=1000000047117.54..1000000047544.46 rows=1000 width=103)
  Merge Key: category.catname, sum(sales.pricepaid)
  ->  XN Network  (cost=1000000047117.54..1000000047544.46 rows=170771 width=103)
        Send to leader
        ->  XN Sort  (cost=1000000047117.54..1000000047544.46 rows=170771 width=103)
              Sort Key: category.catname, sum(sales.pricepaid)
              ->  XN HashAggregate  (cost=30568.37..32276.08 rows=170771 width=103)
                    Filter: (sum(pricepaid) > 9999.00)
                    ->  XN Hash Join DS_DIST_ALL_NONE  (cost=742.08..26299.10
 rows=170771 width=103)
                          Hash Cond: ("outer".buyerid = "inner".userid)
                          ->  XN Hash Join DS_DIST_ALL_NONE  (cost=117.20..21831.99
 rows=170766 width=97)
                                Hash Cond: ("outer".dateid = "inner".dateid)
                                ->  XN Hash Join DS_DIST_ALL_NONE
 (cost=112.64..17985.08 rows=170771 width=90)
                                      Hash Cond: ("outer".catid = "inner".catid)
                                      ->  XN Hash Join DS_DIST_ALL_NONE
 (cost=112.50..14142.59 rows=170771 width=84)
                                            Hash Cond: ("outer".venueid =
 "inner".venueid)
                                            ->  XN Hash Join DS_DIST_ALL_NONE
 (cost=109.98..10276.71 rows=172456 width=47)
```

```
                                                            Hash Cond: ("outer".eventid =
"inner".eventid)
                                                            ->  XN Merge Join DS_DIST_NONE
(cost=0.00..6286.47 rows=172456 width=30)
                                                                  Merge Cond: ("outer".listid =
"inner".listid)
                                                                  ->  XN Seq Scan on listing
(cost=0.00..1924.97 rows=192497 width=14)
                                                                  ->  XN Seq Scan on sales
(cost=0.00..1724.56 rows=172456 width=24)
                                                            ->  XN Hash  (cost=87.98..87.98
rows=8798 width=25)
                                                                  ->  XN Seq Scan on event
(cost=0.00..87.98 rows=8798 width=25)
                                                      ->  XN Hash  (cost=2.02..2.02 rows=202
width=41)
                                                            ->  XN Seq Scan on venue
(cost=0.00..2.02 rows=202 width=41)
                                                ->  XN Hash  (cost=0.11..0.11 rows=11 width=10)
                                                      ->  XN Seq Scan on category
(cost=0.00..0.11 rows=11 width=10)
                                          ->  XN Hash  (cost=3.65..3.65 rows=365 width=11)
                                                ->  XN Seq Scan on date  (cost=0.00..3.65
rows=365 width=11)
                                    ->  XN Hash  (cost=499.90..499.90 rows=49990 width=14)
                                          ->  XN Seq Scan on users  (cost=0.00..499.90 rows=49990
width=14)
```

Distribution examples

The following examples show how data is distributed according to the options that you define in the CREATE TABLE statement.

DISTKEY examples

Look at the schema of the USERS table in the TICKIT database. USERID is defined as the SORTKEY column and the DISTKEY column:

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'users';

    column     |          type          | encoding | distkey | sortkey
---------------+------------------------+----------+---------+---------
```

```
 userid        | integer               | none     | t       |       1
 username      | character(8)          | none     | f       |       0
 firstname     | character varying(30) | text32k  | f       |       0

...
```

USERID is a good choice for the distribution column on this table. If you query the SVV_DISKUSAGE system view, you can see that the table is very evenly distributed. Column numbers are zero-based, so USERID is column 0.

```
select slice, col, num_values as rows, minvalue, maxvalue
from svv_diskusage
where name='users' and col=0 and rows>0
order by slice, col;

slice| col | rows  | minvalue | maxvalue
-----+-----+-------+----------+----------
0    | 0   | 12496 | 4        | 49987
1    | 0   | 12498 | 1        | 49988
2    | 0   | 12497 | 2        | 49989
3    | 0   | 12499 | 3        | 49990
(4 rows)
```

The table contains 49,990 rows. The rows (num_values) column shows that each slice contains about the same number of rows. The minvalue and maxvalue columns show the range of values on each slice. Each slice includes nearly the entire range of values, so there's a good chance that every slice participates in running a query that filters for a range of user IDs.

This example demonstrates distribution on a small test system. The total number of slices is typically much higher.

If you commonly join or group using the STATE column, you might choose to distribute on the STATE column. The following example shows a case where you create a new table with the same data as the USERS table but set the DISTKEY to the STATE column. In this case, the distribution isn't as even. Slice 0 (13,587 rows) holds approximately 30 percent more rows than slice 3 (10,150 rows). In a much larger table, this amount of distribution skew can have an adverse impact on query processing.

```
create table userskey distkey(state) as select * from users;

select slice, col, num_values as rows, minvalue, maxvalue from svv_diskusage
```

```
where name = 'userskey' and col=0 and rows>0
order by slice, col;

slice | col | rows  | minvalue | maxvalue
------+-----+-------+----------+----------
    0 |   0 | 13587 |        5 |    49989
    1 |   0 | 11245 |        2 |    49990
    2 |   0 | 15008 |        1 |    49976
    3 |   0 | 10150 |        4 |    49986
(4 rows)
```

DISTSTYLE EVEN example

If you create a new table with the same data as the USERS table but set the DISTSTYLE to EVEN, rows are always evenly distributed across slices.

```
create table userseven diststyle even as
select * from users;

select slice, col, num_values as rows, minvalue, maxvalue from svv_diskusage
where name = 'userseven' and col=0 and rows>0
order by slice, col;

slice | col | rows  | minvalue | maxvalue
------+-----+-------+----------+----------
    0 |   0 | 12497 |        4 |    49990
    1 |   0 | 12498 |        8 |    49984
    2 |   0 | 12498 |        2 |    49988
    3 |   0 | 12497 |        1 |    49989
(4 rows)
```

However, because distribution is not based on a specific column, query processing can be degraded, especially if the table is joined to other tables. The lack of distribution on a joining column often influences the type of join operation that can be performed efficiently. Joins, aggregations, and grouping operations are optimized when both tables are distributed and sorted on their respective joining columns.

DISTSTYLE ALL example

If you create a new table with the same data as the USERS table but set the DISTSTYLE to ALL, all the rows are distributed to the first slice of each node.

```
select slice, col, num_values as rows, minvalue, maxvalue from svv_diskusage
where name = 'usersall' and col=0 and rows > 0
order by slice, col;

slice | col | rows  | minvalue | maxvalue
------+-----+-------+----------+----------
    0 |   0 | 49990 |        4 |    49990
    2 |   0 | 49990 |        2 |    49990

(4 rows)
```

Sort keys

> **Note**
>
> We recommend that you create your tables with `SORTKEY AUTO`. If you do so, then Amazon Redshift uses automatic table optimization to choose the sort key. For more information, see Automatic table optimization. The rest of this section provides details about the sort order.

When you create a table, you can alternatively define one or more of its columns as *sort keys*. When data is initially loaded into the empty table, the rows are stored on disk in sorted order. Information about sort key columns is passed to the query planner, and the planner uses this information to construct plans that exploit the way that the data is sorted. For more information, see CREATE TABLE. For information on best practices when creating a sort key, see Choose the best sort key.

Sorting enables efficient handling of range-restricted predicates. Amazon Redshift stores columnar data in 1 MB disk blocks. The min and max values for each block are stored as part of the metadata. If a query uses a range-restricted predicate, the query processor can use the min and max values to rapidly skip over large numbers of blocks during table scans. For example, suppose that a table stores five years of data sorted by date and a query specifies a date range of one month. In this case, you can remove up to 98 percent of the disk blocks from the scan. If the data is not sorted, more of the disk blocks (possibly all of them) have to be scanned.

You can specify either a compound or interleaved sort key. A compound sort key is more efficient when query predicates use a *prefix*, which is a subset of the sort key columns in order. An interleaved sort key gives equal weight to each column in the sort key, so query predicates can use any subset of the columns that make up the sort key, in any order.

To understand the impact of the chosen sort key on query performance, use the EXPLAIN command. For more information, see Query planning and execution workflow.

To define a sort type, use either the INTERLEAVED or COMPOUND keyword with your CREATE TABLE or CREATE TABLE AS statement. The default is COMPOUND. COMPOUND is recommended when you update your tables regularly with INSERT, UPDATE, or DELETE operations. An INTERLEAVED sort key can use a maximum of eight columns. Depending on your data and cluster size, VACUUM REINDEX takes significantly longer than VACUUM FULL because it makes an additional pass to analyze the interleaved sort keys. The sort and merge operation can take longer for interleaved tables because the interleaved sort might have to rearrange more rows than a compound sort.

To view the sort keys for a table, query the SVV_TABLE_INFO system view.

Topics

Multidimensional data layout sorting (preview)

The following is prerelease documentation for the multidimensional data layout sorting of tables, which is in preview release. The documentation and the feature are both subject to change. We recommend that you use this feature only with test clusters, and not in production environments. For preview terms and conditions, see* Beta Service Participation *in AWS Service Terms.

> **Note**
>
> This feature is only available using a preview cluster. To create a preview cluster, see Creating a preview cluster in the *Amazon Redshift Management Guide*.

A multidimensional data layout sort key is a type of AUTO sort key that is based on repetitive predicates found in a workload. If your workload has repetitive predicates, then Amazon Redshift can improve table scan performance by colocating data rows that satisfy the repetitive predicates. Instead of storing data of a table in strict column order, a multidimensional data layout sort key stores data by analyzing repetitive predicates that appear in a workload. More than one repetitive predicate can be found in a workload. Depending on your workload, this kind of sort key can improve performance of many predicates. Amazon Redshift automatically determines if this sort key method should be used for tables that are defined with an `AUTO` sort key.

For example, suppose you have a table that has data sorted in column order. Many data blocks might need to be examined to determine if they satisfy the predicates in your workload. But, if the data is stored on disk in a predicate order, then fewer blocks need to be scanned to satisfy the query. Using a multidimensional data layout sort key is beneficial in this case.

To view whether a query is using a multidimensional data layout key, see the `step_attribute` column of the SYS_QUERY_DETAIL view. When the value is `multi-dimensional` then multidimensional data layout was used for the query. To view whether a table defined with the AUTO sort key is using a multidimensional data layout, see the `sortkey1` column of the SVV_TABLE_INFO view. When the value is `padb_internal_mddl_key_col` then multidimensional data layout was used for the table sort key.

To prevent Amazon Redshift from using a multidimensional data layout sort key, choose a different table sort key option other than `SORTKEY AUTO`. For more information on SORTKEY options, see CREATE TABLE.

Compound sort key

A compound key is made up of all of the columns listed in the sort key definition, in the order they are listed. A compound sort key is most useful when a query's filter applies conditions, such as filters and joins, that use a prefix of the sort keys. The performance benefits of compound sorting decrease when queries depend only on secondary sort columns, without referencing the primary columns. COMPOUND is the default sort type.

Compound sort keys might speed up joins, GROUP BY and ORDER BY operations, and window functions that use PARTITION BY and ORDER BY. For example, a merge join, which is often faster than a hash join, is feasible when the data is distributed and presorted on the joining columns. Compound sort keys also help improve compression.

As you add rows to a sorted table that already contains data, the unsorted region grows, which has a significant effect on performance. The effect is greater when the table uses interleaved sorting, especially when the sort columns include data that increases monotonically, such as date or timestamp columns. Run a VACUUM operation regularly, especially after large data loads, to re-sort and re-analyze the data. For more information, see Reduce the size of the unsorted region. After vacuuming to resort the data, it's a good practice to run an ANALYZE command to update the statistical metadata for the query planner. For more information, see Analyzing tables.

Interleaved sort key

An interleaved sort gives equal weight to each column, or subset of columns, in the sort key. If multiple queries use different columns for filters, then you can often improve performance for those queries by using an interleaved sort style. When a query uses restrictive predicates on secondary sort columns, interleaved sorting significantly improves query performance as compared to compound sorting.

> **Important**
>
> Don't use an interleaved sort key on columns with monotonically increasing attributes, such as identity columns, dates, or timestamps.

The performance improvements you gain by implementing an interleaved sort key should be weighed against increased load and vacuum times.

Interleaved sorts are most effective with highly selective queries that filter on one or more of the sort key columns in the WHERE clause, for example `select c_name from customer where c_region = 'ASIA'`. The benefits of interleaved sorting increase with the number of sorted columns that are restricted.

An interleaved sort is more effective with large tables. Sorting is applied on each slice. Thus, an interleaved sort is most effective when a table is large enough to require multiple 1 MB blocks per slice. Here, the query processor can skip a significant proportion of the blocks using restrictive predicates. To view the number of blocks a table uses, query the STV_BLOCKLIST system view.

When sorting on a single column, an interleaved sort might give better performance than a compound sort if the column values have a long common prefix. For example, URLs commonly begin with "http://www". Compound sort keys use a limited number of characters from the prefix, which results in a lot of duplication of keys. Interleaved sorts use an internal compression scheme for zone map values that enables them to better discriminate among column values that have a long common prefix.

When migrating Amazon Redshift provisioned clusters to Amazon Redshift Serverless, Redshift converts tables with both interleaved sort keys and DISTSTYLE KEY to compound sort keys. However, tables with only interleaved sort keys remain unchanged. For more information on distribution styles, see Working with data distribution styles.

VACUUM REINDEX

As you add rows to a sorted table that already contains data, performance might deteriorate over time. This deterioration occurs for both compound and interleaved sorts, but it has a greater effect on interleaved tables. A VACUUM restores the sort order, but the operation can take longer for interleaved tables because merging new interleaved data might involve modifying every data block.

When tables are initially loaded, Amazon Redshift analyzes the distribution of the values in the sort key columns and uses that information for optimal interleaving of the sort key columns. As a table grows, the distribution of the values in the sort key columns can change, or skew, especially with date or timestamp columns. If the skew becomes too large, performance might be affected. To re-analyze the sort keys and restore performance, run the VACUUM command with the REINDEX key word. Because it must take an extra analysis pass over the data, VACUUM REINDEX can take longer than a standard VACUUM for interleaved tables. To view information about key distribution skew and last reindex time, query the SVV_INTERLEAVED_COLUMNS system view.

For more information about how to determine how often to run VACUUM and when to run a VACUUM REINDEX, see Decide whether to reindex.

Table constraints

Uniqueness, primary key, and foreign key constraints are informational only; *they are not enforced by Amazon Redshift* when you populate a table. For example, if you insert data into a table with dependencies, the insert can succeed even if it violates the constraint. Nonetheless, primary keys and foreign keys are used as planning hints and they should be declared if your ETL process or some other process in your application enforces their integrity.

For example, the query planner uses primary and foreign keys in certain statistical computations. It does this to infer uniqueness and referential relationships that affect subquery decorrelation techniques. By doing this, it can order large numbers of joins and remove redundant joins.

The planner leverages these key relationships, but it assumes that all keys in Amazon Redshift tables are valid as loaded. If your application allows invalid foreign keys or primary keys, some queries could return incorrect results. For example, a SELECT DISTINCT query might return duplicate rows if the primary key is not unique. Do not define key constraints for your tables if you doubt their validity. However, always declare primary and foreign keys and uniqueness constraints when you know that they are valid.

Amazon Redshift *does* enforce NOT NULL column constraints.

For more information about table constraints, see CREATE TABLE. For information about how to drop a table with dependencies, see DROP TABLE.

Loading data in Amazon Redshift

There are several ways to load data into an Amazon Redshift database. One popular source of data to load are Amazon S3 files. The following table summarizes some of the methods to use with starting from an Amazon S3 source.

Method to use	Description	When method needed
COPY command	Runs a batch file ingestion to load data from your Amazon S3 files. This method leverages parallel processin g capabilities of Amazon Redshift. For more informati on, see Loading tables with the COPY command.	Should be used when basic data loading requirements to initiate batch file ingestion manually is needed. This method is used mostly with custom and third-party file ingestion pipelines or one-time, or ad hoc, file ingestion workloads.
COPY... CREATE JOB command (auto-copy)	Runs your COPY commands automatically when a new file is created on tracked Amazon S3 paths. For more informati on, see Create an S3 event integration to automatically copy files from Amazon S3 buckets.	Should be used when a file ingestion pipeline needs to automatically ingest data when a new file is created on Amazon S3. Amazon Redshift keeps track of ingested files to prevent data duplicati on. This method requires configuration by Amazon S3 bucket owners.
Load from data lake queries	Create external tables to run data lake queries on your Amazon S3 files and then run INSERT INTO command to load results from your data lake queries into local tables. For more information, see	Should be used in any of the following scenarios: • Loading from AWS Glue and open table formats (such as Apache Iceberg, Apache Hudi, or Delta Lake).

Method to use	Description	When method needed
	External tables for Redshift Spectrum.	• Source files need to be ingested partially (for example, needed for running a WHERE clause to ingest particular rows). • More flexibility needed to ingest particular columns (like running a SELECT command) or doing basic data transformation on the go (such as applying basic operations or calling UDFs on the values from the source file).
Other methods that you can consider		
Streaming ingestion	Streaming ingestion provides low-latency, high-speed ingestion of stream data from Amazon Kinesis Data Streams and Amazon Managed Streaming for Apache Kafka into an Amazon Redshift provisioned or Redshift Serverless materialized view. For more informati on, see Getting started with streaming ingestion from Amazon Kinesis Data Streams and Getting started with streaming ingestion from Apache Kafka sources.	Should be considered for use cases when data is first streamed into files on Amazon S3 and then loaded from Amazon S3. If keeping data on Amazon S3 is not needed, you can often consider streaming your data directly into Amazon Redshift.

Method to use	Description	When method needed
Running data lake queries	Running queries directly from a data lake table instead of ingesting contents of the table into a local table. For more information, see Amazon Redshift Spectrum.	Should be used when the use case doesn't require the performance of local table queries in Amazon Redshift.
Batch loading using Amazon Redshift query editor v2	You can prepare and run your batch file ingestion workloads visually on Amazon Redshift query editor v2. For more information, see Loading data from S3 in the *Amazon Redshift Management Guide*.	Should be used when you want the query editor v2 to prepare COPY statements and you want a visual tool to simplify the COPY statement preparation process.
Load data from a local file using Amazon Redshift query editor v2	You can directly upload files from your desktop into Amazon Redshift tables without the need for manually uploading your files into Amazon S3. For more information, see Loading data from a local file setup and workflow in the *Amazon Redshift Management Guide*.	Should be used when you need to quickly load files from your local computer for one-time querying purposes. With this method, Amazon Redshift query editor v2 temporarily stores the file on a customer-owned Amazon S3 bucket and runs a copy command using this Amazon S3 path.

A COPY command is the most efficient way to load a table. You can also add data to your tables using INSERT commands, though it is much less efficient than using COPY. The COPY command is able to read from multiple data files or multiple data streams simultaneously. Amazon Redshift allocates the workload to the Amazon Redshift nodes and performs the load operations in parallel, including sorting the rows and distributing data across node slices.

> **Note**
>
> Amazon Redshift Spectrum external tables are read-only. You can't COPY or INSERT to an external table.

To access data on other AWS resources, Amazon Redshift must have permission to access those resources and to perform the necessary actions to access the data. You can use AWS Identity and Access Management (IAM) to limit the access users have to Amazon Redshift resources and data.

After your initial data load, if you add, modify, or delete a significant amount of data, you should follow up by running a VACUUM command to reorganize your data and reclaim space after deletes. You should also run an ANALYZE command to update table statistics.

Topics

Loading tables with the COPY command

The COPY command leverages the Amazon Redshift massively parallel processing (MPP) architecture to read and load data in parallel from files on Amazon S3, from a DynamoDB table, or from text output from one or more remote hosts.

Before learning all the options of the COPY command, we recommend learning the basic options to load Amazon S3 data. The *Amazon Redshift Getting Started Guide* demonstrates a simple use of the COPY command to load Amazon S3 data using a default IAM role. See Step 4: Load data from Amazon S3 to Amazon Redshift for details.

> **Note**
>
> We strongly recommend using the COPY command to load large amounts of data. Using individual INSERT statements to populate a table might be prohibitively slow. Alternatively, if your data already exists in other Amazon Redshift database tables, use INSERT INTO ... SELECT or CREATE TABLE AS to improve performance. For information, see INSERT or CREATE TABLE AS.

To load data from another AWS resource, Amazon Redshift must have permission to access the resource and perform the necessary actions.

To grant or revoke privilege to load data into a table using a COPY command, grant or revoke the INSERT privilege.

Your data needs to be in the proper format for loading into your Amazon Redshift table. This section presents guidelines for preparing and verifying your data before the load and for validating a COPY statement before you run it.

To protect the information in your files, you can encrypt the data files before you upload them to your Amazon S3 bucket; COPY will decrypt the data as it performs the load. You can also limit access to your load data by providing temporary security credentials to users. Temporary security credentials provide enhanced security because they have short life spans and cannot be reused after they expire.

Amazon Redshift has features built in to COPY to load uncompressed, delimited data quickly. But you can compress your files using gzip, lzop, or bzip2 to save time uploading the files.

If the following keywords are in the COPY query, automatic splitting of uncompressed data is not supported: ESCAPE, REMOVEQUOTES, and FIXEDWIDTH. But the CSV keyword is supported.

To help keep your data secure in transit within the AWS Cloud, Amazon Redshift uses hardware accelerated SSL to communicate with Amazon S3 or Amazon DynamoDB for COPY, UNLOAD, backup, and restore operations.

When you load your table directly from an Amazon DynamoDB table, you have the option to control the amount of Amazon DynamoDB provisioned throughput you consume.

You can optionally let COPY analyze your input data and automatically apply optimal compression encodings to your table as part of the load process.

Topics

Credentials and access permissions

To load or unload data using another AWS resource, such as Amazon S3, Amazon DynamoDB, Amazon EMR, or Amazon EC2, Amazon Redshift must have permission to access the resource and perform the necessary actions to access the data. For example, to load data from Amazon S3, COPY must have LIST access to the bucket and GET access for the bucket objects.

To obtain authorization to access a resource, Amazon Redshift must be authenticated. You can choose either role-based access control or key-based access control. This section presents an overview of the two methods. For complete details and examples, see Permissions to access other AWS Resources.

Role-based access control

With role-based access control, Amazon Redshift temporarily assumes an AWS Identity and Access Management (IAM) role on your behalf. Then, based on the authorizations granted to the role, Amazon Redshift can access the required AWS resources.

We recommend using role-based access control because it is provides more secure, fine-grained control of access to AWS resources and sensitive user data, in addition to safeguarding your AWS credentials.

To use role-based access control, you must first create an IAM role using the Amazon Redshift service role type, and then attach the role to your data warehouse. The role must have, at a minimum, the permissions listed in IAM permissions for COPY, UNLOAD, and CREATE LIBRARY. For steps to create an IAM role and attach it to your cluster, see Creating an IAM Role to Allow Your Amazon Redshift Cluster to Access AWS Services in the *Amazon Redshift Management Guide*.

You can add a role to a cluster or view the roles associated with a cluster by using the Amazon Redshift Management Console, CLI, or API. For more information, see Authorizing COPY and UNLOAD Operations Using IAM Roles in the *Amazon Redshift Management Guide*.

When you create an IAM role, IAM returns an Amazon Resource Name (ARN) for the role. To run a COPY command using an IAM role, provide the role ARN using the IAM_ROLE parameter or the CREDENTIALS parameter.

The following COPY command example uses IAM_ROLE parameter with the role `MyRedshiftRole` for authentication.

```
COPY customer FROM 's3://amzn-s3-demo-bucket/mydata'
IAM_ROLE 'arn:aws:iam::12345678901:role/MyRedshiftRole';
```

The AWS user must have, at a minimum, the permissions listed in IAM permissions for COPY, UNLOAD, and CREATE LIBRARY.

Key-based access control

With key-based access control, you provide the access key ID and secret access key for a user that is authorized to access the AWS resources that contain the data.

Note

We strongly recommend using an IAM role for authentication instead of supplying a plain-text access key ID and secret access key. If you choose key-based access control, never use your AWS account (root) credentials. Always create an IAM user and provide that user's access key ID and secret access key. For steps to create an IAM user, see Creating an IAM User in Your AWS Account.

Preparing your input data

If your input data is not compatible with the table columns that will receive it, the COPY command will fail.

Use the following guidelines to help ensure that your input data is valid:

- Your data can only contain UTF-8 characters up to four bytes long.
- Verify that CHAR and VARCHAR strings are no longer than the lengths of the corresponding columns. VARCHAR strings are measured in bytes, not characters, so, for example, a four-character string of Chinese characters that occupy four bytes each requires a VARCHAR(16) column.
- Multibyte characters can only be used with VARCHAR columns. Verify that multibyte characters are no more than four bytes long.
- Verify that data for CHAR columns only contains single-byte characters.
- Do not include any special characters or syntax to indicate the last field in a record. This field can be a delimiter.
- If your data includes null terminators, also referred to as NUL (UTF-8 0000) or binary zero (0x000), you can load these characters as NULLS into CHAR or VARCHAR columns by using the NULL AS option in the COPY command: `null as '\0'` or `null as '\000'` . If you do not use NULL AS, null terminators will cause your COPY to fail.
- If your strings contain special characters, such as delimiters and embedded newlines, use the ESCAPE option with the COPY command.
- Verify that all single and double quotation marks are appropriately matched.
- Verify that floating-point strings are in either standard floating-point format, such as 12.123, or an exponential format, such as 1.0E4.
- Verify that all timestamp and date strings follow the specifications for DATEFORMAT and TIMEFORMAT strings. The default timestamp format is YYYY-MM-DD hh:mm:ss, and the default date format is YYYY-MM-DD.
- For more information about boundaries and limitations on individual data types, see Data types. For information about multibyte character errors, see Multibyte character load errors

Loading data from Amazon S3

The COPY command leverages the Amazon Redshift massively parallel processing (MPP) architecture to read and load data in parallel from a file or multiple files in an Amazon S3 bucket. You can take maximum advantage of parallel processing by splitting your data into multiple files, in cases where the files are compressed. (There are exceptions to this rule. These are detailed in Loading data files.) You can also take maximum advantage of parallel processing by setting distribution keys on your tables. For more information about distribution keys, see Data distribution for query optimization.

Data is loaded into the target table, one line per row. The fields in the data file are matched to table columns in order, left to right. Fields in the data files can be fixed-width or character delimited; the default delimiter is a pipe (|). By default, all the table columns are loaded, but you can optionally define a comma-separated list of columns. If a table column is not included in the column list specified in the COPY command, it is loaded with a default value. For more information, see Loading default column values.

Topics

Loading data from compressed and uncompressed files

When you load compressed data, we recommend that you split the data for each table into multiple files. When you load uncompressed, delimited data, the COPY command uses massively parallel processing (MPP) and scan ranges to load data from large files in an Amazon S3 bucket.

Loading data from multiple compressed files

In cases where you have compressed data, we recommend that you split the data for each table into multiple files. The COPY command can load data from multiple files in parallel. You can load multiple files by specifying a common prefix, or *prefix key*, for the set, or by explicitly listing the files in a manifest file.

Split your data into files so that the number of files is a multiple of the number of slices in your cluster. That way, Amazon Redshift can divide the data evenly among the slices. The number of slices per node depends on the node size of the cluster. For example, each dc2.large compute node has two slices, and each dc2.8xlarge compute node has 16 slices. For more information about the number of slices that each node size has, see About clusters and nodes in the *Amazon Redshift Management Guide*.

The nodes all participate in running parallel queries, working on data that is distributed as evenly as possible across the slices. If you have a cluster with two dc2.large nodes, you might split your data into four files or some multiple of four. Amazon Redshift doesn't take file size into account when dividing the workload. Thus, you need to ensure that the files are roughly the same size, from 1 MB to 1 GB after compression.

To use object prefixes to identify the load files, name each file with a common prefix. For example, you might split the `venue.txt` file might be split into four files, as follows.

```
venue.txt.1
venue.txt.2
venue.txt.3
venue.txt.4
```

If you put multiple files in a folder in your bucket and specify the folder name as the prefix, COPY loads all of the files in the folder. If you explicitly list the files to be loaded by using a manifest file, the files can reside in different buckets or folders.

For more information about manifest files, see Example: COPY from Amazon S3 using a manifest.

Loading data from uncompressed, delimited files

When you load uncompressed, delimited data, the COPY command uses the massively parallel processing (MPP) architecture in Amazon Redshift. Amazon Redshift automatically uses slices working in parallel to load ranges of data from a large file in an Amazon S3 bucket. The file must be delimited for parallel loading to occur. For example, pipe delimited. Automatic, parallel data loading with the COPY command is also available for CSV files. You can also take advantage of parallel processing by setting distribution keys on your tables. For more information about distribution keys, see Data distribution for query optimization.

Automatic, parallel data loading isn't supported when the COPY query includes any of the following keywords: ESCAPE, REMOVEQUOTES, and FIXEDWIDTH.

Data from the file or files is loaded into the target table, one line per row. The fields in the data file are matched to table columns in order, left to right. Fields in the data files can be fixed-width or character delimited; the default delimiter is a pipe (|). By default, all the table columns are loaded, but you can optionally define a comma-separated list of columns. If a table column isn't included in the column list specified in the COPY command, it's loaded with a default value. For more information, see Loading default column values.

Follow this general process to load data from Amazon S3, when your data is uncompressed and delimited:

1. Upload your files to Amazon S3.
2. Run a COPY command to load the table.
3. Verify that the data was loaded correctly.

For examples of COPY commands, see COPY examples. For information about data loaded into Amazon Redshift, check the STL_LOAD_COMMITS and STL_LOAD_ERRORS system tables.

For more information about nodes and the slices contained in each, see About clusters and nodes in the *Amazon Redshift Management Guide*.

Uploading files to Amazon S3 to use with COPY

There are a couple approaches to take when uploading text files to Amazon S3:

- If you have compressed files, we recommend that you split large files to take advantage of parallel processing in Amazon Redshift.
- On the other hand, COPY automatically splits large, uncompressed, text-delimited file data to facilitate parallelism and effectively distribute the data from large files.

Create an Amazon S3 bucket to hold your data files, and then upload the data files to the bucket. For information about creating buckets and uploading files, see Working with Amazon S3 Buckets in the *Amazon Simple Storage Service User Guide.*

> **Important**
>
> The Amazon S3 bucket that holds the data files must be created in the same AWS Region as your cluster unless you use the REGION option to specify the Region in which the Amazon S3 bucket is located.

Ensure that the S3 IP ranges are added to your allowlist. To learn more about the required S3 IP ranges, see [Network isolation](#).

You can create an Amazon S3 bucket in a specific Region either by selecting the Region when you create the bucket by using the Amazon S3 console, or by specifying an endpoint when you create the bucket using the Amazon S3 API or CLI.

Following the data load, verify that the correct files are present on Amazon S3.

Topics

- Managing data consistency
- Uploading encrypted data to Amazon S3
- Verifying that the correct files are present in your bucket

Managing data consistency

Amazon S3 provides strong read-after-write consistency for COPY, UNLOAD, INSERT (external table), CREATE EXTERNAL TABLE AS, and Amazon Redshift Spectrum operations on Amazon S3 buckets in all AWS Regions. In addition, read operations on Amazon S3 Select, Amazon S3 Access Control Lists, Amazon S3 Object Tags, and object metadata (for example, HEAD object) are strongly consistent. For more information about data consistency, see Amazon S3 Data Consistency Model in the *Amazon Simple Storage Service User Guide*.

Uploading encrypted data to Amazon S3

Amazon S3 supports both server-side encryption and client-side encryption. This topic discusses the differences between the server-side and client-side encryption and describes the steps to use client-side encryption with Amazon Redshift. Server-side encryption is transparent to Amazon Redshift.

Server-side encryption

Server-side encryption is data encryption at rest—that is, Amazon S3 encrypts your data as it uploads it and decrypts it for you when you access it. When you load tables using a COPY command, there is no difference in the way you load from server-side encrypted or unencrypted objects on Amazon S3. For more information about server-side encryption, see Using Server-Side Encryption in the *Amazon Simple Storage Service User Guide*.

Client-side encryption

In client-side encryption, your client application manages encryption of your data, the encryption keys, and related tools. You can upload data to an Amazon S3 bucket using client-side encryption, and then load the data using the COPY command with the ENCRYPTED option and a private encryption key to provide greater security.

You encrypt your data using envelope encryption. With *envelope encryption,* your application handles all encryption exclusively. Your private encryption keys and your unencrypted data are never sent to AWS, so it's very important that you safely manage your encryption keys. If you lose your encryption keys, you won't be able to unencrypt your data, and you can't recover your encryption keys from AWS. Envelope encryption combines the performance of fast symmetric encryption while maintaining the greater security that key management with asymmetric keys provides. A one-time-use symmetric key (the envelope symmetric key) is generated by your Amazon S3 encryption client to encrypt your data, then that key is encrypted by your root key and stored alongside your data in Amazon S3. When Amazon Redshift accesses your data during a load, the encrypted symmetric key is retrieved and decrypted with your real key, then the data is decrypted.

To work with Amazon S3 client-side encrypted data in Amazon Redshift, follow the steps outlined in Protecting Data Using Client-Side Encryption in the *Amazon Simple Storage Service User Guide*, with the additional requirements that you use:

- **Symmetric encryption –** The AWS SDK for Java `AmazonS3EncryptionClient` class uses envelope encryption, described preceding, which is based on symmetric key encryption. Use this class to create an Amazon S3 client to upload client-side encrypted data.
- **A 256-bit AES root symmetric key –** A root key encrypts the envelope key. You pass the root key to your instance of the `AmazonS3EncryptionClient` class. Save this key, because you will need it to copy data into Amazon Redshift.
- **Object metadata to store encrypted envelope key –** By default, Amazon S3 stores the envelope key as object metadata for the `AmazonS3EncryptionClient` class. The encrypted envelope key that is stored as object metadata is used during the decryption process.

> **Note**
>
> If you get a cipher encryption error message when you use the encryption API for the first time, your version of the JDK may have a Java Cryptography Extension (JCE)

jurisdiction policy file that limits the maximum key length for encryption and decryption transformations to 128 bits. For information about addressing this issue, go to Specifying Client-Side Encryption Using the AWS SDK for Java in the *Amazon Simple Storage Service User Guide*.

For information about loading client-side encrypted files into your Amazon Redshift tables using the COPY command, see Loading encrypted data files from Amazon S3.

Example: Uploading client-side encrypted data

For an example of how to use the AWS SDK for Java to upload client-side encrypted data, go to Protecting data using client-side encryption in the *Amazon Simple Storage Service User Guide*.

The second option shows the choices you must make during client-side encryption so that the data can be loaded in Amazon Redshift. Specifically, the example shows using object metadata to store the encrypted envelope key and the use of a 256-bit AES root symmetric key.

This example provides example code using the AWS SDK for Java to create a 256-bit AES symmetric root key and save it to a file. Then the example upload an object to Amazon S3 using an S3 encryption client that first encrypts sample data on the client-side. The example also downloads the object and verifies that the data is the same.

Verifying that the correct files are present in your bucket

After you upload your files to your Amazon S3 bucket, we recommend listing the contents of the bucket to verify that all of the correct files are present and that no unwanted files are present. For example, if the bucket `amzn-s3-demo-bucket` holds a file named `venue.txt.back`, that file will be loaded, perhaps unintentionally, by the following command:

```
COPY venue FROM 's3://amzn-s3-demo-bucket/venue' … ;
```

If you want to control specifically which files are loaded, you can use a manifest file to explicitly list the data files. For more information about using a manifest file, see the copy_from_s3_manifest_file option for the COPY command and Example: COPY from Amazon S3 using a manifest in the COPY examples.

For more information about listing the contents of the bucket, see Listing Object Keys in the *Amazon S3 Developer Guide*.

Using the COPY command to load from Amazon S3

Use the COPY command to load a table in parallel from data files on Amazon S3. You can specify the files to be loaded by using an Amazon S3 object prefix or by using a manifest file.

The syntax to specify the files to be loaded by using a prefix is as follows:

```
COPY <table_name> FROM 's3://<bucket_name>/<object_prefix>'
authorization;
```

The manifest file is a JSON-formatted file that lists the data files to be loaded. The syntax to specify the files to be loaded by using a manifest file is as follows:

```
COPY <table_name> FROM 's3://<bucket_name>/<manifest_file>'
authorization
MANIFEST;
```

The table to be loaded must already exist in the database. For information about creating a table, see CREATE TABLE in the SQL Reference.

The values for *authorization* provide the AWS authorization Amazon Redshift needs to access the Amazon S3 objects. For information about required permissions, see IAM permissions for COPY, UNLOAD, and CREATE LIBRARY. The preferred method for authentication is to specify the IAM_ROLE parameter and provide the Amazon Resource Name (ARN) for an IAM role with the necessary permissions. For more information, see Role-based access control .

To authenticate using the IAM_ROLE parameter, replace *<aws-account-id>* and *<role-name>* as shown in the following syntax.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-name>'
```

The following example shows authentication using an IAM role.

```
COPY customer
FROM 's3://amzn-s3-demo-bucket/mydata'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

For more information about other authorization options, see Authorization parameters

If you want to validate your data without actually loading the table, use the NOLOAD option with the COPY command.

The following example shows the first few rows of a pipe-delimited data in a file named `venue.txt`.

```
1|Toyota Park|Bridgeview|IL|0
2|Columbus Crew Stadium|Columbus|OH|0
3|RFK Stadium|Washington|DC|0
```

Before uploading the file to Amazon S3, split the file into multiple files so that the COPY command can load it using parallel processing. The number of files should be a multiple of the number of slices in your cluster. Split your load data files so that the files are about equal size, between 1 MB and 1 GB after compression. For more information, see Loading data from compressed and uncompressed files.

For example, the `venue.txt` file might be split into four files, as follows:

```
venue.txt.1
venue.txt.2
venue.txt.3
venue.txt.4
```

The following COPY command loads the VENUE table using the pipe-delimited data in the data files with the prefix 'venue' in the Amazon S3 bucket `amzn-s3-demo-bucket`.

Note

The Amazon S3 bucket `amzn-s3-demo-bucket` in the following examples does not exist. For sample COPY commands that use real data in an existing Amazon S3 bucket, see Load sample data.

```
COPY venue FROM 's3://amzn-s3-demo-bucket/venue'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
DELIMITER '|';
```

If no Amazon S3 objects with the key prefix 'venue' exist, the load fails.

Topics

- Using a manifest to specify data files
- Loading compressed data files from Amazon S3

- Loading fixed-width data from Amazon S3
- Loading multibyte data from Amazon S3
- Loading encrypted data files from Amazon S3

Using a manifest to specify data files

You can use a manifest to make sure that the COPY command loads all of the required files, and only the required files, for a data load. You can use a manifest to load files from different buckets or files that do not share the same prefix. Instead of supplying an object path for the COPY command, you supply the name of a JSON-formatted text file that explicitly lists the files to be loaded. The URL in the manifest must specify the bucket name and full object path for the file, not just a prefix.

For more information about manifest files, see the COPY example Using a manifest to specify data files.

The following example shows the JSON to load files from different buckets and with file names that begin with date stamps.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket1/2013-10-04-custdata", "mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket1/2013-10-05-custdata", "mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket2/2013-10-04-custdata", "mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket2/2013-10-05-custdata", "mandatory":true}
  ]
}
```

The optional `mandatory` flag specifies whether COPY should return an error if the file is not found. The default of `mandatory` is `false`. Regardless of any mandatory settings, COPY will terminate if no files are found.

The following example runs the COPY command with the manifest in the previous example, which is named `cust.manifest`.

```
COPY customer
FROM 's3://amzn-s3-demo-bucket/cust.manifest'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
MANIFEST;
```

Using a manifest created by UNLOAD

A manifest created by an UNLOAD operation using the MANIFEST parameter might have keys that are not required for the COPY operation. For example, the following UNLOAD manifest includes a `meta` key that is required for an Amazon Redshift Spectrum external table and for loading data files in an `ORC` or `Parquet` file format. The `meta` key contains a `content_length` key with a value that is the actual size of the file in bytes. The COPY operation requires only the `url` key and an optional `mandatory` key.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/unload/manifest_0000_part_00", "meta":
 { "content_length": 5956875 }},
    {"url":"s3://amzn-s3-demo-bucket/unload/unload/manifest_0001_part_00", "meta":
 { "content_length": 5997091 }}
 ]
}
```

For more information about manifest files, see Example: COPY from Amazon S3 using a manifest.

Loading compressed data files from Amazon S3

To load data files that are compressed using gzip, lzop, or bzip2, include the corresponding option: GZIP, LZOP, or BZIP2.

For example, the following command loads from files that were compressing using lzop.

```
COPY customer FROM 's3://amzn-s3-demo-bucket/customer.lzo'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
DELIMITER '|' LZOP;
```

Note

If you compress a data file with lzop compression and use the *--filter* option, the COPY command doesn't support it.

Loading fixed-width data from Amazon S3

Fixed-width data files have uniform lengths for each column of data. Each field in a fixed-width data file has exactly the same length and position. For character data (CHAR and VARCHAR) in a fixed-width data file, you must include leading or trailing spaces as placeholders in order to keep the width uniform. For integers, you must use leading zeros as placeholders. A fixed-width data file has no delimiter to separate columns.

To load a fixed-width data file into an existing table, USE the FIXEDWIDTH parameter in the COPY command. Your table specifications must match the value of fixedwidth_spec in order for the data to load correctly.

To load fixed-width data from a file to a table, issue the following command:

```
COPY table_name FROM 's3://amzn-s3-demo-bucket/prefix'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
FIXEDWIDTH 'fixedwidth_spec';
```

The *fixedwidth_spec* parameter is a string that contains an identifier for each column and the width of each column, separated by a colon. The **`column:width`** pairs are delimited by commas. The identifier can be anything that you choose: numbers, letters, or a combination of the two. The identifier has no relation to the table itself, so the specification must contain the columns in the same order as the table.

The following two examples show the same specification, with the first using numeric identifiers and the second using string identifiers:

```
'0:3,1:25,2:12,3:2,4:6'
```

```
'venueid:3,venuename:25,venuecity:12,venuestate:2,venueseats:6'
```

The following example shows fixed-width sample data that could be loaded into the VENUE table using the preceding specifications:

```

1  Toyota Park              Bridgeview  IL0
2  Columbus Crew Stadium    Columbus    OH0
3  RFK Stadium              Washington  DC0
4  CommunityAmerica Ballpark Kansas City KS0
5  Gillette Stadium         Foxborough  MA68756
```

The following COPY command loads this data set into the VENUE table:

```
COPY venue
```

```
FROM 's3://amzn-s3-demo-bucket/data/venue_fw.txt'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
FIXEDWIDTH 'venueid:3,venuename:25,venuecity:12,venuestate:2,venueseats:6';
```

Loading multibyte data from Amazon S3

If your data includes non-ASCII multibyte characters (such as Chinese or Cyrillic characters), you must load the data to VARCHAR columns. The VARCHAR data type supports four-byte UTF-8 characters, but the CHAR data type only accepts single-byte ASCII characters. You cannot load five-byte or longer characters into Amazon Redshift tables. For more information about CHAR and VARCHAR, see Data types.

To check which encoding an input file uses, use the Linux *file* command:

```
$ file ordersdata.txt
ordersdata.txt: ASCII English text
$ file uni_ordersdata.dat
uni_ordersdata.dat: UTF-8 Unicode text
```

Loading encrypted data files from Amazon S3

You can use the COPY command to load data files that were uploaded to Amazon S3 using server-side encryption, client-side encryption, or both.

The COPY command supports the following types of Amazon S3 encryption:

- Server-side encryption with Amazon S3-managed keys (SSE-S3)
- Server-side encryption with AWS KMS keys (SSE-KMS)
- Client-side encryption using a client-side symmetric root key

The COPY command doesn't support the following types of Amazon S3 encryption:

- Server-side encryption with customer-provided keys (SSE-C)
- Client-side encryption using an AWS KMS key
- Client-side encryption using a customer-provided asymmetric root key

For more information about Amazon S3 encryption, see Protecting Data Using Server-Side Encryption and Protecting Data Using Client-Side Encryption in the Amazon Simple Storage Service User Guide.

The UNLOAD command automatically encrypts files using SSE-S3. You can also unload using SSE-KMS or client-side encryption with a customer managed symmetric key. For more information, see Unloading encrypted data files

The COPY command automatically recognizes and loads files encrypted using SSE-S3 and SSE-KMS. You can load files encrypted using a client-side symmetric root key by specifying the ENCRYPTED option and providing the key value. For more information, see Uploading encrypted data to Amazon S3.

To load client-side encrypted data files, provide the root key value using the MASTER_SYMMETRIC_KEY parameter and include the ENCRYPTED option.

```
COPY customer FROM 's3://amzn-s3-demo-bucket/encrypted/customer'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
MASTER_SYMMETRIC_KEY '<root_key>'
ENCRYPTED
DELIMITER '|';
```

To load encrypted data files that are gzip, lzop, or bzip2 compressed, include the GZIP, LZOP, or BZIP2 option along with the root key value and the ENCRYPTED option.

```
COPY customer FROM 's3://amzn-s3-demo-bucket/encrypted/customer'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
MASTER_SYMMETRIC_KEY '<root_key>'
ENCRYPTED
DELIMITER '|'
GZIP;
```

Loading data from Amazon EMR

You can use the COPY command to load data in parallel from an Amazon EMR cluster configured to write text files to the cluster's Hadoop Distributed File System (HDFS) as fixed-width files, character-delimited files, CSV files, or JSON-formatted files.

Process for loading data from Amazon EMR

This section walks you through the process of loading data from an Amazon EMR cluster. The following sections provide the details that you must accomplish each step.

- **Step 1: Configure IAM permissions**

The users that create the Amazon EMR cluster and run the Amazon Redshift COPY command must have the necessary permissions.

- **Step 2: Create an Amazon EMR cluster**

  Configure the cluster to output text files to the Hadoop Distributed File System (HDFS). You will need the Amazon EMR cluster ID and the cluster's main public DNS (the endpoint for the Amazon EC2 instance that hosts the cluster).

- **Step 3: Retrieve the Amazon Redshift cluster public key and cluster node IP addresses**

  The public key enables the Amazon Redshift cluster nodes to establish SSH connections to the hosts. You will use the IP address for each cluster node to configure the host security groups to permit access from your Amazon Redshift cluster using these IP addresses.

- **Step 4: Add the Amazon Redshift cluster public key to each Amazon EC2 host's authorized keys file**

  You add the Amazon Redshift cluster public key to the host's authorized keys file so that the host will recognize the Amazon Redshift cluster and accept the SSH connection.

- **Step 5: Configure the hosts to accept all of the Amazon Redshift cluster's IP addresses**

  Modify the Amazon EMR instance's security groups to add input rules to accept the Amazon Redshift IP addresses.

- **Step 6: Run the COPY command to load the data**

  From an Amazon Redshift database, run the COPY command to load the data into an Amazon Redshift table.

Step 1: Configure IAM permissions

The users that create the Amazon EMR cluster and run the Amazon Redshift COPY command must have the necessary permissions.

To configure IAM permissions

1. Add the following permissions for the user that will create the Amazon EMR cluster.

```
ec2:DescribeSecurityGroups
ec2:RevokeSecurityGroupIngress
ec2:AuthorizeSecurityGroupIngress
```

```
redshift:DescribeClusters
```

2. Add the following permission for the IAM role or user that will run the COPY command.

```
elasticmapreduce:ListInstances
```

3. Add the following permission to the Amazon EMR cluster's IAM role.

```
redshift:DescribeClusters
```

Step 2: Create an Amazon EMR cluster

The COPY command loads data from files on the Amazon EMR Hadoop Distributed File System (HDFS). When you create the Amazon EMR cluster, configure the cluster to output data files to the cluster's HDFS.

To create an Amazon EMR cluster

1. Create an Amazon EMR cluster in the same AWS Region as the Amazon Redshift cluster.

   If the Amazon Redshift cluster is in a VPC, the Amazon EMR cluster must be in the same VPC group. If the Amazon Redshift cluster uses EC2-Classic mode (that is, it is not in a VPC), the Amazon EMR cluster must also use EC2-Classic mode. For more information, see [Managing Clusters in Virtual Private Cloud (VPC)](#) in the *Amazon Redshift Management Guide*.
2. Configure the cluster to output data files to the cluster's HDFS. The HDFS file names must not include asterisks (*) or question marks (?).

   > **Important**
   >
   > The file names must not include asterisks (*) or question marks (?).
3. Specify **No** for the **Auto-terminate** option in the Amazon EMR cluster configuration so that the cluster remains available while the COPY command runs.

   > **Important**
   >
   > If any of the data files are changed or deleted before the COPY completes, you might have unexpected results, or the COPY operation might fail.

4. Note the cluster ID and the main public DNS (the endpoint for the Amazon EC2 instance that hosts the cluster). You will use that information in later steps.

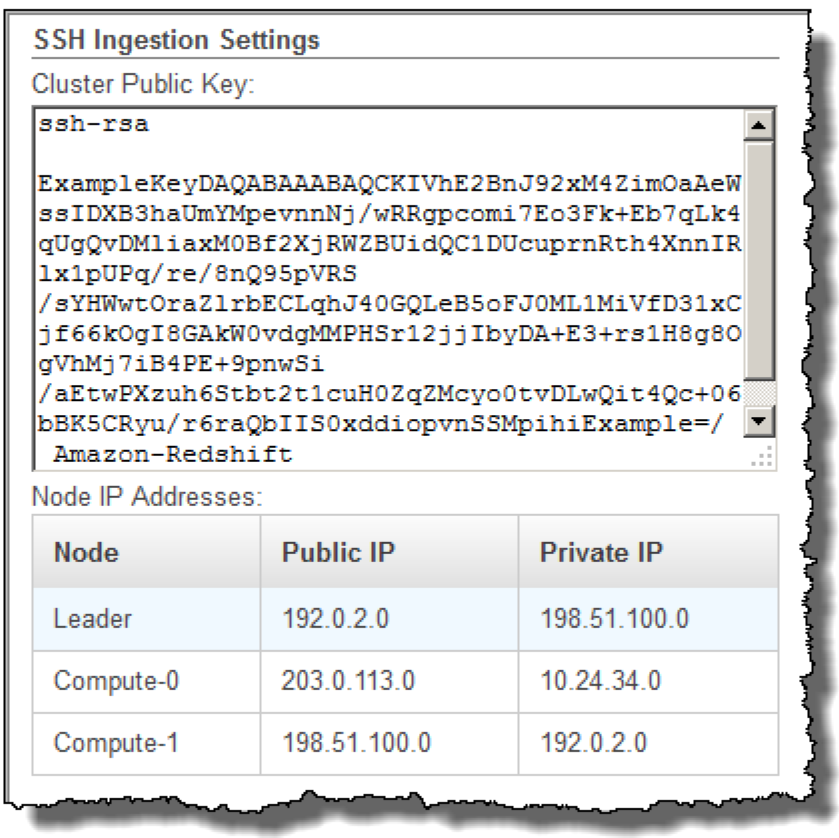
Step 3: Retrieve the Amazon Redshift cluster public key and cluster node IP addresses

You will use the IP address for each cluster node to configure the host security groups to permit access from your Amazon Redshift cluster using these IP addresses.

To retrieve the Amazon Redshift cluster public key and cluster node IP addresses for your cluster using the console

1. Access the Amazon Redshift Management Console.
2. Choose the **Clusters** link in the navigation pane.
3. Select your cluster from the list.
4. Locate the **SSH Ingestion Settings** group.

   Note the **Cluster Public Key** and **Node IP addresses**. You will use them in later steps.



You will use the private IP addresses in Step 3 to configure the Amazon EC2 host to accept the connection from Amazon Redshift.

To retrieve the cluster public key and cluster node IP addresses for your cluster using the Amazon Redshift CLI, run the describe-clusters command. For example:

```
aws redshift describe-clusters --cluster-identifier <cluster-identifier>
```

The response will include a ClusterPublicKey value and the list of private and public IP addresses, similar to the following:

```
{
    "Clusters": [
        {
            "VpcSecurityGroups": [],
            "ClusterStatus": "available",
            "ClusterNodes": [
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "LEADER",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                },
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "COMPUTE-0",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                },
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "COMPUTE-1",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                }
            ],
            "AutomatedSnapshotRetentionPeriod": 1,
            "PreferredMaintenanceWindow": "wed:05:30-wed:06:00",
            "AvailabilityZone": "us-east-1a",
            "NodeType": "dc2.large",
            "ClusterPublicKey": "ssh-rsa AAAABexamplepublickey...Y3TAl Amazon-
Redshift",
             ...
             ...
```

```
}
```

To retrieve the cluster public key and cluster node IP addresses for your cluster using the Amazon Redshift API, use the `DescribeClusters` action. For more information, see describe-clusters in the *Amazon Redshift CLI Guide* or DescribeClusters in the Amazon Redshift API Guide.

Step 4: Add the Amazon Redshift cluster public key to each Amazon EC2 host's authorized keys file

You add the cluster public key to each host's authorized keys file for all of the Amazon EMR cluster nodes so that the hosts will recognize Amazon Redshift and accept the SSH connection.

To add the Amazon Redshift cluster public key to the host's authorized keys file

1. Access the host using an SSH connection.

   For information about connecting to an instance using SSH, see Connect to Your Instance in the *Amazon EC2 User Guide*.

2. Copy the Amazon Redshift public key from the console or from the CLI response text.
3. Copy and paste the contents of the public key into the `/home/<ssh_username>/.ssh/authorized_keys` file on the host. Include the complete string, including the prefix "`ssh-rsa `" and suffix "`Amazon-Redshift`". For example:

   ```
   ssh-rsa AAAACTP3isxgGzVWoIWpbVvRCOzYdVifMrh… uA70BnMHCaMiRdmvsDOedZDOedZ Amazon-Redshift
   ```

Step 5: Configure the hosts to accept all of the Amazon Redshift cluster's IP addresses

To allow inbound traffic to the host instances, edit the security group and add one Inbound rule for each Amazon Redshift cluster node. For **Type**, select SSH with TCP protocol on Port 22. For **Source**, enter the Amazon Redshift cluster node private IP addresses you retrieved in Step 3: Retrieve the Amazon Redshift cluster public key and cluster node IP addresses. For information about adding rules to an Amazon EC2 security group, see Authorizing Inbound Traffic for Your Instances in the *Amazon EC2 User Guide*.

Step 6: Run the COPY command to load the data

Run a COPY command to connect to the Amazon EMR cluster and load the data into an Amazon Redshift table. The Amazon EMR cluster must continue running until the COPY command completes. For example, do not configure the cluster to auto-terminate.

> **Important**
>
> If any of the data files are changed or deleted before the COPY completes, you might have unexpected results, or the COPY operation might fail.

In the COPY command, specify the Amazon EMR cluster ID and the HDFS file path and file name.

```
COPY sales
FROM 'emr://myemrclusterid/myoutput/part*' CREDENTIALS
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

You can use the wildcard characters asterisk (*) and question mark (?) as part of the file name argument. For example, `part*` loads the files `part-0000`, `part-0001`, and so on. If you specify only a folder name, COPY attempts to load all files in the folder.

> **Important**
>
> If you use wildcard characters or use only the folder name, verify that no unwanted files will be loaded or the COPY command will fail. For example, some processes might write a log file to the output folder.

Loading data from remote hosts

You can use the COPY command to load data in parallel from one or more remote hosts, such as Amazon EC2 instances or other computers. COPY connects to the remote hosts using SSH and runs commands on the remote hosts to generate text output.

The remote host can be an Amazon EC2 Linux instance or another Unix or Linux computer configured to accept SSH connections. This guide assumes your remote host is an Amazon EC2 instance. Where the procedure is different for another computer, the guide will point out the difference.

Amazon Redshift can connect to multiple hosts, and can open multiple SSH connections to each host. Amazon Redshifts sends a unique command through each connection to generate text output to the host's standard output, which Amazon Redshift then reads as it would a text file.

Before you begin

Before you begin, you should have the following in place:

- One or more host machines, such as Amazon EC2 instances, that you can connect to using SSH.
- Data sources on the hosts.

  You will provide commands that the Amazon Redshift cluster will run on the hosts to generate the text output. After the cluster connects to a host, the COPY command runs the commands, reads the text from the hosts' standard output, and loads the data in parallel into an Amazon Redshift table. The text output must be in a form that the COPY command can ingest. For more information, see Preparing your input data
- Access to the hosts from your computer.

  For an Amazon EC2 instance, you will use an SSH connection to access the host. You must access the host to add the Amazon Redshift cluster's public key to the host's authorized keys file.
- A running Amazon Redshift cluster.

  For information about how to launch a cluster, see Amazon Redshift Getting Started Guide.

Loading data process

This section walks you through the process of loading data from remote hosts. The following sections provide the details that that you must accomplish in each step.

- **Step 1: Retrieve the cluster public key and cluster node IP addresses**

  The public key enables the Amazon Redshift cluster nodes to establish SSH connections to the remote hosts. You will use the IP address for each cluster node to configure the host security groups or firewall to permit access from your Amazon Redshift cluster using these IP addresses.
- **Step 2: Add the Amazon Redshift cluster public key to the host's authorized keys file**

  You add the Amazon Redshift cluster public key to the host's authorized keys file so that the host will recognize the Amazon Redshift cluster and accept the SSH connection.

- **Step 3: Configure the host to accept all of the Amazon Redshift cluster's IP addresses**

  For Amazon EC2, modify the instance's security groups to add input rules to accept the Amazon Redshift IP addresses. For other hosts, modify the firewall so that your Amazon Redshift nodes are able to establish SSH connections to the remote host.

- **Step 4: Get the public key for the host**

  You can optionally specify that Amazon Redshift should use the public key to identify the host. You must locate the public key and copy the text into your manifest file.

- **Step 5: Create a manifest file**

  The manifest is a JSON-formatted text file with the details Amazon Redshift needs to connect to the hosts and fetch the data.

- **Step 6: Upload the manifest file to an Amazon S3 bucket**

  Amazon Redshift reads the manifest and uses that information to connect to the remote host. If the Amazon S3 bucket does not reside in the same Region as your Amazon Redshift cluster, you must use the REGION option to specify the Region in which the data is located.

- **Step 7: Run the COPY command to load the data**

  From an Amazon Redshift database, run the COPY command to load the data into an Amazon Redshift table.

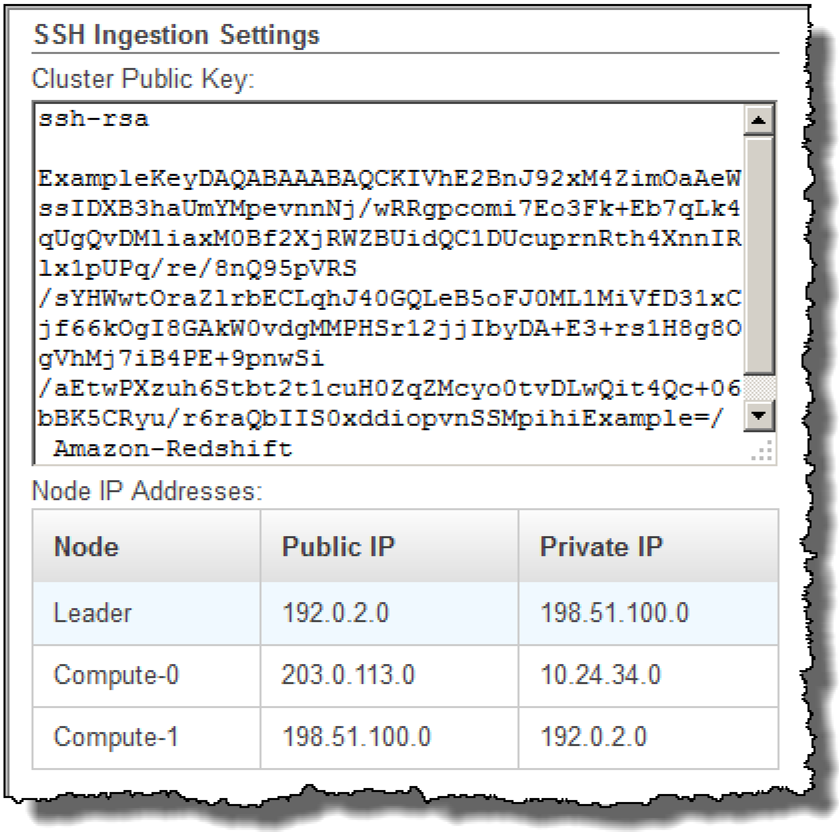
Step 1: Retrieve the cluster public key and cluster node IP addresses

You will use the IP address for each cluster node to configure the host security groups to permit access from your Amazon Redshift cluster using these IP addresses.

To retrieve the cluster public key and cluster node IP addresses for your cluster using the console

1. Access the Amazon Redshift Management Console.
2. Choose the **Clusters** link in the navigation pane.
3. Select your cluster from the list.
4. Locate the **SSH Ingestion Settings** group.

   Note the **Cluster Public Key** and **Node IP addresses**. You will use them in later steps.



You will use the IP addresses in Step 3 to configure the host to accept the connection from Amazon Redshift. Depending on what type of host you connect to and whether it is in a VPC, you will use either the public IP addresses or the private IP addresses.

To retrieve the cluster public key and cluster node IP addresses for your cluster using the Amazon Redshift CLI, run the describe-clusters command.

For example:

```
aws redshift describe-clusters --cluster-identifier <cluster-identifier>
```

The response will include the ClusterPublicKey and the list of private and public IP addresses, similar to the following:

```
{
    "Clusters": [
        {
            "VpcSecurityGroups": [],
            "ClusterStatus": "available",
```

```
            "ClusterNodes": [
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "LEADER",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                },
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "COMPUTE-0",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                },
                {
                    "PrivateIPAddress": "10.nnn.nnn.nnn",
                    "NodeRole": "COMPUTE-1",
                    "PublicIPAddress": "10.nnn.nnn.nnn"
                }
            ],
            "AutomatedSnapshotRetentionPeriod": 1,
            "PreferredMaintenanceWindow": "wed:05:30-wed:06:00",
            "AvailabilityZone": "us-east-1a",
            "NodeType": "dc2.large",
            "ClusterPublicKey": "ssh-rsa AAAABexamplepublickey...Y3TAl Amazon-
Redshift",
             ...
             ...
}
```

To retrieve the cluster public key and cluster node IP addresses for your cluster using the Amazon Redshift API, use the DescribeClusters action. For more information, see describe-clusters in the *Amazon Redshift CLI Guide* or DescribeClusters in the Amazon Redshift API Guide.

Step 2: Add the Amazon Redshift cluster public key to the host's authorized keys file

You add the cluster public key to each host's authorized keys file so that the host will recognize Amazon Redshift and accept the SSH connection.

To add the Amazon Redshift cluster public key to the host's authorized keys file

1. Access the host using an SSH connection.

For information about connecting to an instance using SSH, see Connect to Your Instance in the *Amazon EC2 User Guide*.

2. Copy the Amazon Redshift public key from the console or from the CLI response text.
3. Copy and paste the contents of the public key into the `/home/<ssh_username>/.ssh/authorized_keys` file on the remote host. The `<ssh_username>` must match the value for the "username" field in the manifest file. Include the complete string, including the prefix "`ssh-rsa` " and suffix "`Amazon-Redshift`". For example:

```
ssh-rsa AAAACTP3isxgGzVWoIWpbVvRCOzYdVifMrh… uA70BnMHCaMiRdmvsDOedZDOedZ Amazon-
Redshift
```

Step 3: Configure the host to accept all of the Amazon Redshift cluster's IP addresses

If you are working with an Amazon EC2 instance or an Amazon EMR cluster, add Inbound rules to the host's security group to allow traffic from each Amazon Redshift cluster node. For **Type**, select SSH with TCP protocol on Port 22. For **Source**, enter the Amazon Redshift cluster node IP addresses you retrieved in Step 1: Retrieve the cluster public key and cluster node IP addresses. For information about adding rules to an Amazon EC2 security group, see Authorizing Inbound Traffic for Your Instances in the *Amazon EC2 User Guide*.

Use the private IP addresses when:

- You have an Amazon Redshift cluster that is not in a Virtual Private Cloud (VPC), and an Amazon EC2 -Classic instance, both of which are in the same AWS Region.
- You have an Amazon Redshift cluster that is in a VPC, and an Amazon EC2 -VPC instance, both of which are in the same AWS Region and in the same VPC.

Otherwise, use the public IP addresses.

For more information about using Amazon Redshift in a VPC, see Managing Clusters in Virtual Private Cloud (VPC) in the *Amazon Redshift Management Guide*.

Step 4: Get the public key for the host

You can optionally provide the host's public key in the manifest file so that Amazon Redshift can identify the host. The COPY command does not require the host public key but, for security reasons, we strongly recommend using a public key to help prevent 'man-in-the-middle' attacks.

You can find the host's public key in the following location, where `<ssh_host_rsa_key_name>` is the unique name for the host's public key:

```
:  /etc/ssh/<ssh_host_rsa_key_name>.pub
```

> **Note**
>
> Amazon Redshift only supports RSA keys. We do not support DSA keys.

When you create your manifest file in Step 5, you will paste the text of the public key into the "Public Key" field in the manifest file entry.

Step 5: Create a manifest file

The COPY command can connect to multiple hosts using SSH, and can create multiple SSH connections to each host. COPY runs a command through each host connection, and then loads the output from the commands in parallel into the table. The manifest file is a text file in JSON format that Amazon Redshift uses to connect to the host. The manifest file specifies the SSH host endpoints and the commands that are run on the hosts to return data to Amazon Redshift. Optionally, you can include the host public key, the login user name, and a mandatory flag for each entry.

Create the manifest file on your local computer. In a later step, you upload the file to Amazon S3.

The manifest file is in the following format:

```
{
   "entries": [
     {"endpoint":"<ssh_endpoint_or_IP>",
       "command": "<remote_command>",
       "mandatory":true,
       "publickey": "<public_key>",
       "username": "<host_user_name>"},
```

```
      {"endpoint":"<ssh_endpoint_or_IP>",
        "command": "<remote_command>",
        "mandatory":true,
        "publickey": "<public_key>",
        "username": "host_user_name"}
     ]
}
```

The manifest file contains one "entries" construct for each SSH connection. Each entry represents a single SSH connection. You can have multiple connections to a single host or multiple connections to multiple hosts. The double quotation marks are required as shown, both for the field names and the values. The only value that does not need double quotation marks is the Boolean value **`true`** or **`false`** for the mandatory field.

The following describes the fields in the manifest file.

endpoint

The URL address or IP address of the host. For example, "`ec2-111-222-333.compute-1.amazonaws.com`" or "`22.33.44.56`"

command

The command that will be run by the host to generate text or binary (gzip, lzop, or bzip2) output. The command can be any command that the user *"host_user_name"* has permission to run. The command can be as simple as printing a file, or it could query a database or launch a script. The output (text file, gzip binary file, lzop binary file, or bzip2 binary file) must be in a form the Amazon Redshift COPY command can ingest. For more information, see Preparing your input data.

publickey

(Optional) The public key of the host. If provided, Amazon Redshift will use the public key to identify the host. If the public key is not provided, Amazon Redshift will not attempt host identification. For example, if the remote host's public key is: `ssh-rsa AbcCbaxxx…xxxDHKJ root@amazon.com`, enter the following text in the public key field: `AbcCbaxxx…xxxDHKJ`.

mandatory

(Optional) Indicates whether the COPY command should fail if the connection fails. The default is `false`. If Amazon Redshift does not successfully make at least one connection, the COPY command fails.

username

(Optional) The username that will be used to log on to the host system and run the remote command. The user login name must be the same as the login that was used to add the public key to the host's authorized keys file in Step 2. The default username is "redshift".

The following example shows a completed manifest to open four connections to the same host and run a different command through each connection:

```
{
  "entries": [
       {"endpoint":"ec2-184-72-204-112.compute-1.amazonaws.com",
          "command": "cat loaddata1.txt",
          "mandatory":true,
          "publickey": "ec2publickeyportionoftheec2keypair",
          "username": "ec2-user"},
       {"endpoint":"ec2-184-72-204-112.compute-1.amazonaws.com",
          "command": "cat loaddata2.txt",
          "mandatory":true,
          "publickey": "ec2publickeyportionoftheec2keypair",
          "username": "ec2-user"},
       {"endpoint":"ec2-184-72-204-112.compute-1.amazonaws.com",
          "command": "cat loaddata3.txt",
          "mandatory":true,
          "publickey": "ec2publickeyportionoftheec2keypair",
          "username": "ec2-user"},
       {"endpoint":"ec2-184-72-204-112.compute-1.amazonaws.com",
          "command": "cat loaddata4.txt",
          "mandatory":true,
          "publickey": "ec2publickeyportionoftheec2keypair",
          "username": "ec2-user"}
     ]
}
```

Step 6: Upload the manifest file to an Amazon S3 bucket

Upload the manifest file to an Amazon S3 bucket. If the Amazon S3 bucket does not reside in the same AWS Region as your Amazon Redshift cluster, you must use the REGION option to specify the AWS Region in which the manifest is located. For information about creating an Amazon S3 bucket and uploading a file, see Amazon Simple Storage Service User Guide.

Step 7: Run the COPY command to load the data

Run a COPY command to connect to the host and load the data into an Amazon Redshift table. In the COPY command, specify the explicit Amazon S3 object path for the manifest file and include the SSH option. For example,

```
COPY sales
FROM 's3://amzn-s3-demo-bucket/ssh_manifest'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
DELIMITER '|'
SSH;
```

Note

If you use automatic compression, the COPY command performs two data reads, which means it runs the remote command twice. The first read is to provide a sample for compression analysis, then the second read actually loads the data. If running the remote command twice might cause a problem because of potential side effects, you should turn off automatic compression. To turn off automatic compression, run the COPY command with the COMPUPDATE option set to OFF. For more information, see Loading tables with automatic compression.

Loading data from an Amazon DynamoDB table

You can use the COPY command to load a table with data from a single Amazon DynamoDB table.

Important

The Amazon DynamoDB table that provides the data must be created in the same AWS Region as your cluster unless you use the REGION option to specify the AWS Region in which the Amazon DynamoDB table is located.

The COPY command uses the Amazon Redshift massively parallel processing (MPP) architecture to read and load data in parallel from an Amazon DynamoDB table. You can take maximum advantage of parallel processing by setting distribution styles on your Amazon Redshift tables. For more information, see Data distribution for query optimization.

> **Important**
>
> When the COPY command reads data from the Amazon DynamoDB table, the resulting data transfer is part of that table's provisioned throughput.

To avoid consuming excessive amounts of provisioned read throughput, we recommend that you not load data from Amazon DynamoDB tables that are in production environments. If you do load data from production tables, we recommend that you set the READRATIO option much lower than the average percentage of unused provisioned throughput. A low READRATIO setting will help minimize throttling issues. To use the entire provisioned throughput of an Amazon DynamoDB table, set READRATIO to 100.

The COPY command matches attribute names in the items retrieved from the DynamoDB table to column names in an existing Amazon Redshift table by using the following rules:

- Amazon Redshift table columns are case-insensitively matched to Amazon DynamoDB item attributes. If an item in the DynamoDB table contains multiple attributes that differ only in case, such as Price and PRICE, the COPY command will fail.
- Amazon Redshift table columns that do not match an attribute in the Amazon DynamoDB table are loaded as either NULL or empty, depending on the value specified with the EMPTYASNULL option in the COPY command.
- Amazon DynamoDB attributes that do not match a column in the Amazon Redshift table are discarded. Attributes are read before they are matched, and so even discarded attributes consume part of that table's provisioned throughput.
- Only Amazon DynamoDB attributes with scalar STRING and NUMBER data types are supported. The Amazon DynamoDB BINARY and SET data types are not supported. If a COPY command tries to load an attribute with an unsupported data type, the command will fail. If the attribute does not match an Amazon Redshift table column, COPY does not attempt to load it, and it does not raise an error.

The COPY command uses the following syntax to load data from an Amazon DynamoDB table:

```
COPY <redshift_tablename> FROM 'dynamodb://<dynamodb_table_name>'
authorization
readratio '<integer>';
```

The values for *authorization* are the AWS credentials needed to access the Amazon DynamoDB table. If these credentials correspond to a user, that user must have permission to SCAN and DESCRIBE the Amazon DynamoDB table that is being loaded.

The values for *authorization* provide the AWS authorization your cluster needs to access the Amazon DynamoDB table. The permission must include SCAN and DESCRIBE for the Amazon DynamoDB table that is being loaded. For more information about required permissions, see IAM permissions for COPY, UNLOAD, and CREATE LIBRARY. The preferred method for authentication is to specify the IAM_ROLE parameter and provide the Amazon Resource Name (ARN) for an IAM role with the necessary permissions. For more information, see Role-based access control.

To authenticate using the IAM_ROLE parameter, *<aws-account-id>* and *<role-name>* as shown in the following syntax.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-name>'
```

The following example shows authentication using an IAM role.

```
COPY favoritemovies
FROM 'dynamodb://ProductCatalog'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

For more information about other authorization options, see Authorization parameters

If you want to validate your data without actually loading the table, use the NOLOAD option with the COPY command.

The following example loads the FAVORITEMOVIES table with data from the DynamoDB table my-favorite-movies-table. The read activity can consume up to 50% of the provisioned throughput.

```
COPY favoritemovies FROM 'dynamodb://my-favorite-movies-table'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
READRATIO 50;
```

To maximize throughput, the COPY command loads data from an Amazon DynamoDB table in parallel across the compute nodes in the cluster.

Provisioned throughput with automatic compression

By default, the COPY command applies automatic compression whenever you specify an empty target table with no compression encoding. The automatic compression analysis initially samples a large number of rows from the Amazon DynamoDB table. The sample size is based on the value of the COMPROWS parameter. The default is 100,000 rows per slice.

After sampling, the sample rows are discarded and the entire table is loaded. As a result, many rows are read twice. For more information about how automatic compression works, see Loading tables with automatic compression.

Important

When the COPY command reads data from the Amazon DynamoDB table, including the rows used for sampling, the resulting data transfer is part of that table's provisioned throughput.

Loading multibyte data from Amazon DynamoDB

If your data includes non-ASCII multibyte characters (such as Chinese or Cyrillic characters), you must load the data to VARCHAR columns. The VARCHAR data type supports four-byte UTF-8 characters, but the CHAR data type only accepts single-byte ASCII characters. You cannot load five-byte or longer characters into Amazon Redshift tables. For more information about CHAR and VARCHAR, see Data types.

Verifying that the data loaded correctly

After the load operation is complete, query the STL_LOAD_COMMITS system table to verify that the expected files were loaded. Run the COPY command and load verification within the same transaction so that if there is problem with the load you can roll back the entire transaction.

The following query returns entries for loading the tables in the TICKIT database:

```
SELECT query, trim(filename) AS filename, curtime, status
FROM stl_load_commits
WHERE filename like '%tickit%' order by query;


 query |         filename          |          curtime           | status
-------+---------------------------+----------------------------+--------
 22475 | tickit/allusers_pipe.txt  | 2013-02-08 20:58:23.274186 |      1
 22478 | tickit/venue_pipe.txt     | 2013-02-08 20:58:25.070604 |      1
 22480 | tickit/category_pipe.txt  | 2013-02-08 20:58:27.333472 |      1
```

```
 22482 | tickit/date2008_pipe.txt  | 2013-02-08 20:58:28.608305 |       1
 22485 | tickit/allevents_pipe.txt | 2013-02-08 20:58:29.99489  |       1
 22487 | tickit/listings_pipe.txt  | 2013-02-08 20:58:37.632939 |       1
 22489 | tickit/sales_tab.txt      | 2013-02-08 20:58:37.632939 |       1
(6 rows)
```

Validating input data

To validate the data in the Amazon S3 input files or Amazon DynamoDB table before you actually load the data, use the NOLOAD option with the COPY command. Use NOLOAD with the same COPY commands and options you would use to load the data. NOLOAD checks the integrity of all of the data without loading it into the database. The NOLOAD option displays any errors that occur if you attempt to load the data.

For example, if you specified the incorrect Amazon S3 path for the input file, Amazon Redshift would display the following error.

```
ERROR:  No such file or directory
DETAIL:
-----------------------------------------------
Amazon Redshift error:  The specified key does not exist
code:      2
context:   S3 key being read :
location:  step_scan.cpp:1883
process:   xenmaster [pid=22199]
-----------------------------------------------
```

To troubleshoot error messages, see the Load error reference.

For an example using the NOLOAD option, see COPY command with the NOLOAD option.

Loading tables with automatic compression

You can apply compression encodings to columns in tables manually, based on your own evaluation of the data. Or you can use the COPY command with COMPUPDATE set to ON to analyze and apply compression automatically based on sample data.

You can use automatic compression when you create and load a brand new table. The COPY command performs a compression analysis. You can also perform a compression analysis without loading data or changing the compression on a table by running the ANALYZE COMPRESSION command on an already populated table. For example, you can run ANALYZE COMPRESSION when you want to analyze compression on a table for future use, while preserving the existing data definition language (DDL) statements.

Automatic compression balances overall performance when choosing compression encodings. Range-restricted scans might perform poorly if sort key columns are compressed much more highly than other columns in the same query. As a result, automatic compression skips the data analyzing phase on the sort key columns and keeps the user-defined encoding types.

Automatic compression chooses RAW encoding if you haven't explicitly defined a type of encoding. ANALYZE COMPRESSION behaves the same. For optimal query performance, consider using RAW for sort keys.

How automatic compression works

When the COMPUPDATE parameter is ON, the COPY command applies automatic compression whenever you run the COPY command with an empty target table and all of the table columns either have RAW encoding or no encoding.

To apply automatic compression to an empty table, regardless of its current compression encodings, run the COPY command with the COMPUPDATE option set to ON. To turn off automatic compression, run the COPY command with the COMPUPDATE option set to OFF.

You cannot apply automatic compression to a table that already contains data.

> **Note**
>
> Automatic compression analysis requires enough rows in the load data (at least 100,000 rows per slice) to generate a meaningful sample.

Automatic compression performs these operations in the background as part of the load transaction:

1. An initial sample of rows is loaded from the input file. Sample size is based on the value of the COMPROWS parameter. The default is 100,000.
2. Compression options are chosen for each column.
3. The sample rows are removed from the table.
4. The table is recreated with the chosen compression encodings.
5. The entire input file is loaded and compressed using the new encodings.

After you run the COPY command, the table is fully loaded, compressed, and ready for use. If you load more data later, appended rows are compressed according to the existing encoding.

If you only want to perform a compression analysis, run ANALYZE COMPRESSION, which is more efficient than running a full COPY. Then you can evaluate the results to decide whether to use automatic compression or recreate the table manually.

Automatic compression is supported only for the COPY command. Alternatively, you can manually apply compression encoding when you create the table. For information about manual compression encoding, see Column compression to reduce the size of stored data.

Automatic compression example

In this example, assume that the TICKIT database contains a copy of the LISTING table called BIGLIST, and you want to apply automatic compression to this table when it is loaded with approximately 3 million rows.

To load and automatically compress the table

1. Make sure that the table is empty. You can apply automatic compression only to an empty table:

```
TRUNCATE biglist;
```

2. Load the table with a single COPY command. Although the table is empty, some earlier encoding might have been specified. To facilitate that Amazon Redshift performs a compression analysis, set the COMPUPDATE parameter to ON.

```
COPY biglist FROM 's3://amzn-s3-demo-bucket/biglist.txt'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
DELIMITER '|' COMPUPDATE ON;
```

   Because no COMPROWS option is specified, the default and recommended sample size of 100,000 rows per slice is used.

3. Look at the new schema for the BIGLIST table in order to review the automatically chosen encoding schemes.

```
SELECT "column", type, encoding
from pg_table_def where tablename = 'biglist';
```

```
    Column     |            Type             | Encoding
----------------+-----------------------------+----------
 listid         | integer                     | az64
 sellerid       | integer                     | az64
 eventid        | integer                     | az64
 dateid         | smallint                    | none
 numtickets     | smallint                    | az64
 priceperticket | numeric(8,2)                | az64
 totalprice     | numeric(8,2)                | az64
 listtime       | timestamp without time zone | az64
```

4. Verify that the expected number of rows were loaded:

```
select count(*) from biglist;

count
---------
3079952
(1 row)
```

When rows are later appended to this table using COPY or INSERT statements, the same compression encodings are applied.

Optimizing storage for narrow tables

If you have a table with very few columns but a very large number of rows, the three hidden metadata identity columns (INSERT_XID, DELETE_XID, ROW_ID) will consume a disproportionate amount of the disk space for the table.

In order to optimize compression of the hidden columns, load the table in a single COPY transaction where possible. If you load the table with multiple separate COPY commands, the INSERT_XID column will not compress well. You must perform a vacuum operation if you use multiple COPY commands, but it will not improve compression of INSERT_XID.

Loading default column values

You can optionally define a column list in your COPY command. If a column in the table is omitted from the column list, COPY will load the column with either the value supplied by the DEFAULT option that was specified in the CREATE TABLE command, or with NULL if the DEFAULT option was not specified.

If COPY attempts to assign NULL to a column that is defined as NOT NULL, the COPY command fails. For information about assigning the DEFAULT option, see CREATE TABLE.

When loading from data files on Amazon S3, the columns in the column list must be in the same order as the fields in the data file. If a field in the data file does not have a corresponding column in the column list, the COPY command fails.

When loading from Amazon DynamoDB table, order does not matter. Any fields in the Amazon DynamoDB attributes that do not match a column in the Amazon Redshift table are discarded.

The following restrictions apply when using the COPY command to load DEFAULT values into a table:

- If an IDENTITY column is included in the column list, the EXPLICIT_IDS option must also be specified in the COPY command, or the COPY command will fail. Similarly, if an IDENTITY column is omitted from the column list, and the EXPLICIT_IDS option is specified, the COPY operation will fail.
- Because the evaluated DEFAULT expression for a given column is the same for all loaded rows, a DEFAULT expression that uses a RANDOM() function will assign to same value to all the rows.
- DEFAULT expressions that contain CURRENT_DATE or SYSDATE are set to the timestamp of the current transaction.

For an example, see "Load data from a file with default values" in COPY examples.

Troubleshooting data loads

When you load data into Amazon Redshift tables you might encounter errors from Amazon S3, invalid input data, and COPY command errors. The following sections provide information about identifying and resolving data load errors.

Topics

Troubleshooting S3 event integration and COPY JOB errors

Use the following information to troubleshoot common issues with Amazon S3 event integrations and COPY JOB with Amazon Redshift.

Creation of the S3 event integration failed

If the creation of the S3 event integration failed, the status of the integration is `Inactive`. Make sure that the following are correct for your Amazon Redshift data warehouse.

- You added the correct authorized principal and integration source for your target namespace in Amazon Redshift. See Prerequisites to creating an S3 event integration.
- You added the correct resource-based policy to the source Amazon S3 bucket. See Prerequisites to creating an S3 event integration.

Your Amazon S3 data is not appearing in the target database

If data from a COPY JOB doesn't appear, check the following.

- Query SYS_COPY_JOB_DETAIL to view if the Amazon S3 file has been loaded, whether its pending ingestion, or there is an error. For more information, see SYS_COPY_JOB_DETAIL.
- Consult STL_ERROR or SYS_COPY_JOB_INFO if the Amazon S3 file is not there or there is unexpected wait time. Look for credential errors or anything that suggests the integration is inactive. For more information, see STL_ERROR and SYS_COPY_JOB_INFO.

S3ServiceException errors

The most common s3ServiceException errors are caused by an improperly formatted or incorrect credentials string, having your cluster and your bucket in different AWS Regions, and insufficient Amazon S3 permissions.

The section provides troubleshooting information for each type of error.

Invalid credentials string

If your credentials string was improperly formatted, you will receive the following error message:

```
ERROR: Invalid credentials. Must be of the format: credentials
'aws_access_key_id=<access-key-id>;aws_secret_access_key=<secret-access-key>
[;token=<temporary-session-token>]'
```

Verify that the credentials string does not contain any spaces or line breaks, and is enclosed in single quotation marks.

Invalid access key ID

If your access key ID does not exist, you will receive the following error message:

```
[Amazon](500310) Invalid operation: S3ServiceException:The AWS Access Key Id you
 provided does not exist in our records.
```

This is often a copy and paste error. Verify that the access key ID was entered correctly. Also, if you are using temporary session keys, check that the value for `token` is set.

Invalid secret access key

If your secret access key is incorrect, you will receive the following error message:

```
[Amazon](500310) Invalid operation: S3ServiceException:The request signature we
 calculated does not match the signature you provided.
Check your key and signing method.,Status 403,Error SignatureDoesNotMatch
```

This is often a copy and paste error. Verify that the secret access key was entered correctly and that it is the correct key for the access key ID.

Bucket is in a different Region

The Amazon S3 bucket specified in the COPY command must be in the same AWS Region as the cluster. If your Amazon S3 bucket and your cluster are in different Regions, you will receive an error similar to the following:

```
ERROR: S3ServiceException:The bucket you are attempting to access must be addressed
 using the specified endpoint.
```

You can create an Amazon S3 bucket in a specific Region either by selecting the Region when you create the bucket by using the Amazon S3 Management Console, or by specifying an endpoint when you create the bucket using the Amazon S3 API or CLI. For more information, see Uploading files to Amazon S3 to use with COPY.

For more information about Amazon S3 regions, see Accessing a Bucket in the *Amazon Simple Storage Service User Guide*.

Alternatively, you can specify the Region using the REGION option with the COPY command.

Access denied

If the user does not have sufficient permissions, you will receive the following error message:

```
ERROR: S3ServiceException:Access Denied,Status 403,Error AccessDenied
```

One possible cause is the user identified by the credentials does not have LIST and GET access to the Amazon S3 bucket. For other causes, see Troubleshoot Access Denied (403 Forbidden) errors in Amazon S3 in the *Amazon Simple Storage Service User Guide*.

For information about managing user access to buckets, see Identity and access management in Amazon S3 in the *Amazon Simple Storage Service User Guide*.

System tables for troubleshooting data loads

The following Amazon Redshift system tables can be helpful in troubleshooting data load issues:

- Query STL_LOAD_ERRORS to discover the errors that occurred during specific loads.
- Query STL_FILE_SCAN to view load times for specific files or to see if a specific file was even read.
- Query STL_S3CLIENT_ERROR to find details for errors encountered while transferring data from Amazon S3.

To find and diagnose load errors

1. Create a view or define a query that returns details about load errors. The following example joins the STL_LOAD_ERRORS table to the STV_TBL_PERM table to match table IDs with actual table names.

   ```
   create view loadview as
   (select distinct tbl, trim(name) as table_name, query, starttime,
   trim(filename) as input, line_number, colname, err_code,
   trim(err_reason) as reason
   from stl_load_errors sl, stv_tbl_perm sp
   where sl.tbl = sp.id);
   ```

2. Set the MAXERRORS option in your COPY command to a large enough value to enable COPY to return useful information about your data. If the COPY encounters errors, an error message directs you to consult the STL_LOAD_ERRORS table for details.
3. Query the LOADVIEW view to see error details. For example:

```
select * from loadview where table_name='venue';
```

```

  tbl    | table_name | query |         starttime
--------+------------+-------+----------------------------
 100551 | venue      | 20974 | 2013-01-29 19:05:58.365391

|     input      | line_number | colname | err_code |       reason
+----------------+-------------+---------+----------+--------------------
| venue_pipe.txt |           1 |       0 |     1214 | Delimiter not found
```

4. Fix the problem in the input file or the load script, based on the information that the view returns. Some typical load errors to watch for include:

   - Mismatch between data types in table and values in input data fields.
   - Mismatch between number of columns in table and number of fields in input data.
   - Mismatched quotation marks. Amazon Redshift supports both single and double quotation marks; however, these quotation marks must be balanced appropriately.
   - Incorrect format for date/time data in input files.
   - Out-of-range values in input files (for numeric columns).
   - Number of distinct values for a column exceeds the limitation for its compression encoding.

Multibyte character load errors

Columns with a CHAR data type only accept single-byte UTF-8 characters, up to byte value 127, or 7F hex, which is also the ASCII character set. VARCHAR columns accept multibyte UTF-8 characters, to a maximum of four bytes. For more information, see Character types.

If a line in your load data contains a character that is not valid for the column data type, COPY returns an error and logs a row in the STL_LOAD_ERRORS system log table with error number 1220. The ERR_REASON field includes the byte sequence, in hex, for the invalid character.

An alternative to fixing not valid characters in your load data is to replace the not valid characters during the load process. To replace not valid UTF-8 characters, specify the ACCEPTINVCHARS option with the COPY command. If the ACCEPTINVCHARS option is set, the character you specify replaces the code point. If the ACCEPTINVCHARS option isn't set, Amazon Redshift accepts the characters as valid UTF-8. For more information, see ACCEPTINVCHARS.

The following list of code points are valid UTF-8, COPY operations don't return an error if the ACCEPTINVCHARS option is not set. However, these code points are not valid characters. You can use the ACCEPTINVCHARS option to replace a code point with a character that you specify. These code points include the range of values from `0xFDD0` to `0xFDEF` and values up to `0x10FFFF`, ending with FFFE or FFFF:

- `0xFFFE`, `0x1FFFE`, `0x2FFFE`, …, `0xFFFFE`, `0x10FFFE`
- `0xFFFF`, `0x1FFFF`, `0x2FFFF`, …, `0xFFFFF`, `0x10FFFF`

The following example shows the error reason when COPY attempts to load UTF-8 character `e0 a1 c7a4` into a CHAR column.

```
Multibyte character not supported for CHAR
(Hint: Try using  VARCHAR). Invalid char: e0 a1 c7a4
```

If the error is related to a VARCHAR data type, the error reason includes an error code as well as the not valid UTF-8 hex sequence. The following example shows the error reason when COPY attempts to load UTF-8 `a4` into a VARCHAR field.

```
String contains invalid or unsupported UTF-8 codepoints.
Bad UTF-8 hex sequence: a4 (error 3)
```

The following table lists the descriptions and suggested workarounds for VARCHAR load errors. If one of these errors occurs, replace the character with a valid UTF-8 code sequence or remove the character.

Error code	Description
1	The UTF-8 byte sequence exceeds the four-byte maximum supported by VARCHAR.
2	The UTF-8 byte sequence is incomplete. COPY did not find the expected number of continuation bytes for a multibyte character before the end of the string.
3	The UTF-8 single-byte character is out of range. The starting byte must not be 254, 255 or any character between 128 and 191 (inclusive).

Error code	Description
4	The value of the trailing byte in the byte sequence is out of range. The continuation byte must be between 128 and 191 (inclusive).
5	The UTF-8 character is reserved as a surrogate. Surrogate code points (U+D800 through U+DFFF) are not valid.
8	The byte sequence exceeds the maximum UTF-8 code point.
9	The UTF-8 byte sequence does not have a matching code point.

Load error reference

If any errors occur while loading data from a file, query the STL_LOAD_ERRORS table to identify the error and determine the possible explanation. The following table lists all error codes that might occur during data loads:

Load error codes

Error code	Description
1200	Unknown parse error. Contact support.
1201	Field delimiter was not found in the input file.
1202	Input data had more columns than were defined in the DDL.
1203	Input data had fewer columns than were defined in the DDL.
1204	Input data exceeded the acceptable range for the data type.
1205	Date format is not valid. See DATEFORMAT and TIMEFORMAT strings for valid formats.
1206	Timestamp format is not valid. See DATEFORMAT and TIMEFORMAT strings for valid formats.
1207	Data contained a value outside of the expected range of 0-9.

Error code	Description
1208	FLOAT data type format error.
1209	DECIMAL data type format error.
1210	BOOLEAN data type format error.
1211	Input line contained no data.
1212	Load file was not found.
1213	A field specified as NOT NULL contained no data.
1214	Delimiter not found.
1215	CHAR field error.
1216	Input line is not valid.
1217	Identity column value is not valid.
1218	When using NULL AS '\0', a field containing a null terminator (NUL, or UTF-8 0000) contained more than one byte.
1219	UTF-8 hexadecimal contains an invalid digit.
1220	String contains invalid or unsupported UTF-8 code points.
1221	Encoding of the file is not the same as that specified in the COPY command.
1222	Integer value overflow error.
1223	Data type not valid.
1224	Input data not well formed JSON format for super data type.
8001	COPY with MANIFEST parameter requires full path of an Amazon S3 object.
9005	Invalid end key specified.

Create an S3 event integration to automatically copy files from Amazon S3 buckets

> **Note**
>
> The preview release for auto-copy has ended. Consequently, preview clusters will be automatically removed 30 days after the end of the preview period. If you plan to continue using auto-copy, we recommend re-creating your existing auto-copy jobs on another Amazon Redshift cluster. Upgrading a preview cluster to the latest Amazon Redshift version is not supported.

You can use an auto-copy job to load data into your Amazon Redshift tables from files that are stored in Amazon S3. Amazon Redshift detects when new Amazon S3 files are added to the path specified in your COPY command. A COPY command is then automatically run without you having to create an external data ingestion pipeline. Amazon Redshift keeps track of which files have been loaded. Amazon Redshift determines the number of files batched together per COPY command. You can see the resulting COPY commands in system views.

The first step to create an automatic COPY JOB is to create an S3 event integration. When a new file appears in the Amazon S3 source bucket, Amazon Redshift then manages loading the files into your database using the COPY command.

Prerequisites to creating an S3 event integration

To set up your s3 event integration, confirm the following prerequisites are completed.

- Your Amazon S3 bucket must have a bucket policy that allows several Amazon S3 permissions. For example, the following example policy allows permissions for the resource bucket `amzn-s3-demo-bucket` that is hosted in *`us-east-1`*. Both the Amazon S3 bucket and the integration are in the same AWS Region.
- Your target Amazon Redshift provisioned cluster or Redshift Serverless namespace must have permission to the bucket. Confirm an IAM role that is associated with your cluster or serverless namespace has a IAM policy that allows the proper permissions. The policy must allow both `s3:GetObject` for a bucket resource such as *`amzn-s3-demo-bucket`* and `s3:ListBucket` for a bucket resource and its contents such as *`amzn-s3-demo-bucket`*`/*`.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AutoCopyReadId",
            "Effect": "Allow",
            "Action": [
                "s3:GetObject",
                "s3:ListBucket"
            ],
            "Resource": [
                "arn:aws:s3:::amzn-s3-demo-bucket",
                "arn:aws:s3:::amzn-s3-demo-bucket/*"
            ]
        }
    ]
}
```

Add your policy to an IAM role that has a trust relationship for the role is as follows.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": [
                    "redshift.amazonaws.com"
                ]
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

If your target data warehouse is a provisioned cluster, you can associate an IAM role to your provisioned cluster using the Amazon Redshift console, **Cluster permissions** tab in your cluster details. For information about how to associate a role to your provisioned cluster, see [Associating IAM roles with clusters]() in the *Amazon Redshift Management Guide*.

If your target data warehouse is Redshift Serverless, you can associate an IAM role to your serverless namespace using the Redshift Serverless console, **Security and encryption** tab in your namespace details. For information about how to associate a role to your serverless namespace, see [Granting permissions to Amazon Redshift Serverless]() in the *Amazon Redshift Management Guide*.

- Your Amazon Redshift data warehouse must also have a resource policy that allows the Amazon S3 bucket. If you use the Amazon Redshift console, when you create the s3 event integration, Amazon Redshift provides the option **Fix it for me** to add this policy to your Amazon Redshift data warehouse. To update a resource policy yourself, you can use the [put-resource-policy]() AWS CLI command. For example, to attach a resource policy to your Amazon Redshift provisioned cluster for an S3 event integration with an Amazon S3 bucket, run a AWS CLI command similar to the following. The following example shows a policy for a provisioned cluster namespace in the *`us-east-1`* AWS Region for user account *`123456789012`*. The bucket is named *`amzn-s3-demo-bucket`*.

```
aws redshift put-resource-policy \
--policy file://rs-rp.json \
--resource-arn "arn:aws:redshift: us-east-1:123456789012:namespace/cc4ffe56-
ad2c-4fd1-a5a2-f29124a56433"
```

Where `rs-rp.json` contains:

To attach a resource policy to your Redshift Serverless namespace for an S3 event integration with an Amazon S3 bucket, run a AWS CLI command similar to the following. The following example shows a policy for a serverless namespace in the *`us-east-1`* AWS Region for user account *`123456789012`*. The bucket is named *`amzn-s3-demo-bucket`*.

```
aws redshift put-resource-policy \
--policy file://rs-rp.json \
--resource-arn "arn:aws:redshift-serverless:us-east-1:123456789012:namespace/
namespace-1"
```

Where `rs-rp.json` contains:

Create an S3 event integration

To set up your copy job, you first define an S3 event integration.

Amazon Redshift console

To create an Amazon S3 event integration on the Amazon Redshift console

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. In the left navigation pane, choose **S3 event integrations**.
3. Choose **Create Amazon S3 event integration** to open the wizard to create and S3 event integration to use with auto-copy. Your source Amazon S3 bucket and target Amazon Redshift data warehouse must be in the same AWS Region. Specify the following information when going through the steps to create an integration:

   - **Integration name –** Is a unique identifier across all integrations owned by your AWS account in the current AWS Region.
   - **Description –** Is text that describes the Amazon S3 event integration for later reference.
   - **Source S3 bucket –** Is the Amazon S3 bucket in the current AWS account and AWS Region which is the source of ingesting data into Amazon Redshift.
   - **Amazon Redshift data warehouse –** Is the target Amazon Redshift provisioned cluster or Redshift Serverless workgroup that receives the data from the integration.

     If your target Amazon Redshift is in the same account, you are able to select the target. If the target is in a different account, you specify the **Amazon Redshift data warehouse ARN**. The target must have a resource policy with authorized principals and integration source. If you do not have the correct resource policies on the target and your target is in the same account, you can select the **Fix it for me** option to automatically apply the resource policies during the create integration process. If your target is in a different AWS account, you need to apply the resource policy on the Amazon Redshift warehouse manually.
4. Enter up to 50 tag **Keys** and with an optional **Value** – To provide additional metadata about the integration.
5. A review page is shown where you can choose **Create S3 event integration**.

AWS CLI

To create an Amazon S3 event integration using the AWS CLI, use the `create-integration` command with the following options:

- `integration-name` – Specify a name for the integration.
- `source-arn` – Specify the ARN of the Amazon S3 source bucket.
- `target-arn` – Specify the namespace ARN of the Amazon Redshift provisioned cluster or Redshift Serverless workgroup target.

The following example creates an integration by providing the integration name, source ARN, and target ARN. The integration is not encrypted.

```
aws redshift create-integration \
--integration-name s3-integration \
--source-arn arn:aws:s3:us-east-1::s3-example-bucket \
--target-arn arn:aws:redshift:us-east-1:123456789012:namespace:a1b2c3d4-5678-90ab-
cdef-EXAMPLE22222
          {
    "IntegrationArn": "arn:aws:redshift:us-
east-1:123456789012:integration:a1b2c3d4-5678-90ab-cdef-EXAMPLE11111",
    "IntegrationName": "s3-integration",
    "SourceArn": "arn:aws:s3:::s3-example-bucket",
    "SourceType": "s3-event-notifications",
    "TargetArn": "arn:aws:redshift:us-
east-1:123456789012:namespace:a1b2c3d4-5678-90ab-cdef-EXAMPLE22222",
    "Status": "creating",
    "Errors": [],
    "CreateTime": "2024-10-09T19:08:52.758000+00:00",
    "Tags": []
}
```

You can also use the following AWS CLI commands to manage your S3 event integration.

- `delete-integration` – Specify an integration ARN to delete an S3 event integration.
- `modify-integration` – Specify an integration ARN to change the name or description (or both) of an S3 event integration.
- `describe-integrations` – Specify an integration ARN to view properties of an S3 event integration.

See the *Amazon Redshift CLI Guide* for more information about these commands.

Amazon Redshift then creates an S3 event integration with its associated source and target, status, and information about the status of an associated auto-copy job. You can view information about an S3 event integration on the Amazon Redshift console by choosing **S3 event integrations**, and choosing the integration to show its details. Integrations are separated by those created **In my account** and **From other accounts**. The **In my account** list shows integrations where the source and target are in the same account. The **From other accounts** list shows integrations where the source is owned by another account.

If you delete an S3 event integration, the corresponding COPY JOB status changes from 1 (active) to `0` (inactive/pending). However, the corresponding COPY JOB is not automatically dropped. If later you try to create a COPY JOB with the same name, there might be a conflict.

Create and monitor a COPY JOB

After the integration is created, on the **S3 event integration details** page for the integration you created, choose **Create autocopy job** to go to Amazon Redshift query editor v2 where you can create the auto-copy job for the integration. Amazon Redshift matches the bucket in the FROM clause in the COPY JOB CREATE statement to the bucket used in S3 event integration. For information about how to use Amazon Redshift query editor v2, see Querying a database using the Amazon Redshift query editor v2 in the *Amazon Redshift Management Guide*. For example, run the following COPY command in query editor v2 to create an automatic COPY JOB that matches the Amazon S3 bucket `s3://amzn-s3-demo-bucket/staging-folder` to an Amazon S3 event integration.

```
COPY public.target_table
FROM 's3://amzn-s3-demo-bucket/staging-folder'
IAM_ROLE 'arn:aws:iam::123456789012:role/MyLoadRoleName'
JOB CREATE my_copy_job_name
AUTO ON;
```

You define a COPY JOB one time. The same parameters are used for future runs.

To define and manage a COPY JOB, you must have permission. For information about granting and revoking permission on a COPY JOB, see GRANT and REVOKE. For more information about granting and revoking scoped permissions for a COPY JOB, see Granting scoped permissions and Revoking scoped permissions.

You manage the load operations using options to CREATE, LIST, SHOW, DROP, ALTER, and RUN jobs. For more information, see COPY JOB.

You can query system views to see the COPY JOB status and progress. Views are provided as follows:

- SYS_COPY_JOB – contains a row for each currently defined COPY JOB.
- SYS_COPY_JOB_DETAIL – contains details on pending, error, and ingested files for each COPY JOB.
- SYS_COPY_JOB_INFO – contains messages logged about a COPY JOB.
- SYS_LOAD_HISTORY – contains details of COPY commands.
- SYS_LOAD_ERROR_DETAIL – contains details of COPY command errors.
- SVV_COPY_JOB_INTEGRATIONS – contains details of S3 event integrations.
- STL_LOAD_ERRORS – contains errors from COPY commands.
- STL_LOAD_COMMITS – contains information used to troubleshoot a COPY command data load.

For information about troubleshooting S3 event integration errors, see Troubleshooting S3 event integration and COPY JOB errors.

To get the list of files loaded by a COPY JOB, run the following SQL, but first replace *<job_id>*:

```
SELECT job_id, job_name, data_source, copy_query, filename, status, curtime
FROM sys_copy_job copyjob
JOIN stl_load_commits loadcommit
ON copyjob.job_id = loadcommit.copy_job_id
WHERE job_id = <job_id>;
```

Considerations when creating S3 event integration for auto-copy

Consider the following when using auto-copy.

- You can create a maximum of 200 COPY JOBS for each cluster or workgroup in an AWS account.
- You can create a maximum of 50 S3 event integrations for each Amazon Redshift target.
- You can't create an S3 event integration with a source Amazon S3 bucket which has a period (.) in the bucket name.

- You can only create one S3 event integration between the same source and target. That is, there can only be one S3 event integration between an Amazon S3 bucket and a Amazon Redshift data warehouse at a time.
- You can't have any existing event notifications for event type `S3_OBJECT_CREATED` that are defined on the source Amazon S3 bucket. However, after an S3 event integration is created, you can update the Amazon S3 bucket event notification with a prefix/suffix with a narrower scope. In this way, you can also configure `S3_OBJECT_CREATED` for another prefix/suffix to other targets and avoid a conflict with S3 event integration. If you experience problems that auto-copy was not running as expected, prepare the AWS CloudTrail log of the `s3:PutBucketNotificationConfiguration` action on your S3 bucket for the time frame in question when you contact AWS Support.

Loading tables with DML commands

Amazon Redshift supports standard data manipulation language (DML) commands (INSERT, UPDATE, and DELETE) that you can use to modify rows in tables. You can also use the TRUNCATE command to do fast bulk deletes.

> **Note**
>
> We strongly encourage you to use the COPY command to load large amounts of data. Using individual INSERT statements to populate a table might be prohibitively slow. Alternatively, if your data already exists in other Amazon Redshift database tables, use INSERT INTO ... SELECT FROM or CREATE TABLE AS to improve performance. For information, see INSERT or CREATE TABLE AS.

If you insert, update, or delete a significant number of rows in a table, relative to the number of rows before the changes, run the ANALYZE and VACUUM commands against the table when you are done. If a number of small changes accumulate over time in your application, you might want to schedule the ANALYZE and VACUUM commands to run at regular intervals. For more information, see Analyzing tables and Vacuuming tables.

Topics

Updating and inserting new data

You can efficiently add new data to an existing table by using the MERGE command. Perform a merge operation by creating a staging table and then using one of the methods described in this section to update the target table from the staging table. For more information on the MERGE command, see MERGE.

The Merge examples use a sample dataset for Amazon Redshift, called the TICKIT data set. As a prerequisite, you can set up the TICKIT tables and data by following the instructions available in Getting started with common database tasks. More detailed information about the sample data set is found at Sample database.

Merge method 1: Replacing existing rows

If you are overwriting all of the columns in the target table, the fastest method to perform a merge is to replace the existing rows. This scans the target table only once, by using an inner join to delete rows that will be updated. After the rows are deleted, they are replaced with new rows by a single insert operation from the staging table.

Use this method if all of the following are true:

- Your target table and your staging table contain the same columns.
- You intend to replace all of the data in the target table columns with all of the staging table columns.
- You will use all of the rows in the staging table in the merge.

If any of these criteria do not apply, use Merge method 2: Specifying a column list without using MERGE, described in the following section.

If you will not use all of the rows in the staging table, filter the DELETE and INSERT statements by using a WHERE clause to leave out rows that are not changing. However, if most of the rows in the staging table will not participate in the merge, we recommend performing an UPDATE and an INSERT in separate steps, as described later in this section.

Merge method 2: Specifying a column list without using MERGE

Use this method to update specific columns in the target table instead of overwriting entire rows. This method takes longer than the previous method because it requires an extra update step and doesn't use the MERGE command. Use this method if any of the following are true:

- Not all of the columns in the target table are to be updated.
- Most rows in the staging table will not be used in the updates.

Topics

Creating a temporary staging table

The *staging table* is a temporary table that holds all of the data that will be used to make changes to the *target table*, including both updates and inserts.

A merge operation requires a join between the staging table and the target table. To collocate the joining rows, set the staging table's distribution key to the same column as the target table's distribution key. For example, if the target table uses a foreign key column as its distribution key, use the same column for the staging table's distribution key. If you create the staging table by using a CREATE TABLE LIKE statement, the staging table will inherit the distribution key from the parent table. If you use a CREATE TABLE AS statement, the new table does not inherit the distribution key. For more information, see Data distribution for query optimization

If the distribution key is not the same as the primary key and the distribution key is not updated as part of the merge operation, add a redundant join predicate on the distribution key columns to enable a collocated join. For example:

```
where target.primarykey = stage.primarykey
and target.distkey = stage.distkey
```

To verify that the query will use a collocated join, run the query with EXPLAIN and check for DS_DIST_NONE on all of the joins. For more information, see Evaluating the query plan

Performing a merge operation by replacing existing rows

When you run the merge operation detailed in the procedure, put all of the steps except for creating and dropping the temporary staging table in a single transaction. The transaction rolls back if any step fails. Using a single transaction also reduces the number of commits, which saves time and resources.

To perform a merge operation by replacing existing rows

1. Create a staging table, and then populate it with data to be merged, as shown in the following pseudocode.

```
CREATE temp table stage (like target);

INSERT INTO stage
SELECT * FROM source
WHERE source.filter = 'filter_expression';
```

2. Use MERGE to perform an inner join with the staging table to update the rows from the target table that match the staging table, then insert all the remaining rows into the target table that don't match the staging table.

   We recommend you run the update and insert operations in a single MERGE command.

```
MERGE INTO target
USING stage [optional alias] on (target.primary_key = stage.primary_key)
WHEN MATCHED THEN
UPDATE SET col_name1 = stage.col_name1 , col_name2= stage.col_name2, col_name3 =
 {expr}
WHEN NOT MATCHED THEN
INSERT (col_name1 , col_name2, col_name3) VALUES (stage.col_name1, stage.col_name2,
 {expr});
```

3. Drop the staging table.

```
DROP TABLE stage;
```

Performing a merge operation by specifying a column list without using the MERGE command

When you run the merge operation detailed in the procedure, put all of the steps in a single transaction. The transaction rolls back if any step fails. Using a single transaction also reduces the number of commits, which saves time and resources.

To perform a merge operation by specifying a column list

1. Put the entire operation in a single transaction block.

```
BEGIN transaction;
…
END transaction;
```

2. Create a staging table, and then populate it with data to be merged, as shown in the following pseudocode.

```
create temp table stage (like target);
insert into stage
select * from source
where source.filter = 'filter_expression';
```

3. Update the target table by using an inner join with the staging table.

   - In the UPDATE clause, explicitly list the columns to be updated.
   - Perform an inner join with the staging table.
   - If the distribution key is different from the primary key and the distribution key is not being updated, add a redundant join on the distribution key. To verify that the query will use a collocated join, run the query with EXPLAIN and check for DS_DIST_NONE on all of the joins. For more information, see Evaluating the query plan
   - If your target table is sorted by timestamp, add a predicate to take advantage of range-restricted scans on the target table. For more information, see Amazon Redshift best practices for designing queries.
   - If you will not use all of the rows in the merge, add a clause to filter the rows that you want to change. For example, add an inequality filter on one or more columns to exclude rows that have not changed.
   - Put the update, delete, and insert operations in a single transaction block so that if there is a problem, everything will be rolled back.

   For example:

```
begin transaction;

update target
```

```
set col1 = stage.col1,
col2 = stage.col2,
col3 = 'expression'
from stage
where target.primarykey = stage.primarykey
and target.distkey = stage.distkey
and target.col3 > 'last_update_time'
and (target.col1 != stage.col1
or target.col2 != stage.col2
or target.col3 = 'filter_expression');
```

4. Delete unneeded rows from the staging table by using an inner join with the target table. Some rows in the target table already match the corresponding rows in the staging table, and others were updated in the previous step. In either case, they are not needed for the insert.

```
delete from stage
using target
where stage.primarykey = target.primarykey;
```

5. Insert the remaining rows from the staging table. Use the same column list in the VALUES clause that you used in the UPDATE statement in step two.

```
insert into target
(select col1, col2, 'expression'
from stage);

end transaction;
```

6. Drop the staging table.

```
drop table stage;
```

Merge examples

The following examples perform a merge to update the SALES table. The first example uses the simpler method of deleting from the target table and then inserting all of the rows from the staging table. The second example requires updating on select columns in the target table, so it includes an extra update step.

The Merge examples use a sample dataset for Amazon Redshift, called the TICKIT data set. As a prerequisite, you can set up the TICKIT tables and data by following the instructions available in the guide Getting started with common database tasks. More detailed information about the sample data set is found at Sample database.

Sample merge data source

The examples in this section need a sample data source that includes both updates and inserts. For the examples, we will create a sample table named SALES_UPDATE that uses data from the SALES table. We'll populate the new table with random data that represents new sales activity for December. We will use the SALES_UPDATE sample table to create the staging table in the examples that follow.

```
-- Create a sample table as a copy of the SALES table.

create table tickit.sales_update as
select * from tickit.sales;

-- Change every fifth row to have updates.

update tickit.sales_update
set qtysold = qtysold*2,
pricepaid = pricepaid*0.8,
commission = commission*1.1
where saletime > '2008-11-30'
and mod(sellerid, 5) = 0;

-- Add some new rows to have inserts.
-- This example creates a duplicate of every fourth row.

insert into tickit.sales_update
select (salesid + 172456) as salesid, listid, sellerid, buyerid, eventid, dateid,
 qtysold, pricepaid, commission, getdate() as saletime
from tickit.sales_update
where saletime > '2008-11-30'
and mod(sellerid, 4) = 0;
```

Example of a merge that replaces existing rows based on matching keys

The following script uses the SALES_UPDATE table to perform a merge operation on the SALES table with new data for December sales activity. This example replaces rows in the SALES table that have updates. For this example, we will update the qtysold and pricepaid columns, but leave commission and saletime unchanged.

```
MERGE into tickit.sales
USING tickit.sales_update sales_update
on ( sales.salesid = sales_update.salesid
and sales.listid = sales_update.listid
and sales_update.saletime > '2008-11-30'
and (sales.qtysold != sales_update.qtysold
or sales.pricepaid != sales_update.pricepaid))
WHEN MATCHED THEN
update SET qtysold = sales_update.qtysold,
pricepaid = sales_update.pricepaid
WHEN NOT MATCHED THEN
INSERT (salesid, listid, sellerid, buyerid, eventid, dateid, qtysold , pricepaid,
 commission, saletime)
values (sales_update.salesid, sales_update.listid, sales_update.sellerid,
 sales_update.buyerid, sales_update.eventid,
sales_update.dateid, sales_update.qtysold , sales_update.pricepaid,
 sales_update.commission, sales_update.saletime);

-- Drop the staging table.
drop table tickit.sales_update;

-- Test to see that commission and salestime were not impacted.
SELECT sales.salesid, sales.commission, sales.salestime, sales_update.commission,
 sales_update.salestime
FROM tickit.sales
INNER JOIN tickit.sales_update sales_update
ON
sales.salesid = sales_update.salesid
AND sales.listid = sales_update.listid
AND sales_update.saletime > '2008-11-30'
AND (sales.commission != sales_update.commission
OR sales.salestime != sales_update.salestime);
```

Example of a merge that specifies a column list without using MERGE

The following example performs a merge operation to update SALES with new data for December sales activity. We need sample data that includes both updates and inserts, along with rows that have not changed. For this example, we want to update the QTYSOLD and PRICEPAID columns but leave COMMISSION and SALETIME unchanged. The following script uses the SALES_UPDATE table to perform a merge operation on the SALES table.

```
-- Create a staging table and populate it with rows from SALES_UPDATE for Dec
```

```
create temp table stagesales as select * from sales_update
where saletime > '2008-11-30';

-- Start a new transaction
begin transaction;

-- Update the target table using an inner join with the staging table
-- The join includes a redundant predicate to collocate on the distribution key -- A
 filter on saletime enables a range-restricted scan on SALES

update sales
set qtysold = stagesales.qtysold,
pricepaid = stagesales.pricepaid
from stagesales
where sales.salesid = stagesales.salesid
and sales.listid = stagesales.listid
and stagesales.saletime > '2008-11-30'
and (sales.qtysold != stagesales.qtysold
or sales.pricepaid != stagesales.pricepaid);

-- Delete matching rows from the staging table
-- using an inner join with the target table

delete from stagesales
using sales
where sales.salesid = stagesales.salesid
and sales.listid = stagesales.listid;

-- Insert the remaining rows from the staging table into the target table
insert into sales
select * from stagesales;

-- End transaction and commit
end transaction;

-- Drop the staging table
drop table stagesales;
```

Performing a deep copy

A deep copy recreates and repopulates a table by using a bulk insert, which automatically sorts the table. If a table has a large unsorted Region, a deep copy is much faster than a vacuum. We recommend that you only make concurrent updates during a deep copy operation if you can track them. After the process has completed, move the delta updates into the new table. A VACUUM operation supports concurrent updates automatically.

You can choose one of the following methods to create a copy of the original table:

- Use the original table DDL.

  If the CREATE TABLE DDL is available, this is the fastest and preferred method. If you create a new table, you can specify all table and column attributes, including primary key and foreign keys. You can find the original DDL by using the SHOW TABLE function.
- Use CREATE TABLE LIKE.

  If the original DDL is not available, you can use CREATE TABLE LIKE to recreate the original table. The new table inherits the encoding, distribution key, sort key, and not-null attributes of the parent table. The new table doesn't inherit the primary key and foreign key attributes of the parent table, but you can add them using ALTER TABLE.
- Create a temporary table and truncate the original table.

  If you must retain the primary key and foreign key attributes of the parent table. If the parent table has dependencies, you can use CREATE TABLE ... AS (CTAS) to create a temporary table. Then truncate the original table and populate it from the temporary table.

  Using a temporary table improves performance significantly compared to using a permanent table, but there is a risk of losing data. A temporary table is automatically dropped at the end of the session in which it is created. TRUNCATE commits immediately, even if it is inside a transaction block. If the TRUNCATE succeeds but the session shuts down before the following INSERT completes, the data is lost. If data loss is unacceptable, use a permanent table.

After you create a copy of a table, you might have to grant access to the new table. You can use GRANT to define access privileges. To view and grant all of a table's access privileges, you must be one of the following:

- A superuser.
- The owner of the table you want to copy.
- A user with the ACCESS SYSTEM TABLE privilege to see the table's privileges, and with the grant privilege for all relevant permissions.

Additionally, you might have to grant usage permission for the schema your deep copy is in. Granting usage permission is necessary if your deep copy's schema is different from the original table's schema, and also isn't the `public` schema. To view and grant usage privileges you must be one of the following:

- A superuser.
- A user who can grant the USAGE permission for the deep copy's schema.

To perform a deep copy using the original table DDL

1. (Optional) Recreate the table DDL by running a script called `v_generate_tbl_ddl`.
2. Create a copy of the table using the original CREATE TABLE DDL.
3. Use an INSERT INTO … SELECT statement to populate the copy with data from the original table.
4. Check for permissions granted on the old table. You can see these permissions in the SVV_RELATION_PRIVILEGES system view.
5. If necessary, grant the permissions of the old table to the new table.
6. Grant usage permission to every group and user that has privileges in the original table. This step isn't necessary if your deep copy table is in the `public` schema, or is in the same schema as the original table.
7. Drop the original table.
8. Use an ALTER TABLE statement to rename the copy to the original table name.

The following example performs a deep copy on the SAMPLE table using a duplicate of SAMPLE named sample_copy.

```
--Create a copy of the original table in the sample_namespace namespace using the
 original CREATE TABLE DDL.
create table sample_namespace.sample_copy ( … );

--Populate the copy with data from the original table in the public namespace.
insert into sample_namespace.sample_copy (select * from public.sample);

--Check SVV_RELATION_PRIVILEGES for the original table's privileges.
select * from svv_relation_privileges where namespace_name = 'public' and relation_name
 = 'sample' order by identity_type, identity_id, privilege_type;
```

```
--Grant the original table's privileges to the copy table.
grant DELETE on table sample_namespace.sample_copy to group group1;
grant INSERT, UPDATE on table sample_namespace.sample_copy to group group2;
grant SELECT on table sample_namespace.sample_copy to user1;
grant INSERT, SELECT, UPDATE on table sample_namespace.sample_copy to user2;

--Grant usage permission to every group and user that has privileges in the original
 table.
grant USAGE on schema sample_namespace to group group1, group group2, user1, user2;

--Drop the original table.
drop table public.sample;

--Rename the copy table to match the original table's name.
alter table sample_namespace.sample_copy rename to sample;
```

To perform a deep copy using CREATE TABLE LIKE

1. Create a new table using CREATE TABLE LIKE.
2. Use an INSERT INTO … SELECT statement to copy the rows from the current table to the new table.
3. Check for permissions granted on the old table. You can see these permissions in the SVV_RELATION_PRIVILEGES system view.
4. If necessary, grant the permissions of the old table to the new table.
5. Grant usage permission to every group and user that has privileges in the original table. This step isn't necessary if your deep copy table is in the `public` schema, or is in the same schema as the original table.
6. Drop the current table.
7. Use an ALTER TABLE statement to rename the new table to the original table name.

The following example performs a deep copy on the SAMPLE table using CREATE TABLE LIKE.

```
--Create a copy of the original table in the sample_namespace namespace using CREATE
 TABLE LIKE.
create table sameple_namespace.sample_copy (like public.sample);

--Populate the copy with data from the original table.
insert into sample_namespace.sample_copy (select * from public.sample);
```

```
--Check SVV_RELATION_PRIVILEGES for the original table's privileges.
select * from svv_relation_privileges where namespace_name = 'public' and relation_name
 = 'sample' order by identity_type, identity_id, privilege_type;

--Grant the original table's privileges to the copy table.
grant DELETE on table sample_namespace.sample_copy to group group1;
grant INSERT, UPDATE on table sample_namespace.sample_copy to group group2;
grant SELECT on table sample_namespace.sample_copy to user1;
grant INSERT, SELECT, UPDATE on table sample_namespace.sample_copy to user2;

--Grant usage permission to every group and user that has privileges in the original
 table.
grant USAGE on schema sample_namespace to group group1, group group2, user1, user2;

--Drop the original table.
drop table public.sample;

--Rename the copy table to match the original table's name.
alter table sample_namespace.sample_copy rename to sample;
```

To perform a deep copy by creating a temporary table and truncating the original table

1. Use CREATE TABLE AS to create a temporary table with the rows from the original table.
2. Truncate the current table.
3. Use an INSERT INTO … SELECT statement to copy the rows from the temporary table to the original table.
4. Drop the temporary table.

The following example performs a deep copy on the SALES table by creating a temporary table and truncating the original table. Since the original table remains, you don't need to grant permissions to the copy table.

```
--Create a temp table copy using CREATE TABLE AS.
create temp table salestemp as select * from sales;

--Truncate the original table.
truncate sales;

--Copy the rows from the temporary table to the original table.
insert into sales (select * from salestemp);
```

```
--Drop the temporary table.
drop table salestemp;
```

Analyzing tables

The ANALYZE operation updates the statistical metadata that the query planner uses to choose optimal plans.

In most cases, you don't need to explicitly run the ANALYZE command. Amazon Redshift monitors changes to your workload and automatically updates statistics in the background. In addition, the COPY command performs an analysis automatically when it loads data into an empty table.

To explicitly analyze a table or the entire database, run the ANALYZE command.

Automatic analyze

Amazon Redshift continuously monitors your database and automatically performs analyze operations in the background. To minimize impact to your system performance, automatic analyze runs during periods when workloads are light.

Automatic analyze is enabled by default. To turn off automatic analyze, set the `auto_analyze` parameter to **`false`** by modifying your cluster's parameter group.

To reduce processing time and improve overall system performance, Amazon Redshift skips automatic analyze for any table where the extent of modifications is small.

An analyze operation skips tables that have up-to-date statistics. If you run ANALYZE as part of your extract, transform, and load (ETL) workflow, automatic analyze skips tables that have current statistics. Similarly, an explicit ANALYZE skips tables when automatic analyze has updated the table's statistics.

Analysis of new table data

By default, the COPY command performs an ANALYZE after it loads data into an empty table. You can force an ANALYZE regardless of whether a table is empty by setting STATUPDATE ON. If you specify STATUPDATE OFF, an ANALYZE is not performed. Only the table owner or a superuser can run the ANALYZE command or run the COPY command with STATUPDATE set to ON.

Amazon Redshift also analyzes new tables that you create with the following commands:

- CREATE TABLE AS (CTAS)
- CREATE TEMP TABLE AS
- SELECT INTO

Amazon Redshift returns a warning message when you run a query against a new table that was not analyzed after its data was initially loaded. No warning occurs when you query a table after a subsequent update or load. The same warning message is returned when you run the EXPLAIN command on a query that references tables that have not been analyzed.

Whenever adding data to a nonempty table significantly changes the size of the table, you can explicitly update statistics. You do so either by running an ANALYZE command or by using the STATUPDATE ON option with the COPY command. To view details about the number of rows that have been inserted or deleted since the last ANALYZE, query the PG_STATISTIC_INDICATOR system catalog table.

You can specify the scope of the ANALYZE command to one of the following:

- The entire current database
- A single table
- One or more specific columns in a single table
- Columns that are likely to be used as predicates in queries

The ANALYZE command gets a sample of rows from the table, does some calculations, and saves resulting column statistics. By default, Amazon Redshift runs a sample pass for the DISTKEY column and another sample pass for all of the other columns in the table. If you want to generate statistics for a subset of columns, you can specify a comma-separated column list. You can run ANALYZE with the PREDICATE COLUMNS clause to skip columns that aren't used as predicates.

ANALYZE operations are resource intensive, so run them only on tables and columns that actually require statistics updates. You don't need to analyze all columns in all tables regularly or on the same schedule. If the data changes substantially, analyze the columns that are frequently used in the following:

- Sorting and grouping operations
- Joins

- Query predicates

To reduce processing time and improve overall system performance, Amazon Redshift skips ANALYZE for any table that has a low percentage of changed rows, as determined by the analyze_threshold_percent parameter. By default, the analyze threshold is set to 10 percent. You can change the analyze threshold for the current session by running a SET command.

Columns that are less likely to require frequent analysis are those that represent facts and measures and any related attributes that are never actually queried, such as large VARCHAR columns. For example, consider the LISTING table in the TICKIT database.

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'listing';


column          |        type        | encoding | distkey | sortkey
---------------+--------------------+----------+---------+---------
listid          | integer            | none     | t       | 1
sellerid        | integer            | none     | f       | 0
eventid         | integer            | mostly16 | f       | 0
dateid          | smallint           | none     | f       | 0
numtickets      | smallint           | mostly8  | f       | 0
priceperticket  | numeric(8,2)       | bytedict | f       | 0
totalprice      | numeric(8,2)       | mostly32 | f       | 0
listtime        | timestamp with...  | none     | f       | 0
```

If this table is loaded every day with a large number of new records, the LISTID column, which is frequently used in queries as a join key, must be analyzed regularly. If TOTALPRICE and LISTTIME are the frequently used constraints in queries, you can analyze those columns and the distribution key on every weekday.

```
analyze listing(listid, totalprice, listtime);
```

Suppose that the sellers and events in the application are much more static, and the date IDs refer to a fixed set of days covering only two or three years. In this case,the unique values for these columns don't change significantly. However, the number of instances of each unique value will increase steadily.

In addition, consider the case where the NUMTICKETS and PRICEPERTICKET measures are queried infrequently compared to the TOTALPRICE column. In this case, you can run the ANALYZE command on the whole table once every weekend to update statistics for the five columns that are not analyzed daily:

Predicate columns

As a convenient alternative to specifying a column list, you can choose to analyze only the columns that are likely to be used as predicates. When you run a query, any columns that are used in a join, filter condition, or group by clause are marked as predicate columns in the system catalog. When you run ANALYZE with the PREDICATE COLUMNS clause, the analyze operation includes only columns that meet the following criteria:

- The column is marked as a predicate column.
- The column is a distribution key.
- The column is part of a sort key.

If none of a table's columns are marked as predicates, ANALYZE includes all of the columns, even when PREDICATE COLUMNS is specified. If no columns are marked as predicate columns, it might be because the table has not yet been queried.

You might choose to use PREDICATE COLUMNS when your workload's query pattern is relatively stable. When the query pattern is variable, with different columns frequently being used as predicates, using PREDICATE COLUMNS might temporarily result in stale statistics. Stale statistics can lead to suboptimal query runtime plans and long runtimes. However, the next time you run ANALYZE using PREDICATE COLUMNS, the new predicate columns are included.

To view details for predicate columns, use the following SQL to create a view named PREDICATE_COLUMNS.

```
CREATE VIEW predicate_columns AS
WITH predicate_column_info as (
SELECT ns.nspname AS schema_name, c.relname AS table_name, a.attnum as col_num,
 a.attname as col_name,
        CASE
            WHEN 10002 = s.stakind1 THEN array_to_string(stavalues1, '||')
            WHEN 10002 = s.stakind2 THEN array_to_string(stavalues2, '||')
            WHEN 10002 = s.stakind3 THEN array_to_string(stavalues3, '||')
            WHEN 10002 = s.stakind4 THEN array_to_string(stavalues4, '||')
            ELSE NULL::varchar
        END AS pred_ts
```

```
   FROM pg_statistic s
   JOIN pg_class c ON c.oid = s.starelid
   JOIN pg_namespace ns ON c.relnamespace = ns.oid
   JOIN pg_attribute a ON c.oid = a.attrelid AND a.attnum = s.staattnum)
SELECT schema_name, table_name, col_num, col_name,
       pred_ts NOT LIKE '2000-01-01%' AS is_predicate,
       CASE WHEN pred_ts NOT LIKE '2000-01-01%' THEN (split_part(pred_ts,
 '||',1))::timestamp ELSE NULL::timestamp END as first_predicate_use,
       CASE WHEN pred_ts NOT LIKE '%||2000-01-01%' THEN (split_part(pred_ts,
 '||',2))::timestamp ELSE NULL::timestamp END as last_analyze
FROM predicate_column_info;
```

Suppose that you run the following query against the LISTING table. Note that LISTID, LISTTIME, and EVENTID are used in the join, filter, and group by clauses.

```
select s.buyerid,l.eventid, sum(l.totalprice)
from listing l
join sales s on l.listid = s.listid
where l.listtime > '2008-12-01'
group by l.eventid, s.buyerid;
```

When you query the PREDICATE_COLUMNS view, as shown in the following example, you see that LISTID, EVENTID, and LISTTIME are marked as predicate columns.

```
select * from predicate_columns
where table_name = 'listing';
```

```
schema_name | table_name | col_num | col_name       | is_predicate |
 first_predicate_use | last_analyze
------------+------------+---------+----------------+--------------
+---------------------+--------------------
public      | listing    |       1 | listid         | true         | 2017-05-05
 19:27:59 | 2017-05-03 18:27:41
public      | listing    |       2 | sellerid       | false        |
  | 2017-05-03 18:27:41
public      | listing    |       3 | eventid        | true         | 2017-05-16
 20:54:32 | 2017-05-03 18:27:41
public      | listing    |       4 | dateid         | false        |
  | 2017-05-03 18:27:41
public      | listing    |       5 | numtickets     | false        |
  | 2017-05-03 18:27:41
```

```
public      | listing    |       6 | priceperticket | false        |
  | 2017-05-03 18:27:41
public      | listing    |       7 | totalprice     | false        |
  | 2017-05-03 18:27:41
public      | listing    |       8 | listtime       | true         | 2017-05-16
 20:54:32 | 2017-05-03 18:27:41
```

Keeping statistics current improves query performance by enabling the query planner to choose optimal plans. Amazon Redshift refreshes statistics automatically in the background, and you can also explicitly run the ANALYZE command. If you choose to explicitly run ANALYZE, do the following:

- Run the ANALYZE command before running queries.
- Run the ANALYZE command on the database routinely at the end of every regular load or update cycle.
- Run the ANALYZE command on any new tables that you create and any existing tables or columns that undergo significant change.
- Consider running ANALYZE operations on different schedules for different types of tables and columns, depending on their use in queries and their propensity to change.
- To save time and cluster resources, use the PREDICATE COLUMNS clause when you run ANALYZE.

You don't have to explicitly run the ANALYZE command after restoring a snapshot to a provisioned cluster or serverless namespace, nor after resuming a paused provisioned cluster. Amazon Redshift preserves system table information in these cases, making manual ANALYZE commands unnecessary. Amazon Redshift will continue to run automatic analyze operations as needed.

An analyze operation skips tables that have up-to-date statistics. If you run ANALYZE as part of your extract, transform, and load (ETL) workflow, automatic analyze skips tables that have current statistics. Similarly, an explicit ANALYZE skips tables when automatic analyze has updated the table's statistics.

ANALYZE command history

It's useful to know when the last ANALYZE command was run on a table or database. When an ANALYZE command is run, Amazon Redshift runs multiple queries that look like this:

```
padb_fetch_sample: select * from table_name
```

Query STL_ANALYZE to view the history of analyze operations. If Amazon Redshift analyzes a table using automatic analyze, the `is_background` column is set to `t` (true). Otherwise, it is set to `f` (false). The following example joins STV_TBL_PERM to show the table name and runtime details.

```
select distinct a.xid, trim(t.name) as name, a.status, a.rows, a.modified_rows,
 a.starttime, a.endtime
from stl_analyze a
join stv_tbl_perm t  on t.id=a.table_id
where name = 'users'
order by starttime;


xid    | name  | status          | rows  | modified_rows | starttime           |
 endtime
-------+-------+-----------------+-------+---------------+---------------------
+--------------------
  1582 | users | Full            | 49990 |         49990 | 2016-09-22 22:02:23 |
 2016-09-22 22:02:28
244287 | users | Full            | 24992 |         74988 | 2016-10-04 22:50:58 |
 2016-10-04 22:51:01
244712 | users | Full            | 49984 |         24992 | 2016-10-04 22:56:07 |
 2016-10-04 22:56:07
245071 | users | Skipped         | 49984 |             0 | 2016-10-04 22:58:17 |
 2016-10-04 22:58:17
245439 | users | Skipped         | 49984 |          1982 | 2016-10-04 23:00:13 |
 2016-10-04 23:00:13
(5 rows)
```

Alternatively, you can run a more complex query that returns all the statements that ran in every completed transaction that included an ANALYZE command:

```
select xid, to_char(starttime, 'HH24:MM:SS.MS') as starttime,
datediff(sec,starttime,endtime ) as secs, substring(text, 1, 40)
from svl_statementtext
where sequence = 0
and xid in (select xid from svl_statementtext s where s.text like 'padb_fetch_sample
%' )
order by xid desc, starttime;

xid  |  starttime   | secs |                  substring
```

```
-----+--------------+------+----------------------------------------
1338 | 12:04:28.511 |    4 | Analyze date
1338 | 12:04:28.511 |    1 | padb_fetch_sample: select count(*) from
1338 | 12:04:29.443 |    2 | padb_fetch_sample: select * from date
1338 | 12:04:31.456 |    1 | padb_fetch_sample: select * from date
1337 | 12:04:24.388 |    1 | padb_fetch_sample: select count(*) from
1337 | 12:04:24.388 |    4 | Analyze sales
1337 | 12:04:25.322 |    2 | padb_fetch_sample: select * from sales
1337 | 12:04:27.363 |    1 | padb_fetch_sample: select * from sales
...
```

Vacuuming tables

Amazon Redshift can automatically sort and perform a VACUUM DELETE operation on tables in the background. To clean up tables after a load or a series of incremental updates, you can also run the VACUUM command, either against the entire database or against individual tables.

> **Note**
>
> Only users with the necessary table permissions can effectively vacuum a table. If VACUUM is run without the necessary table permissions, the operation completes successfully but has no effect. For a list of valid table permissions to effectively run VACUUM, see VACUUM. For this reason, we recommend vacuuming individual tables as needed. We also recommend this approach because vacuuming the entire database is potentially an expensive operation.

Automatic table sort

Amazon Redshift automatically sorts data in the background to maintain table data in the order of its sort key. Amazon Redshift keeps track of your scan queries to determine which sections of the table will benefit from sorting.

Depending on the load on the system, Amazon Redshift automatically initiates the sort. This automatic sort lessens the need to run the VACUUM command to keep data in sort key order. If you need data fully sorted in sort key order, for example after a large data load, then you can still manually run the VACUUM command. To determine whether your table will benefit by running VACUUM SORT, monitor the `vacuum_sort_benefit` column in SVV_TABLE_INFO.

Amazon Redshift tracks scan queries that use the sort key on each table. Amazon Redshift estimates the maximum percentage of improvement in scanning and filtering of data for each table (if the table was fully sorted). This estimate is visible in the `vacuum_sort_benefit` column in SVV_TABLE_INFO. You can use this column, along with the `unsorted` column, to determine when queries can benefit from manually running VACUUM SORT on a table. The `unsorted` column reflects the physical sort order of a table. The `vacuum_sort_benefit` column specifies the impact of sorting a table by manually running VACUUM SORT.

For example, consider the following query:

```
select "table", unsorted,vacuum_sort_benefit from svv_table_info order by 1;
```

```
 table | unsorted | vacuum_sort_benefit
-------+----------+---------------------
 sales |    85.71 |                5.00
 event |    45.24 |               67.00
```

For the table “sales”, even though the table is ~86% physically unsorted, the query performance impact from the table being 86% unsorted is only 5%. This might be either because only a small portion of the table is accessed by queries, or very few queries accessed the table. For the table “event”, the table is ~45% physically unsorted. But the query performance impact of 67% indicates that either a larger portion of the table was accessed by queries, or the number of queries accessing the table was large. The table "event" can potentially benefit from running VACUUM SORT.

Automatic vacuum delete

When you perform a delete, the rows are marked for deletion, but not removed. Amazon Redshift automatically runs a VACUUM DELETE operation in the background based on the number of deleted rows in database tables. Amazon Redshift schedules the VACUUM DELETE to run during periods of reduced load and pauses the operation during periods of high load.

Topics

- VACUUM frequency
- Sort stage and merge stage
- Vacuum threshold

- Vacuum types
- Minimizing vacuum times

VACUUM frequency

You should vacuum as often as necessary to maintain consistent query performance. Consider these factors when determining how often to run your VACUUM command:

- Run VACUUM during time periods when you expect minimal activity on the cluster, such as evenings or during designated database administration windows.
- Run VACUUM commands outside of maintenance windows. For more information, see Schedule around maintenance windows.
- A large unsorted region results in longer vacuum times. If you delay vacuuming, the vacuum will take longer because more data has to be reorganized.
- VACUUM is an I/O intensive operation, so the longer it takes for your vacuum to complete, the more impact it will have on concurrent queries and other database operations running on your cluster.
- VACUUM takes longer for tables that use interleaved sorting. To evaluate whether interleaved tables must be re-sorted, query the SVV_INTERLEAVED_COLUMNS view.

Sort stage and merge stage

Amazon Redshift performs a vacuum operation in two stages: first, it sorts the rows in the unsorted region, then, if necessary, it merges the newly sorted rows at the end of the table with the existing rows. When vacuuming a large table, the vacuum operation proceeds in a series of steps consisting of incremental sorts followed by merges. If the operation fails or if Amazon Redshift goes offline during the vacuum, the partially vacuumed table or database will be in a consistent state, but you must manually restart the vacuum operation. Incremental sorts are lost, but merged rows that were committed before the failure do not need to be vacuumed again. If the unsorted region is large, the lost time might be significant. For more information about the sort and merge stages, see Reduce the volume of merged rows.

Users can access tables while they are being vacuumed. You can perform queries and write operations while a table is being vacuumed, but when DML and a vacuum run concurrently, both might take longer. If you run UPDATE and DELETE statements during a vacuum, system performance might be reduced. Incremental merges temporarily block concurrent UPDATE and

DELETE operations, and UPDATE and DELETE operations in turn temporarily block incremental merge steps on the affected tables. DDL operations, such as ALTER TABLE, are blocked until the vacuum operation finishes with the table.

> **Note**
>
> Various modifiers to VACUUM control the way that it works. You can use them to tailor the vacuum operation for the current need. For example, using VACUUM RECLUSTER shortens the vacuum operation by not performing a full merge operation. For more information, see VACUUM.

Vacuum threshold

By default, VACUUM skips the sort phase for any table where more than 95 percent of the table's rows are already sorted. Skipping the sort phase can significantly improve VACUUM performance. To change the default sort threshold for a single table, include the table name and the TO *threshold* PERCENT parameter when you run the VACUUM command.

Vacuum types

For information about different vacuum types, see VACUUM.

Minimizing vacuum times

Amazon Redshift automatically sorts data and runs VACUUM DELETE in the background. This lessens the need to run the VACUUM command. Vacuuming is potentially a time consuming process. Depending on the nature of your data, we recommend the following practices to minimize vacuum times.

Topics

Decide whether to reindex

You can often significantly improve query performance by using an interleaved sort style, but over time performance might degrade if the distribution of the values in the sort key columns changes.

When you initially load an empty interleaved table using COPY or CREATE TABLE AS, Amazon Redshift automatically builds the interleaved index. If you initially load an interleaved table using INSERT, you need to run VACUUM REINDEX afterwards to initialize the interleaved index.

Over time, as you add rows with new sort key values, performance might degrade if the distribution of the values in the sort key columns changes. If your new rows fall primarily within the range of existing sort key values, you don't need to reindex. Run VACUUM SORT ONLY or VACUUM FULL to restore the sort order.

The query engine is able to use sort order to efficiently select which data blocks need to be scanned to process a query. For an interleaved sort, Amazon Redshift analyzes the sort key column values to determine the optimal sort order. If the distribution of key values changes, or skews, as rows are added, the sort strategy will no longer be optimal, and the performance benefit of sorting will degrade. To reanalyze the sort key distribution you can run a VACUUM REINDEX. The reindex operation is time consuming, so to decide whether a table will benefit from a reindex, query the SVV_INTERLEAVED_COLUMNS view.

For example, the following query shows details for tables that use interleaved sort keys.

```
select tbl as tbl_id, stv_tbl_perm.name as table_name,
col, interleaved_skew, last_reindex
from svv_interleaved_columns, stv_tbl_perm
where svv_interleaved_columns.tbl = stv_tbl_perm.id
and interleaved_skew is not null;


 tbl_id | table_name | col | interleaved_skew | last_reindex
--------+------------+-----+------------------+--------------------
 100048 | customer   |   0 |             3.65 | 2015-04-22 22:05:45
 100068 | lineorder  |   1 |             2.65 | 2015-04-22 22:05:45
 100072 | part       |   0 |             1.65 | 2015-04-22 22:05:45
 100077 | supplier   |   1 |             1.00 | 2015-04-22 22:05:45
(4 rows)
```

The value for `interleaved_skew` is a ratio that indicates the amount of skew. A value of 1 means that there is no skew. If the skew is greater than 1.4, a VACUUM REINDEX will usually improve performance unless the skew is inherent in the underlying set.

You can use the date value in `last_reindex` to determine how long it has been since the last reindex.

Reduce the size of the unsorted region

The unsorted region grows when you load large amounts of new data into tables that already contain data or when you do not vacuum tables as part of your routine maintenance operations. To avoid long-running vacuum operations, use the following practices:

- Run vacuum operations on a regular schedule.

  If you load your tables in small increments (such as daily updates that represent a small percentage of the total number of rows in the table), running VACUUM regularly will help ensure that individual vacuum operations go quickly.
- Run the largest load first.

  If you need to load a new table with multiple COPY operations, run the largest load first. When you run an initial load into a new or truncated table, all of the data is loaded directly into the sorted region, so no vacuum is required.
- Truncate a table instead of deleting all of the rows.

  Deleting rows from a table does not reclaim the space that the rows occupied until you perform a vacuum operation; however, truncating a table empties the table and reclaims the disk space, so no vacuum is required. Alternatively, drop the table and re-create it.
- Truncate or drop test tables.

  If you are loading a small number of rows into a table for test purposes, don't delete the rows when you are done. Instead, truncate the table and reload those rows as part of the subsequent production load operation.
- Perform a deep copy.

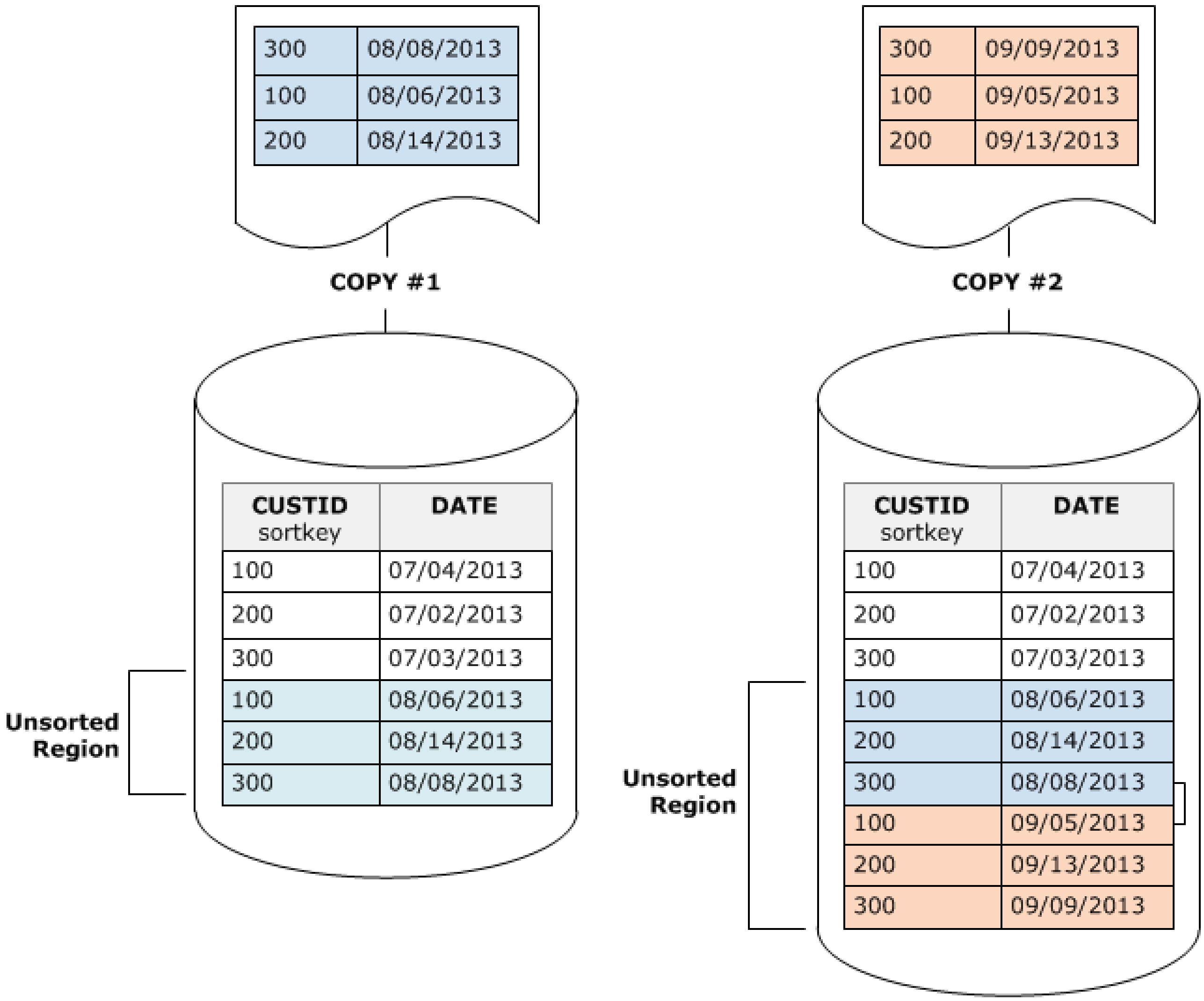
  If a table that uses a compound sort key table has a large unsorted region, a deep copy is much faster than a vacuum. A deep copy recreates and repopulates a table by using a bulk insert, which automatically re-sorts the table. If a table has a large unsorted region, a deep copy is much faster than a vacuum. The trade off is that you cannot make concurrent updates during a deep copy operation, which you can do during a vacuum. For more information, see Amazon Redshift best practices for designing queries.

Reduce the volume of merged rows

If a vacuum operation needs to merge new rows into a table's sorted region, the time required for a vacuum will increase as the table grows larger. You can improve vacuum performance by reducing the number of rows that must be merged.

Before a vacuum, a table consists of a sorted region at the head of the table, followed by an unsorted region, which grows whenever rows are added or updated. When a set of rows is added by a COPY operation, the new set of rows is sorted on the sort key as it is added to the unsorted region at the end of the table. The new rows are ordered within their own set, but not within the unsorted region.

The following diagram illustrates the unsorted region after two successive COPY operations, where the sort key is CUSTID. For simplicity, this example shows a compound sort key, but the same principles apply to interleaved sort keys, except that the impact of the unsorted region is greater for interleaved tables.



A vacuum restores the table's sort order in two stages:

1. Sort the unsorted region into a newly-sorted region.

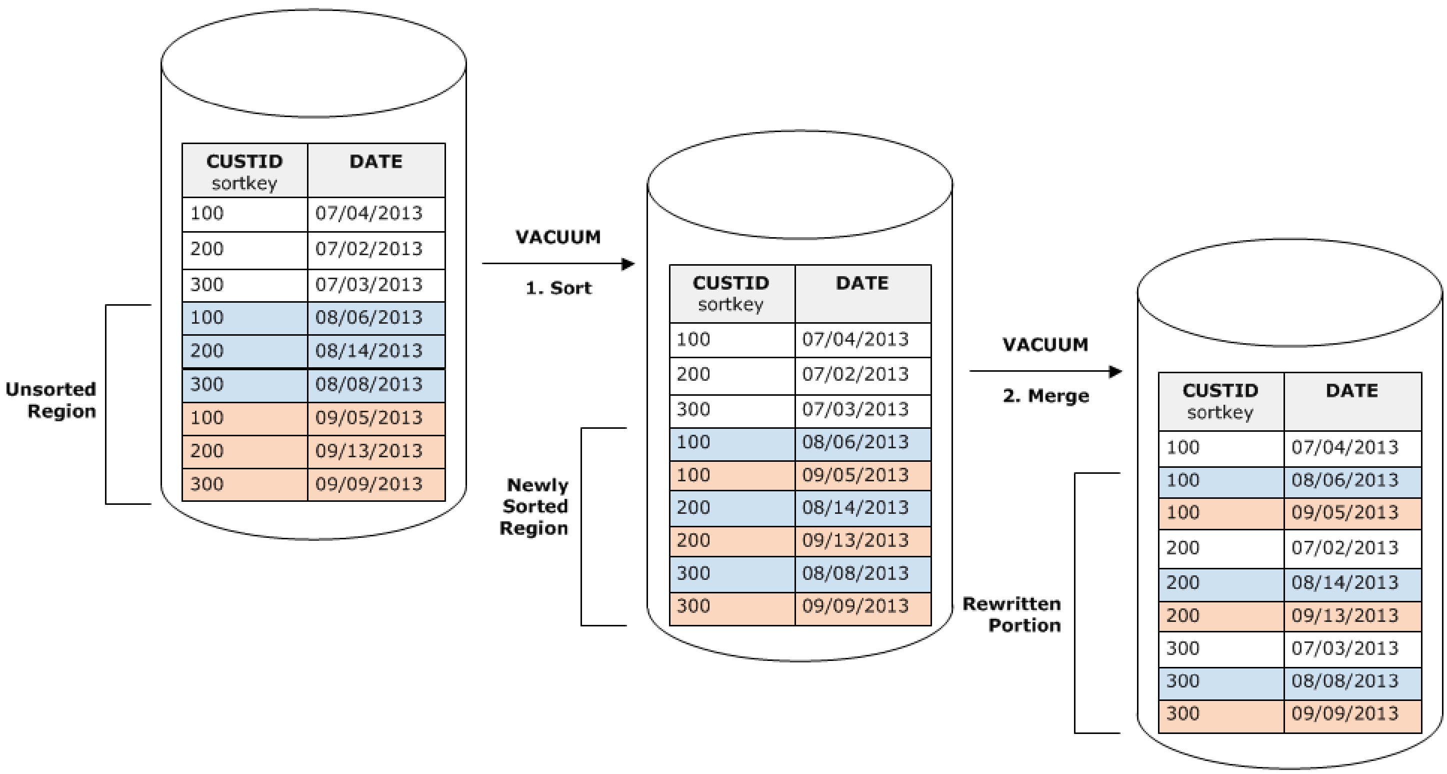
   The first stage is relatively cheap, because only the unsorted region is rewritten. If the range of sort key values of the newly sorted region is higher than the existing range, only the new rows need to be rewritten, and the vacuum is complete. For example, if the sorted region contains ID values 1 to 500 and subsequent copy operations add key values greater than 500, then only the unsorted region needs to be rewritten.

2. Merge the newly-sorted region with the previously-sorted region.

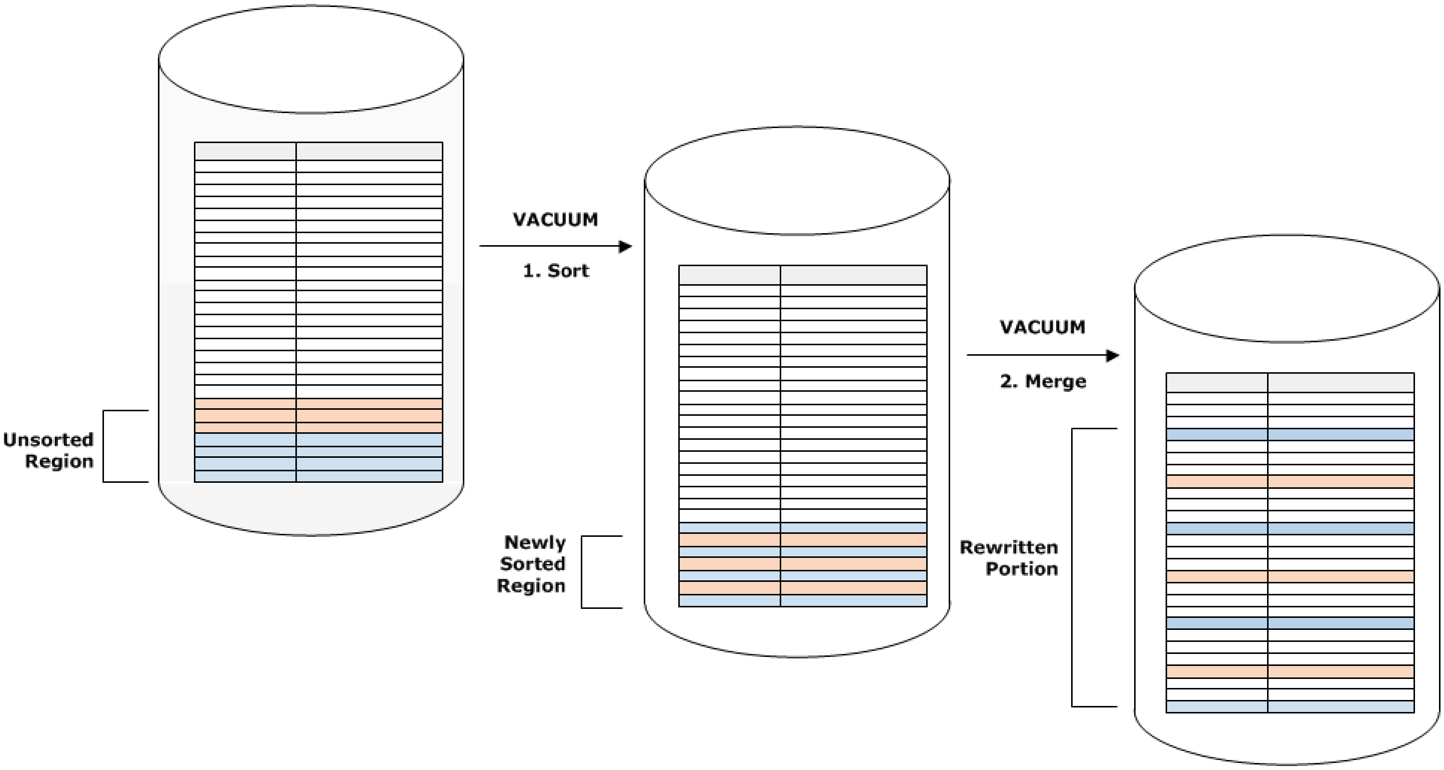
   If the keys in the newly sorted region overlap the keys in the sorted region, then VACUUM needs to merge the rows. Starting at the beginning of the newly-sorted region (at the lowest sort key), the vacuum writes the merged rows from the previously sorted region and the newly sorted region into a new set of blocks.

The extent to which the new sort key range overlaps the existing sort keys determines the extent to which the previously-sorted region will need to be rewritten. If the unsorted keys are scattered throughout the existing sort range, a vacuum might need to rewrite existing portions of the table.

The following diagram shows how a vacuum would sort and merge rows that are added to a table where CUSTID is the sort key. Because each copy operation adds a new set of rows with key values that overlap the existing keys, almost the entire table needs to be rewritten. The diagram shows single sort and merge, but in practice, a large vacuum consists of a series of incremental sort and merge steps.



If the range of sort keys in a set of new rows overlaps the range of existing keys, the cost of the merge stage continues to grow in proportion to the table size as the table grows while the cost of the sort stage remains proportional to the size of the unsorted region. In such a case, the cost of the merge stage overshadows the cost of the sort stage, as the following diagram shows.



To determine what proportion of a table was remerged, query SVV_VACUUM_SUMMARY after the vacuum operation completes. The following query shows the effect of six successive vacuums as CUSTSALES grew larger over time.

```
select * from svv_vacuum_summary
where table_name = 'custsales';


 table_name | xid  | sort_      | merge_     | elapsed_   | row_  | sortedrow_ | block_
  | max_merge_
            |      | partitions | increments | time       | delta | delta      | delta
  | partitions
 -----------+------+------------+------------+------------+-------+------------
+---------+---------------
  custsales | 7072 |          3 |          2 |  143918314 |     0 |   88297472 |   1524
  |      47
  custsales | 7122 |          3 |          3 |  164157882 |     0 |   88297472 |    772
  |      47
  custsales | 7212 |          3 |          4 |  187433171 |     0 |   88297472 |    767
  |      47
  custsales | 7289 |          3 |          4 |  255482945 |     0 |   88297472 |    770
  |      47
```

```
 custsales | 7420 |          3 |          5 |  316583833 |     0 |   88297472 |    769
 |      47
 custsales | 9007 |          3 |          6 |  306685472 |     0 |   88297472 |    772
 |      47
(6 rows)
```

The merge_increments column gives an indication of the amount of data that was merged for each vacuum operation. If the number of merge increments over consecutive vacuums increases in proportion to the growth in table size, it indicates that each vacuum operation is remerging an increasing number of rows in the table because the existing and newly sorted regions overlap.

Load your data in sort key order

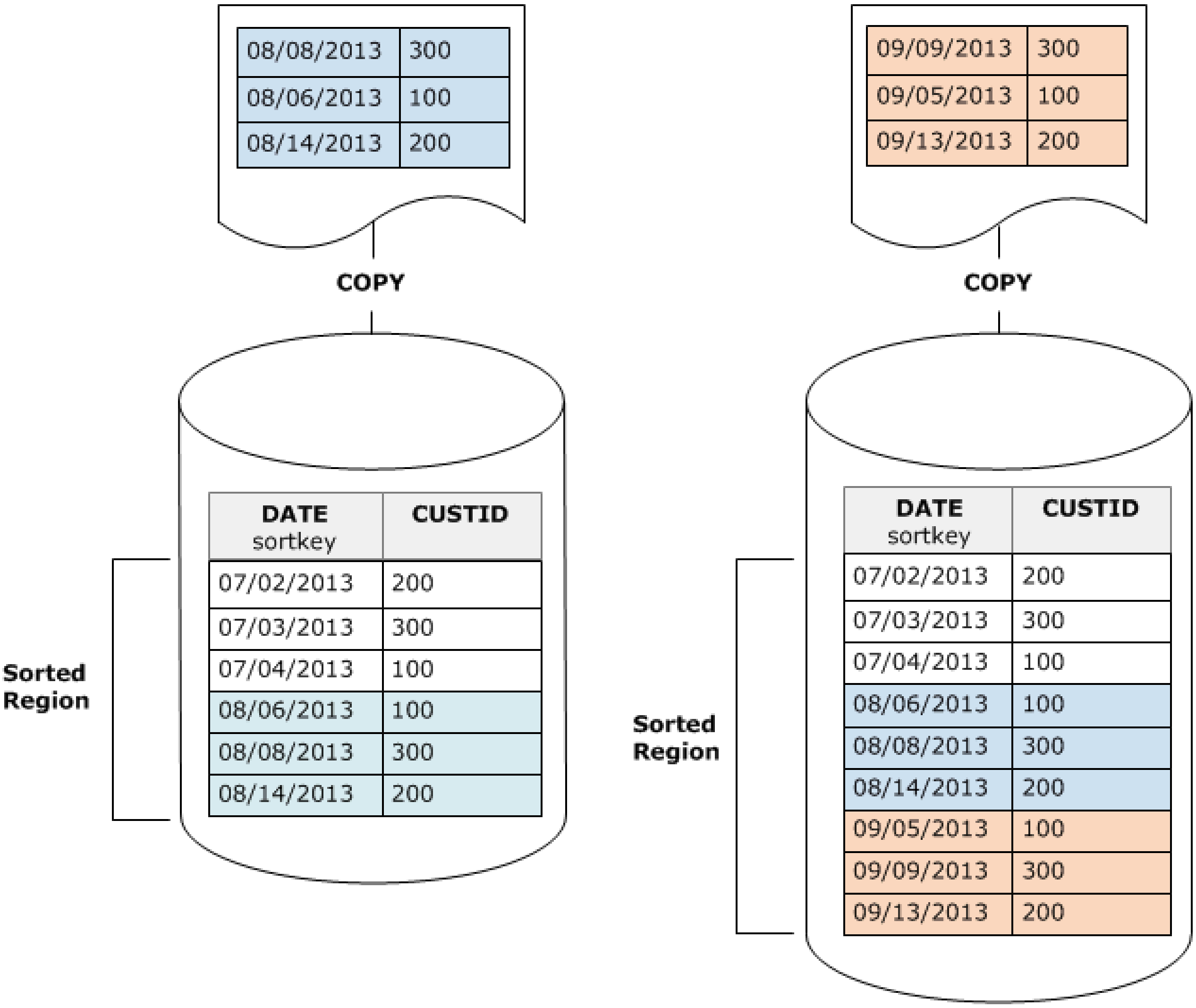
If you load your data in sort key order using a COPY command, you might reduce or even remove the need to vacuum.

COPY automatically adds new rows to the table's sorted region when all of the following are true:

- The table uses a compound sort key with only one sort column.
- The sort column is NOT NULL.
- The table is 100 percent sorted or empty.
- All the new rows are higher in sort order than the existing rows, including rows marked for deletion. In this instance, Amazon Redshift uses the first eight bytes of the sort key to determine sort order.

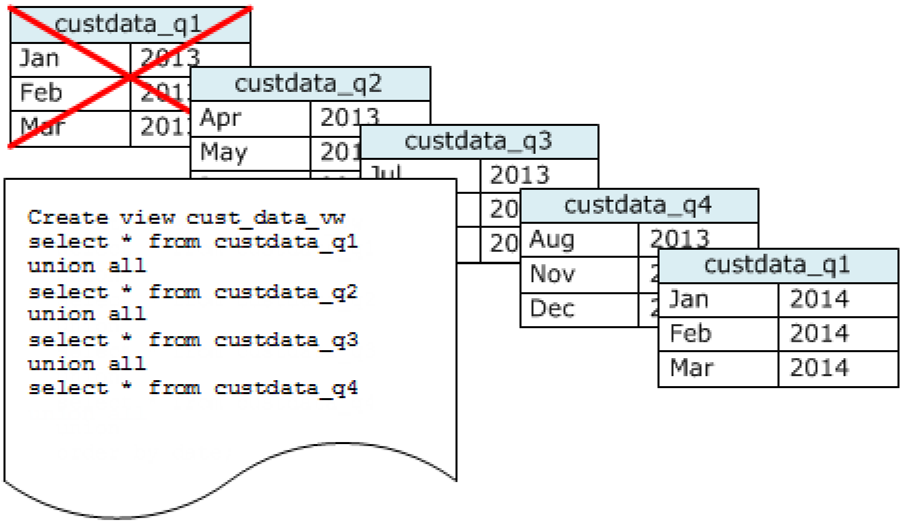
For example, suppose you have a table that records customer events using a customer ID and time. If you sort on customer ID, it’s likely that the sort key range of new rows added by incremental loads will overlap the existing range, as shown in the previous example, leading to an expensive vacuum operation.

If you set your sort key to a timestamp column, your new rows will be appended in sort order at the end of the table, as the following diagram shows, reducing or even removing the need to vacuum.



Use time series tables to reduce stored data

If you maintain data for a rolling time period, use a series of tables, as the following diagram illustrates.



Create a new table each time you add a set of data, then delete the oldest table in the series. You gain a double benefit:

- You avoid the added cost of deleting rows, because a DROP TABLE operation is much more efficient than a mass DELETE.
- If the tables are sorted by timestamp, no vacuum is needed. If each table contains data for one month, a vacuum will at most have to rewrite one month's worth of data, even if the tables are not sorted by timestamp.

You can create a UNION ALL view for use by reporting queries that hides the fact that the data is stored in multiple tables. If a query filters on the sort key, the query planner can efficiently skip all the tables that aren't used. A UNION ALL can be less efficient for other types of queries, so you should evaluate query performance in the context of all queries that use the tables.

Managing concurrent write operations

Amazon Redshift allows tables to be read while they are being incrementally loaded or modified.

In some traditional data warehousing and business intelligence applications, the database is available to users only when the nightly load is complete. In such cases, no updates are allowed during regular work hours, when analytic queries are run and reports are generated; however, an increasing number of applications remain live for long periods of the day or even all day, making the notion of a load window obsolete.

Amazon Redshift supports these types of applications by allowing tables to be read while they are being incrementally loaded or modified. Queries simply see the latest committed version, or *snapshot*, of the data, rather than waiting for the next version to be committed. If you want a particular query to wait for a commit from another write operation, you have to schedule it accordingly.

The following topics describe some of the key concepts and use cases that involve transactions, database snapshots, updates, and concurrent behavior.

Topics

Serializable isolation

Some applications require not only concurrent querying and loading, but also the ability to write to multiple tables or the same table concurrently. In this context, *concurrently* means overlapping, not scheduled to run at precisely the same time. Two transactions are considered to be concurrent if the second one starts before the first commits. Concurrent operations can originate from different sessions that are controlled either by the same user or by different users.

> **Note**
>
> Amazon Redshift supports a default *automatic commit* behavior in which each separately run SQL command commits individually. If you enclose a set of commands in a transaction block (defined by BEGIN and END statements), the block commits as one transaction, so you can roll it back if necessary. Exceptions to this behavior are the TRUNCATE and VACUUM commands, which automatically commit all outstanding changes made in the current transaction.
> Some SQL clients issue BEGIN and COMMIT commands automatically, so the client controls whether a group of statements are run as a transaction or each individual statement is run as its own transaction. Check the documentation for the interface you are using. For example, when using the Amazon Redshift JDBC driver, a JDBC `PreparedStatement` with a query string that contains multiple (semicolon separated) SQL commands runs all the statements as a single transaction. In contrast, if you use SQL Workbench/J and set AUTO COMMIT ON, then if you run multiple statements, each statement runs as its own transaction.

Concurrent write operations are supported in Amazon Redshift in a protective way, using write locks on tables and the principle of *serializable isolation*. Serializable isolation preserves the illusion that a transaction running against a table is the only transaction that is running against that table. For example, two concurrently running transactions, T1 and T2, must produce the same results as at least one of the following:

- T1 and T2 run serially in that order.
- T2 and T1 run serially in that order.

Concurrent transactions are invisible to each other; they cannot detect each other's changes. Each concurrent transaction will create a snapshot of the database at the beginning of the transaction. A database snapshot is created within a transaction on the first occurrence of most SELECT statements, DML commands such as COPY, DELETE, INSERT, UPDATE, and TRUNCATE, and the following DDL commands:

- ALTER TABLE (to add or drop columns)
- CREATE TABLE
- DROP TABLE
- TRUNCATE TABLE

If any serial execution of the concurrent transactions produces the same results as their concurrent execution, those transactions are deemed "serializable" and can be run safely. If no serial execution of those transactions can produce the same results, the transaction that runs a statement that might break the ability to serialize is stopped and rolled back.

System catalog tables (PG) and other Amazon Redshift system tables (STL and STV) are not locked in a transaction. Therefore, changes to database objects that arise from DDL and TRUNCATE operations are visible on commit to any concurrent transactions.

For example, suppose that table A exists in the database when two concurrent transactions, T1 and T2, start. Suppose that T2 returns a list of tables by selecting from the PG_TABLES catalog table. Then T1 drops table A and commits, and then T2 lists the tables again. Table A is now no longer listed. If T2 tries to query the dropped table, Amazon Redshift returns a "relation does not exist" error. The catalog query that returns the list of tables to T2 or checks that table A exists isn't subject to the same isolation rules as operations performed on user tables.

Transactions for updates to these tables run in a read committed isolation mode. PG-prefix catalog tables don't support snapshot isolation.

Serializable isolation for system tables and catalog tables

A database snapshot is also created in a transaction for any SELECT query that references a user-created table or Amazon Redshift system table (STL or STV). SELECT queries that don't reference any table don't create a new transaction database snapshot. INSERT, DELETE, and UPDATE statements that operate solely on system catalog tables (PG) also don't create a new transaction database snapshot.

How to fix serializable isolation errors

ERROR:1023 DETAIL: Serializable isolation violation on a table in Redshift

When Amazon Redshift detects a serializable isolation error, you see an error message such as the following.

```
ERROR:1023 DETAIL: Serializable isolation violation on table in Redshift
```

To address a serializable isolation error, you can try the following methods:

- Retry the canceled transaction.

  Amazon Redshift detected that a concurrent workload is not serializable. It suggests gaps in the application logic, which can usually be worked around by retrying the transaction that encountered the error. If the issue persists, try one of the other methods.
- Move any operations that don't have to be in the same atomic transaction outside of the transaction.

  This method applies when individual operations inside two transactions cross-reference each other in a way that can affect the outcome of the other transaction. For example, the following two sessions each start a transaction.

  ```
  Session1_Redshift=# begin;
  ```

  ```
  Session2_Redshift=# begin;
  ```

The result of a SELECT statement in each transaction might be affected by an INSERT statement in the other. In other words, suppose that you run the following statements serially, in any order. In every case, the result is one of the SELECT statements returning one more row than if the transactions were run concurrently. There is no order in which the operations can run serially that produces the same result as when run concurrently. Thus, the last operation that is run results in a serializable isolation error.

```
Session1_Redshift=# select * from tab1;
Session1_Redshift=# insert into tab2 values (1);
```

```
Session2_Redshift=# insert into tab1 values (1);
Session2_Redshift=# select * from tab2;
```

In many cases, the result of the SELECT statements isn't important. In other words, the atomicity of the operations in the transactions isn't important. In these cases, move the SELECT statements outside of their transactions, as shown in the following examples.

```
Session1_Redshift=# begin;
Session1_Redshift=# insert into tab1 values (1)
Session1_Redshift=# end;
Session1_Redshift=# select * from tab2;
```

```
Session2_Redshift # select * from tab1;
Session2_Redshift=# begin;
Session2_Redshift=# insert into tab2 values (1)
Session2_Redshift=# end;
```

In these examples, there are no cross-references in the transactions. The two INSERT statements don't affect each other. In these examples, there is at least one order in which the transactions can run serially and produce the same result as if run concurrently. This means that the transactions are serializable.

- Force serialization by locking all tables in each session.

  The LOCK command blocks operations that can result in serializable isolation errors. When you use the LOCK command, be sure to do the following:

  - Lock all tables affected by the transaction, including those affected by read-only SELECT statements inside the transaction.

  - Lock tables in the same order, regardless of the order that operations are performed in.
  - Lock all tables at the beginning of the transaction, before performing any operations.
- Use snapshot isolation for concurrent transactions

  Use an ALTER DATABASE command with snapshot isolation. For more information about the SNAPSHOT parameter for ALTER DATABASE, see Parameters.

ERROR:1018 DETAIL: Relation does not exist

When you run concurrent Amazon Redshift operations in different sessions, you see an error message such as the following.

```
ERROR: 1018 DETAIL: Relation does not exist.
```

Transactions in Amazon Redshift follow snapshot isolation. After a transaction begins, Amazon Redshift takes a snapshot of the database. For the entire lifecycle of the transaction, the transaction operates on the state of the database as reflected in the snapshot. If the transaction reads from a table that doesn't exist in the snapshot, it throws the 1018 error message shown previously. Even when another concurrent transaction creates a table after the transaction has taken the snapshot, the transaction can't read from the newly created table.

To address this serialization isolation error, you can try to move the start of the transaction to a point where you know the table exists.

If the table is created by another transaction, this point is at least after that transaction has been committed. Also, ensure that no concurrent transaction has been committed that might have dropped the table.

```
session1 = # BEGIN;
session1 = # DROP TABLE A;
session1 = # COMMIT;
```

```
session2 = # BEGIN;
```

```
session3 = # BEGIN;
session3 = # CREATE TABLE A (id INT);
session3 = # COMMIT;
```

```
session2 = # SELECT * FROM A;
```

The last operation that is run as the read operation by session2 results in a serializable isolation error. This error happens when session2 takes a snapshot and the table has already been dropped by a committed session1. In other words, even though a concurrent session3 has created the table, session2 doesn't see the table because it's not in the snapshot.

To resolve this error, you can reorder the sessions as follows.

```
session1 = # BEGIN;
session1 = # DROP TABLE A;
session1 = # COMMIT;
```

```
session3 = # BEGIN;
session3 = # CREATE TABLE A (id INT);
session3 = # COMMIT;
```

```
session2 = # BEGIN;
session2 = # SELECT * FROM A;
```

Now when session2 takes its snapshot, session3 has already been committed, and the table is in the database. Session2 can read from the table without any error.

Write and read/write operations

You can manage the specific behavior of concurrent write operations by deciding when and how to run different types of commands. The following commands are relevant to this discussion:

- COPY commands, which perform loads (initial or incremental)
- INSERT commands that append one or more rows at a time
- UPDATE commands, which modify existing rows
- DELETE commands, which remove rows

COPY and INSERT operations are pure write operations. DELETE and UPDATE operations are read/write operations (for rows to be deleted or updated, they have to be read first). The results of concurrent write operations depend on the specific commands that are being run concurrently.

UPDATE and DELETE operations behave differently because they rely on an initial table read before they do any writes. Given that concurrent transactions are invisible to each other, both UPDATEs and DELETEs have to read a snapshot of the data from the last commit. When the first UPDATE or DELETE releases its lock, the second UPDATE or DELETE needs to determine whether the data that it is going to work with is potentially stale. It will not be stale, because the second transaction does not obtain its snapshot of data until after the first transaction has released its lock.

Potential deadlock situation for concurrent write transactions involving multiple tables

When transactions involve updates of more than one table, there is always the possibility of concurrently running transactions becoming deadlocked when they both try to write to the same set of tables. A transaction releases all of its table locks at once when it either commits or rolls back; it doesn't relinquish locks one at a time.

For example, suppose that transactions T1 and T2 start at roughly the same time. If T1 starts writing to table A and T2 starts writing to table B, both transactions can proceed without conflict. However, if T1 finishes writing to table A and needs to start writing to table B, it won’t be able to proceed because T2 still holds the lock on B. Similarly, if T2 finishes writing to table B and needs to start writing to table A, it will not be able to proceed either because T1 still holds the lock on A. Because neither transaction can release its locks until all its write operations are committed, neither transaction can proceed. To avoid this kind of deadlock, you need to schedule concurrent write operations carefully. For example, you should always update tables in the same order in transactions and, if specifying locks, lock tables in the same order before you perform any DML operations.

Potential deadlock situation for concurrent write transactions involving a single table

In a snapshot isolation environment, deadlocks can occur when running concurrent write transactions on the same table. The snapshot isolation deadlock happens when concurrent INSERT or COPY statements are sharing a lock and making progress, and another statement needs to perform an operation (UPDATE, DELETE, MERGE, or DDL operation) that requires an exclusive lock on the same table.

Consider the following scenario:

Transaction 1 (T1):

```
INSERT/COPY INTO table_A;
```

Transaction 2 (T2):

```
INSERT/COPY INTO table_A;
          <UPDATE/DELETE/MERGE/DDL statement> table_A
```

A deadlock can occur when multiple transactions with INSERT or COPY operations are running concurrently on the same table with a shared lock, and one of those transactions follows its pure write operation with an operation that requires an exclusive lock, such as an UPDATE, MERGE, DELETE, or DDL statement.

To avoid the deadlock in these situations, you can separate statements requiring an exclusive lock (UPDATE/MERGE/DELETE/DDL statements) to a different transaction so that any INSERT/COPY statements can progress simultaneously, and the statements requiring exclusive locks can execute after them. Alternatively, for transactions with INSERT/COPY statements and MERGE/UPDATE/MERGE statements on same table, you can include retry logic in your applications to work around potential deadlocks.

Concurrent write examples

The following pseudo-code examples demonstrate how transactions either proceed or wait when they are run concurrently.

Concurrent write examples with serializable isolation

Concurrent COPY operations into the same table with serializable isolation

Transaction 1 copies rows into the LISTING table:

```
begin;
copy listing from ...;
end;
```

Transaction 2 starts concurrently in a separate session and attempts to copy more rows into the LISTING table. Transaction 2 must wait until transaction 1 releases the write lock on the LISTING table, then it can proceed.

```
begin;
[waits]
```

```
copy listing from ;
end;
```

The same behavior would occur if one or both transactions contained an INSERT command instead of a COPY command.

Concurrent DELETE operations from the same table with serializable isolation

Transaction 1 deletes rows from a table:

```
begin;
delete from listing where ...;
end;
```

Transaction 2 starts concurrently and attempts to delete rows from the same table. It will succeed because it waits for transaction 1 to complete before attempting to delete rows.

```
begin
[waits]
delete from listing where ;
end;
```

The same behavior would occur if one or both transactions contained an UPDATE command to the same table instead of a DELETE command.

Concurrent transactions with a mixture of read and write operations with serializable isolation

In this example, transaction 1 deletes rows from the USERS table, reloads the table, runs a COUNT(*) query, and then ANALYZE, before committing:

```
begin;
delete one row from USERS table;
copy ;
select count(*) from users;
analyze ;
end;
```

Meanwhile, transaction 2 starts. This transaction attempts to copy additional rows into the USERS table, analyze the table, and then run the same COUNT(*) query as the first transaction:

```
begin;
```

```
[waits]
copy users from ...;
select count(*) from users;
analyze;
end;
```

The second transaction will succeed because it must wait for the first to complete. Its COUNT query will return the count based on the load it has completed.

Concurrent write examples with snapshot isolation

Concurrent COPY operations into the same table with snapshot isolation

Transaction 1 copies rows into the LISTING table:

```
begin;
copy listing from ...;
end;
```

Transaction 2 starts concurrently in a separate session and attempts to copy more rows into the LISTING table. Transaction 2 can progress simultaneously until either transaction needs to write data to the target table `listing`, at which point they will run sequentially.

```
begin;
//When the COPY statement from T1 needs to write data to the table, the COPY statement
 from T2 waits.
copy listing from ...;
end;
```

The same behavior would occur if one or both transactions contained an INSERT command instead of a COPY command.

Concurrent DELETE operations from the same table with snapshot isolation

Concurrent DELETE or UPDATE operations from the same table with snapshot isolation run the same as operations run with serializable isolation.

Concurrent transactions with a mixture of read and write operations with snapshot isolation

Concurrent transactions that are run with mixes of operations with snapshot isolation run the same as transactions with mixes of operations that are run with serializable isolation.

Tutorial: Loading data from Amazon S3

In this tutorial, you walk through the process of loading data into your Amazon Redshift database tables from data files in an Amazon S3 bucket from beginning to end.

In this tutorial, you do the following:

- Download data files that use comma-separated value (CSV), character-delimited, and fixed width formats.
- Create an Amazon S3 bucket and then upload the data files to the bucket.
- Launch an Amazon Redshift cluster and create database tables.
- Use COPY commands to load the tables from the data files on Amazon S3.
- Troubleshoot load errors and modify your COPY commands to correct the errors.

Prerequisites

You need the following prerequisites:

- An AWS account to launch an Amazon Redshift cluster and to create a bucket in Amazon S3.
- Your AWS credentials (IAM role) to load test data from Amazon S3. If you need a new IAM role, go to Creating IAM roles.
- An SQL client such as the Amazon Redshift console query editor.

This tutorial is designed so that it can be taken by itself. In addition to this tutorial, we recommend completing the following tutorials to gain a more complete understanding of how to design and use Amazon Redshift databases:

- Amazon Redshift Getting Started Guide walks you through the process of creating an Amazon Redshift cluster and loading sample data.

Overview

You can add data to your Amazon Redshift tables either by using an INSERT command or by using a COPY command. At the scale and speed of an Amazon Redshift data warehouse, the COPY command is many times faster and more efficient than INSERT commands.

The COPY command uses the Amazon Redshift massively parallel processing (MPP) architecture to read and load data in parallel from multiple data sources. You can load from data files on Amazon S3, Amazon EMR, or any remote host accessible through a Secure Shell (SSH) connection. Or you can load directly from an Amazon DynamoDB table.

In this tutorial, you use the COPY command to load data from Amazon S3. Many of the principles presented here apply to loading from other data sources as well.

To learn more about using the COPY command, see these resources:

- Amazon Redshift best practices for loading data
- Loading data from Amazon EMR
- Loading data from remote hosts
- Loading data from an Amazon DynamoDB table

Step 1: Create a cluster

If you already have a cluster that you want to use, you can skip this step.

For the exercises in this tutorial, use a four-node cluster.

To create a cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.

   Using the navigation menu, choose the **Provisioned clusters dashboard**.

   > **Important**
   >
   > Make sure that you have the necessary permissions to perform the cluster operations. For information on granting the necessary permissions, see Authorizing Amazon Redshift to access AWS services.

2. At top right, choose the AWS Region in which you want to create the cluster. For the purposes of this tutorial, choose **US West (Oregon)**.
3. On the navigation menu, choose **Clusters**, then choose **Create cluster**. The **Create cluster** page appears.

4. On the **Create cluster** page enter parameters for your cluster. Choose your own values for the parameters, except change the following values:

   - Choose **dc2.large** for the node type.
   - Choose **4** for the **Number of nodes**.
   - In the **Cluster permissions** section, choose an IAM role from **Available IAM roles**. This role should be one that you previously created and that has access to Amazon S3. Then choose **Associate IAM role** to add it to the list of **Associated IAM roles** for the cluster.

5. Choose **Create cluster**.

Follow the Amazon Redshift Getting Started Guide steps to connect to your cluster from a SQL client and test a connection. You don't need to complete the remaining Getting Started steps to create tables, upload data, and try example queries.

Step 2: Download the data files

In this step, you download a set of sample data files to your computer. In the next step, you upload the files to an Amazon S3 bucket.

To download the data files

1. Download the zipped file: LoadingDataSampleFiles.zip.
2. Extract the files to a folder on your computer.
3. Verify that your folder contains the following files.

```
customer-fw-manifest
customer-fw.tbl-000
customer-fw.tbl-000.bak
customer-fw.tbl-001
customer-fw.tbl-002
customer-fw.tbl-003
customer-fw.tbl-004
customer-fw.tbl-005
customer-fw.tbl-006
customer-fw.tbl-007
customer-fw.tbl.log
dwdate-tab.tbl-000
dwdate-tab.tbl-001
dwdate-tab.tbl-002
```

```
dwdate-tab.tbl-003
dwdate-tab.tbl-004
dwdate-tab.tbl-005
dwdate-tab.tbl-006
dwdate-tab.tbl-007
part-csv.tbl-000
part-csv.tbl-001
part-csv.tbl-002
part-csv.tbl-003
part-csv.tbl-004
part-csv.tbl-005
part-csv.tbl-006
part-csv.tbl-007
```

Step 3: Upload the files to an Amazon S3 bucket

In this step, you create an Amazon S3 bucket and upload the data files to the bucket.

To upload the files to an Amazon S3 bucket

1. Create a bucket in Amazon S3.

   For more information about creating a bucket, see Creating a bucket in the *Amazon Simple Storage Service User Guide*.

   a. Sign in to the AWS Management Console and open the Amazon S3 console at https://console.aws.amazon.com/s3/.
   b. Choose **Create bucket**.
   c. Choose an AWS Region.

      Create the bucket in the same Region as your cluster. If your cluster is in the US West (Oregon) Region, choose **US West (Oregon) Region (us-west-2)**.
   d. In the **Bucket Name** box of the **Create bucket** dialog box, enter a bucket name.

      The bucket name you choose must be unique among all existing bucket names in Amazon S3. One way to help ensure uniqueness is to prefix your bucket names with the name of your organization. Bucket names must comply with certain rules. For more information, go to Bucket restrictions and limitations in the *Amazon Simple Storage Service User Guide.*
   e. Choose the recommended defaults for the rest of the options.

   f. Choose **Create bucket**.

      When Amazon S3 successfully creates your bucket, the console displays your empty bucket in the **Buckets** panel.

2. Create a folder.

   a. Choose the name of the new bucket.

   b. Choose the **Create Folder** button.

   c. Name the new folder **`load`**.

   > **Note**
   >
   > The bucket that you created is not in a sandbox. In this exercise, you add objects to a real bucket. You're charged a nominal amount for the time that you store the objects in the bucket. For more information about Amazon S3 pricing, go to the [Amazon S3 pricing](#) page.

3. Upload the data files to the new Amazon S3 bucket.

   a. Choose the name of the data folder.

   b. In the Upload wizard, choose **Add files**.

      Follow the Amazon S3 console instructions to upload all of the files you downloaded and extracted,

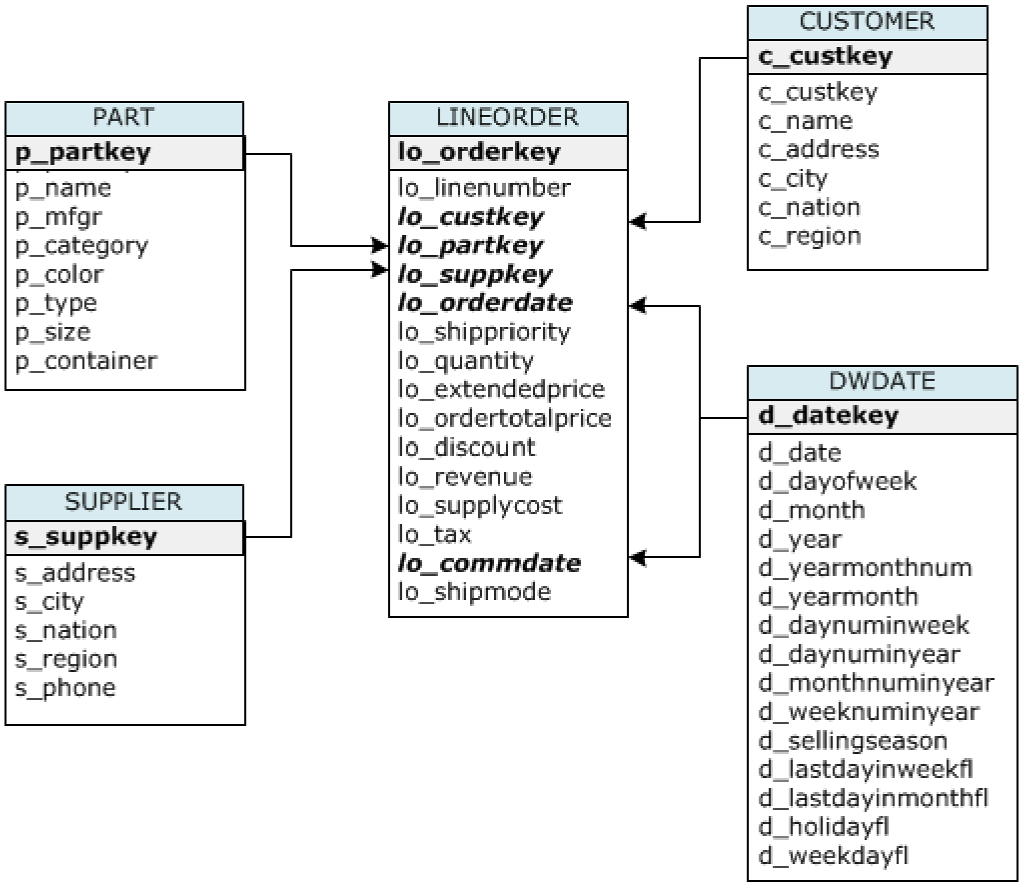
   c. Choose **Upload**.

User Credentials

The Amazon Redshift COPY command must have access to read the file objects in the Amazon S3 bucket. If you use the same user credentials to create the Amazon S3 bucket and to run the Amazon Redshift COPY command, the COPY command has all necessary permissions. If you want to use different user credentials, you can grant access by using the Amazon S3 access controls. The Amazon Redshift COPY command requires at least ListBucket and GetObject permissions to access the file objects in the Amazon S3 bucket. For more information about controlling access to Amazon S3 resources, go to [Managing access permissions to your Amazon S3 resources](#).

Step 4: Create the sample tables

For this tutorial, you use a set of tables based on the Star Schema Benchmark (SSB) schema. The following diagram shows the SSB data model.



The SSB tables might already exist in the current database. If so, drop the tables to remove them from the database before you create them using the CREATE TABLE commands in the next step. The tables used in this tutorial might have different attributes than the existing tables.

To create the sample tables

1. To drop the SSB tables, run the following commands in your SQL client.

```
drop table part cascade;
drop table supplier;
drop table customer;
drop table dwdate;
drop table lineorder;
```

2. Run the following CREATE TABLE commands in your SQL client.

```
CREATE TABLE part
(
  p_partkey     INTEGER NOT NULL,
  p_name        VARCHAR(22) NOT NULL,
  p_mfgr        VARCHAR(6),
  p_category    VARCHAR(7) NOT NULL,
  p_brand1      VARCHAR(9) NOT NULL,
  p_color       VARCHAR(11) NOT NULL,
  p_type        VARCHAR(25) NOT NULL,
  p_size        INTEGER NOT NULL,
  p_container   VARCHAR(10) NOT NULL
);

CREATE TABLE supplier
(
  s_suppkey   INTEGER NOT NULL,
  s_name      VARCHAR(25) NOT NULL,
  s_address   VARCHAR(25) NOT NULL,
  s_city      VARCHAR(10) NOT NULL,
  s_nation    VARCHAR(15) NOT NULL,
  s_region    VARCHAR(12) NOT NULL,
  s_phone     VARCHAR(15) NOT NULL
);

CREATE TABLE customer
(
  c_custkey      INTEGER NOT NULL,
  c_name         VARCHAR(25) NOT NULL,
  c_address      VARCHAR(25) NOT NULL,
  c_city         VARCHAR(10) NOT NULL,
  c_nation       VARCHAR(15) NOT NULL,
  c_region       VARCHAR(12) NOT NULL,
  c_phone        VARCHAR(15) NOT NULL,
  c_mktsegment   VARCHAR(10) NOT NULL
);

CREATE TABLE dwdate
(
  d_datekey            INTEGER NOT NULL,
  d_date               VARCHAR(19) NOT NULL,
  d_dayofweek          VARCHAR(10) NOT NULL,
  d_month              VARCHAR(10) NOT NULL,
  d_year               INTEGER NOT NULL,
```

```
  d_yearmonthnum       INTEGER NOT NULL,
  d_yearmonth          VARCHAR(8) NOT NULL,
  d_daynuminweek       INTEGER NOT NULL,
  d_daynuminmonth      INTEGER NOT NULL,
  d_daynuminyear       INTEGER NOT NULL,
  d_monthnuminyear     INTEGER NOT NULL,
  d_weeknuminyear      INTEGER NOT NULL,
  d_sellingseason      VARCHAR(13) NOT NULL,
  d_lastdayinweekfl    VARCHAR(1) NOT NULL,
  d_lastdayinmonthfl   VARCHAR(1) NOT NULL,
  d_holidayfl          VARCHAR(1) NOT NULL,
  d_weekdayfl          VARCHAR(1) NOT NULL
);
CREATE TABLE lineorder
(
  lo_orderkey          INTEGER NOT NULL,
  lo_linenumber        INTEGER NOT NULL,
  lo_custkey           INTEGER NOT NULL,
  lo_partkey           INTEGER NOT NULL,
  lo_suppkey           INTEGER NOT NULL,
  lo_orderdate         INTEGER NOT NULL,
  lo_orderpriority     VARCHAR(15) NOT NULL,
  lo_shippriority      VARCHAR(1) NOT NULL,
  lo_quantity          INTEGER NOT NULL,
  lo_extendedprice     INTEGER NOT NULL,
  lo_ordertotalprice   INTEGER NOT NULL,
  lo_discount          INTEGER NOT NULL,
  lo_revenue           INTEGER NOT NULL,
  lo_supplycost        INTEGER NOT NULL,
  lo_tax               INTEGER NOT NULL,
  lo_commitdate        INTEGER NOT NULL,
  lo_shipmode          VARCHAR(10) NOT NULL
);
```

Step 5: Run the COPY commands

You run COPY commands to load each of the tables in the SSB schema. The COPY command examples demonstrate loading from different file formats, using several COPY command options, and troubleshooting load errors.

COPY command syntax

The basic COPY command syntax is as follows.

```
COPY table_name [ column_list ] FROM data_source CREDENTIALS access_credentials
 [options]
```

To run a COPY command, you provide the following values.

Table name

The target table for the COPY command. The table must already exist in the database. The table can be temporary or persistent. The COPY command appends the new input data to any existing rows in the table.

Column list

By default, COPY loads fields from the source data to the table columns in order. You can optionally specify a *column list,* that is a comma-separated list of column names, to map data fields to specific columns. You don't use column lists in this tutorial. For more information, see Column List in the COPY command reference.

Data source

You can use the COPY command to load data from an Amazon S3 bucket, an Amazon EMR cluster, a remote host using an SSH connection, or an Amazon DynamoDB table. For this tutorial, you load from data files in an Amazon S3 bucket. When loading from Amazon S3, you must provide the name of the bucket and the location of the data files. To do this, provide either an object path for the data files or the location of a manifest file that explicitly lists each data file and its location.

- Key prefix

  An object stored in Amazon S3 is uniquely identified by an object key, which includes the bucket name, folder names, if any, and the object name. A *key prefix* refers to a set of objects with the same prefix. The object path is a key prefix that the COPY command uses to load all objects that share the key prefix. For example, the key prefix `custdata.txt` can refer to a single file or to a set of files, including `custdata.txt.001`, `custdata.txt.002`, and so on.
- Manifest file

  In some cases, you might need to load files with different prefixes, for example from multiple buckets or folders. In others, you might need to exclude files that share a prefix. In these cases, you can use a manifest file. A *manifest file* explicitly lists each load file and its unique object key. You use a manifest file to load the PART table later in this tutorial.

Credentials

To access the AWS resources that contain the data to load, you must provide AWS access credentials for a user with sufficient privileges. These credentials include an IAM role Amazon Resource Name (ARN). To load data from Amazon S3, the credentials must include ListBucket and GetObject permissions. Additional credentials are required if your data is encrypted. For more information, see Authorization parameters in the COPY command reference. For more information about managing access, go to Managing access permissions to your Amazon S3 resources.

Options

You can specify a number of parameters with the COPY command to specify file formats, manage data formats, manage errors, and control other features. In this tutorial, you use the following COPY command options and features:

- Key prefix

  For information on how to load from multiple files by specifying a key prefix, see Load the PART table using NULL AS.
- CSV format

  For information on how to load data that is in CSV format, see Load the PART table using NULL AS.
- NULL AS

  For information on how to load PART using the NULL AS option, see Load the PART table using NULL AS.
- Character-delimited format

  For information on how to use the DELIMITER option, see The DELIMITER and REGION options.
- REGION

  For information on how to use the REGION option, see The DELIMITER and REGION options.
- Fixed-format width

For information on how to load the CUSTOMER table from fixed-width data, see Load the CUSTOMER table using MANIFEST.

- MAXERROR

  For information on how to use the MAXERROR option, see Load the CUSTOMER table using MANIFEST.
- ACCEPTINVCHARS

  For information on how to use the ACCEPTINVCHARS option, see Load the CUSTOMER table using MANIFEST.
- MANIFEST

  For information on how to use the MANIFEST option, see Load the CUSTOMER table using MANIFEST.
- DATEFORMAT

  For information on how to use the DATEFORMAT option, see Load the DWDATE table using DATEFORMAT.
- GZIP, LZOP and BZIP2

  For information on how to compress your files, see Load multiple data files.
- COMPUPDATE

  For information on how to use the COMPUPDATE option, see Load multiple data files.
- Multiple files

  For information on how to load multiple files, see Load multiple data files.

Loading the SSB tables

You use the following COPY commands to load each of the tables in the SSB schema. The command to each table demonstrates different COPY options and troubleshooting techniques.

To load the SSB tables, follow these steps:

1. Replace the bucket name and AWS credentials
2. Load the PART table using NULL AS

3. Load the CUSTOMER table using MANIFEST
4. Load the DWDATE table using DATEFORMAT

Replace the bucket name and AWS credentials

The COPY commands in this tutorial are presented in the following format.

```
copy table from 's3://<your-bucket-name>/load/key_prefix'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
options;
```

For each COPY command, do the following:

1. Replace *<your-bucket-name>* with the name of a bucket in the same region as your cluster.

   This step assumes the bucket and the cluster are in the same region. Alternatively, you can specify the region using the REGION option with the COPY command.
2. Replace *<aws-account-id>* and *<role-name>* with your own AWS account and IAM role. The segment of the credentials string that is enclosed in single quotation marks must not contain any spaces or line breaks. Note that the ARN might differ slightly in format than the sample. It's best to copy the ARN for the role from the IAM console, to ensure that it's accurate, when you run the COPY commands.

Load the PART table using NULL AS

In this step, you use the CSV and NULL AS options to load the PART table.

The COPY command can load data from multiple files in parallel, which is much faster than loading from a single file. To demonstrate this principle, the data for each table in this tutorial is split into eight files, even though the files are very small. In a later step, you compare the time difference between loading from a single file and loading from multiple files. For more information, see Loading data files.

Key prefix

You can load from multiple files by specifying a key prefix for the file set, or by explicitly listing the files in a manifest file. In this step, you use a key prefix. In a later step, you use a manifest file. The key prefix `'s3://amzn-s3-demo-bucket/load/part-csv.tbl'` loads the following set of the files in the `load` folder.

```
part-csv.tbl-000
part-csv.tbl-001
part-csv.tbl-002
part-csv.tbl-003
part-csv.tbl-004
part-csv.tbl-005
part-csv.tbl-006
part-csv.tbl-007
```

CSV format

CSV, which stands for comma separated values, is a common format used for importing and exporting spreadsheet data. CSV is more flexible than comma-delimited format because it enables you to include quoted strings within fields. The default quotation mark character for COPY from CSV format is a double quotation mark ("), but you can specify another quotation mark character by using the QUOTE AS option. When you use the quotation mark character within the field, escape the character with an additional quotation mark character.

The following excerpt from a CSV-formatted data file for the PART table shows strings enclosed in double quotation marks (`"LARGE ANODIZED BRASS"`). It also shows a string enclosed in two double quotation marks within a quoted string (`"MEDIUM ""BURNISHED"" TIN"`).

```
15,dark sky,MFGR#3,MFGR#47,MFGR#3438,indigo,"LARGE ANODIZED BRASS",45,LG CASE
22,floral beige,MFGR#4,MFGR#44,MFGR#4421,medium,"PROMO, POLISHED BRASS",19,LG DRUM
23,bisque slate,MFGR#4,MFGR#41,MFGR#4137,firebrick,"MEDIUM ""BURNISHED"" TIN",42,JUMBO
 JAR
```

The data for the PART table contains characters that cause COPY to fail. In this exercise, you troubleshoot the errors and correct them.

To load data that is in CSV format, add `csv` to your COPY command. Run the following command to load the PART table.

```
copy part from 's3://<your-bucket-name>/load/part-csv.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
csv;
```

You might get an error message similar to the following.

```
An error occurred when executing the SQL command:
```

```
copy part from 's3://amzn-s3-demo-bucket/load/part-csv.tbl'
credentials' ...

ERROR: Load into table 'part' failed.  Check 'stl_load_errors' system table for
 details. [SQL State=XX000]

Execution time: 1.46s

1 statement(s) failed.
1 statement(s) failed.
```

To get more information about the error, query the STL_LOAD_ERRORS table. The following query uses the SUBSTRING function to shorten columns for readability and uses LIMIT 10 to reduce the number of rows returned. You can adjust the values in `substring(filename,22,25)` to allow for the length of your bucket name.

```
select query, substring(filename,22,25) as filename,line_number as line,
substring(colname,0,12) as column, type, position as pos, substring(raw_line,0,30) as
 line_text,
substring(raw_field_value,0,15) as field_text,
substring(err_reason,0,45) as reason
from stl_load_errors
order by query desc
limit 10;
```

```
 query  |    filename      | line |  column    |    type    | pos |
--------+-------------------------+-----------+------------+------------+-----+----
 333765 | part-csv.tbl-000 |    1 |            |            |   0 |

 line_text        | field_text |                    reason
------------------+------------+----------------------------------------------
 15,NUL next,     |            | Missing newline: Unexpected character 0x2c f
```

NULL AS

The `part-csv.tbl` data files use the NUL terminator character (`\x000` or `\x0`) to indicate NULL values.

> **Note**
>
> Despite very similar spelling, NUL and NULL are not the same. NUL is a UTF-8 character with codepoint `x000` that is often used to indicate end of record (EOR). NULL is a SQL value that represents an absence of data.

By default, COPY treats a NUL terminator character as an EOR character and terminates the record, which often results in unexpected results or an error. There is no single standard method of indicating NULL in text data. Thus, the NULL AS COPY command option enables you to specify which character to substitute with NULL when loading the table. In this example, you want COPY to treat the NUL terminator character as a NULL value.

> **Note**
>
> The table column that receives the NULL value must be configured as *nullable.* That is, it must not include the NOT NULL constraint in the CREATE TABLE specification.

To load PART using the NULL AS option, run the following COPY command.

```
copy part from 's3://<your-bucket-name>/load/part-csv.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
csv
null as '\000';
```

To verify that COPY loaded NULL values, run the following command to select only the rows that contain NULL.

```
select p_partkey, p_name, p_mfgr, p_category from part where p_mfgr is null;
```

```
 p_partkey |  p_name  | p_mfgr | p_category
-----------+----------+--------+------------
        15 | NUL next |        | MFGR#47
        81 | NUL next |        | MFGR#23
       133 | NUL next |        | MFGR#44
(2 rows)
```

The DELIMITER and REGION options

The DELIMITER and REGION options are important to understand how load data.

Character-delimited format

The fields in a character-delimited file are separated by a specific character, such as a pipe character (|), a comma (,) or a tab (\t). Character-delimited files can use any single ASCII character, including one of the nonprinting ASCII characters, as the delimiter. You specify the delimiter character by using the DELIMITER option. The default delimiter is a pipe character (|).

The following excerpt from the data for the SUPPLIER table uses pipe-delimited format.

```
1|1|257368|465569|41365|19950218|2-HIGH|0|17|2608718|9783671|4|2504369|92072|2|
19950331|TRUCK
1|2|257368|201928|8146|19950218|2-HIGH|0|36|6587676|9783671|9|5994785|109794|6|
19950416|MAIL
```

REGION

Whenever possible, you should locate your load data in the same AWS region as your Amazon Redshift cluster. If your data and your cluster are in the same region, you reduce latency and avoid cross-region data transfer costs. For more information, see Amazon Redshift best practices for loading data.

If you must load data from a different AWS region, use the REGION option to specify the AWS region in which the load data is located. If you specify a region, all of the load data, including manifest files, must be in the named region. For more information, see REGION.

For example, if your cluster is in the US East (N. Virginia) Region, and your Amazon S3 bucket is located in the US West (Oregon) Region, the following COPY command shows how to load the SUPPLIER table from pipe-delimited data.

```
copy supplier from 's3://amzn-s3-demo-bucket/ssb/supplier.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
delimiter '|'
gzip
region 'us-west-2';
```

Load the CUSTOMER table using MANIFEST

In this step, you use the FIXEDWIDTH, MAXERROR, ACCEPTINVCHARS, and MANIFEST options to load the CUSTOMER table.

The sample data for this exercise contains characters that cause errors when COPY attempts to load them. You use the MAXERRORS option and the STL_LOAD_ERRORS system table to troubleshoot the load errors and then use the ACCEPTINVCHARS and MANIFEST options to eliminate the errors.

Fixed-Width Format

Fixed-width format defines each field as a fixed number of characters, rather than separating fields with a delimiter. The following excerpt from the data for the CUSTOMER table uses fixed-width format.

```
1   Customer#000000001   IVhzIApeRb             MOROCCO  0MOROCCO  AFRICA      25-705
2   Customer#000000002   XSTf4,NCwDVaWNe6tE     JORDAN   6JORDAN   MIDDLE EAST 23-453
3   Customer#000000003   MG9kdTD                ARGENTINA5ARGENTINAAMERICA     11-783
```

The order of the label/width pairs must match the order of the table columns exactly. For more information, see FIXEDWIDTH.

The fixed-width specification string for the CUSTOMER table data is as follows.

```
fixedwidth 'c_custkey:10, c_name:25, c_address:25, c_city:10, c_nation:15,
c_region :12, c_phone:15,c_mktsegment:10'
```

To load the CUSTOMER table from fixed-width data, run the following command.

```
copy customer
from 's3://<your-bucket-name>/load/customer-fw.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
fixedwidth 'c_custkey:10, c_name:25, c_address:25, c_city:10, c_nation:15,
 c_region :12, c_phone:15,c_mktsegment:10';
```

You should get an error message, similar to the following.

```
An error occurred when executing the SQL command:
```

```
copy customer
from 's3://amzn-s3-demo-bucket/load/customer-fw.tbl'
credentials'...

ERROR: Load into table 'customer' failed.  Check 'stl_load_errors' system table for
 details. [SQL State=XX000]

Execution time: 2.95s

1 statement(s) failed.
```

MAXERROR

By default, the first time COPY encounters an error, the command fails and returns an error message. To save time during testing, you can use the MAXERROR option to instruct COPY to skip a specified number of errors before it fails. Because we expect errors the first time we test loading the CUSTOMER table data, add `maxerror 10` to the COPY command.

To test using the FIXEDWIDTH and MAXERROR options, run the following command.

```
copy customer
from 's3://<your-bucket-name>/load/customer-fw.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
fixedwidth 'c_custkey:10, c_name:25, c_address:25, c_city:10, c_nation:15,
 c_region :12, c_phone:15,c_mktsegment:10'
maxerror 10;
```

This time, instead of an error message, you get a warning message similar to the following.

```
Warnings:
Load into table 'customer' completed, 112497 record(s) loaded successfully.
Load into table 'customer' completed, 7 record(s) could not be loaded.  Check
 'stl_load_errors' system table for details.
```

The warning indicates that COPY encountered seven errors. To check the errors, query the STL_LOAD_ERRORS table, as shown in the following example.

```
select query, substring(filename,22,25) as filename,line_number as line,
substring(colname,0,12) as column, type, position as pos, substring(raw_line,0,30) as
 line_text,
substring(raw_field_value,0,15) as field_text,
```

```
substring(err_reason,0,45) as error_reason
from stl_load_errors
order by query desc, filename
limit 7;
```

The results of the STL_LOAD_ERRORS query should look similar to the following.

```
 query  |         filename          | line |  column   |    type    | pos |
 line_text            | field_text |              error_reason
--------+-------------------------+------+-----------
+------------+-----+-------------------------------+------------
+----------------------------------------------
 334489 | customer-fw.tbl.log       |    2 | c_custkey | int4       |  -1 | customer-
fw.tbl                | customer-f | Invalid digit, Value 'c', Pos 0, Type: Integ
 334489 | customer-fw.tbl.log       |    6 | c_custkey | int4       |  -1 | Complete
                    | Complete   | Invalid digit, Value 'C', Pos 0, Type: Integ
 334489 | customer-fw.tbl.log       |    3 | c_custkey | int4       |  -1 | #Total rows
                    | #Total row | Invalid digit, Value '#', Pos 0, Type: Integ
 334489 | customer-fw.tbl.log       |    5 | c_custkey | int4       |  -1 | #Status
                    | #Status    | Invalid digit, Value '#', Pos 0, Type: Integ
 334489 | customer-fw.tbl.log       |    1 | c_custkey | int4       |  -1 | #Load file
                    | #Load file | Invalid digit, Value '#', Pos 0, Type: Integ
 334489 | customer-fw.tbl000        |    1 | c_address | varchar    |  34 | 1
 Customer#000000001  | .Mayag.ezR | String contains invalid or unsupported UTF8
 334489 | customer-fw.tbl000        |    1 | c_address | varchar    |  34 | 1
 Customer#000000001  | .Mayag.ezR | String contains invalid or unsupported UTF8
(7 rows)
```

By examining the results, you can see that there are two messages in the `error_reasons` column:

- ```
  Invalid digit, Value '#', Pos 0, Type: Integ
  ```

  These errors are caused by the `customer-fw.tbl.log` file. The problem is that it is a log file, not a data file, and should not be loaded. You can use a manifest file to avoid loading the wrong file.

- ```
  String contains invalid or unsupported UTF8
  ```

  The VARCHAR data type supports multibyte UTF-8 characters up to three bytes. If the load data contains unsupported or invalid characters, you can use the ACCEPTINVCHARS option to replace each invalid character with a specified alternative character.

Another problem with the load is more difficult to detect—the load produced unexpected results. To investigate this problem, run the following command to query the CUSTOMER table.

```
select c_custkey, c_name, c_address
from customer
order by c_custkey
limit 10;
```

```
 c_custkey |          c_name           |         c_address
-----------+---------------------------+---------------------------
         2 | Customer#000000002        | XSTf4,NCwDVaWNe6tE
         2 | Customer#000000002        | XSTf4,NCwDVaWNe6tE
         3 | Customer#000000003        | MG9kdTD
         3 | Customer#000000003        | MG9kdTD
         4 | Customer#000000004        | XxVSJsL
         4 | Customer#000000004        | XxVSJsL
         5 | Customer#000000005        | KvpyuHCplrB84WgAi
         5 | Customer#000000005        | KvpyuHCplrB84WgAi
         6 | Customer#000000006        | sKZz0CsnMD7mp4Xd0YrBvx
         6 | Customer#000000006        | sKZz0CsnMD7mp4Xd0YrBvx
(10 rows)
```

The rows should be unique, but there are duplicates.

Another way to check for unexpected results is to verify the number of rows that were loaded. In our case, 100000 rows should have been loaded, but the load message reported loading 112497 records. The extra rows were loaded because the COPY loaded an extraneous file, `customer-fw.tbl0000.bak`.

In this exercise, you use a manifest file to avoid loading the wrong files.

ACCEPTINVCHARS

By default, when COPY encounters a character that is not supported by the column's data type, it skips the row and returns an error. For information about invalid UTF-8 characters, see [Multibyte character load errors](#).

You could use the MAXERRORS option to ignore errors and continue loading, then query STL_LOAD_ERRORS to locate the invalid characters, and then fix the data files. However, MAXERRORS is best used for troubleshooting load problems and should generally not be used in a production environment.

The ACCEPTINVCHARS option is usually a better choice for managing invalid characters. ACCEPTINVCHARS instructs COPY to replace each invalid character with a specified valid character and continue with the load operation. You can specify any valid ASCII character, except NULL, as the replacement character. The default replacement character is a question mark (?). COPY replaces multibyte characters with a replacement string of equal length. For example, a 4-byte character would be replaced with `'????'`.

COPY returns the number of rows that contained invalid UTF-8 characters. It also adds an entry to the STL_REPLACEMENTS system table for each affected row, up to a maximum of 100 rows per node slice. Additional invalid UTF-8 characters are also replaced, but those replacement events are not recorded.

ACCEPTINVCHARS is valid only for VARCHAR columns.

For this step, you add the ACCEPTINVCHARS with the replacement character `'^'`.

MANIFEST

When you COPY from Amazon S3 using a key prefix, there is a risk that you might load unwanted tables. For example, the `'s3://amzn-s3-demo-bucket/load/` folder contains eight data files that share the key prefix `customer-fw.tbl`: `customer-fw.tbl0000`, `customer-fw.tbl0001`, and so on. However, the same folder also contains the extraneous files `customer-fw.tbl.log` and `customer-fw.tbl-0001.bak`.

To ensure that you load all of the correct files, and only the correct files, use a manifest file. The manifest is a text file in JSON format that explicitly lists the unique object key for each source file to be loaded. The file objects can be in different folders or different buckets, but they must be in the same region. For more information, see MANIFEST.

The following shows the `customer-fw-manifest` text.

```
{
  "entries": [
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-000"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-001"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-002"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-003"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-004"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-005"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-006"},
    {"url":"s3://<your-bucket-name>/load/customer-fw.tbl-007"}
    ]
```

```
}
```

To load the data for the CUSTOMER table using the manifest file

1. Open the file `customer-fw-manifest` in a text editor.
2. Replace *<your-bucket-name>* with the name of your bucket.
3. Save the file.
4. Upload the file to the load folder on your bucket.
5. Run the following COPY command.

```
copy customer from 's3://<your-bucket-name>/load/customer-fw-manifest'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
fixedwidth 'c_custkey:10, c_name:25, c_address:25, c_city:10, c_nation:15,
 c_region :12, c_phone:15,c_mktsegment:10'
maxerror 10
acceptinvchars as '^'
manifest;
```

Load the DWDATE table using DATEFORMAT

In this step, you use the DELIMITER and DATEFORMAT options to load the DWDATE table.

When loading DATE and TIMESTAMP columns, COPY expects the default format, which is YYYY-MM-DD for dates and YYYY-MM-DD HH:MI:SS for timestamps. If the load data does not use a default format, you can use DATEFORMAT and TIMEFORMAT to specify the format.

The following excerpt shows date formats in the DWDATE table. Notice that the date formats in column two are inconsistent.

```
19920104 1992-01-04          Sunday  January 1992 199201 Jan1992 1 4 4 1...
19920112 January 12, 1992 Monday  January 1992 199201 Jan1992 2 12 12 1...
19920120 January 20, 1992 Tuesday     January 1992 199201 Jan1992 3 20 20 1...
```

DATEFORMAT

You can specify only one date format. If the load data contains inconsistent formats, possibly in different columns, or if the format is not known at load time, you use DATEFORMAT with the `'auto'` argument. When `'auto'` is specified, COPY recognizes any valid date or time format and convert it to the default format. The `'auto'` option recognizes several formats that are not supported when using a DATEFORMAT and TIMEFORMAT string. For more information, see [Using automatic recognition with DATEFORMAT and TIMEFORMAT](#).

To load the DWDATE table, run the following COPY command.

```
copy dwdate from 's3://<your-bucket-name>/load/dwdate-tab.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
delimiter '\t'
dateformat 'auto';
```

Load multiple data files

You can use the GZIP and COMPUPDATE options to load a table.

You can load a table from a single data file or multiple files. Do this to compare the load times for the two methods.

GZIP, LZOP and BZIP2

You can compress your files using either gzip, lzop, or bzip2 compression formats. When loading from compressed files, COPY uncompresses the files during the load process. Compressing your files saves storage space and shortens upload times.

COMPUPDATE

When COPY loads an empty table with no compression encodings, it analyzes the load data to determine the optimal encodings. It then alters the table to use those encodings before beginning the load. This analysis process takes time, but it occurs, at most, once per table. To save time, you can skip this step by turning COMPUPDATE off. To enable an accurate evaluation of COPY times, you turn COMPUPDATE off for this step.

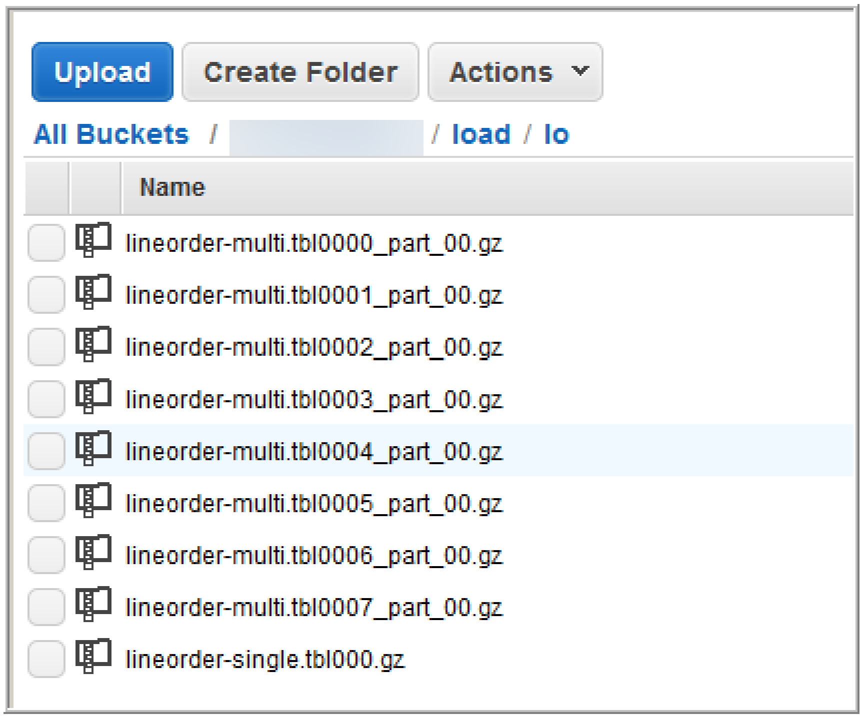
Multiple Files

The COPY command can load data very efficiently when it loads from multiple files in parallel instead of from a single file. You can split your data into files so that the number of files is a multiple of the number of slices in your cluster. If you do, Amazon Redshift divides the workload and distributes the data evenly among the slices. The number of slices per node depends on the node size of the cluster. For more information about the number of slices that each node size has, see [About clusters and nodes](#) in the *Amazon Redshift Management Guide*.

For example, the compute nodes in your cluster in this tutorial can have two slices each, so a four-node cluster has eight slices. In previous steps, the load data was contained in eight files, even though the files are very small. You can compare the time difference between loading from a single large file and loading from multiple files.

Even files that contain 15 million records and occupy about 1.2 GB are very small in Amazon Redshift scale. But they are sufficient to demonstrate the performance advantage of loading from multiple files.

The following image shows the data files for LINEORDER.



To evaluate the performance of COPY with multiple files

1. In a lab test, the following command was run to COPY from a single file. This command shows a fictitious bucket.

```
copy lineorder from 's3://amzn-s3-demo-bucket/load/lo/lineorder-single.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
gzip
compupdate off
region 'us-east-1';
```

2. The results were as follows. Note the execution time.

```
Warnings:
Load into table 'lineorder' completed, 14996734 record(s) loaded successfully.
```

```
0 row(s) affected.
copy executed successfully

Execution time: 51.56s
```

3. Then the following command to COPY from multiple files was run.

```
copy lineorder from 's3://amzn-s3-demo-bucket/load/lo/lineorder-multi.tbl'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
gzip
compupdate off
region 'us-east-1';
```

4. The results were as follows. Note the execution time.

```
Warnings:
Load into table 'lineorder' completed, 14996734 record(s) loaded successfully.

0 row(s) affected.
copy executed successfully

Execution time: 17.7s
```

5. Compare execution times.

   In our experiment, the time to load 15 million records decreased from 51.56 seconds to 17.7 seconds, a reduction of 65.7 percent.

   These results are based on using a four-node cluster. If your cluster has more nodes, the time savings is multiplied. For typical Amazon Redshift clusters, with tens to hundreds of nodes, the difference is even more dramatic. If you have a single node cluster, there is little difference between the execution times.

Step 6: Vacuum and analyze the database

Whenever you add, delete, or modify a significant number of rows, you should run a VACUUM command and then an ANALYZE command. A *vacuum* recovers the space from deleted rows and restores the sort order. The ANALYZE command updates the statistics metadata, which enables the query optimizer to generate more accurate query plans. For more information, see Vacuuming tables.

If you load the data in sort key order, a vacuum is fast. In this tutorial, you added a significant number of rows, but you added them to empty tables. That being the case, there is no need to resort, and you didn't delete any rows. COPY automatically updates statistics after loading an empty table, so your statistics should be up-to-date. However, as a matter of good housekeeping, you complete this tutorial by vacuuming and analyzing your database.

To vacuum and analyze the database, run the following commands.

```
vacuum;
analyze;
```

Step 7: Clean up your resources

Your cluster continues to accrue charges as long as it is running. When you have completed this tutorial, you should return your environment to the previous state by following the steps in Step 5: Revoke access and delete your sample cluster in the *Amazon Redshift Getting Started Guide*.

If you want to keep the cluster, but recover the storage used by the SSB tables, run the following commands.

```
drop table part;
drop table supplier;
drop table customer;
drop table dwdate;
drop table lineorder;
```

Next

Summary

Summary

In this tutorial, you uploaded data files to Amazon S3 and then used COPY commands to load the data from the files into Amazon Redshift tables.

You loaded data using the following formats:

- Character-delimited
- CSV

- Fixed-width

You used the STL_LOAD_ERRORS system table to troubleshoot load errors, and then used the REGION, MANIFEST, MAXERROR, ACCEPTINVCHARS, DATEFORMAT, and NULL AS options to resolve the errors.

You applied the following best practices for loading data:

- Use a COPY command to load data
- Loading data files
- Use a single COPY command to load from multiple files
- Compressing your data files
- Verify data files before and after a load

For more information about Amazon Redshift best practices, see the following links:

- Amazon Redshift best practices for loading data
- Amazon Redshift best practices for designing tables
- Amazon Redshift best practices for designing queries

Unloading data in Amazon Redshift

To unload data from database tables to a set of files in an Amazon S3 bucket, you can use the UNLOAD command with a SELECT statement. You can unload text data in either delimited format or fixed-width format, regardless of the data format that was used to load it. You can also specify whether to create compressed GZIP files.

You can limit the access users have to your Amazon S3 bucket by using temporary security credentials.

Topics

Unloading data to Amazon S3

Amazon Redshift splits the results of a select statement across a set of files, one or more files per node slice, to simplify parallel reloading of the data. Alternatively, you can specify that UNLOAD should write the results serially to one or more files by adding the PARALLEL OFF option. You can limit the size of the files in Amazon S3 by specifying the MAXFILESIZE parameter. UNLOAD automatically encrypts data files using Amazon S3 server-side encryption (SSE-S3).

You can use any select statement in the UNLOAD command that Amazon Redshift supports, except for a select that uses a LIMIT clause in the outer select. For example, you can use a select statement that includes specific columns or that uses a where clause to join multiple tables. If your query contains quotation marks (enclosing literal values, for example), you need to escape them in the query text (\'). For more information, see the SELECT command reference. For more information about using a LIMIT clause, see the Usage notes for the UNLOAD command.

For example, the following UNLOAD command sends the contents of the VENUE table to the Amazon S3 bucket `s3://amzn-s3-demo-bucket/tickit/unload/`.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/unload/venue_'
```

```
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The file names created by the previous example include the prefix 'venue_'.

```
venue_0000_part_00
venue_0001_part_00
venue_0002_part_00
venue_0003_part_00
```

By default, UNLOAD writes data in parallel to multiple files, according to the number of slices in the cluster. To write data to a single file, specify PARALLEL OFF. UNLOAD writes the data serially, sorted absolutely according to the ORDER BY clause, if one is used. The maximum size for a data file is 6.2 GB. If the data size is greater than the maximum, UNLOAD creates additional files, up to 6.2 GB each.

The following example writes the contents VENUE to a single file. Only one file is required because the file size is less than 6.2 GB.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/unload/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
parallel off;
```

Note

The UNLOAD command is designed to use parallel processing. We recommend leaving PARALLEL enabled for most cases, especially if the files will be used to load tables using a COPY command.

Assuming the total data size for VENUE is 5 GB, the following example writes the contents of VENUE to 50 files, each 100 MB in size.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/unload/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
parallel off
maxfilesize 100 mb;
```

If you include a prefix in the Amazon S3 path string, UNLOAD will use that prefix for the file names.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/unload/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

You can create a manifest file that lists the unload files by specifying the MANIFEST option in the UNLOAD command. The manifest is a text file in JSON format that explicitly lists the URL of each file that was written to Amazon S3.

The following example includes the manifest option.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest;
```

The following example shows a manifest for four unload files.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0000_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0001_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0002_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0003_part_00"}
  ]
}
```

The manifest file can be used to load the same files by using a COPY with the MANIFEST option. For more information, see Using a manifest to specify data files.

After you complete an UNLOAD operation, confirm that the data was unloaded correctly by navigating to the Amazon S3 bucket where UNLOAD wrote the files. You will see one or more numbered files per slice, starting with the number zero. If you specified the MANIFEST option, you will also see a file ending with '`manifest`'. For example:

```
amzn-s3-demo-bucket/tickit/venue_0000_part_00
amzn-s3-demo-bucket/tickit/venue_0001_part_00
amzn-s3-demo-bucket/tickit/venue_0002_part_00
amzn-s3-demo-bucket/tickit/venue_0003_part_00
```

```
amzn-s3-demo-bucket/tickit/venue_manifest
```

You can programmatically get a list of the files that were written to Amazon S3 by calling an Amazon S3 list operation after the UNLOAD completes. You can also query STL_UNLOAD_LOG.

The following query returns the pathname for files that were created by an UNLOAD. The PG_LAST_QUERY_ID function returns the most recent query.

```
select query, substring(path,0,40) as path
from stl_unload_log
where query=2320
order by path;

query |             path
-------+--------------------------------------
  2320 | s3://amzn-s3-demo-bucket/venue0000_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0001_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0002_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0003_part_00
(4 rows)
```

If the amount of data is very large, Amazon Redshift might split the files into multiple parts per slice. For example:

```
venue_0000_part_00
venue_0000_part_01
venue_0000_part_02
venue_0001_part_00
venue_0001_part_01
venue_0001_part_02
...
```

The following UNLOAD command includes a quoted string in the select statement, so the quotation marks are escaped (`=\'OH\' '`).

```
unload ('select venuename, venuecity from venue where venuestate=\'OH\' ')
to 's3://amzn-s3-demo-bucket/tickit/venue/ '
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

By default, UNLOAD will fail rather than overwrite existing files in the destination bucket. To overwrite the existing files, including the manifest file, specify the ALLOWOVERWRITE option.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest
allowoverwrite;
```

Unloading encrypted data files

UNLOAD automatically creates files using Amazon S3 server-side encryption with AWS managed encryption keys (SSE-S3). You can also specify server-side encryption with an AWS Key Management Service key (SSE-KMS) or client-side encryption with a customer managed key. UNLOAD doesn't support Amazon S3 server-side encryption using a customer-supplied key. For more information, see Protecting data using server-side encryption.

To unload to Amazon S3 using server-side encryption with an AWS KMS key, use the KMS_KEY_ID parameter to provide the key ID as shown in the following example.

```
unload ('select venuename, venuecity from venue')
to 's3://amzn-s3-demo-bucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
KMS_KEY_ID '1234abcd-12ab-34cd-56ef-1234567890ab'
encrypted;
```

If you want to provide your own encryption key, you can create client-side encrypted data files in Amazon S3 by using the UNLOAD command with the ENCRYPTED option. UNLOAD uses the same envelope encryption process that Amazon S3 client-side encryption uses. You can then use the COPY command with the ENCRYPTED option to load the encrypted files.

The process works like this:

1. You create a base64 encoded 256-bit AES key that you will use as your private encryption key, or *root symmetric key*.
2. You issue an UNLOAD command that includes your root symmetric key and the ENCRYPTED option.
3. UNLOAD generates a one-time-use symmetric key (called the *envelope symmetric key*) and an initialization vector (IV), which it uses to encrypt your data.
4. UNLOAD encrypts the envelope symmetric key using your root symmetric key.

5. UNLOAD then stores the encrypted data files in Amazon S3 and stores the encrypted envelope key and IV as object metadata with each file. The encrypted envelope key is stored as object metadata `x-amz-meta-x-amz-key` and the IV is stored as object metadata `x-amz-meta-x-amz-iv`.

For more information about the envelope encryption process, see the [Client-side data encryption with the AWS SDK for Java and Amazon S3]() article.

To unload encrypted data files, add the root key value to the credentials string and include the ENCRYPTED option. If you use the MANIFEST option, the manifest file is also encrypted.

```
unload ('select venuename, venuecity from venue')
to 's3://amzn-s3-demo-bucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<root_key>'
manifest
encrypted;
```

To unload encrypted data files that are GZIP compressed, include the GZIP option along with the root key value and the ENCRYPTED option.

```
unload ('select venuename, venuecity from venue')
to 's3://amzn-s3-demo-bucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<root_key>'
encrypted gzip;
```

To load the encrypted data files, add the MASTER_SYMMETRIC_KEY parameter with the same root key value and include the ENCRYPTED option.

```
copy venue from 's3://amzn-s3-demo-bucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<root_key>'
encrypted;
```

Unloading data in delimited or fixed-width format

You can unload data in delimited format or fixed-width format. The default output is pipe-delimited (using the '|' character).

The following example specifies a comma as the delimiter:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/venue/comma'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter ',';
```

The resulting output files look like this:

```
20,Air Canada Centre,Toronto,ON,0
60,Rexall Place,Edmonton,AB,0
100,U.S. Cellular Field,Chicago,IL,40615
200,Al Hirschfeld Theatre,New York City,NY,0
240,San Jose Repertory Theatre,San Jose,CA,0
300,Kennedy Center Opera House,Washington,DC,0
...
```

To unload the same result set to a tab-delimited file, issue the following command:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/venue/tab'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter as '\t';
```

Alternatively, you can use a FIXEDWIDTH specification. This specification consists of an identifier for each table column and the width of the column (number of characters). The UNLOAD command will fail rather than truncate data, so specify a width that is at least as long as the longest entry for that column. Unloading fixed-width data works similarly to unloading delimited data, except that the resulting output contains no delimiting characters. For example:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/tickit/venue/fw'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
fixedwidth '0:3,1:100,2:30,3:2,4:6';
```

The fixed-width output looks like this:

```


20 Air Canada Centre         Toronto      ON0
60 Rexall Place              Edmonton     AB0
```

```
100U.S. Cellular Field       Chicago      IL40615
200Al Hirschfeld Theatre     New York CityNY0
240San Jose Repertory TheatreSan Jose     CA0
300Kennedy Center Opera HouseWashington   DC0
```

For more details about FIXEDWIDTH specifications, see the UNLOAD command.

Reloading unloaded data

To reload the results of an unload operation, you can use a COPY command.

The following example shows a simple case in which the VENUE table is unloaded using a manifest file, truncated, and reloaded.

```
unload  ('select * from venue order by venueid')
to 's3://amzn-s3-demo-bucket/tickit/venue/reload_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest
delimiter '|';

truncate venue;

copy venue
from 's3://amzn-s3-demo-bucket/tickit/venue/reload_manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest
delimiter '|';
```

After it is reloaded, the VENUE table looks like this:

```
select * from venue order by venueid limit 5;

 venueid |         venuename          |  venuecity  | venuestate | venueseats
---------+---------------------------+-------------+------------+-----------
       1 | Toyota Park                | Bridgeview  | IL         |          0
       2 | Columbus Crew Stadium      | Columbus    | OH         |          0
       3 | RFK Stadium                | Washington  | DC         |          0
       4 | CommunityAmerica Ballpark | Kansas City | KS         |          0
       5 | Gillette Stadium           | Foxborough  | MA         |      68756
(5 rows)
```

User-defined functions in Amazon Redshift

You can create a custom scalar user-defined function (UDF) using either a SQL SELECT clause or a Python program. The new function is stored in the database and is available for any user with sufficient privileges to run. You run a custom scalar UDF in much the same way as you run existing Amazon Redshift functions.

For Python UDFs, in addition to using the standard Python functionality, you can import your own custom Python modules. For more information, see Python language support for UDFs. Note that Python 3 isn't available for Python UDFs. To get Python 3 support for Amazon Redshift UDFs, use Scalar Lambda UDFs instead.

You can also create AWS Lambda UDFs that use custom functions defined in Lambda as part of your SQL queries. Lambda UDFs enable you to write complex UDFs and integrate with third-party components. They also can help you overcome some of the limitations of current Python and SQL UDFs. For example, they can help you access network and storage resources and write more full-fledged SQL statements. You can create Lambda UDFs in any of the programming languages supported by Lambda, such as Java, Go, PowerShell, Node.js, C#, Python, and Ruby. Or you can use a custom runtime.

By default, all users can run UDFs. For more information about privileges, see UDF security and permissions.

Topics

UDF security and permissions

To create a UDF, you must have permission for usage on language for SQL or plpythonu (Python). By default, USAGE ON LANGUAGE SQL is granted to PUBLIC, but you must explicitly grant USAGE ON LANGUAGE PLPYTHONU to specific users or groups.

To revoke usage for SQL, first revoke usage from PUBLIC. Then grant usage on SQL only to the specific users or groups permitted to create SQL UDFs. The following example revokes usage on SQL from PUBLIC. Then it grants usage to the user group `udf_devs`.

```
revoke usage on language sql from PUBLIC;
grant usage on language sql to group udf_devs;
```

To run a UDF, you must have permission to do so for each function. By default, permission to run new UDFs is granted to PUBLIC. To restrict usage, revoke this permission from PUBLIC for the function. Then grant the privilege to specific individuals or groups.

The following example revokes execution on function `f_py_greater` from PUBLIC. Then it grants usage to the user group `udf_devs`.

```
revoke execute on function f_py_greater(a float, b float) from PUBLIC;
grant execute on function f_py_greater(a float, b float) to group udf_devs;
```

Superusers have all privileges by default.

For more information, see GRANT and REVOKE.

Preventing UDF naming conflicts

You can avoid potential conflicts and unexpected results considering your UDF naming conventions before implementation. Because function names can be overloaded, they can collide with existing and future Amazon Redshift function names. This topic discusses overloading and presents a strategy for avoiding conflict.

Overloading function names

A function is identified by its name and *signature*, which is the number of input arguments and the data types of the arguments. Two functions in the same schema can have the same name if they have different signatures. In other words, the function names can be *overloaded*.

When you run a query, the query engine determines which function to call based on the number of arguments you provide and the data types of the arguments. You can use overloading to simulate functions with a variable number of arguments, up to the limit allowed by the CREATE FUNCTION command.

Avoiding conflict with built-in Amazon Redshift functions

We recommend that you name all UDFs using the prefix `f_`. Amazon Redshift reserves the `f_` prefix exclusively for UDFs and by prefixing your UDF names with `f_`, you ensure that your UDF name won't conflict with any existing or future Amazon Redshift built-in SQL function names. For example, by naming a new UDF `f_sum`, you avoid conflict with the Amazon Redshift SUM function. Similarly, if you name a new function `f_fibonacci`, you avoid conflict if Amazon Redshift adds a function named FIBONACCI in a future release.

You can create a UDF with the same name and signature as an existing Amazon Redshift built-in SQL function without the function name being overloaded if the UDF and the built-in function exist in different schemas. Because built-in functions exist in the system catalog schema, pg_catalog, you can create a UDF with the same name in another schema, such as public or a user-defined schema. In some cases, you might call a function that is not explicitly qualified with a schema name. If so, Amazon Redshift searches the pg_catalog schema first by default. Thus, a built-in function runs before a new UDF with the same name.

You can change this behavior by setting the search path to place pg_catalog at the end. If you do so, your UDFs take precedence over built-in functions, but the practice can cause unexpected results. Adopting a unique naming strategy, such as using the reserved prefix `f_`, is a more reliable practice. For more information, see SET and search_path.

Scalar SQL UDFs

A scalar SQL UDF incorporates a SQL SELECT clause that runs when the function is called and returns a single value. The CREATE FUNCTION command defines the following parameters:

- (Optional) Input arguments. Each argument must have a data type.
- One return data type.
- One SQL SELECT clause. In the SELECT clause, refer to the input arguments using $1, $2, and so on, according to the order of the arguments in the function definition.

The input and return data types can be any standard Amazon Redshift data type.

Don't include a FROM clause in your SELECT clause. Instead, include the FROM clause in the SQL statement that calls the SQL UDF.

The SELECT clause can't include any of the following types of clauses:

- FROM
- INTO
- WHERE
- GROUP BY
- ORDER BY
- LIMIT

Scalar SQL function example

The following example creates a function that compares two numbers and returns the larger value. For more information, see CREATE FUNCTION.

```
create function f_sql_greater (float, float)
  returns float
stable
as $$
  select case when $1 > $2 then $1
    else $2
  end
$$ language sql;
```

The following query calls the new f_sql_greater function to query the SALES table and return either COMMISSION or 20 percent of PRICEPAID, whichever is greater.

```
select f_sql_greater(commission, pricepaid*0.20) from sales;
```

Scalar Python UDFs

A scalar Python UDF incorporates a Python program that runs when the function is called and returns a single value. The CREATE FUNCTION command defines the following parameters:

- (Optional) Input arguments. Each argument must have a name and a data type.
- One return data type.
- One executable Python program.

The input and return data types for Python UDFs can be any of the following types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- REAL
- DOUBLE PRECISION
- BOOLEAN
- CHAR
- VARCHAR
- DATE
- TIMESTAMP
- ANYELEMENT

The aliases for these types are also valid. For a full list of data types and their aliases, see Data types.

When Python UDFs use the data type ANYELEMENT, Amazon Redshift automatically converts to a standard data type based on the arguments supplied at runtime. For more information, see ANYELEMENT data type.

When an Amazon Redshift query calls a scalar UDF, the following steps occur at runtime:

1. The function converts the input arguments to Python data types.

   For a mapping of Amazon Redshift data types to Python data types, see Python UDF data types.
2. The function runs the Python program, passing the converted input arguments.
3. The Python code returns a single value. The data type of the return value must correspond to the RETURNS data type specified by the function definition.
4. The function converts the Python return value to the specified Amazon Redshift data type, then returns that value to the query.

Note

Python 3 isn’t available for Python UDFs. To get Python 3 support for Amazon Redshift UDFs, use Scalar Lambda UDFs instead.

Scalar Python UDF example

The following example creates a function that compares two numbers and returns the larger value. Note that the indentation of the code between the double dollar signs ($$) is a Python requirement. For more information, see CREATE FUNCTION.

```
create function f_py_greater (a float, b float)
  returns float
stable
as $$
  if a > b:
    return a
  return b
$$ language plpythonu;
```

The following query calls the new `f_greater` function to query the SALES table and return either COMMISSION or 20 percent of PRICEPAID, whichever is greater.

```
select f_py_greater (commission, pricepaid*0.20) from sales;
```

Python UDF data types

Python UDFs can use any standard Amazon Redshift data type for the input arguments and the function's return value. In addition to the standard data types, UDFs support the data type *ANYELEMENT*, which Amazon Redshift automatically converts to a standard data type based on the arguments supplied at runtime. Scalar UDFs can return a data type of ANYELEMENT. For more information, see ANYELEMENT data type.

During execution, Amazon Redshift converts the arguments from Amazon Redshift data types to Python data types for processing. It then converts the return value from the Python data type to the corresponding Amazon Redshift data type. For more information about Amazon Redshift data types, see Data types.

The following table maps Amazon Redshift data types to Python data types.

Amazon Redshift data type	Python data type
smallint integer bigint short long	int
decimal or numeric	decimal
double real	float
boolean	bool
char varchar	string
timestamp	datetime

ANYELEMENT data type

ANYELEMENT is a *polymorphic data type*. This means that if a function is declared using ANYELEMENT for an argument's data type, the function can accept any standard Amazon Redshift data type as input for that argument when the function is called. The ANYELEMENT argument is set to the data type actually passed to it when the function is called.

If a function uses multiple ANYELEMENT data types, they must all resolve to the same actual data type when the function is called. All ANYELEMENT argument data types are set to the actual data type of the first argument passed to an ANYELEMENT. For example, a function declared as `f_equal(anyelement, anyelement)` will take any two input values, so long as they are of the same data type.

If the return value of a function is declared as ANYELEMENT, at least one input argument must be ANYELEMENT. The actual data type for the return value is the same as the actual data type supplied for the ANYELEMENT input argument.

Python language support for UDFs

You can create a custom UDF based on the Python programming language. The Python 2.7 standard library is available for use in UDFs, with the exception of the following modules:

- ScrolledText
- Tix
- Tkinter
- tk
- turtle
- smtpd

In addition to the Python Standard Library, the following modules are part of the Amazon Redshift implementation:

- numpy 1.8.2
- pandas 0.14.1
- python-dateutil 2.2
- pytz 2014.7
- scipy 0.12.1
- six 1.3.0
- wsgiref 0.1.2

You can also import your own custom Python modules and make them available for use in UDFs by executing a CREATE LIBRARY command. For more information, see Example: Importing custom Python library modules.

Important

Amazon Redshift blocks all network access and write access to the file system through UDFs.

> **Note**
>
> Python 3 isn’t available for Python UDFs. To get Python 3 support for Amazon Redshift UDFs, use Scalar Lambda UDFs instead.

Example: Importing custom Python library modules

You define scalar functions using Python language syntax. You can use the Python Standard Library modules and Amazon Redshift preinstalled modules. You can also create your own custom Python library modules and import the libraries into your clusters, or use existing libraries from Python or third parties.

You cannot create a library that contains a module with the same name as a Python Standard Library module or an Amazon Redshift preinstalled Python module. If an existing user-installed library uses the same Python package as a library you create, you must drop the existing library before installing the new library.

You must be a superuser or have `USAGE ON LANGUAGE plpythonu` privilege to install custom libraries; however, any user with sufficient privileges to create functions can use the installed libraries. You can query the PG_LIBRARY system catalog to view information about the libraries installed on your cluster.

Importing a custom Python module into your cluster

This section provides an example of importing a custom Python module into your cluster. To perform the steps in this section, you must have an Amazon S3 bucket, where you upload the library package. You then install the package in your cluster. For more information about creating buckets, go to Creating a bucket in the *Amazon Simple Storage Service User Guide*.

In this example, let's suppose that you create UDFs to work with positions and distances in your data. Connect to your Amazon Redshift cluster from a SQL client tool, and run the following commands to create the functions.

```
CREATE FUNCTION f_distance (x1 float, y1 float, x2 float, y2 float) RETURNS float
 IMMUTABLE as $$
    def distance(x1, y1, x2, y2):
        import math
        return math.sqrt((y2 - y1) ** 2 + (x2 - x1) ** 2)
```

```
    return distance(x1, y1, x2, y2)
$$ LANGUAGE plpythonu;

CREATE FUNCTION f_within_range (x1 float, y1 float, x2 float, y2 float) RETURNS bool
 IMMUTABLE as $$
    def distance(x1, y1, x2, y2):
        import math
        return math.sqrt((y2 - y1) ** 2 + (x2 - x1) ** 2)

    return distance(x1, y1, x2, y2) < 20
$$ LANGUAGE plpythonu;
```

Note that a few lines of code are duplicated in the previous functions. This duplication is necessary because a UDF cannot reference the contents of another UDF, and both functions require the same functionality. However, instead of duplicating code in multiple functions, you can create a custom library and configure your functions to use it.

To do so, first create the library package by following these steps:

1. Create a folder named **geometry**. This folder is the top level package of the library.
2. In the **geometry** folder, create a file named `__init__.py`. Note that the file name contains two double underscore characters. This file indicates to Python that the package can be initialized.
3. Also in the **geometry** folder, create a folder named **trig**. This folder is the subpackage of the library.
4. In the **trig** folder, create another file named `__init__.py` and a file named `line.py`. In this folder, `__init__.py` indicates to Python that the subpackage can be initialized and that `line.py` is the file that contains library code.

   Your folder and file structure should be the same as the following:

   ```
   geometry/
      __init__.py
      trig/
         __init__.py
         line.py
   ```

   For more information about package structure, go to Modules in the Python tutorial on the Python website.

5. The following code contains a class and member functions for the library. Copy and paste it into `line.py`.

```
class LineSegment:
  def __init__(self, x1, y1, x2, y2):
    self.x1 = x1
    self.y1 = y1
    self.x2 = x2
    self.y2 = y2
  def angle(self):
    import math
    return math.atan2(self.y2 - self.y1, self.x2 - self.x1)
  def distance(self):
    import math
    return math.sqrt((self.y2 - self.y1) ** 2 + (self.x2 - self.x1) ** 2)
```

After you have created the package, do the following to prepare the package and upload it to Amazon S3.

1. Compress the contents of the **geometry** folder into a .zip file named **geometry.zip**. Do not include the **geometry** folder itself; only include the contents of the folder as shown following:

```
geometry.zip
   __init__.py
   trig/
      __init__.py
      line.py
```

2. Upload **geometry.zip** to your Amazon S3 bucket.

> **Important**
>
> If the Amazon S3 bucket does not reside in the same region as your Amazon Redshift cluster, you must use the REGION option to specify the region in which the data is located. For more information, see CREATE LIBRARY.

3. From your SQL client tool, run the following command to install the library. Replace *<bucket_name>* with the name of your bucket, and replace *<access key id>* and *<secret*

key> with an access key and secret access key from your AWS Identity and Access Management (IAM) user credentials.

```
CREATE LIBRARY geometry LANGUAGE plpythonu FROM 's3://<bucket_name>/geometry.zip'
 CREDENTIALS 'aws_access_key_id=<access key id>;aws_secret_access_key=<secret key>';
```

After you install the library in your cluster, you need to configure your functions to use the library. To do this, run the following commands.

```
CREATE OR REPLACE FUNCTION f_distance (x1 float, y1 float, x2 float, y2 float) RETURNS
 float IMMUTABLE as $$
    from trig.line import LineSegment

    return LineSegment(x1, y1, x2, y2).distance()
$$ LANGUAGE plpythonu;

CREATE OR REPLACE FUNCTION f_within_range (x1 float, y1 float, x2 float, y2 float)
 RETURNS bool IMMUTABLE as $$
    from trig.line import LineSegment

    return LineSegment(x1, y1, x2, y2).distance() < 20
$$ LANGUAGE plpythonu;
```

In the preceding commands, `import trig/line` eliminates the duplicated code from the original functions in this section. You can reuse the functionality provided by this library in multiple UDFs. Note that to import the module, you only need to specify the path to the subpackage and module name (`trig/line`).

Python UDF constraints

Within the constraints listed in this topic, you can use UDFs anywhere you use the Amazon Redshift built-in scalar functions. For more information, see [SQL functions reference](#).

Amazon Redshift Python UDFs have the following constraints:

- Python UDFs cannot access the network or read or write to the file system.
- The total size of user-installed Python libraries cannot exceed 100 MB.
- Amazon Redshift can only run one Python UDF at a time for provisioned clusters using automatic workload management (WLM) and for serverless workgroups. If you try to run more than one

UDF concurrently, Amazon Redshift queues the remaining Python UDFs to run in the workload management queues. SQL UDFs don’t have a concurrency limit when using automatic WLM.

- When using manual WLM for provisioned clusters, the number of Python UDFs that can run concurrently per cluster is limited to one-fourth of the cluster’s total concurrency level. For example, a provisioned cluster with a concurrency of 15 can run a maximum of three concurrent Python UDFs.
- When using Python UDFs, Amazon Redshift doesn't support the SUPER and HLLSKETCH data types.

Logging errors and warnings in Python UDFs

You can use the Python logging module to create user-defined error and warning messages in your UDFs. Following query execution, you can query the SVL_UDF_LOG system view to retrieve logged messages.

> **Note**
>
> UDF logging consumes cluster resources and might affect system performance. We recommend implementing logging only for development and troubleshooting.

During query execution, the log handler writes messages to the SVL_UDF_LOG system view, along with the corresponding function name, node, and slice. The log handler writes one row to the SVL_UDF_LOG per message, per slice. Messages are truncated to 4096 bytes. The UDF log is limited to 500 rows per slice. When the log is full, the log handler discards older messages and adds a warning message to SVL_UDF_LOG.

> **Note**
>
> The Amazon Redshift UDF log handler escapes newlines (`\n`), pipe (`|`) characters, and backslash (`\`) characters with a backslash (`\`) character.

By default, the UDF log level is set to WARNING. Messages with a log level of WARNING, ERROR, and CRITICAL are logged. Messages with lower severity INFO, DEBUG, and NOTSET are ignored. To set the UDF log level, use the Python logger method. For example, the following sets the log level to INFO.

```
logger.setLevel(logging.INFO)
```

For more information about using the Python logging module, see [Logging facility for Python] in the Python documentation.

The following example creates a function named f_pyerror that imports the Python logging module, instantiates the logger, and logs an error.

```
CREATE OR REPLACE FUNCTION f_pyerror()
RETURNS INTEGER
VOLATILE AS
$$
import logging

logger = logging.getLogger()
logger.setLevel(logging.INFO)
logger.info('Your info message here')
return 0
$$ language plpythonu;
```

The following example queries SVL_UDF_LOG to view the message logged in the previous example.

```
select funcname, node, slice, trim(message) as message
from svl_udf_log;

  funcname   | query | node | slice |   message
------------+-------+------+-------+------------------
  f_pyerror | 12345 |     1|     1 | Your info message here
```

Scalar Lambda UDFs

Amazon Redshift can use custom functions defined in AWS Lambda as part of SQL queries. You can write scalar Lambda UDFs in any programming languages supported by Lambda, such as Java, Go, PowerShell, Node.js, C#, Python, and Ruby. Or you can use a custom runtime.

The CREATE EXTERNAL FUNCTION command creates the following parameters:

- (Optional) A list of arguments with data type.
- One return data type.
- One function name of the external function that is called by Amazon Redshift.

- One IAM role that the Amazon Redshift cluster is authorized to assume and call to Lambda.
- One Lambda function name that the Lambda UDF invokes.

For information about CREATE EXTERNAL FUNCTION, see CREATE EXTERNAL FUNCTION.

The input and return data types for Lambda UDFs can be any of the following types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- REAL
- DOUBLE PRECISION
- CHAR
- VARCHAR
- BOOLEAN
- DATE
- TIMESTAMP

The aliases for these types are also valid. For a full list of data types and their aliases, see Data types.

Amazon Redshift ensures that the external function can send and receive batched arguments and results.

Lambda UDFs are defined and managed in Lambda, and you can control the access privileges to invoke these UDFs in Amazon Redshift. You can invoke multiple Lambda functions in the same query or invoke the same function multiple times.

Use Lambda UDFs in any clauses of the SQL statements where scalar functions are supported. You can also use Lambda UDFs in any SQL statement such as SELECT, UPDATE, INSERT, or DELETE.

Note

Using Lambda UDFs can incur additional charges from the Lambda service. Whether it does so depends on factors such as the numbers of Lambda requests (UDF invocations) and the total duration of the Lambda program execution. However, there is no additional charge to use Lambda UDFs in Amazon Redshift. For information about AWS Lambda pricing, see [AWS Lambda Pricing](https://aws.amazon.com/lambda/pricing/).

The number of Lambda requests varies depending on the specific SQL statement clause where the Lambda UDF is used. For example, suppose the function is used in a WHERE clause such as the following.

`SELECT a, b FROM t1 WHERE lambda_multiply(a, b) = 64; SELECT a, b FROM t1 WHERE a*b = lambda_multiply(2, 32)`

In this case, Amazon Redshift calls the first SELECT statement for each and calls the second SELECT statement only once.

However, using a UDF in the projection part of the query might only invoke the Lambda function once for every qualified or aggregated row in the result set.

UDF security and permissions

To create a Lambda UDF, make sure that you have permissions for usage on the LANGUAGE EXFUNC. You must explicitly grant USAGE ON LANGUAGE EXFUNC or revoke USAGE ON LANGUAGE EXFUNC to specific users, groups, or public.

The following example grants usage on EXFUNC to PUBLIC.

```
grant usage on language exfunc to PUBLIC;
```

The following example revokes usage on exfunc from PUBLIC and then grants usage to the user group lambda_udf_devs.

```
revoke usage on language exfunc from PUBLIC;
grant usage on language exfunc to group lambda_udf_devs;
```

To run a Lambda UDF, make sure that you have permission for each function called. By default, permission to run new Lambda UDFs is granted to PUBLIC. To restrict usage, revoke this permission from PUBLIC for the function. Then, grant the privilege to specific users or groups.

The following example revokes execution on the function exfunc_sum from PUBLIC. Then, it grants usage to the user group lambda_udf_devs.

```
revoke execute on function exfunc_sum(int, int) from PUBLIC;
```

```
grant execute on function exfunc_sum(int, int) to group lambda_udf_devs;
```

Superusers have all privileges by default.

For more information about granting and revoking privileges, see GRANT and REVOKE.

Configuring the authorization parameter for Lambda UDFs

The CREATE EXTERNAL FUNCTION command requires authorization to invoke Lambda functions in AWS Lambda. To start authorization, specify an AWS Identity and Access Management (IAM) role when you run the CREATE EXTERNAL FUNCTION command. For more information about IAM roles, see IAM roles in the *IAM User Guide*.

If there is an existing IAM role with permissions to invoke Lambda functions attached to your cluster, then you can substitute your role Amazon Resource Name (ARN) in the IAM_ROLE parameter for the command. Following sections describe the steps for using an IAM role in the CREATE EXTERNAL FUNCTION command.

Creating an IAM role for Lambda

The IAM role requires permission to invoke Lambda functions. While creating the IAM role, provide the permission in one of the following ways:

- Attach the `AWSLambdaRole` policy on the **Attach permissions policy** page while creating an IAM role. The `AWSLambdaRole` policy grants permissions to invoke Lambda functions which is the minimal requirement. For more information and other policies, see Identity-based IAM policies for AWS Lambda in the *AWS Lambda Developer Guide*.
- Create your own custom policy to attach to your IAM role with the `lambda:InvokeFunction` permission of either all resources or a particular Lambda function with the ARN of that function. For more information on how to create a policy, see Creating IAM policies in the *IAM User Guide*.

  The following example policy enables invoking Lambda on a particular Lambda function.

  JSON

  ```
  {
      "Version": "2012-10-17",
      "Statement": [
          {
              "Sid": "Invoke",
  ```

```
                "Effect": "Allow",
                "Action": [
                    "lambda:InvokeFunction"
                ],
                "Resource": "arn:aws:lambda:us-west-2:123456789012:function:my-
function"
            }
        ]
}
```

For more information on resources for Lambda functions, see Resources and conditions for Lambda actions in the *IAM API Reference*.

After creating your custom policy with the required permissions, you can attach your policy to the IAM role on the **Attach permissions policy** page while creating an IAM role.

For steps to create an IAM role, see Authorizing Amazon Redshift to access other AWS services on your behalf in the *Amazon Redshift Management Guide*.

If you don't want to create a new IAM role, you can add the permissions mentioned previously to your existing IAM role.

Associating an IAM role with the cluster

Attach the IAM role to your cluster. You can add a role to a cluster or view the roles associated with a cluster by using the Amazon Redshift Management Console, CLI, or API. For more information, see Associating an IAM Role With a Cluster in the *Amazon Redshift Management Guide*.

Including the IAM role in the command

Include the IAM role ARN in the CREATE EXTERNAL FUNCTION command. When you create an IAM role, IAM returns an Amazon Resource Name (ARN) for the role. To specify an IAM role, provide the role ARN with the `IAM_ROLE` parameter. The following shows the syntax for the `IAM_ROLE` parameter.

```
IAM_ROLE 'arn:aws:iam::aws-account-id:role/role-name'
```

To invoke Lambda functions which reside in other accounts within the same Region, see Chaining IAM roles in Amazon Redshift.

Using the JSON interface between Amazon Redshift and AWS Lambda

Amazon Redshift uses a common interface for all Lambda functions that Amazon Redshift communicates to.

The following table shows the list of input fields that the designated Lambda functions that you can expect for the JSON payload.

Field name	Description	Value range
request_id	A universally unique identifier (UUID) that uniquely identifies each invoke request.	A valid UUID.
cluster	The full Amazon Resource Name (ARN) of the cluster.	A valid cluster ARN.
user	The name of the user that makes the call.	A valid user name.
database	The name of the database that the query is running on.	A valid database name.
external_function	The fully qualified name of the external function that makes the call.	A valid fully qualified function name.
query_id	The query ID of the query that is making the call.	A valid query ID.
num_records	The number of arguments in the payload.	A value of 1 - 2^64.

Field name	Description	Value range
arguments	The data payload in the specified format.	The data in array format must be a JSON array. Each element is a record that is an array if the number of arguments is larger than 1. By using an array, Amazon Redshift preserves the order of the records in the payload.

The order of the JSON array determines the order of batch processing. The Lambda function must process the arguments iteratively and produce the exact number of records. The following is an example of a payload.

```
{
  "request_id" : "23FF1F97-F28A-44AA-AB67-266ED976BF40",
  "cluster" : "arn:aws:redshift:xxxx",
  "user" : "adminuser",
  "database" : "db1",
  "external_function": "public.foo",
  "query_id" : 5678234,
  "num_records" : 4,
  "arguments" : [
     [ 1, 2 ],
     [ 3, null],
     null,
     [ 4, 6]
   ]
 }
```

The return output of the Lambda function contains the following fields.

Field name	Description	Value range
success	The indication of success or failure for the function.	A value of "`true`" or "`false`".
error_msg	The error message if the success value is "`false`" (if the	A valid message.

Field name	Description	Value range
	function fails); otherwise, this field is ignored.	
num_records	The number of records in the payload.	A value of 1 - 2^64.
results	The results of the call in the specified format.	N/A

The following is an example of the Lambda function output.

```
{
  "success": true,   // true indicates the call succeeded
  "error_msg" : "my function isn't working",  // shall only exist when success != true
  "num_records": 4,      // number of records in this payload
  "results" : [
     1,
     4,
     null,
     7
   ]
}
```

When you call Lambda functions from SQL queries, Amazon Redshift ensures the security of the connection with the following considerations:

- GRANT and REVOKE permissions. For more information about UDF security and permissions, see UDF security and permissions.
- Amazon Redshift only submits the minimum set of data to the designated Lambda function.
- Amazon Redshift only calls the designated Lambda function with the designated IAM role.

Use case examples for user-defined functions (UDFs)

> **Note**
>
> Starting November 1, 2025, Amazon Redshift will no longer support the creation of new Python UDFs. Existing Python UDFs will continue to function until June 30, 2026. Starting July 1, 2026, Amazon Redshift will no longer support Python UDFs. We recommend that you migrate your existing Python UDFs to Lambda UDFs before November 1, 2025. For information on creating and using Lambda UDFs, see Scalar Lambda UDFs. For information on converting existing Python UDFs to Lambda UDFs, see the blog post .

You can use user-defined functions to solve business problems by integrating Amazon Redshift with other components. Following are some examples of how others have used UDFs for their use cases:

- Accessing external components using Amazon Redshift Lambda UDFs – describes how Amazon Redshift Lambda UDFs work and walks through creating a Lambda UDF.
- Translate and analyze text using SQL functions with Amazon Redshift, Amazon Translate, and Amazon Comprehend – provides prebuilt Amazon Redshift Lambda UDFs that you can install with a few clicks to translate, redact, and analyze text fields.
- Access Amazon Location Service from Amazon Redshift – describes how to use Amazon Redshift Lambda UDFs to integrate with Amazon Location Service.
- Data Tokenization with Amazon Redshift and Protegrity – describes how to integrate Amazon Redshift Lambda UDFs with the Protegrity Serverless product.
- Amazon Redshift UDFs – a collection of Amazon Redshift SQL, Lambda, and Python UDFs.

Creating stored procedures in Amazon Redshift

This topic describes how to create and use stored procedures in Amazon Redshift. A stored procedure is a collection of SQL statements that multiple programs can use.

You can define an Amazon Redshift stored procedure using the PostgreSQL procedural language PL/pgSQL to perform a set of SQL queries and logical operations. The procedure is stored in the database and available for any user with sufficient database privileges.

Unlike a user-defined function (UDF), a stored procedure can incorporate data definition language (DDL) and data manipulation language (DML) in addition to SELECT queries. A stored procedure doesn't need to return a value. You can use procedural language, including looping and conditional expressions, to control logical flow.

For details about SQL commands to create and manage stored procedures, see the following command topics:

- CREATE PROCEDURE
- ALTER PROCEDURE
- DROP PROCEDURE
- SHOW PROCEDURE
- CALL
- GRANT
- REVOKE
- ALTER DEFAULT PRIVILEGES

Topics

- Overview of stored procedures in Amazon Redshift
- PL/pgSQL language reference

Overview of stored procedures in Amazon Redshift

This topic describes details about the purpose and use of stored procedures.

Stored procedures are commonly used to encapsulate logic for data transformation, data validation, and business-specific logic. By combining multiple SQL steps into a stored procedure, you can reduce round trips between your applications and the database.

For fine-grained access control, you can create stored procedures to perform functions without giving a user access to the underlying tables. For example, only the owner or a superuser can truncate a table, and a user needs write privileges to insert data into a table. Instead of granting a user privileges on the underlying tables, you can create a stored procedure that performs the task. You then give the user privileges to run the stored procedure.

A stored procedure with the DEFINER security attribute runs with the privileges of the stored procedure's owner. By default, a stored procedure has INVOKER security, which means the procedure uses the privileges of the user that calls the procedure.

To create a stored procedure, use the CREATE PROCEDURE command. To run a procedure, use the CALL command. Examples follow later in this section.

Note

Some clients might display the following error when creating an Amazon Redshift stored procedure.

```
ERROR: 42601: [Amazon](500310) unterminated dollar-quoted string at or near "$$
```

This error occurs due to the inability of the client to correctly parse the CREATE PROCEDURE statement with semicolons delimiting statements and with dollar sign ($) quoting. This results in only a part of the statement sent to the Amazon Redshift server. You can often work around this error by using the `Run as batch` or `Execute selected` option of the client.
For example, when using an Aginity client, use the `Run entire script as batch` option. When you use SQL Workbench/J, we recommend version 124. When you use SQL Workbench/J version 125, consider specifying an alternate delimiter as a workaround. CREATE PROCEDURE contains SQL statements delimited with a semicolon (;). Defining an alternate delimiter such as a slash (/) and placing it at the end of the CREATE PROCEDURE statement sends the statement to the Amazon Redshift server for processing. Following is an example.

```
CREATE OR REPLACE PROCEDURE test()
AS $$
```

```
BEGIN
  SELECT 1 a;
END;
$$
LANGUAGE plpgsql
;
/
```

You can use a client with support for parsing CREATE PROCEDURE statements, such as the query editor in the Amazon Redshift console or TablePlus.

Topics

- Naming stored procedures
- Security and privileges for stored procedures
- Returning a result set from a stored procedure
- Managing transactions
- Trapping errors
- Logging stored procedures
- Stored procedure limitations

The following example shows a procedure with no output arguments. By default, arguments are input (IN) arguments.

```
CREATE OR REPLACE PROCEDURE test_sp1(f1 int, f2 varchar)
AS $$
BEGIN
  RAISE INFO 'f1 = %, f2 = %', f1, f2;
END;
$$ LANGUAGE plpgsql;

call test_sp1(5, 'abc');
INFO: f1 = 5, f2 = abc
CALL
```

Note

When you write stored procedures, we recommend a best practice for securing sensitive values:

Don't hardcode any sensitive information in stored procedure logic. For example, don't assign a user password in a CREATE USER statement in the body of a stored procedure. This poses a security risk, because hardcoded values can be recorded as schema metadata in catalog tables. Instead, pass sensitive values, such as passwords, as arguments to the stored procedure, by means of parameters.

For more information about stored procedures, see CREATE PROCEDURE and Creating stored procedures in Amazon Redshift. For more information about catalog tables, see System catalog tables.

The following example shows a procedure with output arguments. Arguments are input (IN), input and output (INOUT), and output (OUT).

```
CREATE OR REPLACE PROCEDURE test_sp2(f1 IN int, f2 INOUT varchar(256), out_var OUT
 varchar(256))
AS $$
DECLARE
  loop_var int;
BEGIN
  IF f1 is null OR f2 is null THEN
    RAISE EXCEPTION 'input cannot be null';
  END IF;
  DROP TABLE if exists my_etl;
  CREATE TEMP TABLE my_etl(a int, b varchar);
    FOR loop_var IN 1..f1 LOOP
        insert into my_etl values (loop_var, f2);
        f2 := f2 || '+' || f2;
    END LOOP;
  SELECT INTO out_var count(*) from my_etl;
END;
$$ LANGUAGE plpgsql;


call test_sp2(2,'2019');

         f2          | column2
---------------------+---------
```

```
 2019+2019+2019+2019 | 2
(1 row)
```

Naming stored procedures

This topic describes details about stored procedure names.

If you define a procedure with the same name and different input argument data types or signature, you create a new procedure. As a result, the procedure name is overloaded. For more information, see Overloading procedure names. Amazon Redshift doesn't enable procedure overloading based on output arguments. You can't have two procedures with the same name and input argument data types but different output argument types.

The owner or a superuser can replace the body of a stored procedure with a new one with the same signature. To change the signature or return types of a stored procedure, drop the stored procedure and recreate it. For more information, see DROP PROCEDURE and CREATE PROCEDURE.

You can avoid potential conflicts and unexpected results by considering your naming conventions for stored procedures before implementing them. Because you can overload procedure names, they can collide with existing and future Amazon Redshift procedure names.

Overloading procedure names

A procedure is identified by its name and signature, which is the number of input arguments and the data types of the arguments. Two procedures in the same schema can have the same name if they have different signatures. In other words, you can overload procedure names.

When you run a procedure, the query engine determines which procedure to call based on the number of arguments that you provide and the data types of the arguments. You can use overloading to simulate procedures with a variable number of arguments, up to the limit allowed by the CREATE PROCEDURE command. For more information, see CREATE PROCEDURE.

Preventing naming conflicts

We recommend that you name all procedures using the prefix `sp_`. Amazon Redshift reserves the `sp_` prefix exclusively for stored procedures. By prefixing your procedure names with `sp_`, you make sure that your procedure name won't conflict with any existing or future Amazon Redshift procedure name.

Security and privileges for stored procedures

This topic describes the database credentials needed to create and run stored procedures.

By default, all users have privileges to create a procedure. To create a procedure, you must have USAGE privilege on the language PL/pgSQL, which is granted to PUBLIC by default. Only superusers and owners have the privilege to call a procedure by default. Superusers can run REVOKE USAGE on PL/pgSQL from a user if they want to prevent the user from creating a stored procedure.

To call a procedure, you must be granted EXECUTE privilege on the procedure. By default, EXECUTE privilege for new procedures is granted to the procedure owner and superusers. For more information, see GRANT.

The user creating a procedure is the owner by default. The owner has CREATE, DROP, and EXECUTE privileges on the procedure by default. Superusers have all privileges.

The SECURITY attribute controls a procedure's privileges to access database objects. When you create a stored procedure, you can set the SECURITY attribute to either DEFINER or INVOKER. This attribute determines which privileges are used when executing the statements in the body of the stored procedure. If you specify SECURITY INVOKER, the procedure uses the privileges of the user invoking the procedure. If you specify SECURITY DEFINER, the procedure uses the privileges of the owner of the procedure. INVOKER is the default.

Because a SECURITY DEFINER procedure runs with the privileges of the user that owns it, you must make sure that the procedure can't be misused. To make sure that SECURITY DEFINER procedures can't be misused, do the following:

- Grant EXECUTE on SECURITY DEFINER procedures to specific users, and not to PUBLIC.
- Qualify all database objects that the procedure must access with the schema names. For example, use `myschema.mytable` instead of just `mytable`.
- If you can't qualify an object name by its schema, set `search_path` when creating the procedure by using the SET option. Set `search_path` to exclude any schemas that are writable by untrusted users. This approach prevents any callers of this procedure from creating objects (for example, tables or views) that mask objects intended to be used by the procedure. For more information about the SET option, see CREATE PROCEDURE.

The following example sets `search_path` to `admin` to ensure that the `user_creds` table is accessed from the `admin` schema and not from public or any other schema in the caller's `search_path`.

```
CREATE OR REPLACE PROCEDURE sp_get_credentials(userid int, o_creds OUT varchar)
AS $$
BEGIN
  SELECT creds INTO o_creds
  FROM user_creds
  WHERE user_id = $1;
END;
$$ LANGUAGE plpgsql
SECURITY DEFINER
-- Set a secure search_path
SET search_path = admin;
```

Returning a result set from a stored procedure

This topic describes how stored procedures return data.

You can return a result set using a cursor or a temp table.

Returning a cursor

To return a cursor, create a procedure with an INOUT argument defined with a `refcursor` data type. When you call the procedure, give the cursor a name. Then you can fetch the results from the cursor by name.

The following example creates a procedure named `get_result_set` with an INOUT argument named `rs_out` using the `refcursor` data type. The procedure opens the cursor using a SELECT statement.

```
CREATE OR REPLACE PROCEDURE get_result_set (param IN integer, rs_out INOUT refcursor)
AS $$
BEGIN
  OPEN rs_out FOR SELECT * FROM fact_tbl where id >= param;
END;
$$ LANGUAGE plpgsql;
```

The following CALL command opens the cursor with the name `mycursor`. Use cursors only within transactions.

```
BEGIN;
CALL get_result_set(1, 'mycursor');
```

After the cursor is opened, you can fetch from the cursor, as the following example shows.

```
FETCH ALL FROM mycursor;

    id | secondary_id | name
-------+--------------+---------
     1 |            1 | Joe
     1 |            2 | Ed
     2 |            1 | Mary
     1 |            3 | Mike
(4 rows)
```

In the end, the transaction is either committed or rolled back.

```
COMMIT;
```

A cursor returned by a stored procedure is subject to the same constraints and performance considerations as described in DECLARE CURSOR. For more information, see Cursor constraints.

The following example shows the calling of the `get_result_set` stored procedure using a `refcursor` data type from JDBC. The literal `'mycursor'` (the name of the cursor) is passed to the `prepareStatement`. Then the results are fetched from the `ResultSet`.

```
static void refcursor_example(Connection conn) throws SQLException {
    conn.setAutoCommit(false);
    PreparedStatement proc = conn.prepareStatement("CALL get_result_set(1,
 'mycursor')");
    proc.execute();
    ResultSet rs = statement.executeQuery("fetch all from mycursor");
    while (rs.next()) {
      int n = rs.getInt(1);
      System.out.println("n " + n);
    }
```

Using a temp table

To return results, you can return a handle to a temp table containing result rows. The client can supply a name as a parameter to the stored procedure. Inside the stored procedure, dynamic SQL can be used to operate on the temp table. The following shows an example.

```
CREATE PROCEDURE get_result_set(param IN integer, tmp_name INOUT varchar(256)) as $$
DECLARE
  row record;
BEGIN
  EXECUTE 'drop table if exists ' || tmp_name;
  EXECUTE 'create temp table ' || tmp_name || ' as select * from fact_tbl where id <= '
 || param;
END;
$$ LANGUAGE plpgsql;

CALL get_result_set(2, 'myresult');
 tmp_name
-----------
 myresult
(1 row)

SELECT * from myresult;
 id | secondary_id | name
----+--------------+------
  1 |            1 | Joe
  2 |            1 | Mary
  1 |            2 | Ed
  1 |            3 | Mike
(4 rows)
```

Managing transactions

You can create a stored procedure with default transaction management behavior or nonatomic behavior.

Default mode stored procedure transaction management

The default transaction mode automatic commit behavior causes each SQL command that runs separately to commit individually. A call to a stored procedure is treated as a single SQL command. The SQL statements inside a procedure behave as if they are in a transaction block that implicitly begins when the call starts and ends when the call finishes. A nested call to another procedure is treated like any other SQL statement and operates within the context of the same transaction as the caller. For more information about automatic commit behavior, see Serializable isolation.

However, suppose that you call a stored procedure from within a user specified transaction block (defined by BEGIN...COMMIT). In this case, all statements in the stored procedure run in the context of the user-specified transaction. The procedure doesn't commit implicitly on exit. The caller controls the procedure commit or rollback.

If any error is encountered while running a stored procedure, all changes made in the current transaction are rolled back.

You can use the following transaction control statements in a stored procedure:

- COMMIT – commits all work done in the current transaction and implicitly begins a new transaction. For more information, see COMMIT.
- ROLLBACK – rolls back the work done in the current transaction and implicitly begins a new transaction. For more information, see ROLLBACK.

TRUNCATE is another statement that you can issue from within a stored procedure and influences transaction management. In Amazon Redshift, TRUNCATE issues a commit implicitly. This behavior stays the same in the context of stored procedures. When a TRUNCATE statement is issued from within a stored procedure, it commits the current transaction and begins a new one. For more information, see TRUNCATE.

All statements that follow a COMMIT, ROLLBACK, or TRUNCATE statement run in the context of a new transaction. They do so until a COMMIT, ROLLBACK, or TRUNCATE statement is encountered or the stored procedure exits.

When you use a COMMIT, ROLLBACK, or TRUNCATE statement from within a stored procedure, the following constraints apply:

- If the stored procedure is called from within a transaction block, it can't issue a COMMIT, ROLLBACK, or TRUNCATE statement. This restriction applies within the stored procedure's own body and within any nested procedure call.
- If the stored procedure is created with `SET config` options, it can't issue a COMMIT, ROLLBACK, or TRUNCATE statement. This restriction applies within the stored procedure's own body and within any nested procedure call.

- Any cursor that is open (explicitly or implicitly) is closed automatically when a COMMIT, ROLLBACK, or TRUNCATE statement is processed. For constraints on explicit and implicit cursors, see Stored procedure limitations.

Additionally, you can't run COMMIT or ROLLBACK using dynamic SQL. However, you can run TRUNCATE using dynamic SQL. For more information, see Dynamic SQL.

When working with stored procedures, consider that the BEGIN and END statements in PL/pgSQL are only for grouping. They don't start or end a transaction. For more information, see Block.

The following example demonstrates transaction behavior when calling a stored procedure from within an explicit transaction block. The two insert statements issued from outside the stored procedure and the one from within it are all part of the same transaction (3382). The transaction is committed when the user issues the explicit commit.

```
CREATE OR REPLACE PROCEDURE sp_insert_table_a(a int) LANGUAGE plpgsql
AS $$
BEGIN
  INSERT INTO test_table_a values (a);
END;
$$;

Begin;
  insert into test_table_a values (1);
  Call sp_insert_table_a(2);
  insert into test_table_a values (3);
Commit;

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  | pid |  type   |                stmt_text
--------+------+-----+---------+----------------------------------------
    103 | 3382 | 599 | UTILITY | Begin;
    103 | 3382 | 599 | QUERY   | insert into test_table_a values (1);
    103 | 3382 | 599 | UTILITY | Call sp_insert_table_a(2);
    103 | 3382 | 599 | QUERY   | INSERT INTO test_table_a values ( $1 )
    103 | 3382 | 599 | QUERY   | insert into test_table_a values (3);
    103 | 3382 | 599 | UTILITY | COMMIT
```

In contrast, take an example when the same statements are issued from outside of an explicit transaction block and the session has autocommit set to ON. In this case, each statement runs in its own transaction.

```
insert into test_table_a values (1);
Call sp_insert_table_a(2);
insert into test_table_a values (3);

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  | pid |  type   |
             stmt_text
--------+------+-----+---------
+------------------------------------------------------------------------------------------------------------------
    103 | 3388 | 599 | QUERY   | insert into test_table_a values (1);
    103 | 3388 | 599 | UTILITY | COMMIT
    103 | 3389 | 599 | UTILITY | Call sp_insert_table_a(2);
    103 | 3389 | 599 | QUERY   | INSERT INTO test_table_a values ( $1 )
    103 | 3389 | 599 | UTILITY | COMMIT
    103 | 3390 | 599 | QUERY   | insert into test_table_a values (3);
    103 | 3390 | 599 | UTILITY | COMMIT
```

The following example issues a TRUNCATE statement after inserting into `test_table_a`. The TRUNCATE statement issues an implicit commit that commits the current transaction (3335) and starts a new one (3336). The new transaction is committed when the procedure exits.

```
CREATE OR REPLACE PROCEDURE sp_truncate_proc(a int, b int) LANGUAGE plpgsql
AS $$
BEGIN
  INSERT INTO test_table_a values (a);
  TRUNCATE test_table_b;
  INSERT INTO test_table_b values (b);
END;
$$;

Call sp_truncate_proc(1,2);

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;
```

```
 userid | xid  |  pid  |  type   |
                                        stmt_text
--------+------+-------+---------
+---------------------------------------------------------------------------------
    103 | 3335 | 23636 | UTILITY | Call sp_truncate_proc(1,2);
    103 | 3335 | 23636 | QUERY   | INSERT INTO test_table_a values ( $1 )
    103 | 3335 | 23636 | UTILITY | TRUNCATE test_table_b
    103 | 3335 | 23636 | UTILITY | COMMIT
    103 | 3336 | 23636 | QUERY   | INSERT INTO test_table_b values ( $1 )
    103 | 3336 | 23636 | UTILITY | COMMIT
```

The following example issues a TRUNCATE from a nested call. The TRUNCATE commits all work done so far in the outer and inner procedures in a transaction (3344). It starts a new transaction (3345). The new transaction is committed when the outer procedure exits.

```
CREATE OR REPLACE PROCEDURE sp_inner(c int, d int) LANGUAGE plpgsql
AS $$
BEGIN
  INSERT INTO inner_table values (c);
  TRUNCATE outer_table;
  INSERT INTO inner_table values (d);
END;
$$;

CREATE OR REPLACE PROCEDURE sp_outer(a int, b int, c int, d int) LANGUAGE plpgsql
AS $$
BEGIN
  INSERT INTO outer_table values (a);
  Call sp_inner(c, d);
  INSERT INTO outer_table values (b);
END;
$$;

Call sp_outer(1, 2, 3, 4);

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  |  pid  |  type   |
                                         stmt_text
```

```
--------+------+-------+---------
+----------------------------------------------------------------------------------------------------
    103 | 3344 | 23636 | UTILITY | Call sp_outer(1, 2, 3, 4);
    103 | 3344 | 23636 | QUERY   | INSERT INTO outer_table values ( $1 )
    103 | 3344 | 23636 | UTILITY | CALL sp_inner( $1 , $2 )
    103 | 3344 | 23636 | QUERY   | INSERT INTO inner_table values ( $1 )
    103 | 3344 | 23636 | UTILITY | TRUNCATE outer_table
    103 | 3344 | 23636 | UTILITY | COMMIT
    103 | 3345 | 23636 | QUERY   | INSERT INTO inner_table values ( $1 )
    103 | 3345 | 23636 | QUERY   | INSERT INTO outer_table values ( $1 )
    103 | 3345 | 23636 | UTILITY | COMMIT
```

The following example shows that cursor `cur1` was closed when the TRUNCATE statement committed.

```
CREATE OR REPLACE PROCEDURE sp_open_cursor_truncate()
LANGUAGE plpgsql
AS $$
DECLARE
  rec RECORD;
  cur1 cursor for select * from test_table_a order by 1;
BEGIN
  open cur1;
  TRUNCATE table test_table_b;
  Loop
    fetch cur1 into rec;
    raise info '%', rec.c1;
    exit when not found;
  End Loop;
END
$$;

call sp_open_cursor_truncate();
ERROR: cursor "cur1" does not exist
CONTEXT: PL/pgSQL function "sp_open_cursor_truncate" line 8 at fetch
```

The following example issues a TRUNCATE statement and can't be called from within an explicit transaction block.

```
CREATE OR REPLACE PROCEDURE sp_truncate_atomic() LANGUAGE plpgsql
AS $$
BEGIN
```

```
  TRUNCATE test_table_b;
END;
$$;

Begin;
  Call sp_truncate_atomic();
ERROR: TRUNCATE cannot be invoked from a procedure that is executing in an atomic
 context.
HINT: Try calling the procedure as a top-level call i.e. not from within an explicit
 transaction block.
Or, if this procedure (or one of its ancestors in the call chain) was created with SET
 config options, recreate the procedure without them.
CONTEXT: SQL statement "TRUNCATE test_table_b"
PL/pgSQL function "sp_truncate_atomic" line 2 at SQL statement
```

The following example shows that a user who is not a superuser or the owner of a table can issue a TRUNCATE statement on the table. The user does this using a `Security Definer` stored procedure. The example shows the following actions:

- The user1 creates table `test_tbl`.
- The user1 creates stored procedure `sp_truncate_test_tbl`.
- The user1 grants `EXECUTE` privilege on the stored procedure to user2.
- The user2 runs the stored procedure to truncate table `test_tbl`. The example shows the row count before and after the `TRUNCATE` command.

```
set session_authorization to user1;
create table test_tbl(id int, name varchar(20));
insert into test_tbl values (1,'john'), (2, 'mary');
CREATE OR REPLACE PROCEDURE sp_truncate_test_tbl() LANGUAGE plpgsql
AS $$
DECLARE
  tbl_rows int;
BEGIN
  select count(*) into tbl_rows from test_tbl;
  RAISE INFO 'RowCount before Truncate: %', tbl_rows;
  TRUNCATE test_tbl;
  select count(*) into tbl_rows from test_tbl;
  RAISE INFO 'RowCount after Truncate: %', tbl_rows;
END;
$$ SECURITY DEFINER;
```

```
grant execute on procedure sp_truncate_test_tbl() to user2;
reset session_authorization;


set session_authorization to user2;
call sp_truncate_test_tbl();
INFO:  RowCount before Truncate: 2
INFO:  RowCount after Truncate: 0
CALL
reset session_authorization;
```

The following example issues COMMIT twice. The first COMMIT commits all work done in transaction 10363 and implicitly starts transaction 10364. Transaction 10364 is committed by the second COMMIT statement.

```
CREATE OR REPLACE PROCEDURE sp_commit(a int, b int) LANGUAGE plpgsql
AS $$
BEGIN
  INSERT INTO test_table values (a);
  COMMIT;
  INSERT INTO test_table values (b);
  COMMIT;
END;
$$;

call sp_commit(1,2);

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;
 userid |  xid  | pid  |  type   |
                               stmt_text
--------+-------+------+---------
+--------------------------------------------------------------------------------------------
    100 | 10363 | 3089 | UTILITY | call sp_commit(1,2);
    100 | 10363 | 3089 | QUERY   | INSERT INTO test_table values ( $1 )
    100 | 10363 | 3089 | UTILITY | COMMIT
    100 | 10364 | 3089 | QUERY   | INSERT INTO test_table values ( $1 )
    100 | 10364 | 3089 | UTILITY | COMMIT
```

The following example issues a ROLLBACK statement if `sum_vals` is greater than 2. The first ROLLBACK statement rolls back all the work done in transaction 10377 and starts a new transaction 10378. Transaction 10378 is committed when the procedure exits.

```
CREATE OR REPLACE PROCEDURE sp_rollback(a int, b int) LANGUAGE plpgsql
AS $$
DECLARE
  sum_vals int;
BEGIN
  INSERT INTO test_table values (a);
  SELECT sum(c1) into sum_vals from test_table;
  IF sum_vals > 2 THEN
    ROLLBACK;
  END IF;

  INSERT INTO test_table values (b);
END;
$$;

call sp_rollback(1, 2);

select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

userid |  xid  | pid  |  type   |
                              stmt_text
--------+-------+------+---------
+-----------------------------------------------------------------------------------------
    100 | 10377 | 3089 | UTILITY | call sp_rollback(1, 2);
    100 | 10377 | 3089 | QUERY   | INSERT INTO test_table values ( $1 )
    100 | 10377 | 3089 | QUERY   | SELECT sum(c1) from test_table
    100 | 10377 | 3089 | QUERY   | Undoing 1 transactions on table 133646 with current
 xid 10377 : 10377
    100 | 10378 | 3089 | QUERY   | INSERT INTO test_table values ( $1 )
    100 | 10378 | 3089 | UTILITY | COMMIT
```

Nonatomic mode stored procedure transaction management

A stored procedure created in NONATOMIC mode has different transaction control behavior from a procedure created in default mode. Similar to the automatic commit behavior of SQL commands outside stored procedures, each SQL statement inside a NONATOMIC procedure runs in its own transaction and commits automatically. If a user begins an explicit transaction block within a NONATOMIC stored procedure, then the SQL statements within the block do not automatically commit. The transaction block controls commit or rollback of statements within it.

In NONATOMIC stored procedures, you can open an explicit transaction block inside the procedure using the START TRANSACTION statement. However, if there is already an open transaction block, this statement will do nothing because Amazon Redshift does not support sub transactions. The previous transaction continues.

When you work with cursor FOR loops inside a NONATOMIC procedure, make sure you open an explicit transaction block before iterating through the results of a query. Otherwise, the cursor is closed when the SQL statement inside the loop is automatically committed.

Some of the considerations when using NONATOMIC mode behavior are as follows:

- Each SQL statement inside the stored procedure is automatically committed if there is no open transaction block, and the session has autocommit set to ON.
- You can issue a COMMIT/ROLLBACK/TRUNCATE statement to end the transaction if the stored procedure is called from within a transaction block. This is not possible in default mode.
- You can issue a START TRANSACTION statement to begin a transaction block inside the stored procedure.

The following examples demonstrate transaction behavior when working with NONATOMIC stored procedures. The session for all the following examples has autocommit set to ON.

In the following example, a NONATOMIC stored procedure has two INSERT statements. When the procedure is called outside of a transaction block, every INSERT statement within the procedure automatically commits.

```
CREATE TABLE test_table_a(v int);
CREATE TABLE test_table_b(v int);

CREATE OR REPLACE PROCEDURE sp_nonatomic_insert_table_a(a int, b int) NONATOMIC AS
$$
BEGIN
    INSERT INTO test_table_a values (a);
    INSERT INTO test_table_b values (b);
END;
$$
```

```
LANGUAGE plpgsql;

Call sp_nonatomic_insert_table_a(1,2);

Select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  |    pid     |  type   |               stmt_text
--------+------+------------+---------+----------------------------------------
      1 | 1792 | 1073807554 | UTILITY | Call sp_nonatomic_insert_table_a(1,2);
      1 | 1792 | 1073807554 | QUERY   | INSERT INTO test_table_a values ( $1 )
      1 | 1792 | 1073807554 | UTILITY | COMMIT
      1 | 1793 | 1073807554 | QUERY   | INSERT INTO test_table_b values ( $1 )
      1 | 1793 | 1073807554 | UTILITY | COMMIT
(5 rows)
```

However, when the procedure is called from within a BEGIN..COMMIT block, all the statements are part of the same transaction (xid=1799).

```
Begin;
  INSERT INTO test_table_a values (10);
  Call sp_nonatomic_insert_table_a(20,30);
  INSERT INTO test_table_b values (40);
Commit;

Select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  |    pid     |  type   |                stmt_text
--------+------+------------+---------+------------------------------------------
      1 | 1799 | 1073914035 | UTILITY | Begin;
      1 | 1799 | 1073914035 | QUERY   | INSERT INTO test_table_a values (10);
      1 | 1799 | 1073914035 | UTILITY | Call sp_nonatomic_insert_table_a(20,30);
      1 | 1799 | 1073914035 | QUERY   | INSERT INTO test_table_a values ( $1 )
      1 | 1799 | 1073914035 | QUERY   | INSERT INTO test_table_b values ( $1 )
      1 | 1799 | 1073914035 | QUERY   | INSERT INTO test_table_b values (40);
      1 | 1799 | 1073914035 | UTILITY | COMMIT
(7 rows)
```

In this example, two INSERT statements are between START TRANSACTION...COMMIT. When the procedure is called outside of a transaction block, the two INSERT statements are in the same transaction (xid=1866).

```
CREATE OR REPLACE PROCEDURE sp_nonatomic_txn_block(a int, b int) NONATOMIC AS
$$
BEGIN
    START TRANSACTION;
    INSERT INTO test_table_a values (a);
    INSERT INTO test_table_b values (b);
    COMMIT;
END;
$$
LANGUAGE plpgsql;

Call sp_nonatomic_txn_block(1,2);

Select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;

 userid | xid  |    pid     |  type   |               stmt_text
--------+------+------------+---------+----------------------------------------
      1 | 1865 | 1073823998 | UTILITY | Call sp_nonatomic_txn_block(1,2);
      1 | 1866 | 1073823998 | QUERY   | INSERT INTO test_table_a values ( $1 )
      1 | 1866 | 1073823998 | QUERY   | INSERT INTO test_table_b values ( $1 )
      1 | 1866 | 1073823998 | UTILITY | COMMIT
(4 rows)
```

When the procedure is called from within a BEGIN...COMMIT block, the START TRANSACTION inside the procedure does nothing because there is already an open transaction. The COMMIT inside the procedure commits the current transaction (xid=1876) and starts a new one.

```
Begin;
  INSERT INTO test_table_a values (10);
  Call sp_nonatomic_txn_block(20,30);
  INSERT INTO test_table_b values (40);
Commit;

Select userid, xid, pid, type, trim(text) as stmt_text
from svl_statementtext where pid = pg_backend_pid() order by xid , starttime ,
 sequence;
```

```
 userid | xid  |    pid     |  type   |                stmt_text
--------+------+------------+---------+----------------------------------------
      1 | 1876 | 1073832133 | UTILITY | Begin;
      1 | 1876 | 1073832133 | QUERY   | INSERT INTO test_table_a values (10);
      1 | 1876 | 1073832133 | UTILITY | Call sp_nonatomic_txn_block(20,30);
      1 | 1876 | 1073832133 | QUERY   | INSERT INTO test_table_a values ( $1 )
      1 | 1876 | 1073832133 | QUERY   | INSERT INTO test_table_b values ( $1 )
      1 | 1876 | 1073832133 | UTILITY | COMMIT
      1 | 1878 | 1073832133 | QUERY   | INSERT INTO test_table_b values (40);
      1 | 1878 | 1073832133 | UTILITY | COMMIT
(8 rows)
```

This example shows how to work with cursor loops. Table test_table_a has three values. The objective is to iterate through the three values and insert them into table test_table_b. If a NONATOMIC stored procedure is created in the following way, it will throw the error cursor "cur1" does not exist after executing INSERT statement in the first loop. This is because the auto commit of the INSERT closes the open cursor.

```
insert into test_table_a values (1), (2), (3);

CREATE OR REPLACE PROCEDURE sp_nonatomic_cursor() NONATOMIC
LANGUAGE plpgsql
AS $$
DECLARE
  rec RECORD;
  cur1 cursor for select * from test_table_a order by 1;
BEGIN
  open cur1;
  Loop
    fetch cur1 into rec;
    exit when not found;
    raise info '%', rec.v;
    insert into test_table_b values (rec.v);
  End Loop;
END
$$;

CALL sp_nonatomic_cursor();

INFO:  1
ERROR:  cursor "cur1" does not exist
```

```
CONTEXT:  PL/pgSQL function "sp_nonatomic_cursor" line 7 at fetch
```

To make the cursor loop work, put it between START TRANSACTION...COMMIT.

```
insert into test_table_a values (1), (2), (3);

CREATE OR REPLACE PROCEDURE sp_nonatomic_cursor() NONATOMIC
LANGUAGE plpgsql
AS $$
DECLARE
  rec RECORD;
  cur1 cursor for select * from test_table_a order by 1;
BEGIN
  START TRANSACTION;
  open cur1;
  Loop
    fetch cur1 into rec;
    exit when not found;
    raise info '%', rec.v;
    insert into test_table_b values (rec.v);
  End Loop;
  COMMIT;
END
$$;

CALL sp_nonatomic_cursor();

INFO:  1
INFO:  2
INFO:  3
CALL
```

Trapping errors

This topic describes how Amazon Redshift handles errors.

When a query or command in a stored procedure causes an error, subsequent queries don't run and the transaction is rolled back. But you can handle errors using an EXCEPTION block.

> **Note**
>
> The default behavior is that an error will cause subsequent queries not to run, even when there are no additional error-generating conditions in the stored procedure.

```
[ <<label>> ]
[ DECLARE
  declarations ]
BEGIN
  statements
EXCEPTION
  WHEN OTHERS THEN
    statements
END;
```

When an exception occurs, and you add an exception-handling block, you can write RAISE statements and most other PL/pgSQL statements. For example, you can raise an exception with a custom message or insert a record into a logging table.

When entering the exception-handling block, the current transaction is rolled back and a new transaction is created to run the statements in the block. If the statements in the block run without error, the transaction is committed and the exception is re-thrown. Lastly, the stored procedure exits.

The only supported condition in an exception block is OTHERS, which matches every error type except query cancellation. Also, if an error occurs in an exception-handling block, it can be caught by an outer exception-handling block.

When an error occurs inside the NONATOMIC procedure, the error is not re-thrown if it is handled by an exception block. See the PL/pgSQL statement `RAISE` to throw an exception caught by the exception handling block. This statement is only valid in exception handling blocks. For more information see RAISE.

Controlling what happens after an error in a stored procedure, with the CONTINUE handler

The `CONTINUE` handler is a type of exception handler that controls the flow of execution within a NONATOMIC stored procedure. By using it, you can catch and handle exceptions without ending the existing statement block. Normally, when an error occurs in a stored procedure, the flow is interrupted and the error is returned to the caller. However, in some use cases, the error condition isn't severe enough to warrant interrupting the flow. You might want to handle the error gracefully, using error-handling logic of your choosing in a seperate transaction, and then continue running statements that follow the error. The following shows the syntax.

```
[ DECLARE
  declarations ]
BEGIN
  statements
EXCEPTION
  [ CONTINUE_HANDLER | EXIT_HANDLER ] WHEN OTHERS THEN
    handler_statements
END;
```

There are several system tables available to help you gather information about various types of errors. For more information, see STL_LOAD_ERRORS, STL_ERROR, and SYS_STREAM_SCAN_ERRORS. There are also additional system tables you can use to troubleshoot errors. More information about these can be found at System tables and views reference.

Example

The following example shows how to write statements in the exception-handling block. The stored procedure is using default transaction management behavior.

```
CREATE TABLE employee (firstname varchar, lastname varchar);
INSERT INTO employee VALUES ('Tomas','Smith');
CREATE TABLE employee_error_log (message varchar);

CREATE OR REPLACE PROCEDURE update_employee_sp() AS
$$
BEGIN
    UPDATE employee SET firstname = 'Adam' WHERE lastname = 'Smith';
    EXECUTE 'select invalid';
EXCEPTION WHEN OTHERS THEN
    RAISE INFO 'An exception occurred.';
    INSERT INTO employee_error_log VALUES ('Error message: ' || SQLERRM);
END;
$$
LANGUAGE plpgsql;

CALL update_employee_sp();

INFO:  An exception occurred.
```

```
ERROR:  column "invalid" does not exist
CONTEXT:  SQL statement "select invalid"
PL/pgSQL function "update_employee_sp" line 3 at execute statement
```

In this example, if we call `update_employee_sp`, the informational message *An exception occurred.* is raised and the error message is inserted in the logging table's `employee_error_log` log. The original exception is thrown again before the stored procedure exits. The following queries show records that result from running the example.

```
SELECT * from employee;

firstname | lastname
-----------+----------
 Tomas     | Smith

SELECT * from employee_error_log;

          message
------------------------------------------------
 Error message: column "invalid" does not exist
```

For more information about RAISE, including formatting help and a list of additional levels, see [Supported PL/pgSQL statements](https://docs.aws.amazon.com/redshift/latest/dg/c_PLpgSQL-statements.html).

The following example shows how to write statements in the exception-handling block. The stored procedure is using NONATOMIC transaction management behavior. In this example, there is no error thrown back to caller after the procedure call completes. The UPDATE statement is not rolled back due to the error in the next statement. The informational message is raised and the error message is inserted in the logging table.

```
CREATE TABLE employee (firstname varchar, lastname varchar);
INSERT INTO employee VALUES ('Tomas','Smith');
CREATE TABLE employee_error_log (message varchar);

-- Create the SP in NONATOMIC mode
CREATE OR REPLACE PROCEDURE update_employee_sp_2() NONATOMIC AS
$$
BEGIN
    UPDATE employee SET firstname = 'Adam' WHERE lastname = 'Smith';
    EXECUTE 'select invalid';
EXCEPTION WHEN OTHERS THEN
```

```
    RAISE INFO 'An exception occurred.';
    INSERT INTO employee_error_log VALUES ('Error message: ' || SQLERRM);
END;
$$
LANGUAGE plpgsql;

CALL update_employee_sp_2();
INFO:  An exception occurred.
CALL

SELECT * from employee;

 firstname | lastname
-----------+----------
 Adam      | Smith
(1 row)

SELECT * from employee_error_log;

                    message
------------------------------------------------
 Error message: column "invalid" does not exist
(1 row)
```

This example shows how to create a procedure with two sub blocks. When the stored procedure is called, the error from the first sub block is handled by its exception handling block. After the first sub block completes, the procedure continues to execute the second sub block. You can see from the result that no error is thrown when the procedure call completes. The UPDATE and INSERT operations on table employee are committed. Error messages from both exception blocks are inserted in the logging table.

```
CREATE TABLE employee (firstname varchar, lastname varchar);
INSERT INTO employee VALUES ('Tomas','Smith');
CREATE TABLE employee_error_log (message varchar);

CREATE OR REPLACE PROCEDURE update_employee_sp_3() NONATOMIC AS
$$
BEGIN
    BEGIN
        UPDATE employee SET firstname = 'Adam' WHERE lastname = 'Smith';
        EXECUTE 'select invalid1';
    EXCEPTION WHEN OTHERS THEN
```

```
        RAISE INFO 'An exception occurred in the first block.';
        INSERT INTO employee_error_log VALUES ('Error message: ' || SQLERRM);
    END;
    BEGIN
        INSERT INTO employee VALUES ('Edie','Robertson');
        EXECUTE 'select invalid2';
    EXCEPTION WHEN OTHERS THEN
        RAISE INFO 'An exception occurred in the second block.';
        INSERT INTO employee_error_log VALUES ('Error message: ' || SQLERRM);
    END;
END;
$$
LANGUAGE plpgsql;

CALL update_employee_sp_3();
INFO:  An exception occurred in the first block.
INFO:  An exception occurred in the second block.
CALL

SELECT * from employee;

 firstname | lastname
-----------+-----------
 Adam      | Smith
 Edie      | Robertson
(2 rows)

SELECT * from employee_error_log;

                     message
-------------------------------------------------
 Error message: column "invalid1" does not exist
 Error message: column "invalid2" does not exist
(2 rows)
```

The following example shows how to use the CONTINUE exception handler. This sample creates two tables and uses them in a stored procedure. The CONTINUE handler controls the flow of execution in a stored procedure with NONATOMIC transaction-management behavior.

```
CREATE TABLE tbl_1 (a int);
CREATE TABLE tbl_error_logging(info varchar, err_state varchar, err_msg varchar);

CREATE OR REPLACE PROCEDURE sp_exc_handling_1() NONATOMIC AS
```

```
$$
BEGIN
    INSERT INTO tbl_1 VALUES (1);
    -- Expect an error for the insert statement following, because of the invalid value
    INSERT INTO tbl_1 VALUES ("val");
    INSERT INTO tbl_1 VALUES (2);
EXCEPTION CONTINUE_HANDLER WHEN OTHERS THEN
    INSERT INTO tbl_error_logging VALUES ('Encountered error', SQLSTATE, SQLERRM);
END;
$$ LANGUAGE plpgsql;
```

Call the stored procedure:

```
CALL sp_exc_handling_1();
```

Flow proceeds like so:

1. An error occurs because an attempt is made to insert an incompatible data type in a column. Control passes to the EXCEPTION block. When the exception-handling block is entered, the current transaction is rolled back and a new implicit transaction is created to run the statements in it.
2. If the statements in CONTINUE_HANDLER run without error, control passes to the statement immediately following the statement causing the exception. (If a statement in CONTINUE_HANDLER raises a new exception, you can handle it with an exception handler within the EXCEPTION block.)

After you call the sample stored procedure, the tables contain the following records:

- If you run `SELECT * FROM tbl_1;`, it returns two records. These contain the values 1 and 2.
- If you run `SELECT * FROM tbl_error_logging;`, it returns one record with these values: *Encountered error*, *42703*, and *column "val" does not exist in tbl_1*.

The following additional error-handling example uses both an EXIT handler and a CONTINUE handler. It creates two tables: a data table and a logging table. It also creates a stored procedure that demonstrates error handling:

```
CREATE TABLE tbl_1 (a int);
CREATE TABLE tbl_error_logging(info varchar, err_state varchar, err_msg varchar);
```

```
CREATE OR REPLACE PROCEDURE sp_exc_handling_2() NONATOMIC AS
$$
BEGIN
    INSERT INTO tbl_1 VALUES (1);
    BEGIN
        INSERT INTO tbl_1 VALUES (100);
        -- Expect an error for the insert statement following, because of the invalid
 value
        INSERT INTO tbl_1 VALUES ("val");
        INSERT INTO tbl_1 VALUES (101);
    EXCEPTION EXIT_HANDLER WHEN OTHERS THEN
        INSERT INTO tbl_error_logging VALUES ('Encountered error', SQLSTATE, SQLERRM);
    END;
    INSERT INTO tbl_1 VALUES (2);
    -- Expect an error for the insert statement following, because of the invalid value
    INSERT INTO tbl_1 VALUES ("val");
    INSERT INTO tbl_1 VALUES (3);
EXCEPTION CONTINUE_HANDLER WHEN OTHERS THEN
    INSERT INTO tbl_error_logging VALUES ('Encountered error', SQLSTATE, SQLERRM);
END;
$$ LANGUAGE plpgsql;
```

After you create the stored procedure, call it with the following:

```
CALL sp_exc_handling_2();
```

When an error occurs in the inner exception block, which is bracketed by the inner set of BEGIN and END, it's handled by the EXIT handler. Any errors that occur in the outer block are handled by the CONTINUE handler.

After you call the sample stored procedure, the tables contain the following records:

- If you run `SELECT * FROM tbl_1;`, it returns four records, with the values 1, 2, 3, and 100.
- If you run `SELECT * FROM tbl_error_logging;`, it returns two records. They have these values: *Encountered error*, *42703*, and *column "val" does not exist in tbl_1*.

If the table **tbl_error_logging** doesn't exist, it raises an exception.

The following example shows how to use the CONTINUE exception handler with the FOR loop. This sample creates three tables and uses them in a FOR loop within a stored procedure. The FOR loop is result set variant, meaning that it iterates over the results of a query:

```
CREATE TABLE tbl_1 (a int);
INSERT INTO tbl_1 VALUES (1), (2), (3);
CREATE TABLE tbl_2 (a int);
CREATE TABLE tbl_error_logging(info varchar, err_state varchar, err_msg varchar);

CREATE OR REPLACE PROCEDURE sp_exc_handling_loop() NONATOMIC AS
$$
DECLARE
 rec RECORD;
BEGIN
    FOR rec IN SELECT a FROM tbl_1
    LOOP
        IF rec.a = 2 THEN
            -- Expect an error for the insert statement following, because of the
 invalid value
            INSERT INTO tbl_2 VALUES("val");
        ELSE
            INSERT INTO tbl_2 VALUES (rec.a);
        END IF;
    END LOOP;
EXCEPTION CONTINUE_HANDLER WHEN OTHERS THEN
    INSERT INTO tbl_error_logging VALUES ('Encountered error', SQLSTATE, SQLERRM);
END;
$$ LANGUAGE plpgsql;
```

Call the stored procedure:

```
CALL sp_exc_handling_loop();
```

After you call the sample stored procedure, the tables contain the following records:

- If you run `SELECT * FROM tbl_2;`, it returns two records. These contain the values 1 and 3.
- If you run `SELECT * FROM tbl_error_logging;`, it returns one record with these values: *Encountered error*, *42703*, and *column "val" does not exist in tbl_2*.

Usage notes regarding the CONTINUE handler:

- CONTINUE_HANDLER and EXIT_HANDLER keywords can be used only in NONATOMIC stored procedures.
- CONTINUE_HANDLER and EXIT_HANDLER keywords are optional. EXIT_HANDLER is the default.

Logging stored procedures

This topic describes the stored procedures and views that Amazon Redshift uses for stored procedure logging.

Details about stored procedures are logged in the following system tables and views:

- SVL_STORED_PROC_CALL – details are logged about the stored procedure call's start time and end time, and whether the call is ended before completion. For more information, see SVL_STORED_PROC_CALL.
- SVL_STORED_PROC_MESSAGES – messages in stored procedures emitted by the RAISE query are logged with the corresponding logging level. For more information, see SVL_STORED_PROC_MESSAGES.
- SVL_QLOG – the query ID of the procedure call is logged for each query called from a stored procedure. For more information, see SVL_QLOG.
- STL_UTILITYTEXT – stored procedure calls are logged after they are completed. For more information, see STL_UTILITYTEXT.
- PG_PROC_INFO – this system catalog view shows information about stored procedures. For more information, see PG_PROC_INFO.

Stored procedure limitations

This topic describes limitations for Amazon Redshift stored procedures.

The following considerations apply when you use Amazon Redshift stored procedures.

Differences between Amazon Redshift and PostgreSQL for stored procedure support

The following are differences between stored procedure support in Amazon Redshift and PostgreSQL:

- Amazon Redshift doesn't support subtransactions, and hence has limited support for exception handling blocks.

Considerations and limits

The following are considerations on stored procedures in Amazon Redshift:

- The maximum number of stored procedures for a database is 10,000.
- The maximum size of the source code for a procedure is 2 MB.
- The maximum number of explicit and implicit cursors that you can open concurrently in a user session is one. FOR loops that iterate over the result set of a SQL statement open implicit cursors. Nested cursors aren't supported.
- Explicit and implicit cursors have the same restrictions on the result set size as standard Amazon Redshift cursors. For more information, see Cursor constraints.
- The maximum number of levels for nested calls is 16.
- The maximum number of procedure parameters is 32 for input arguments and 32 for output arguments.
- The maximum number of variables in a stored procedure is 1,024.
- Any SQL command that requires its own transaction context isn't supported inside a stored procedure. Examples include:
  - PREPARE
  - CREATE/DROP DATABASE
  - CREATE EXTERNAL TABLE
  - VACUUM
  - SET LOCAL
  - ALTER TABLE APPEND
- The `registerOutParameter` method call through the Java Database Connectivity (JDBC) driver isn't supported for the `refcursor` data type. For an example of using the `refcursor` data type, see Returning a result set from a stored procedure.

PL/pgSQL language reference

Stored procedures in Amazon Redshift are based on the PostgreSQL PL/pgSQL procedural language, with some important differences. In this reference, you can find details of PL/pgSQL syntax as implemented by Amazon Redshift. For more information about PL/pgSQL, see PL/pgSQL - SQL procedural language in the PostgreSQL documentation.

Topics

- PL/pgSQL reference conventions
- Structure of PL/pgSQL

- Supported PL/pgSQL statements

PL/pgSQL reference conventions

In this section, you can find the conventions that are used to write the syntax for the PL/pgSQL stored procedure language.

Character	Description
CAPS	Words in capital letters are keywords.
[ ]	Brackets denote optional arguments. Multiple arguments in brackets indicate that you can choose any number of the arguments. In addition, arguments in brackets on separate lines indicate that the Amazon Redshift parser expects the arguments to be in the order that they are listed in the syntax.
{ }	Braces indicate that you are required to choose one of the arguments inside the braces.
|	Pipes indicate that you can choose between the arguments.
red italics	Words in red italics indicate placeholders. Insert the appropriate value in place of the word in red italics.
...	An ellipsis indicates that you can repeat the preceding element.
'	Words in single quotation marks indicate that you must type the quotes.

Structure of PL/pgSQL

PL/pgSQL is a procedural language with many of the same constructs as other procedural languages.

Topics

- Block
- Variable declaration

Block

PL/pgSQL is a block-structured language. The complete body of a procedure is defined in a block, which contains variable declarations and PL/pgSQL statements. A statement can also be a nested block, or subblock.

End declarations and statements with a semicolon. Follow the END keyword in a block or subblock with a semicolon. Don't use semicolons after the keywords DECLARE and BEGIN.

You can write all keywords and identifiers in mixed uppercase and lowercase. Identifiers are implicitly converted to lowercase unless enclosed in double quotation marks.

A double hyphen (--) starts a comment that extends to the end of the line. A /* starts a block comment that extends to the next occurrence of */. You can't nest block comments. However, you can enclose double-hyphen comments in a block comment, and a double hyphen can hide the block comment delimiters /* and */.

Any statement in the statement section of a block can be a subblock. You can use subblocks for logical grouping or to localize variables to a small group of statements.

```
[ <<label>> ]
[ DECLARE
  declarations ]
BEGIN
  statements
END [ label ];
```

The variables declared in the declarations section preceding a block are initialized to their default values every time the block is entered. In other words, they're not initialized only once per function call.

The following shows an example.

```
CREATE PROCEDURE update_value() AS $$
```

```
DECLARE
  value integer := 20;
BEGIN
  RAISE NOTICE 'Value here is %', value;  -- Value here is 20
  value := 50;
  --
  -- Create a subblock
  --
  DECLARE
    value integer := 80;
  BEGIN
    RAISE NOTICE 'Value here is %', value;  -- Value here is 80
  END;

  RAISE NOTICE 'Value here is %', value;  -- Value here is 50
END;
$$ LANGUAGE plpgsql;
```

Use a label to identify the block to use in an EXIT statement or to qualify the names of the variables declared in the block.

Don't confuse the use of BEGIN/END for grouping statements in PL/pgSQL with the database commands for transaction control. The BEGIN and END in PL/pgSQL are only for grouping. They don't start or end a transaction.

Variable declaration

Declare all variables in a block, except for loop variables, in the block's DECLARE section. Variables can use any valid Amazon Redshift data type. For supported data types, see Data types.

PL/pgSQL variables can be any Amazon Redshift supported data type, plus RECORD and `refcursor`. For more information about RECORD, see Record types. For more information about `refcursor`, see Cursors.

```
DECLARE
name [ CONSTANT ] type [ NOT NULL ] [ { DEFAULT | := } expression ];
```

Following, you can find example variable declarations.

```
customerID integer;
numberofitems numeric(6);
```

```
link varchar;
onerow RECORD;
```

The loop variable of a FOR loop iterating over a range of integers is automatically declared as an integer variable.

The DEFAULT clause, if given, specifies the initial value assigned to the variable when the block is entered. If the DEFAULT clause is not given, then the variable is initialized to the SQL NULL value. The CONSTANT option prevents the variable from being assigned to, so that its value remains constant for the duration of the block. If NOT NULL is specified, an assignment of a null value results in a runtime error. All variables declared as NOT NULL must have a non-null default value specified.

The default value is evaluated every time the block is entered. For example, assigning `now()` to a variable of type `timestamp` causes the variable to have the time of the current function call, not the time when the function was precompiled.

```
quantity INTEGER DEFAULT 32;
url VARCHAR := 'http://mysite.com';
user_id CONSTANT INTEGER := 10;
```

The `refcursor` data type is the data type of cursor variables within stored procedures. A `refcursor` value can be returned from within a stored procedure. For more information, see [Returning a result set from a stored procedure](#).

Alias declaration

If stored procedure's signature omits the argument name, you can declare an alias for the argument.

```
name ALIAS FOR $n;
```

Built-in variables

The following built-in variables are supported:

- FOUND
- SQLSTATE

- SQLERRM
- GET DIAGNOSTICS integer_var := ROW_COUNT;

FOUND is a special variable of type Boolean. FOUND starts out false within each procedure call. FOUND is set by the following types of statements:

- SELECT INTO

  Sets FOUND to true if it returns a row, false if no row is returned.
- UPDATE, INSERT, and DELETE

  Sets FOUND to true if at least one row is affected, false if no row is affected.
- FETCH

  Sets FOUND to true if it returns a row, false if no row is returned.
- FOR statement

  Sets FOUND to true if the FOR statement iterates one or more times, and otherwise false. This applies to all three variants of the FOR statement: integer FOR loops, record-set FOR loops, and dynamic record-set FOR loops.

  FOUND is set when the FOR loop exits. Inside the runtime of the loop, FOUND isn't modified by the FOR statement. However, it can be changed by running other statements within the loop body.

The following shows an example.

```
CREATE TABLE employee(empname varchar);
CREATE OR REPLACE PROCEDURE show_found()
AS  $$
DECLARE
  myrec record;
BEGIN
  SELECT INTO myrec * FROM employee WHERE empname = 'John';
  IF NOT FOUND THEN
    RAISE EXCEPTION 'employee John not found';
  END IF;
END;
$$ LANGUAGE plpgsql;
```

Within an exception handler, the special variable SQLSTATE contains the error code that corresponds to the exception that was raised. The special variable SQLERRM contains the error message associated with the exception. These variables are undefined outside exception handlers and display an error if used.

The following shows an example.

```
CREATE OR REPLACE PROCEDURE sqlstate_sqlerrm() AS
$$
BEGIN
  UPDATE employee SET firstname = 'Adam' WHERE lastname = 'Smith';
  EXECUTE 'select invalid';
  EXCEPTION WHEN OTHERS THEN
  RAISE INFO 'error message SQLERRM %', SQLERRM;
  RAISE INFO 'error message SQLSTATE %', SQLSTATE;
END;
$$ LANGUAGE plpgsql;
```

ROW_COUNT is used with the GET DIAGNOSTICS command. It shows the number of rows processed by the last SQL command sent down to the SQL engine.

The following shows an example.

```
CREATE OR REPLACE PROCEDURE sp_row_count() AS
$$
DECLARE
  integer_var int;
BEGIN
  INSERT INTO tbl_row_count VALUES(1);
  GET DIAGNOSTICS integer_var := ROW_COUNT;
  RAISE INFO 'rows inserted = %', integer_var;
END;
$$ LANGUAGE plpgsql;
```

Record types

A RECORD type is not a true data type, only a placeholder. Record type variables assume the actual row structure of the row that they are assigned during a SELECT or FOR command. The substructure of a record variable can change each time it is assigned a value. Until a record variable is first assigned to, it has no substructure. Any attempt to access a field in it throws a runtime error.

```
name RECORD;
```

The following shows an example.

```
CREATE TABLE tbl_record(a int, b int);
INSERT INTO tbl_record VALUES(1, 2);
CREATE OR REPLACE PROCEDURE record_example()
LANGUAGE plpgsql
AS $$
DECLARE
  rec RECORD;
BEGIN
  FOR rec IN SELECT a FROM tbl_record
  LOOP
    RAISE INFO 'a = %', rec.a;
  END LOOP;
END;
$$;
```

Supported PL/pgSQL statements

PL/pgSQL statements augment SQL commands with procedural constructs, including looping and conditional expressions, to control logical flow. Most SQL commands can be used, including data manipulation language (DML) such as COPY, UNLOAD, and INSERT, and data definition language (DDL) such as CREATE TABLE. For a list of comprehensive SQL commands, see SQL commands. In addition, the following PL/pgSQL statements are supported by Amazon Redshift.

Topics

- Assignment
- SELECT INTO
- No-op
- Dynamic SQL
- Return
- Conditionals: IF
- Conditionals: CASE
- Loops
- Cursors

- RAISE
- Transaction control

Assignment

The assignment statement assigns a value to a variable. The expression must return a single value.

```
identifier := expression;
```

Using the nonstandard = for assignment, instead of `:=`, is also accepted.

If the data type of the expression doesn't match the variable's data type or the variable has a size or precision, the result value is implicitly converted.

The following shows examples.

```
customer_number := 20;
tip := subtotal * 0.15;
```

SELECT INTO

The SELECT INTO statement assigns the result of multiple columns (but only one row) into a record variable or list of scalar variables.

```
SELECT INTO target select_expressions FROM ...;
```

In the preceding syntax, *target* can be a record variable or a comma-separated list of simple variables and record fields. The *select_expressions* list and the remainder of the command are the same as in regular SQL.

If a variable list is used as *target*, the selected values must exactly match the structure of the target, or a runtime error occurs. When a record variable is the target, it automatically configures itself to the row type of the query result columns.

The INTO clause can appear almost anywhere in the SELECT statement. It usually appears just after the SELECT clause, or just before FROM clause. That is, it appears just before or just after the *select_expressions* list.

If the query returns zero rows, NULL values are assigned to *target*. If the query returns multiple rows, the first row is assigned to *target* and the rest are discarded. Unless the statement contains an ORDER BY, the first row is not deterministic.

To determine whether the assignment returned at least one row, use the special FOUND variable.

```
SELECT INTO customer_rec * FROM cust WHERE custname = lname;
IF NOT FOUND THEN
  RAISE EXCEPTION 'employee % not found', lname;
END IF;
```

To test whether a record result is null, you can use the IS NULL conditional. There is no way to determine whether any additional rows might have been discarded. The following example handles the case where no rows have been returned.

```
CREATE OR REPLACE PROCEDURE select_into_null(return_webpage OUT varchar(256))
AS $$
DECLARE
  customer_rec RECORD;
BEGIN
  SELECT INTO customer_rec * FROM users WHERE user_id=3;
  IF customer_rec.webpage IS NULL THEN
    -- user entered no webpage, return "http://"
    return_webpage = 'http://';
  END IF;
END;
$$ LANGUAGE plpgsql;
```

No-op

The no-op statement (`NULL;`) is a placeholder statement that does nothing. A no-op statement can indicate that one branch of an IF-THEN-ELSE chain is empty.

```
NULL;
```

Dynamic SQL

To generate dynamic commands that can involve different tables or different data types each time they are run from a PL/pgSQL stored procedure, use the `EXECUTE` statement.

```
EXECUTE command-string [ INTO target ];
```

In the preceding, *command-string* is an expression yielding a string (of type text) that contains the command to be run. This *command-string* value is sent to the SQL engine. No substitution of PL/pgSQL variables is done on the command string. The values of variables must be inserted in the command string as it is constructed.

> **Note**
>
> You can't use COMMIT and ROLLBACK statements from within dynamic SQL. For information about using COMMIT and ROLLBACK statements within a stored procedure, see [Managing transactions](#).

When working with dynamic commands, you often have to handle escaping of single quotation marks. We recommend enclosing fixed text in quotation marks in your function body using dollar quoting. Dynamic values to insert into a constructed query require special handling because they might themselves contain quotation marks. The following example assumes dollar quoting for the function as a whole, so the quotation marks don't need to be doubled.

```
EXECUTE 'UPDATE tbl SET '
  || quote_ident(colname)
  || ' = '
  || quote_literal(newvalue)
  || ' WHERE key = '
  || quote_literal(keyvalue);
```

The preceding example shows the functions `quote_ident(text)` and `quote_literal(text)`. This example passes variables that contain column and table identifiers to the `quote_ident` function. It also passes variables that contain literal strings in the constructed command to the `quote_literal` function. Both functions take the appropriate steps to return the input text enclosed in double or single quotation marks respectively, with any embedded special characters properly escaped.

Dollar quoting is only useful for quoting fixed text. Don't write the preceding example in the following format.

```
EXECUTE 'UPDATE tbl SET '
```

```
  || quote_ident(colname)
  || ' = $$'
  || newvalue
  || '$$ WHERE key = '
  || quote_literal(keyvalue);
```

You don't do this because the example breaks if the contents of `newvalue` happen to contain $$. The same problem applies to any other dollar-quoting delimiter that you might choose. To safely quote text that is not known in advance, use the `quote_literal` function.

Return

The RETURN statement returns back to the caller from a stored procedure.

```
RETURN;
```

The following shows an example.

```
CREATE OR REPLACE PROCEDURE return_example(a int)
AS $$
BEGIN
  FOR b in 1..10 LOOP
    IF b < a THEN
      RAISE INFO 'b = %', b;
    ELSE
      RETURN;
    END IF;
  END LOOP;
END;
$$ LANGUAGE plpgsql;
```

Conditionals: IF

The IF conditional statement can take the following forms in the PL/pgSQL language that Amazon Redshift uses:

- IF ... THEN

  ```
  IF boolean-expression THEN
    statements
  END IF;
  ```

The following shows an example.

```
IF v_user_id <> 0 THEN
  UPDATE users SET email = v_email WHERE user_id = v_user_id;
END IF;
```

- IF ... THEN ... ELSE

```
IF boolean-expression THEN
  statements
ELSE
  statements
END IF;
```

The following shows an example.

```
IF parentid IS NULL OR parentid = ''
THEN
  return_name = fullname;
  RETURN;
ELSE
  return_name = hp_true_filename(parentid) || '/' || fullname;
  RETURN;
END IF;
```

- IF ... THEN ... ELSIF ... THEN ... ELSE

The key word ELSIF can also be spelled ELSEIF.

```
IF boolean-expression THEN
  statements
[ ELSIF boolean-expression THEN
  statements
[ ELSIF boolean-expression THEN
  statements
    ...] ]
[ ELSE
  statements ]
END IF;
```

The following shows an example.

```
IF number = 0 THEN
  result := 'zero';
ELSIF number > 0 THEN
  result := 'positive';
ELSIF number < 0 THEN
  result := 'negative';
ELSE
  -- the only other possibility is that number is null
  result := 'NULL';
END IF;
```

Conditionals: CASE

The CASE conditional statement can take the following forms in the PL/pgSQL language that Amazon Redshift uses:

- Simple CASE

```
CASE search-expression
WHEN expression [, expression [ ... ]] THEN
  statements
[ WHEN expression [, expression [ ... ]] THEN
  statements
  ... ]
[ ELSE
  statements ]
END CASE;
```

A simple CASE statement provides conditional execution based on equality of operands.

The *search-expression* value is evaluated one time and successively compared to each *expression* in the WHEN clauses. If a match is found, then the corresponding *statements* run, and then control passes to the next statement after END CASE. Subsequent WHEN expressions aren't evaluated. If no match is found, the ELSE *statements* run. However, if ELSE isn't present, then a CASE_NOT_FOUND exception is raised.

The following shows an example.

```
CASE x
```

```
WHEN 1, 2 THEN
  msg := 'one or two';
ELSE
  msg := 'other value than one or two';
END CASE;
```

- Searched CASE

```
CASE
WHEN boolean-expression THEN
  statements
[ WHEN boolean-expression THEN
  statements
  ... ]
[ ELSE
  statements ]
END CASE;
```

The searched form of CASE provides conditional execution based on truth of Boolean expressions.

Each WHEN clause's *boolean-expression* is evaluated in turn, until one is found that yields true. Then the corresponding statements run, and then control passes to the next statement after END CASE. Subsequent WHEN *expressions* aren't evaluated. If no true result is found, the ELSE *statements* are run. However, if ELSE isn't present, then a CASE_NOT_FOUND exception is raised.

The following shows an example.

```
CASE
WHEN x BETWEEN 0 AND 10 THEN
  msg := 'value is between zero and ten';
WHEN x BETWEEN 11 AND 20 THEN
  msg := 'value is between eleven and twenty';
END CASE;
```

Loops

Loop statements can take the following forms in the PL/pgSQL language that Amazon Redshift uses:

- Simple loop

```
[<<label>>]
LOOP
  statements
END LOOP [ label ];
```

A simple loop defines an unconditional loop that is repeated indefinitely until terminated by an EXIT or RETURN statement. The optional label can be used by EXIT and CONTINUE statements within nested loops to specify which loop the EXIT and CONTINUE statements refer to.

The following shows an example.

```
CREATE OR REPLACE PROCEDURE simple_loop()
LANGUAGE plpgsql
AS $$
BEGIN
  <<simple_while>>
  LOOP
    RAISE INFO 'I am raised once';
    EXIT simple_while;
    RAISE INFO 'I am not raised';
  END LOOP;
  RAISE INFO 'I am raised once as well';
END;
$$;
```

- Exit loop

```
EXIT [ label ] [ WHEN expression ];
```

If *`label`* isn't present, the innermost loop is terminated and the statement following the END LOOP runs next. If *`label`* is present, it must be the label of the current or some outer level of nested loop or block. Then, the named loop or block is terminated and control continues with the statement after the loop or block corresponding END.

If WHEN is specified, the loop exit occurs only if *`expression`* is true. Otherwise, control passes to the statement after EXIT.

You can use EXIT with all types of loops; it isn't limited to use with unconditional loops.

When used with a BEGIN block, EXIT passes control to the next statement after the end of the block. A label must be used for this purpose. An unlabeled EXIT is never considered to match a BEGIN block.

The following shows an example.

```
CREATE OR REPLACE PROCEDURE simple_loop_when(x int)
LANGUAGE plpgsql
AS $$
DECLARE i INTEGER := 0;
BEGIN
  <<simple_loop_when>>
  LOOP
    RAISE INFO 'i %', i;
    i := i + 1;
    EXIT simple_loop_when WHEN (i >= x);
  END LOOP;
END;
$$;
```

- Continue loop

```
CONTINUE [ label ] [ WHEN expression ];
```

If *label* is not given, the execution jumps to the next iteration of the innermost loop. That is, all statements remaining in the loop body are skipped. Control then returns to the loop control expression (if any) to determine whether another loop iteration is needed. If *label* is present, it specifies the label of the loop whose execution is continued.

If WHEN is specified, the next iteration of the loop is begun only if *expression* is true. Otherwise, control passes to the statement after CONTINUE.

You can use CONTINUE with all types of loops; it isn't limited to use with unconditional loops.

```
CONTINUE mylabel;
```

- WHILE loop

```
[<<label>>]
WHILE expression LOOP
```

```
  statements
END LOOP [ label ];
```

The WHILE statement repeats a sequence of statements so long as the *boolean-expression* evaluates to true. The expression is checked just before each entry to the loop body.

The following shows an example.

```
WHILE amount_owed > 0 AND gift_certificate_balance > 0 LOOP
  -- some computations here
END LOOP;

WHILE NOT done LOOP
  -- some computations here
END LOOP;
```

- FOR loop (integer variant)

```
[<<label>>]
FOR name IN [ REVERSE ] expression .. expression LOOP
  statements
END LOOP [ label ];
```

The FOR loop (integer variant) creates a loop that iterates over a range of integer values. The variable name is automatically defined as type integer and exists only inside the loop. Any existing definition of the variable name is ignored within the loop. The two expressions giving the lower and upper bound of the range are evaluated one time when entering the loop. If you specify REVERSE, then the step value is subtracted, rather than added, after each iteration.

If the lower bound is greater than the upper bound (or less than, in the REVERSE case), the loop body doesn't run. No error is raised.

If a label is attached to the FOR loop, then you can reference the integer loop variable with a qualified name, using that label.

The following shows an example.

```
FOR i IN 1..10 LOOP
  -- i will take on the values 1,2,3,4,5,6,7,8,9,10 within the loop
END LOOP;
```

```
FOR i IN REVERSE 10..1 LOOP
  -- i will take on the values 10,9,8,7,6,5,4,3,2,1 within the loop
END LOOP;
```

- FOR loop (result set variant)

```
[<<label>>]
FOR target IN query LOOP
  statements
END LOOP [ label ];
```

The *`target`* is a record variable or comma-separated list of scalar variables. The target is successively assigned each row resulting from the query, and the loop body is run for each row.

The FOR loop (result set variant) enables a stored procedure to iterate through the results of a query and manipulate that data accordingly.

The following shows an example.

```
CREATE PROCEDURE cs_refresh_reports() AS $$
DECLARE
  reports RECORD;
BEGIN
  FOR reports IN SELECT * FROM cs_reports ORDER BY sort_key LOOP
    -- Now "reports" has one record from cs_reports
    EXECUTE 'INSERT INTO ' || quote_ident(reports.report_name) || ' ' ||
 reports.report_query;
  END LOOP;
  RETURN;
END;
$$ LANGUAGE plpgsql;
```

- FOR loop with dynamic SQL

```
[<<label>>]
FOR record_or_row IN EXECUTE text_expression LOOP
  statements
END LOOP;
```

A FOR loop with dynamic SQL enables a stored procedure to iterate through the results of a dynamic query and manipulate that data accordingly.

The following shows an example.

```
CREATE OR REPLACE PROCEDURE for_loop_dynamic_sql(x int)
LANGUAGE plpgsql
AS $$
DECLARE
  rec RECORD;
  query text;
BEGIN
  query := 'SELECT * FROM tbl_dynamic_sql LIMIT ' || x;
  FOR rec IN EXECUTE query
  LOOP
    RAISE INFO 'a %', rec.a;
  END LOOP;
END;
$$;
```

Cursors

Rather than running a whole query at once, you can set up a cursor. A *cursor* encapsulates a query and reads the query result a few rows at a time. One reason for doing this is to avoid memory overrun when the result contains a large number of rows. Another reason is to return a reference to a cursor that a stored procedure has created, which allows the caller to read the rows. This approach provides an efficient way to return large row sets from stored procedures.

To use cursors in a NONATOMIC stored procedure, place the cursor loop between START TRANSACTION...COMMIT.

To set up a cursor, first you declare a cursor variable. All access to cursors in PL/pgSQL goes through cursor variables, which are always of the special data type `refcursor`. A `refcursor` data type simply holds a reference to a cursor.

You can create a cursor variable by declaring it as a variable of type `refcursor`. Or, you can use the cursor declaration syntax following.

```
name CURSOR [ ( arguments ) ] FOR query ;
```

In the preceding, *`arguments`* (if specified) is a comma-separated list of *`name datatype`* pairs that each define names to be replaced by parameter values in *`query`*. The actual values to substitute for these names are specified later, when the cursor is opened.

The following shows examples.

```
DECLARE
  curs1 refcursor;
  curs2 CURSOR FOR SELECT * FROM tenk1;
  curs3 CURSOR (key integer) IS SELECT * FROM tenk1 WHERE unique1 = key;
```

All three of these variables have the data type `refcursor`, but the first can be used with any query. In contrast, the second has a fully specified query already bound to it, and the last has a parameterized query bound to it. The `key` value is replaced by an integer parameter value when the cursor is opened. The variable `curs1` is said to be *unbound* because it is not bound to any particular query.

Before you can use a cursor to retrieve rows, it must be opened. PL/pgSQL has three forms of the OPEN statement, of which two use unbound cursor variables and the third uses a bound cursor variable:

- Open for select: The cursor variable is opened and given the specified query to run. The cursor can't be open already. Also, it must have been declared as an unbound cursor (that is, as a simple `refcursor` variable). The SELECT query is treated in the same way as other SELECT statements in PL/pgSQL.

  ```
  OPEN cursor_name FOR SELECT ...;
  ```

  The following shows an example.

  ```
  OPEN curs1 FOR SELECT * FROM foo WHERE key = mykey;
  ```

- Open for execute: The cursor variable is opened and given the specified query to run. The cursor can't be open already. Also, it must have been declared as an unbound cursor (that is, as a simple `refcursor` variable). The query is specified as a string expression in the same way as in the EXECUTE command. This approach gives flexibility so the query can vary from one run to the next.

```
OPEN cursor_name FOR EXECUTE query_string;
```

The following shows an example.

```
OPEN curs1 FOR EXECUTE 'SELECT * FROM ' || quote_ident($1);
```

- Open a bound cursor: This form of OPEN is used to open a cursor variable whose query was bound to it when it was declared. The cursor can't be open already. A list of actual argument value expressions must appear if and only if the cursor was declared to take arguments. These values are substituted in the query.

```
OPEN bound_cursor_name [ ( argument_values ) ];
```

The following shows an example.

```
OPEN curs2;
OPEN curs3(42);
```

After a cursor has been opened, you can work with it by using the statements described following. These statements don't have to occur in the same stored procedure that opened the cursor. You can return a `refcursor` value out of a stored procedure and let the caller operate on the cursor. All portals are implicitly closed at transaction end. Thus, you can use a `refcursor` value to reference an open cursor only until the end of the transaction.

- FETCH retrieves the next row from the cursor into a target. This target can be a row variable, a record variable, or a comma-separated list of simple variables, just as with SELECT INTO. As with SELECT INTO, you can check the special variable FOUND to see whether a row was obtained.

```
FETCH cursor INTO target;
```

The following shows an example.

```
FETCH curs1 INTO rowvar;
```

- CLOSE closes the portal underlying an open cursor. You can use this statement to release resources earlier than end of the transaction. You can also use this statement to free the cursor variable to be opened again.

  ```
  CLOSE cursor;
  ```

  The following shows an example.

  ```
  CLOSE curs1;
  ```

RAISE

Use the `RAISE level` statement to report messages and raise errors.

```
RAISE level 'format' [, variable [, ...]];
```

Possible levels are NOTICE, INFO, LOG, WARNING, and EXCEPTION. EXCEPTION raises an error, which normally cancels the current transaction. The other levels generate only messages of different priority levels.

Inside the format string, % is replaced by the next optional argument's string representation. Write %% to emit a literal %. Currently, optional arguments must be simple variables, not expressions, and the format must be a simple string literal.

In the following example, the value of `v_job_id` replaces the % in the string.

```
RAISE NOTICE 'Calling cs_create_job(%)', v_job_id;
```

Use the `RAISE` statement to re-throw the exception caught by an exception handling block. This statement is only valid in exception handling blocks of NONATOMIC mode stored procedures.

```
RAISE;
```

Transaction control

You can work with transaction control statements in the PL/pgSQL language that Amazon Redshift uses. For information about using the statements COMMIT, ROLLBACK, and TRUNCATE within a stored procedure, see Managing transactions.

In NONATOMIC mode stored procedures, use `START TRANSACTION` to start a transaction block.

```
START TRANSACTION;
```

Note

The PL/pgSQL statement START TRANSACTION is different from the SQL command START TRANSACTION in the following ways:

- Within stored procedures, START TRANSACTION is not synonymous with BEGIN.
- The PL/pgSQL statement does not support optional isolation level and access permission keywords.

Materialized views in Amazon Redshift

This section describes how to create and use materialized views in Amazon Redshift. A materialized view is a database object that stores the results of a query, which can be used to improve performance and efficiency.

In a data warehouse environment, applications often must perform complex queries on large tables. An example is SELECT statements that perform multi-table joins and aggregations on tables that contain billions of rows. Processing these queries can be expensive, in terms of system resources and the time it takes to compute the results.

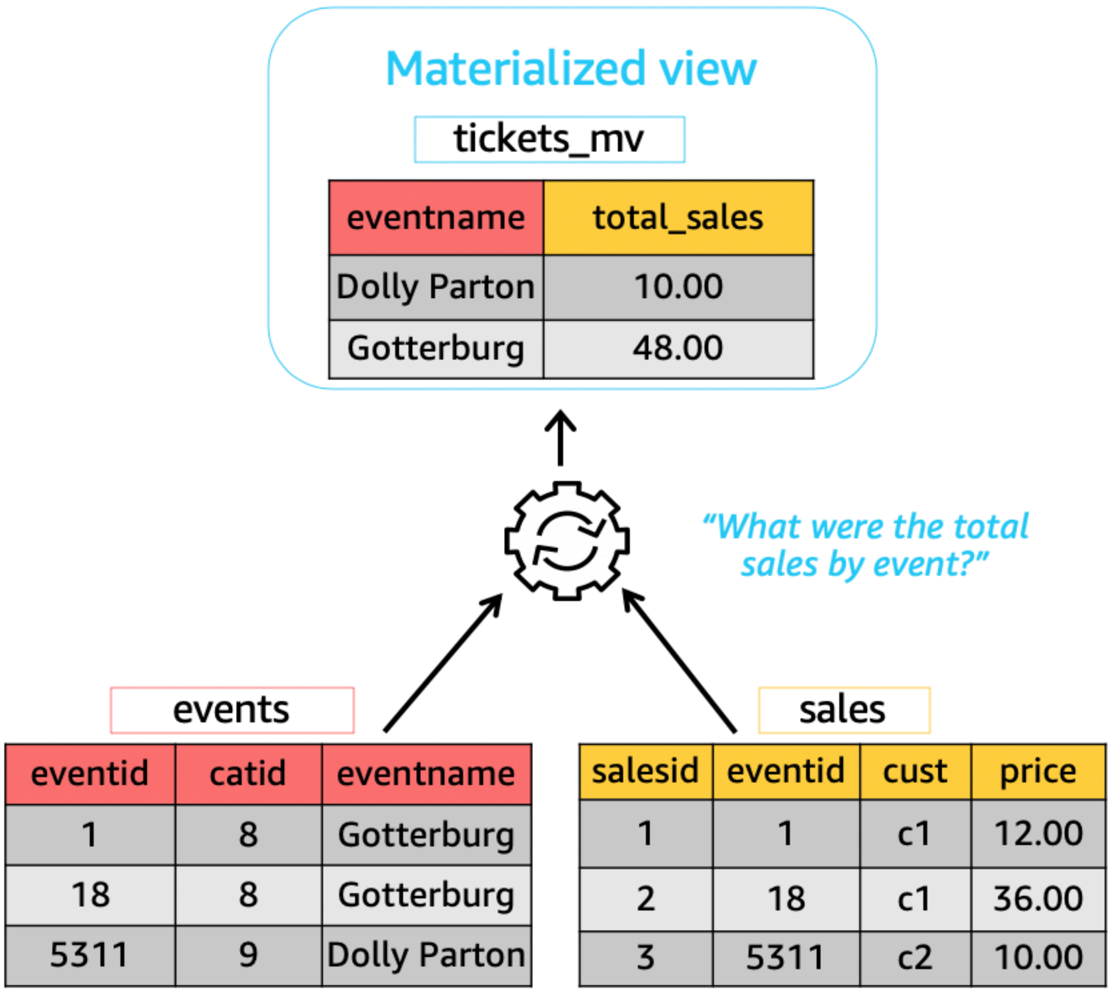
Materialized views in Amazon Redshift provide a way to address these issues. A *materialized view* contains a precomputed result set, based on an SQL query over one or more base tables. You can issue SELECT statements to query a materialized view, in the same way that you can query other tables or views in the database. Amazon Redshift returns the precomputed results from the materialized view, without having to access the base tables at all. From the user standpoint, the query results are returned much faster compared to when retrieving the same data from the base tables.

Materialized views are especially useful for speeding up queries that are predictable and repeated. Instead of performing resource-intensive queries against large tables (such as aggregates or multiple joins), applications can query a materialized view and retrieve a precomputed result set. For example, consider the scenario where a set of queries is used to populate dashboards, such as Amazon QuickSight. This use case is ideal for a materialized view, because the queries are predictable and repeated over and over again.

You can define a materialized view in terms of other materialized views. Use *materialized views on materialized views* to expand the capability of materialized views. In this approach, an existing materialized view plays the same role as a base table for the query to retrieve data.

This approach is especially useful for reusing precomputed joins for different aggregate or GROUP BY options. For example, take a materialized view that joins customer information (containing millions of rows) with item order detail information (containing billions of rows). This is an expensive query to compute on demand repeatedly. You can use different GROUP BY options for the materialized views created on top of this materialized view and join with other tables. Doing this saves compute time otherwise used to run the expensive underlying join every time. The STV_MV_DEPS table shows the dependencies of a materialized view on other materialized views.

When you create a materialized view, Amazon Redshift runs the user-specified SQL statement to gather the data from the base table or tables and stores the result set. The following illustration provides an overview of the materialized view `tickets_mv` that an SQL query defines by using two base tables, `events` and `sales`.



You can then use these materialized views in queries to speed them up. In addition, Amazon Redshift can automatically rewrite these queries to use materialized views, even when the query doesn't explicitly reference a materialized view. Automatic rewrite of queries is especially powerful in enhancing performance when you can't change your queries to use materialized views.

To update the data in the materialized view, you can use the REFRESH MATERIALIZED VIEW statement at any time to manually refresh materialized views. Amazon Redshift identifies changes that have taken place in the base table or tables, and then applies those changes to the materialized view. Because automatic rewriting of queries requires materialized views to be up to date, as a materialized view owner, make sure to refresh materialized views whenever a base table changes.

Amazon Redshift provides a few ways to keep materialized views up to date for automatic rewriting. You can configure materialized views with the automatic refresh option to refresh materialized views when base tables of materialized views are updated. This autorefresh operation runs at a time when cluster resources are available to minimize disruptions to other workloads. Because the scheduling of autorefresh is workload-dependent, you can have more control over when Amazon Redshift refreshes your materialized views. You can schedule a materialized view refresh job by using Amazon Redshift scheduler API and console integration. For more information about query scheduling, see Scheduling a query on the Amazon Redshift console.

Doing this is especially useful when there is a service level agreement (SLA) requirement for up-to-date data from a materialized view. You can also manually refresh any materialized views that you can autorefresh. For information on how to create materialized views, see CREATE MATERIALIZED VIEW.

You can issue SELECT statements to query a materialized view. For information on how to query materialized views, see Materialized view queries. The result set eventually becomes stale when data is inserted, updated, and deleted in the base tables. You can refresh the materialized view at any time to update it with the latest changes from the base tables. For information on how to refresh materialized views, see REFRESH MATERIALIZED VIEW.

For details about SQL commands used to create and manage materialized views, see the following command topics:

- CREATE MATERIALIZED VIEW
- ALTER MATERIALIZED VIEW
- REFRESH MATERIALIZED VIEW
- DROP MATERIALIZED VIEW

For information about system tables and views to monitor materialized views, see the following topics:

- STV_MV_INFO
- STL_MV_STATE
- SVL_MV_REFRESH_STATUS

- STV_MV_DEPS

Topics

Materialized view queries

You can use a materialized view in any SQL query by referencing the materialized view name as the data source, like a table or standard view.

When a query accesses a materialized view, it sees only the data that is stored in the materialized view as of its most recent refresh. Thus, the query might not see all the latest changes from corresponding base tables of the materialized view.

If other users want to query the materialized view, the owner of the materialized view grants the SELECT permission to those users. The other users don't need to have the SELECT permission on the underlying base tables. The owner of the materialized view can also revoke the SELECT permission from other users to prevent them from querying the materialized view. Note that the other users still need the USAGE permission on the schemas that contain the base tables of the materialized view.

If the owner of the materialized view no longer has the local SELECT permission on the underlying base tables:

- The owner can no longer query the materialized view.
- Other users who have the SELECT permission on the materialized view can no longer query the materialized view.

This is limited to local permissions. Changes in permissions managed by Lake Formation are not verified on querying the materialized view. This means that if an underlying base table is managed by Lake Formation and select permissions on the table are revoked in Lake Formation, you can still query the materialized view.

The following example queries the `tickets_mv` materialized view. For more information on the SQL command used to create a materialized view, see CREATE MATERIALIZED VIEW.

```
SELECT sold
FROM tickets_mv
WHERE catgroup = 'Concerts';
```

Because the query results are precomputed, there's no need to access the underlying tables (`category`, `event`, and `sales`). Amazon Redshift can return the results directly from `tickets_mv`.

Automatic query rewriting to use materialized views

You can use automatic query rewriting of materialized views in Amazon Redshift to have Amazon Redshift rewrite queries to use materialized views. Doing this accelerates query workloads even for queries that don't explicitly reference a materialized view. When Amazon Redshift rewrites queries, it only uses materialized views that are up to date.

Usage notes

To check if automatic rewriting of queries is used for a query, you can inspect the query plan or STL_EXPLAIN. The following shows a SELECT statement and the EXPLAIN output of the original query plan.

```
SELECT catgroup, SUM(qtysold) AS sold
FROM category c, event e, sales s
WHERE c.catid = e.catid AND e.eventid = s.eventid
GROUP BY 1;

EXPLAIN
 XN HashAggregate  (cost=920021.24..920021.24 rows=1 width=35)
   ->  XN Hash Join DS_BCAST_INNER  (cost=440004.53..920021.22 rows=4 width=35)
         Hash Cond: ("outer".eventid = "inner".eventid)
         ->  XN Seq Scan on sales s  (cost=0.00..7.40 rows=740 width=6)
         ->  XN Hash  (cost=440004.52..440004.52 rows=1 width=37)
               ->  XN Hash Join DS_BCAST_INNER  (cost=0.01..440004.52 rows=1 width=37)
                     Hash Cond: ("outer".catid = "inner".catid)
```

```
                    ->  XN Seq Scan on event e  (cost=0.00..2.00 rows=200 width=6)
                    ->  XN Hash  (cost=0.01..0.01 rows=1 width=35)
                          ->  XN Seq Scan on category c  (cost=0.00..0.01 rows=1
 width=35)
```

The following shows the EXPLAIN output after a successful automatic rewriting. This output includes a scan on the materialized view in the query plan that replaces parts of the original query plan.

```
* EXPLAIN
     XN HashAggregate  (cost=11.85..12.35 rows=200 width=41)
       ->  XN Seq Scan on mv_tbl__tickets_mv__0 derived_table1  (cost=0.00..7.90
 rows=790 width=41)
```

Only up-to-date (fresh) materialized views are considered for automatic rewriting of queries, irrespective of the refresh strategy, such as auto, scheduled, or manual. Hence, the original query returns up-to-date results. When a materialized view is explicitly referenced in queries, Amazon Redshift accesses currently stored data in the materialized view. This data might not reflect the latest changes from the base tables of the materialized view.

You can use automatic query rewriting of materialized views that are created on cluster version 1.0.20949 or later.

You can stop automatic query rewriting at the session level by using SET mv_enable_aqmv_for_session to FALSE.

How automatic query rewriting of materialized views works

Based on internal optimization, Amazon Redshift may decide to invoke automatic query rewriting of materialized views transparently to provide the most optimal query execution with the lowest possible query times.

For example, suppose User A creates a materialized view M1 on table T1 with the query `SELECT * FROM T1`. User A has full SELECT privileges on T1. User A grants access to M1 to all users, including User B. However, when User B tries to query T1 directly, they are denied access. This is because User B does not have SELECT privileges on T1.

Sometime later, User B again tries to query T1, but this time gets results back from T1. This is because automatic query rewrite using materialized view rewrote User B's query on table T1 (`SELECT <cols> FROM T1`) to a query on materialized view M1 (`SELECT <cols> FROM M1`).

Limitations

Following are limitations for using automatic query rewriting of materialized views:

- Automatic query rewriting works with materialized views that don't reference or include any of the following:
  - Subqueries
  - Left, right, or full outer joins
  - Set operations
  - Any aggregate functions, except SUM, COUNT, MIN, MAX, and AVG. (These are the only aggregate functions that work with automatic query rewriting.)
  - Any aggregate functions with DISTINCT
  - Any window functions
  - SELECT DISTINCT or HAVING clauses
  - External or shared tables
  - Other materialized views
- Automatic query rewriting rewrites SELECT queries that refer to user-defined Amazon Redshift tables. Amazon Redshift doesn't rewrite the following queries:
  - CREATE TABLE AS statements
  - SELECT INTO statements
  - Queries on catalogs or system tables
  - Queries with outer joins or a SELECT DISTINCT clause
- If a query isn't automatically rewritten, check whether you have the SELECT permission on the specified materialized view and the mv_enable_aqmv_for_session option is set to TRUE.

  You can also check if your materialized views are eligible for automatic rewriting of queries by inspecting STV_MV_INFO. For more information, see STV_MV_INFO.

Materialized views on external data lake tables in Amazon Redshift Spectrum

Materialized views can provide incremental maintenance on external data lake tables. With incremental maintenance, Amazon Redshift updates the data in the materialized view with only the changes to the data in the base tables since the last refresh. Incremental maintenance is more cost effective than fully recomputing the materialized view after every data change on the base table.

When you use materialized views on at least one external table, materialized view creation is incremental on:

- Standard data lake tables, partitioned and unpartitioned, with data files in any supported format (Parquet, Avro, CSV, etc.).
- Apache Iceberg tables, partitioned and unpartitioned, with copy-on-write and merge-on-read.
- Amazon Redshift Spectrum tables joined with any Amazon Redshift table in the same database.

Materialized view refresh is incremental on:

- Standard data lake tables after S3 DELETE or PUT overwrite (deletion of data files), if the materialized view doesn't perform aggregation.
- Apache Iceberg tables after INSERT, DELETE, UPDATE, or table compaction.

For more information about Amazon Redshift Spectrum, see [Amazon Redshift Spectrum](#).

Limitations

General limitations on materialized views still apply for materialized views on data lake tables. For more information, see [Refreshing a materialized view](#). In addition, consider the following limitations when you use materialized views on external data lake tables.

- Materialized view creation is non-incremental on:
  - Hudi or Delta Lake tables.
  - Spectrum nested data access.
  - References to VARBYTE columns.
- Materialized view refresh falls back to full recomputation on:
  - Apache Iceberg tables when a required snapshot is expired, if the materialized view performs aggregation.
  - Standard data lake tables after deletion or update of data files on Amazon S3, if the materialized view performs aggregation.
  - Standard data lake tables refreshed more than once within a transaction block.

  - Standard data lake tables governed by a manifest. For more information about manifests, see Using a manifest to specify data files.
  - Amazon Redshift falls back to full recompute if this is expected to be more performant, in particular for materialized views that contain joins and more than one base table has been updated since the last refresh.
- On Apache Iceberg tables, materialized view refresh can handle only up to 4 million positions deleted in a single data file. Once this limit is reached, the Apache Iceberg base table must be compacted to continue refreshing the materialized view.
- On Apache Iceberg tables, concurrency scaling is not supported for materialized view creation and refresh.
- Autonomics features are not supported. These include automated materialized views and automatic query rewrite.
- When an incremental materialized view is refreshed, IAM permissions apply only to the accessed portions of the Amazon Redshift base tables.
- Changes in permissions managed by Lake Formation are not verified on querying a materialized view. This means that if a materialized view is defined on a data lake table and select privileges are removed from the table with Lake Formation, then you can still query the materialized view.

Refreshing a materialized view

This topic describes how to refresh the data in a material view from the underlying tables.

When you create a materialized view, its contents reflect the state of the underlying database relations (tables or other materialized views) at that time. The data in the materialized view remains unchanged, even when applications change the data in the underlying tables. To update the data in the materialized view, you can use the `REFRESH MATERIALIZED VIEW` statement at any time to manually refresh materialized views. When you use this statement, Amazon Redshift identifies changes that have taken place in the base relations and applies those changes to the materialized view.

Amazon Redshift has two strategies for refreshing a materialized view:

- In many cases, Amazon Redshift can perform an incremental refresh. In an *incremental refresh*, Amazon Redshift quickly identifies the changes to the data in the base relations since the last refresh and updates the data in the materialized view. Incremental refresh is supported on the following SQL constructs used in the query when defining the materialized view:

  - Constructs that contain the clauses SELECT, FROM, [INNER] JOIN, WHERE, GROUP BY, or HAVING.
  - Constructs that contain aggregations, such as SUM, MIN, MAX, AVG, and COUNT.
  - Most built-in SQL functions, specifically the ones that are immutable, given that these have the same input arguments and always produce the same output.

  Incremental refresh is also supported for a materialized view that's based on a datashare table.
- If an incremental refresh isn't possible, then Amazon Redshift performs a full refresh. A *full refresh* reruns the underlying SQL statement, replacing all of the data in the materialized view.
- Amazon Redshift automatically chooses the refresh method for a materialized view depending on the SELECT query used to define the materialized view.

Nested materialized views

A materialized view can be defined on top of other materialized view(s). To refresh such a materialized view, you must explicitly use the `CASCADE` keyword at the top-most materialized view refresh. For example, assume the following nested materialized view structure:

```
CREATE TABLE t(a INT);
CREATE MATERIALIZED VIEW u AS SELECT * FROM t;
CREATE MATERIALIZED VIEW v AS SELECT * FROM u;
CREATE MATERIALIZED VIEW w AS SELECT * FROM v;

-- w -> v -> u -> t

INSERT INTO t VALUES (1);
```

To bring w fully up to date you have two choices:

- (Recommended) Refresh w using `REFRESH MATERIALIZED VIEW w CASCADE` command. This command executes refresh of all materialized views in a single transaction.
- Refresh u, v, and w as separate commands, in dependency order (first u, then v, then w).

If the `CASCADE` keyword is not explicitly used, the materialized view will be refreshed in `RESTRICT` mode, refreshing only the current materialized view. The following examples show an informational message when you run `REFRESH MATERIALIZED VIEW` on a materialized view that depends on an out-of-date materialized view.

```
REFRESH MATERIALIZED VIEW w;
INFO:  Materialized view w is already up to date.  However, it depends on another
 materialized view that is not up to date.

REFRESH MATERIALIZED VIEW w CASCADE;
INFO:  Materialized view w was incrementally updated successfully.
```

```
REFRESH MATERIALIZED VIEW v;
INFO: Materialized view v is already up to date. However, it depends on another
 materialized view that is not up to date.

REFRESH MATERIALIZED VIEW v CASCADE;
INFO: Materialized view v was incrementally updated successfully.
```

In the examples above with the cascade refresh option, materialized view u is refreshed first, materialized view v is refreshed next, and materialized view w is not refreshed.

The following example shows how you can create a full refresh plan for a materialized view programmatically. To refresh the materialized view v, first refresh materialized view u. To refresh materialized view w, first refresh materialized view u and then materialized view v.

```
WITH RECURSIVE recursive_deps (mv_tgt, lvl, mv_dep) AS
( SELECT trim(name) as mv_tgt, 0 as lvl, trim(ref_name) as mv_dep
  FROM stv_mv_deps
  UNION ALL
  SELECT R.mv_tgt, R.lvl+1 as lvl, trim(S.ref_name) as mv_dep
  FROM stv_mv_deps S, recursive_deps R
  WHERE R.mv_dep = S.name
)

SELECT mv_tgt, mv_dep from recursive_deps
ORDER BY mv_tgt, lvl DESC;

 mv_tgt | mv_dep
--------+--------
 v      | u
 w      | u
 w      | v
(3 rows)
```

Limitations

Amazon Redshift doesn't support cascading refresh for materialized views based on sources other than:

- Local tables
- Local MVs
- Streaming MVs

Amazon Redshift doesn't support incremental refresh for materialized views that are defined with a query using the following SQL elements:

- OUTER JOIN (RIGHT, LEFT, or FULL).
- The set operations UNION, INTERSECT, EXCEPT, and MINUS.
- The aggregate functions MEDIAN, PERCENTILE_CONT, LISTAGG, STDDEV_SAMP, STDDEV_POP, APPROXIMATE COUNT, APPROXIMATE PERCENTILE, and bitwise aggregate functions.

  > **Note**
  >
  > The COUNT, SUM, and AVG aggregate functions are supported.

- DISTINCT aggregate functions, such as DISTINCT COUNT, DISTINCT SUM, and so on.
- Window functions.
- A query that uses temporary tables for query optimization, such as optimizing common subexpressions.
- Subqueries.
- External tables referencing the following formats in the query that defines the materialized view.
  - Delta Lake
  - Hudi

  Incremental refresh is supported for materialized views defined using formats other than those listed above. For more information, see Materialized views on external data lake tables in Amazon Redshift Spectrum.

Autorefreshing a materialized view

Amazon Redshift can automatically refresh materialized views with up-to-date data from its base tables when materialized views are created with or altered to have the autorefresh option. Amazon Redshift autorefreshes materialized views as soon as possible after base tables changes.

To complete refresh of the most important materialized views with minimal impact to active workloads in your cluster, Amazon Redshift considers multiple factors. These factors include current system load, the resources needed for refresh, available cluster resources, and how often the materialized views are used.

Amazon Redshift prioritizes your workloads over autorefresh and might stop autorefresh to preserve the performance of user workload. This approach might delay refresh of some materialized views. In some cases, you might need more deterministic refresh behavior for your materialized views. If so, consider using manual refresh as described in REFRESH MATERIALIZED VIEW or scheduled refresh using the Amazon Redshift scheduler API operations or the console.

You can set autorefresh for materialized views using CREATE MATERIALIZED VIEW. You can also use the AUTO REFRESH clause to refresh materialized views automatically. For more information about creating materialized views, see CREATE MATERIALIZED VIEW. You can turn on autorefresh for a current materialized view by using ALTER MATERIALIZED VIEW.

Consider the following when you refresh materialized views:

- You can still refresh a materialized view explicitly using REFRESH MATERIALIZED VIEW command even if you haven't enabled autorefresh for the materialized view.
- Amazon Redshift is supported on materialized views defined on datasharing tables and Iceberg tables.
- For refresh status, you can check SVL_MV_REFRESH_STATUS, which records queries that were user-initiated or autorefreshed.
- To run REFRESH on recompute-only materialized views, make sure that you have the CREATE permission on schemas. For more information, see GRANT.

Automated materialized views

This topic describes how Amazon Redshift uses automated materialized views to improve performance. Amazon Redshift creates materialized views automatically based on database activity and performance. Amazon Redshift uses automated materialized views by default.

Materialized views are a powerful tool for improving query performance in Amazon Redshift. They do this by storing a precomputed result set. Similar queries don't have to re-run the same logic each time, because they can retrieve records from the existing result set. Developers and analysts create materialized views after analyzing their workloads to determine which queries would benefit, and whether the maintenance cost of each materialized view is worthwhile. As workloads grow or change, these materialized views must be reviewed to ensure they continue to provide tangible performance benefits.

The Automated Materialized Views (AutoMV) feature in Redshift enhances query performance by automatically creating and managing materialized views based on workload monitoring and machine learning algorithms. The following includes key features of AutoMV:

- *Continuous monitoring* – Redshift continuously monitors the workload using machine learning techniques to identify opportunities for performance improvements through the creation of materialized views.
- *Automatic creation and deletion* – When the system detects that a materialized view would be beneficial, it automatically creates and maintains it. Conversely, if a previously created AutoMV is no longer providing performance benefits, the system will automatically drop it.
- *No user activity requirement* – The AutoMV feature only operates during periods of low user activity or workload running on the cluster. This ensures that the AutoMV operations do not interfere with or impact customer workloads.
- *CPU usage spikes* – During times of no workload activity, the creation or refresh of materialized views by AutoMV may lead to spikes in CPU usage. This is a normal behavior as the system utilizes available resources to create and refresh materialized views.
- *User workload priority* – If you initiate a workload while an AutoMV operation is in progress, the AutoMV task will stop to release resources for the user workload. This ensures that your workloads take priority over the AutoMV operations.

While the AutoMV feature may lead to CPU usage spikes during periods of no user activity, it operates transparently and without impacting your workloads. The system manages materialized views to improve query performance and simultaneously prioritizes user workloads over AutoMV operations.

AutoMV behavior and capabilities are the same as user-created materialized views. They are refreshed automatically and incrementally, using the same criteria and restrictions. Just like materialized views created by users, Automatic query rewriting to use materialized views identifies queries that can benefit from system-created AutoMVs. It automatically rewrites those queries to use the AutoMVs, improving query performance. Developers don't need to revise queries to take advantage of AutoMV.

> **Note**
>
> Automated materialized views are refreshed intermittently. Queries rewritten to use AutoMV always return the latest results. When Redshift detects that data isn't up to date, queries aren't rewritten to read from automated materialized views. Instead, queries select the latest data from base tables.

Any workload with queries that are used repeatedly can benefit from AutoMV. Common use cases include:

- *Dashboards* - Dashboards are widely used to provide quick views of key business indicators (KPIs), events, trends, and other metrics. They often have a common layout with charts and tables, but show different views for filtering, or for dimension-selection operations, like drill down. Dashboards often have a common set of queries used repeatedly with different parameters. Dashboard queries can benefit greatly from automated materialized views.
- *Reports* - Reporting queries may be scheduled at various frequencies, based on business requirements and the type of report. Additionally, they can be automated or on-demand. A common characteristic of reporting queries is that they can be long running and resource-intensive. With AutoMV, these queries don't need to be recomputed each time they run, which reduces runtime for each query and resource utilization in Redshift.

To turn off automated materialized views, you update the `auto_mv` parameter group to `false`. For more information, see Amazon Redshift parameter groups in the Amazon Redshift Cluster Management Guide.

SQL scope and considerations for automated materialized views

- An automated materialized view can be initiated and created by a query or subquery, provided it contains a `GROUP BY` clause or one of the following aggregate functions: SUM, COUNT, MIN, MAX or AVG. But it cannot contain any of the following:
  - Left, right, or full outer joins
  - Aggregate functions other than SUM, COUNT, MIN, MAX, and AVG. (These particular functions work with automatic query rewriting.)

  - Any aggregate function that includes DISTINCT
  - Any window functions
  - SELECT DISTINCT or HAVING clauses
  - Other materialized views

  It isn't guaranteed that a query that meets the criteria will initiate the creation of an automated materialized view. The system determines from which candidates to create a view, based on its expected benefit to the workload and cost in resources to maintain, which includes the cost to the system to refresh. Each resulting materialized view is usable by automatic query rewriting.

- Even though AutoMV might be initiated by a subquery or individual legs of set operators, the resulting materialized view won't contain subqueries or set operators.
- To determine if AutoMV was used for queries, view the EXPLAIN plan and look for `%_auto_mv_%` in the output. For more information, see EXPLAIN.
- Automated materialized views aren't supported on external tables, such as datashares and federated tables.

Automated materialized views limitations

Following are limitations for working with automated materialized views:

- *Maximum number of AutoMVs* - The limit of automated materialized views is 200 per database in the cluster.
- *Storage space and capacity* - An important characteristic of AutoMV is that it is performed using spare background cycles to help achieve that user workloads are not impacted. If the cluster is busy or running out of storage space, AutoMV ceases its activity. Specifically, at 80% of total cluster capacity, no new automated materialized views are created. At 90% of total capacity, they may be dropped to facilitate that user workloads continue without performance degradation. For more information about determining cluster capacity, see STV_NODE_STORAGE_CAPACITY.

Billing for automated materialized views

Amazon Redshift's automatic optimization capability creates and refreshes automated materialized views. There is no charge for compute resources for this process. Storage of automated materialized views is charged at the regular rate for storage. For more information, see Amazon Redshift pricing.

Additional resources

The following blog post provides further explanation regarding automated materialized views. It details how they're created, maintained, and dropped. It also explains the underlying algorithms that drive these decisions: Optimize your Amazon Redshift query performance with automated materialized views.

This video begins with an explanation of materialized views and shows how they improve performance and conserve resources. It then provides an in-depth explanation of automated materialized views with a process-flow animation and a live demonstration.

Using a user-defined function (UDF) in a materialized view

You can use a scalar UDF in an Amazon Redshift materialized view. Define these either in python or SQL and reference them in the materialized view definition.

Referencing a UDF in a materialized view

The following procedure shows how to use UDFs that perform simple arithmetic comparisons, in a materialized-view definition.

1. Create a table to use in the materialized-view definition.

```
CREATE TABLE base_table (a int, b int);
```

2. Create a scalar user-defined function in python that returns a boolean value indicating whether an integer is larger than a comparison integer.

```
CREATE OR REPLACE FUNCTION udf_python_bool(x1 int, x2 int) RETURNS bool IMMUTABLE
AS $$
  return x1 > x2
$$ LANGUAGE plpythonu;
```

Optionally, create a functionally similar UDF with SQL, which you can use to compare results with the first.

```
CREATE OR REPLACE FUNCTION udf_sql_bool(int, int) RETURNS bool IMMUTABLE
```

```
AS $$
  select $1 > $2;
$$ LANGUAGE SQL;
```

3. Create a materialized view that selects from the table you created and references the UDF.

```
CREATE MATERIALIZED VIEW mv_python_udf AS SELECT udf_python_bool(a, b) AS a FROM
 base_table;
```

Optionally, you can create a materialized view that references the SQL UDF.

```
CREATE MATERIALIZED VIEW mv_sql_udf AS SELECT udf_sql_bool(a, b) AS a FROM
 base_table;
```

4. Add data to the table and refresh the materialized view.

```
INSERT INTO base_table VALUES (1,2), (1,3), (4,2);
```

```
REFRESH MATERIALIZED VIEW mv_python_udf;
```

Optionally, you can refresh the materialized view that references the SQL UDF.

```
REFRESH MATERIALIZED VIEW mv_sql_udf;
```

5. Query data from your materialized view.

```
SELECT * FROM mv_python_udf ORDER BY a;
```

The results of the query are the following:

```
a
-----
false
false
true
```

This returns `true` for the last set of values because the value for column a (4) is greater than the value for column b (2).

6. Optionally, you can query the materialized view that references the SQL UDF. The results for the SQL function match the results from the Python version.

```
SELECT * FROM mv_sql_udf ORDER BY a;
```

The results of the query are the following:

```
a
-----
false
false
true
```

This returns `true` for the last set of values to compare.

7. Use a DROP statement with CASCADE to drop the user-defined function and the materialized view that references it.

```
DROP FUNCTION udf_python_bool(int, int) CASCADE;
```

```
DROP FUNCTION udf_sql_bool(int, int) CASCADE;
```

Streaming ingestion to a materialized view

This topic describes how to use materialized views for fast access to streaming data.

Streaming ingestion provides low-latency, high-speed data ingestion from Amazon Kinesis Data Streams or Amazon Managed Streaming for Apache Kafka to an Amazon Redshift provisioned or Amazon Redshift Serverless database. The data lands in a Redshift materialized view that's configured for the purpose. This results in fast access to external data. Streaming ingestion lowers data-access time and reduces storage cost. You can configure it for your Amazon Redshift cluster or for your Amazon Redshift Serverless workgroup, using a small collection of SQL commands. After it's set up, each materialized-view refresh can ingest hundreds of megabytes of data per second.

How data flows from a streaming service to Redshift

It helps to understand how streaming ingestion works and the database objects utilized in the process. Data flows directly from a data-stream provider to an Amazon Redshift provisioned cluster or to an Amazon Redshift Serverless workgroup. There isn't a temporary landing area, such as an Amazon S3 bucket. The provisioned cluster or workgroup is the stream consumer. In the Redshift database, the data read from the stream lands in a materialized view. The data is processed as it arrives. For instance, JSON values can be consumed and mapped to a materialized view's data columns, using SQL. When the materialized view is refreshed, Redshift consumes data from allocated Kinesis data shards or Kafka partitions until the view is brought up to date with the stream.

Use cases for Amazon Redshift streaming ingestion involve data that's generated continually and must be processed within a short period, or *latency*, from its origination. This is commonly called *near real-time* analytics. Sources can include IT devices, system-telemetry devices, and click-stream data from a busy website or application.

Data parsing best practices for improving performance

When you configure streaming ingestion, there are options in how you can parse the incoming data. Practices can include performing business logic or formatting as data arrives. We recommend the following best practices to avoid errors or data loss. These derived from internal testing and helping customers troublehoot configuration and parsing issues.

- **Extracting values from streamed data** – If you use the JSON_EXTRACT_PATH_TEXT function in your materialized view definition to parse or *shred* streamed JSON, it can significantly impact performance and latency. To explain, for each column extracted using JSON_EXTRACT_PATH_TEXT, the incoming JSON is re-parsed. After this, data-type conversion, filtering, and business-logic calculations occur. This means, for example, that if you extract 10 columns from JSON data, each JSON record is parsed 10 times, which includes additional logic. This results in higher ingestion latency. An alternative approach we recommend is to use the JSON_PARSE function to convert JSON records to Redshift's SUPER data type. After the streamed data lands in the materialized view, use PartiQL to extract individual strings from the SUPER representation of the JSON data. For more information, see Querying semi-structured data.

  Additionally, note that JSON_EXTRACT_PATH_TEXT has a 64KB data-size maximum. Thus, if any JSON record is larger than 64KB, processing it with JSON_EXTRACT_PATH_TEXT results in an error.
- **Mapping an Amazon Kinesis Data Streams stream or Amazon MSK topic to multiple materialized views** – We don't recommend creating multiple materialized views to ingest data from a single stream or topic. This is because each materialized view creates a consumer for

each shard in the Kinesis Data Streams stream or partition in the Kafka topic. This can result in throttling or exceeding the throughput of the stream or topic. It also can result in higher cost, because you ingest the same data multiple times. When you configure streaming ingestion, we recommend you create one materialized view for each stream or topic.

If your use case requires that you ingest data from one KDS stream or MSK topic into multiple materialized views, consult the AWS Big Data blog, specifically Best practices to implement near-real-time analytics using Amazon Redshift Streaming Ingestion with Amazon MSK, before you do so.

Streaming ingestion behavior and data types

The following table describes technical behavior details and size limits for various data types. We recommend being familiar with these prior to configuring a materialized view for streaming ingestion.

Feature or behavior	Description
Kafka topic length limit	It isn't possible to use a Kafka topic with a name longer than 128 characters (not including quotation marks). For more information, see Names and identifiers.
Incremental refreshes and JOINs on a materialized view	The materialized view must be incrementally maintainable. Full recompute is not possible for Kinesis or Amazon MSK because they don't preserve stream or topic history past 24 hours or 7 days, by default. You can set longer data retention periods in Kinesis or Amazon MSK. However, this can result in more maintenance and cost. Additionally, JOINs are not currently supported on materialized views created on a Kinesis stream, or on an Amazon MSK topic. After creating a materialized view on your stream or topic, you can create another materialized view in order to join your streaming materialized view to other materialized views, tables, or views. For more information, see REFRESH MATERIALIZED VIEW.
Record parsing	Amazon Redshift streaming ingestion doesn't support parsing records that have been aggregated by the Kinesis Producer

Feature or behavior	Description
	Library (KPL Key Concepts - Aggregation). The aggregated records are ingested, but are stored as binary protocol buffer data. (See Protocol buffers for more information.) Depending on how you push data to Kinesis, you may need to turn off this feature.
Duplicate values in Kafka headers	The Amazon Redshift streaming consumer client for Kafka topics sourced from Amazon MSK, Confluent or Apache Kafka does not support duplicate values in the Kafka topic headers.
Decompression	`VARBYTE` doesn't support decompression. Because of this, records containing compressed data can't be queried in Redshift. Decompress your data before adding it to the Kinesis stream or Amazon MSK topic.
Maximum record size	The maximum size of any record Amazon Redshift can ingest from Kinesis or Amazon MSK is 16,777,216 bytes (16 MiB), the maximum size supported by the VARBYTE datatype in Amazon Redshift. By default, Amazon Redshift streaming materialized views created on a Kinesis data stream or Amazon MSK topic will set the size of the data column to 1,048,576 bytes (1 MiB) and 16,777,216 bytes (16 MiB) respectively. **Note** 1MiB is the current maximum size of any record that can be put in a Kinesis data stream. For more informati on on Kinesis size limits, go to Quotas and limits in the Amazon Kinesis Data Streams Developer Guide.

Feature or behavior	Description
Error records	In each case where a record can't be ingested to Redshift because the size of the data exceeds the maximum , that record is skipped. Materialized view refresh still succeeds, in this case, and a segment of each error record is written to the SYS_STREAM_SCAN_ERRORS system table. Errors that result from business logic, such as an error in a calculation or an error resulting from a type conversion, are not skipped. Test the logic carefully before you add it to your materialized view definition.
Amazon MSK Multi-VPC private connectivity	Amazon MSK multi-VPC private connectivity isn't currently supported for Redshift streaming ingestion. Alternatively, you can use VPC peering to connect VPCs or AWS Transit Gateway to connect VPCs and on-premises networks through a central hub. Either of these can enable Redshift to communicate with an Amazon MSK cluster or with Amazon MSK Serverless in another VPC.
Auto refresh usage and activation	Auto refresh queries for a materialized view or views are treated as any other user workload. Auto refresh loads data from the stream as it arrives. Auto refresh can be turned on explicitly for a materialized view created for streaming ingestion. To do this, specify `AUTO REFRESH` in the materialized view definition. Manual refresh is the default. To specify auto refresh for an existing materialized view for streaming ingestion, you can run `ALTER MATERIALIZED VIEW` to turn it on. For more information, see CREATE MATERIALIZED VIEW or ALTER MATERIALIZED VIEW.

Feature or behavior	Description
Streaming ingestion and Amazon Redshift Serverless	The setup and configuration instructions that apply to Amazon Redshift streaming ingestion on a provisioned cluster also apply to streaming ingestion on Amazon Redshift Serverless. It's important to specify the necessary level of RPUs to support streaming ingestion with auto refresh and other workloads. For more information, see Billing for Amazon Redshift Serverless.
Amazon Redshift nodes in a different availability zone than the Amazon MSK cluster	When you configure streaming ingestion, Amazon Redshift attempts to connect to an Amazon MSK cluster in the same availability zone, if rack awareness is enabled for Amazon MSK. If all of your nodes are in different availability zones than your Amazon Redshift cluster, you can incur cross availability zone data-transfer cost. To avoid this, keep at least one Amazon MSK broker cluster node in the same AZ as your Redshift provisioned cluster or workgroup.
Refresh start location	After creating a materialized view, its initial refresh starts from the `TRIM_HORIZON` of a Kinesis stream, or from offset 0 of an Amazon MSK topic.
Data formats	Supported data formats are limited to those that can be converted from `VARBYTE`. For more information, see VARBYTE type and VARBYTE operators.

<table>
<tr><th>Feature or behavior</th><th>Description</th></tr>
<tr><td>Appending records to a table</td><td>You can run <code>ALTER TABLE APPEND</code> to append rows to a target table from an existing source materialized view. This works only if the materialized view is configured for streaming ingestion. For more information, see ALTER TABLE APPEND.

<code>ALTER TABLE APPEND</code> operations hold exclusive locks when run on Amazon Redshift streaming materialized views connected to any of the following:
An Amazon Kinesis data stream
An Amazon Managed Streaming for Apache Kafka topic
A supported external stream, such as a Confluent Cloud Kafka topic</td></tr>
<tr><td>Running TRUNCATE or DELETE</td><td>You can remove records from a materialized view that's used for streaming ingestion, using the following:
<code>TRUNCATE</code> – This deletes all of the rows from a materialized view that's configured for streaming ingestion. It doesn't do a table scan. For more information, see TRUNCATE.
<code>DELETE</code> – This deletes all of the rows from a materialized view that's configured for streaming ingestion. For more information, see DELETE.
<code>TRUNCATE</code> and <code>DELETE</code> operations hold exclusive locks when run on Amazon Redshift streaming materialized views connected to any of the following:
An Amazon Kinesis data stream
An Amazon Managed Streaming for Apache Kafka topic
A supported external stream, such as a Confluent Cloud Kafka topic</td></tr>
</table>

<table>
<tr><th>Feature or behavior</th><th>Description</th></tr>
<tr><td>Non-lowercase identifiers</td><td>When creating streaming materialized views on Amazon Managed Streaming for Apache Kafka topics or Kinesis Data Streams that contain non-lowercase identifiers, automatic refreshes might fail. To resolve this, do one of the following:
Use manual refreshes with the <code>enable_case_sensitive_identifier</code> parameter set to <code>true</code>
Enable automatic refreshes by setting <code>enable_case_sensitive_identifier</code> to <code>true</code> at the database or cluster level
Note
Setting <code>enable_case_sensitive_identifier</code> at the user level isn't sufficient for automatic refreshes, but will work for manual refreshes.

For more information about case-sensitive identifiers, see enable_case_sensitive_identifier.</td></tr>
<tr><td>Idempotency</td><td>Amazon Redshift guarantees that each record is processed exactly once when ingesting data from streaming sources. This guarantee applies to two types of sources: Amazon Kinesis (using stream, shard, and sequence number identifiers) and Apache Kafka (using topic, partition, and offset identifiers), including Amazon Managed Streaming for Apache Kafka (Amazon MSK) and Confluent Cloud.</td></tr>
</table>

Getting started with streaming ingestion from Amazon Kinesis Data Streams

This topic describes how to consume streaming data from Kinesis Data Streams using a materialized view.

Setting up Amazon Redshift streaming ingestion involves creating an external schema that maps to the streaming data source and creating a materialized view that references the external schema. Amazon Redshift streaming ingestion supports Kinesis Data Streams as a source. As such, you must have a Kinesis Data Streams source available before configuring streaming ingestion. If you don't have a source, follow the instructions in the Kinesis documentation at Getting Started with Amazon Kinesis Data Streams or create one on the console using the instructions at Creating a Stream via the AWS Management Console.

Amazon Redshift streaming ingestion uses a materialized view, which is updated directly from the stream when `REFRESH` is run. The materialized view maps to the stream data source. You can perform filtering and aggregations on the stream data as part of the materialized-view definition. Your streaming ingestion materialized view (the *base* materialized view) can reference only one stream, but you can create additional materialized views that join with the base materialized view and with other materialized views or tables.

> **Note**
>
> *Streaming ingestion and Amazon Redshift Serverless* - The configuration steps in this topic apply both to provisioned Amazon Redshift clusters and to Amazon Redshift Serverless. For more information, see Streaming ingestion behavior and data types.

Assuming you have a Kinesis Data Streams stream available, the first step is to define a schema in Amazon Redshift with `CREATE EXTERNAL SCHEMA` and to reference a Kinesis Data Streams resource. Following that, to access data in the stream, define the `STREAM` in a materialized view. You can store stream records in the semi-structured `SUPER` format, or define a schema that results in data converted to Redshift data types. When you query the materialized view, the returned records are a point-in-time view of the stream.

1. Create an IAM role with a trust policy that allows your Amazon Redshift cluster or Amazon Redshift Serverless workgroup to assume the role. For information about how to configure the trust policy for the IAM role, see Authorizing Amazon Redshift to access other AWS services on your behalf. After it is created, the role should have the following IAM policy, which provides permission for communication with the Amazon Kinesis data stream.

   IAM policy for an unencrypted stream from Kinesis Data Streams

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ReadStream",
            "Effect": "Allow",
            "Action": [
                "kinesis:DescribeStreamSummary",
                "kinesis:GetShardIterator",
                "kinesis:GetRecords",
                "kinesis:ListShards",
                "kinesis:DescribeStream"
            ],
            "Resource": "arn:aws:kinesis:*:111122223333:stream/*"
        },
        {
            "Sid": "ListStream",
            "Effect": "Allow",
            "Action": "kinesis:ListStreams",
            "Resource": "*"
        }
    ]
}
```

IAM policy for an encrypted stream from Kinesis Data Streams

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ReadStream",
            "Effect": "Allow",
            "Action": [
                "kinesis:DescribeStreamSummary",
                "kinesis:GetShardIterator",
```

```
                "kinesis:GetRecords",
                "kinesis:ListShards",
                "kinesis:DescribeStream"
            ],
            "Resource": "arn:aws:kinesis:*:111122223333:stream/*"
        },
        {
            "Sid": "DecryptStream",
            "Effect": "Allow",
            "Action": [
                "kms:Decrypt"
            ],
            "Resource": "arn:aws:kms:us-
east-1:111122223333:key/1234abcd-12ab-34cd-56ef-1234567890ab"
        },
        {
            "Sid": "ListStream",
            "Effect": "Allow",
            "Action": "kinesis:ListStreams",
            "Resource": "*"
        }
    ]
}
```

2. Check your VPC and verify that your Amazon Redshift cluster or Amazon Redshift Serverless has a route to get to the Kinesis Data Streams endpoints over the internet using a NAT gateway or internet gateway. If you want traffic between Redshift and Kinesis Data Streams to remain within the AWS network, consider using a Kinesis Interface VPC Endpoint. For more information, see Using Amazon Kinesis Data Streams Kinesis Data Streams with Interface VPC Endpoints.

3. In Amazon Redshift, create an external schema to map the data from Kinesis to a schema.

```
CREATE EXTERNAL SCHEMA kds
FROM KINESIS
IAM_ROLE { default | 'iam-role-arn' };
```

Streaming ingestion for Kinesis Data Streams doesn't require an authentication type. It uses the IAM role defined in the `CREATE EXTERNAL SCHEMA` statement for making Kinesis Data Streams requests.

Optional: Use the REGION keyword to specify the region where the Amazon Kinesis Data Streams or Amazon MSK stream resides.

```
CREATE EXTERNAL SCHEMA kds
FROM KINESIS
REGION 'us-west-2'
IAM_ROLE { default | 'iam-role-arn' };
```

In this sample, the region specifies the location of the source stream. The IAM_ROLE is a sample.

4. Create a materialized view to consume the stream data. With a statement like the following, if a record can't be parsed, it causes an error. Use a command like this if you don't want error records to be skipped.

```
CREATE MATERIALIZED VIEW my_view AUTO REFRESH YES AS
SELECT *
FROM kds.my_stream_name;
```

Kinesis stream names are case sensitive and can contain both uppercase and lowercase letters. To ingest from streams with uppercase names, you can set the configuration `enable_case_sensitive_identifier` to `true` at the database level. For more information, see Names and identifiers and enable_case_sensitive_identifier.

To turn on auto refresh, use `AUTO REFRESH YES`. The default behavior is manual refresh. Note when you use CAN_JSON_PARSE, it's possible that records that can't be parsed are skipped.

Metadata columns include the following:

Metadata column	Data type	Description
approximate_arrival_timestamp	timestamp without time zone	The approximate time that the record was inserted into the Kinesis stream
partition_key	varchar(256)	The key used by Kinesis to assign the record to a shard

Metadata column	Data type	Description
shard_id	char(20)	The unique identifier of the shard within the stream from which the record was retrieved
sequence_number	varchar(128)	The unique identifier of the record from the Kinesis shard
refresh_time	timestamp without time zone	The time the refresh started
kinesis_data	varbyte	The record from the Kinesis stream

It's important to note if you have business logic in your materialized view definition that business-logic errors can cause streaming ingestion to be blocked in some cases. This might lead to you having to drop and re-create the materialized view. To avoid this, we recommend that you keep your logic as simple as possible and perform most of your business-logic checks on the data after it's ingested.

5. Refresh the view, which invokes Redshift to read from the stream and load data into the materialized view.

```
REFRESH MATERIALIZED VIEW my_view;
```

6. Query data in the materialized view.

```
select * from my_view;
```

Getting started with streaming ingestion from Apache Kafka sources

This topic describes how to consume streaming data from Amazon MSK, Apache Kafka or Confluent Cloud using a materialized view.

The purpose of Amazon Redshift streaming ingestion is to simplify the process for directly ingesting stream data from a streaming service into Amazon Redshift or Amazon Redshift Serverless. This works with Amazon MSK Provisioned and Amazon MSK Serverless, with open-source Apache Kafka, and with Confluent Cloud. Amazon Redshift streaming ingestion removes the need to stage an Apache Kafka topic in Amazon S3 before ingesting the stream data into Redshift.

On a technical level, streaming ingestion provides low-latency, high-speed ingestion of stream or topic data into an Amazon Redshift materialized view. Following setup, using materialized view refresh, you can take in large data volumes.

You must have an Apache Kafka source available before configuring Amazon Redshift streaming ingestion. If you do not have a source, create one using the following instructions:

- **Amazon MSK** — Getting Started Using Amazon MSK
- **Apache Kafka** — Apache Kafka Quickstart
- **Confluent Cloud** — Quick Start for Confluent Cloud

Setting up streaming ingestion from Kafka

Use the following procedures to set up streaming ingestion to Amazon Redshift from Amazon MSK, or Apache Kafka sources that are not AWS-managed (Apache Kafka and Confluent Cloud).

Topics

Set up authentication

This section describes setting up authentication to allow your Amazon Redshift application to access an Amazon MSK source.

After you create your application's role, attach one of the following policies to allow access to your Amazon MSK, Apache Kafka, or Confluent Cloud cluster. For mTLS authentication, you can store the certificates that Amazon Redshift uses in ACM or Secrets Manager, so you must choose the policy that matches where the certificate is stored.

Note that self-signed certificates are not supported for authentication or data in transit when you use direct streaming ingestion into Amazon Redshift with any of the supported Apache Kafka streaming sources. These include Amazon MSK, Apache Kafka, and Confluent Cloud. Consider using certificates generated with AWS Certificate Manager or any other publicly trusted certificate authority.

Amazon Redshift IAM authentication with MSK is only supported on Kafka version 2.7.1 or above.

AUTHENTICATION IAM (Amazon MSK only):

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "MSKIAMpolicy",
            "Effect": "Allow",
            "Action": [
                "kafka-cluster:ReadData",
                "kafka-cluster:DescribeTopic",
                "kafka-cluster:Connect"
            ],
            "Resource": [
                "arn:aws:kafka:*:111122223333:cluster/MyTestCluster/*",
                "arn:aws:kafka:*:111122223333:topic/MyTestCluster/*"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "kafka-cluster:AlterGroup",
                "kafka-cluster:DescribeGroup"
            ],
            "Resource": [
                "arn:aws:kafka:*:111122223333:group/MyTestCluster/*"
            ]
        }
    ]
}
```

AUTHENTICATION MTLS: using a certificate stored in AWS Certificate Manager

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "MSKmTLSACMpolicy",
            "Effect": "Allow",
            "Action": [
                "acm:ExportCertificate"
            ],
            "Resource": [
                "arn:aws:acm:us-east-1:444455556666:certificate/certificate_ID"
            ]
        }
    ]
}
```

AUTHENTICATION MTLS: using a certificate stored in AWS Secrets Manager

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "MSKmTLSSecretsManagerpolicy",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetSecretValue"
            ],
            "Resource": [
                "arn:aws:secretsmanager:us-east-1:444455556666:secret:secret_ID"
            ]
        }
    ]
}
```

Amazon MSK

If you use AUTHENTICATION NONE to connect to a Amazon MSK source, no IAM role is required. However, if you use AUTHENTICATION IAM or MTLS to authenticate with your Amazon MSK cluster, your Amazon Redshift cluster or Amazon Redshift Serverless namespace must have an attached IAM role with appropriate permissions. Create an IAM role with a trust policy that allows your Amazon Redshift cluster or Amazon Redshift Serverless namespace to assume the role. After you create the role, add one of the following permissions to support IAM or MTLS. For mTLS authentication, the certificates that Amazon Redshift uses can be stored in AWS Certificate Manager or AWS Secrets Manager, so you must choose the policy that matches where the certificate is stored. Attach the role to your Amazon Redshift provisioned cluster or Redshift Serverless namespace. For information about how to configure the trust policy for the IAM role, see Authorizing Amazon Redshift to access other AWS services on your behalf.

The following table shows complimentary configuration options to set for streaming ingestion from Amazon MSK:

Amazon Redshift configuration	Amazon MSK configuration	Port to open between Redshift and Amazon MSK
AUTHENTICATION NONE	TLS transport disabled	9092
AUTHENTICATION NONE	TLS transport enabled	9094
AUTHENTICATION IAM	IAM	9098/9198
AUTHENTICATION MTLS	TLS transport enabled	9094

Amazon Redshift authentication is set in the CREATE EXTERNAL SCHEMA statement.

Note

In a case where the Amazon MSK cluster has Mutual Transport Layer Security (mTLS) authentication enabled, configuring Amazon Redshift to use AUTHENTICATION NONE directs it to use port 9094 for unauthenticated access. However, this will fail because the port is being used by mTLS authentication. Because of this, we recommend that you switch to AUTHENTICATION mtls when you use mTLS.

Apache Kafka or Confluent Cloud

For Apache Kafka and Confluent Cloud, Amazon Redshift supports the following connection protocols:

- You can use mTLS or plaintext with TLS transport for authentication when connecting to Apache Kafka.
- You can only use mTLS for authentication when connecting to Confluent Cloud.

Amazon Redshift supports the following encryption protocols for connecting to Apache Kafka or Confluent Cloud:

Supported authentication methods for Apache Kafka and Confluent Cloud

Amazon Redshift	Kafka Security Protocol	Apache Kafka support	Confluent Cloud support
AUTHENTICATION NONE	PLAINTEXT	No	No
AUTHENTICATION NONE	SSL	Yes	No
AUTHENTICATION IAM	SASL_SSL	No	No
AUTHENTICATION MTLS	SSL	Yes (with certificate)	Yes (with certificate)

Note that Amazon Redshift does not support SASL/SCRAM or SASL/PLAINTEXT.

Setting up your VPC

After you create your authentication resources, check your VPC and verify that your Amazon Redshift cluster or Amazon Redshift Serverless workgroup has a route to get to your Apache Kafka source.

> **Note**
>
> For Amazon MSK, the inbound security group rules for your Amazon MSK cluster should allow your Amazon Redshift cluster's or your Redshift Serverless workgroup's security group. The ports you specify depend on the authentication methods configured on your Amazon MSK cluster. For more information, see Port information and Access from within AWS but outside the VPC.

Next, enable enhanced VPC routing on your Amazon Redshift cluster or Amazon Redshift Serverless workgroup. For more information, see Enabling enhanced VPC routing.

Create a Materialized View

In this section, you set up the materialized view that Amazon Redshift uses to access your Apache Kafka streaming data.

Assuming you have an Apache Kafka cluster available, the first step is to define a schema in Redshift with `CREATE EXTERNAL SCHEMA` and to reference the cluster as the data source. Following that, to access data in the topic, define the `STREAM` in a materialized view. You can store records from your topic using the default Amazon Redshift VARBYTE datatype, or define a schema that converts the data to the semi-structured `SUPER` format. When you query the materialized view, the returned records are a point-in-time view of the topic.

1. In Amazon Redshift, create an external schema to map to the Apacke Kafka cluster. The syntax is the following:

   ```
   CREATE EXTERNAL SCHEMA MySchema
   FROM KAFKA
   [ IAM_ROLE [ default | 'iam-role-arn' ] ]
   AUTHENTICATION [ none | iam | mtls ]
   {AUTHENTICATION_ARN 'acm-certificate-arn' |  SECRET_ARN 'asm-secret-arn'};
   ```

   In the `FROM` clause, `KAFKA` denotes that the schema maps data from an Apache Kafka source.

   `AUTHENTICATION` denotes the authentication type for streaming ingestion. There are three types available:

- **none** – Specifies that there is no authentication required. This corresponds to Unauthenticated access on MSK. This corresponds to SSL authentication in Apache Kafka. This authentication method is not supported for Confluent Cloud.
- **iam** – Specifies IAM authentication. You can only use IAM authentication with Amazon MSK. When you choose this, make sure that the IAM role has permissions for IAM authentication. For more information about setting up the required IAM policies, see Setting up streaming ingestion from Kafka.
- **mtls** – Specifies that mutual transport layer security provides secure communication by facilitating authentication between a client and server. In this case, the client is Redshift and the server is Apache Kafka. For more information about configuring streaming ingestion with mTLS, see Authentication with mTLS for Redshift streaming ingestion from Apache Kafka sources.

Note that Amazon MSK authentication with a username and password isn't supported for streaming ingestion.

The `AUTHENTICATION_ARN` parameter specifies the ARN of the ACM mutual transport layer security (mTLS) certificate you use to establish an encrypted connection.

The `SECRET_ARN` parameter specifies the arn of the AWS Secrets Manager secret containing the certificate to be used by Amazon Redshift for mTLS.

The following examples show how to set the broker URI for the Amazon MSK cluster when you create the external schema:

Using IAM authentication:

```
CREATE EXTERNAL SCHEMA my_schema
FROM KAFKA
IAM_ROLE 'arn:aws:iam::012345678901:role/my_role'
AUTHENTICATION IAM
URI 'b-1.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9098,b-2.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9098'
```

Using no authentication:

```
CREATE EXTERNAL SCHEMA my_schema
```

```
FROM KAFKA
AUTHENTICATION none
URI 'b-1.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9092,b-2.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9092'
```

Using mTLS:

```
CREATE EXTERNAL SCHEMA my_schema
FROM KAFKA
IAM_ROLE 'arn:aws:iam::012345678901:role/my_role'
AUTHENTICATION MTLS
URI 'b-1.myTestCluster.123z8u.c2.kafka.us-west-1.amazonaws.com:9094,b-
 2.myTestCluster.123z8u.c2.kafka.us-west-1.amazonaws.com:9094'
{AUTHENTICATION_ARN 'acm-certificate-arn' |  SECRET_ARN 'asm-secret-arn'}
```

For more information on creating an external schema, see CREATE EXTERNAL SCHEMA.

2. Create a materialized view to consume the data from the topic. Use a SQL command such as the following sample.

```
CREATE MATERIALIZED VIEW MyView AUTO REFRESH YES AS
SELECT *
FROM MySchema."mytopic";
```

Kafka topic names are case sensitive and can contain both uppercase and lowercase letters. To ingest from topics with uppercase names, you can set the configuration `enable_case_sensitive_identifier` to `true` at the session or database level. For more information, see Names and identifiers and enable_case_sensitive_identifier.

To turn on auto refresh, use `AUTO REFRESH YES`. The default behavior is manual refresh.

3. Metadata columns include the following:

Metadata column	Data type	Description
kafka_partition	bigint	Partition id of the record from the Kafka topic

Metadata column	Data type	Description
kafka_offset	bigint	Offset of the record in the Kafka topic for a given partition
kafka_timestamp_type	char(1)	Type of timestamp used in the Kafka record: • *C* – Record creation time (CREATE_TIME) on the client side • *L* – Record append time (LOG_APPEND_TIME) on the Kafka server side • *U* – Record creation time is not available (NO_TIMESTAMP_TYPE)
kafka_timestamp	timestamp without time zone	The timestamp value for the record
kafka_key	varbyte	The key of the Kafka record
kafka_value	varbyte	The record received from Kafka
kafka_headers	super	The header of the record received from Kafka
refresh_time	timestamp without time zone	The time the refresh started

It's important to note if you have business logic in your materialized view definition that results in business logic errors, this can result in ingestion failures in streaming ingestion in some cases. This might lead to you having to drop and re-create the materialized view. To avoid this, we recommend that you keep your business logic simple and run additional logic on the data after you ingest it.

4. Refresh the view, which invokes Amazon Redshift to read from the topic and load data into the materialized view.

```
REFRESH MATERIALIZED VIEW MyView;
```

5. Query data in the materialized view.

```
select * from MyView;
```

   The materialized view is updated directly from the topic when REFRESH is run. You create a materialized view that maps to the Kafka topic data source. You can perform filtering and aggregations on the data as part of the materialized view definition. Your streaming ingestion materialized view (base materialized view) can reference only one Kafka topic, but you can create additional materialized views that join with the base materialized view and with other materialized views or tables.

For more information about limitations for streaming ingestion, see Streaming ingestion behavior and data types.

Authentication with mTLS for Redshift streaming ingestion from Apache Kafka sources

Mutual transport-layer security (mTLS) provides the means for a server to authenticate a client it's sending information to, and for the client to authenticate the server. The benefit of using mTLS is to provide trusted authentication for a variety of use cases in several industry-vertical applications. These include use cases in financial, retail, government and healthcare industries. In the case of streaming ingestion to Redshift, authentication occurs between a server, which can be Amazon MSK, Apache Kafka, or Confluent Cloud, and an Amazon Redshift provisioned cluster or an Amazon Redshift Serverless workgroup.

This topic provides procedures and SQL-command examples that show ways to create an external schema that uses mTLS to authenticate between the Redshift client and any Apache Kafka server. The steps in this topic complement the full set of steps for setting up streaming ingestion from Apache Kafka sources. For more information, see Getting started with streaming ingestion from Apache Kafka sources.

Prerequisites for using mTLS for streaming ingestion

This section provides prerequisite steps for using mTLS for streaming ingestion with either AWS Certificate Manager or AWS Secrets Manager.

As a preliminary step, you must have or create a private certificate authority (PCA), which you can use to issue certificates that, among other functions, enable secure communication through secure communication channels. AWS Private Certificate Authority (Private CA) is an available service that performs this function. For more information, see Creating a private CA in the *AWS Private Certificate Authority User Guide*. After creating the Private CA, export the root CA certificate and save it to a file with a .pem extension.

To create a cluster that uses the CA certificate, do the following:

Amazon MSK

1. Create an Amazon MSK cluster that supports mtls client authentication. For more information about configuring an Amazon MSK cluster, see Mutual TLS client authentication for Amazon MSK in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.
2. Edit the security settings for the Amazon MSK cluster, turning on TLS client authentication using AWS Certificate Manager (ACM) and selecting the AWS Private CA (PCA) you created previously. For more information, see Updating security settings of a cluster in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

Confluent Cloud

1. Create a dedicated Confluent Cloud cluster, preferably in the same AWS Region as your Amazon Redshift cluster. For information about creating a Confluent Cloud cluster, see Create a Kafka cluster in Confluent Cloud.
2. Upload the exported AWS Private CA root CA certificate pem file you created earlier. For more information, see Manage certificate authority for mTLS authentication for Confluent Cloud. Confluent Cloud uses this certificate to verify the Amazon Redshift client certificate.

Using mTLS for streaming ingestion with AWS Certificate Manager

The following procedure shows how to configure mTLS for Redshift streaming ingestion by using AWS Certificate Manager (ACM) for certificate storage and management:

1. Request a private certificate through ACM. When you do this, select the PCA you created in the Prerequisites section as the certificate authority. ACM stores the signed certificate and attached private key for secure communication. For more information about managing certificates with ACM, see Issuing and managing certificates in the *AWS Certificate Manager User Guide*.
2. For the IAM role that you use to manage your Redshift cluster or Amazon Redshift Serverless workgroup, attach the permission to export the certificate, which is **acm:ExportCertificate**. For more information about setting up the necessary IAM resources for streaming ingestion, see Setting up streaming ingestion from Kafka. Specify the same IAM role in the next step to create the external schema.

> **Note**
>
> Requests to AWS Certificate Manager require an Internet gateway (IGW) or a NAT gateway (NGW) in your VPC. If your VPC doesn't have either an IGW or a NGW, do the following:
>
> - Use Secrets Manager instead of ACM to store your certificates.
> - Attach a Secrets Manager VPC endpoint to your VPC.
>
> For information about using Secrets Manager with mTLS for streaming ingestion, see Using mTLS for streaming ingestion with AWS Secrets Manager following.

3. Get the bootstrap broker URI for the Amazon MSK, Apache Kafka, or Confluent Cloud cluster. For information about getting the bootstrap broker URI for Amazon MSK, see Getting the bootstrap brokers for an Amazon MSK cluster in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.
4. Run a SQL command such as the following example to create an external schema that maps the cluster to a Redshift external schema, using `mtls`.

   Amazon MSK

```
CREATE EXTERNAL SCHEMA my_schema
FROM KAFKA
IAM_ROLE 'arn:aws:iam::012345678901:role/my_role'
AUTHENTICATION mtls
```

```
URI 'b-1.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9094,b-2.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9094'
AUTHENTICATION_ARN 'arn:aws:acm:Region:444455556666:certificate/certificate_ID';
```

Apache Kafka or Confluent Cloud

```
CREATE EXTERNAL SCHEMA my_schema
FROM KAFKA
IAM_ROLE 'arn:aws:iam::012345678901:role/my_role'
AUTHENTICATION mtls
URI 'lkc-2v531.domz6wj0p.us-west-1.aws.confluent.cloud:9092'
AUTHENTICATION_ARN 'arn:aws:acm:region:444455556666:certificate/certificate_ID';
```

Important parameters:

- IAM_ROLE – The IAM role associated with the cluster, for streaming ingestion.
- URI – The bootstrap broker URI for the cluster. Note that for Amazon MSK, port 9094 is specified for communicating with brokers for TLS encryption.
- AUTHENTICATION_ARN – The ARN of the ACM certificate. The ARN is available in the ACM console when you choose the issued certificate.

After performing these configuration steps, you can create a Redshift materialized view that references the schema defined in the sample and then use REFRESH MATERIALIZED VIEW to stream data. For more information, see Getting started with streaming ingestion from Apache Kafka sources.

Using mTLS for streaming ingestion with AWS Secrets Manager

You can configure mTLS for Redshift streaming ingestion by using AWS Secrets Manager for certificate management if you don't want to reference the certificate in AWS Certificate Manager. The following steps describe how to configure mTLS using Secrets Manager.

1. Create a certificate signing request and private key with your tool of choice. Then you can use the signing request to generate a signed certificate, using the same AWS Private CA (PCA) that you used to generate the certificate for the cluster. For more information about issuing a certificate, see IssueCertificate in the *AWS Private Certificate Authority API Reference*.

2. Extract the certificate using AWS Private Certificate Authority. For more information, see Retrieve a private certificate in the *AWS Private Certificate Authority User Guide*.

3. Store the certificate and private key generated in the previous step in AWS Secrets Manager. Choose `Other type of secret` and use the plaintext format. The key-value pairs should be in the format `{"certificate":"<cert value>","privateKey":"<pkey value>"}`, as in the following example. For more information about creating and managing secrets in AWS Secrets Manager, see Create and manage secrets with AWS Secrets Manager in the *AWS Secrets Manager User Guide*.

```
{"certificate":"-----BEGIN CERTIFICATE-----
klhdslkfjahksgdfkgioeuyihbflahabhbdslv6akybeoiwv1hoaiusdhbahsbdi
H4hAX8/eE96qCcjkpfT84EdvHzp6fC+/WwM0oXlwUEWlvfMCXNaG5D8SqRq3qA==
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
klhdslkfjahksgdfkgioeuyihbflahabhbdslv6akybeoiwv1hoaiusdhbahsbdi
wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
-----END CERTIFICATE-----",
"privateKey":"-----BEGIN PRIVATE KEY-----
klhdslkfjahksgdfkgioeuyihbflahabhbdslv6akybeoiwv1hoaiusdhbahsbdi
7OD4m1dBEs3Fj++hDMH9rYRp99RqtCOf0EWOUe139KOilOsW+cyhAoc9Ci2+Jo/k
17u2N1iGILMQEZuCRtnJOkFYkw==
-----END PRIVATE KEY-----"}
```

4. Attach the permission policy to retrieve the secret to the IAM role that you use to manage your Amazon Redshift cluster or Amazon Redshift Serverless workgroup. This permission is `secretsmanager:GetSecretValue`. For more information, see Set up authentication. For more information about managing IAM policies, see Edit IAM policies. Specify the same IAM role in the next step to create the external schema.

5. In Redshift, run the SQL command to create the external schema. You use the AUTHENTICATION type `mtls`. You also specify the URI of the cluster and the secret ARN in AWS Secrets Manager.

```
CREATE EXTERNAL SCHEMA my_schema
FROM KAFKA
IAM_ROLE 'arn:aws:iam::012345678901:role/my_role'
AUTHENTICATION mtls
URI 'b-1.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9094,b-2.myTestCluster.123z8u.c2.kafka.us-
west-1.amazonaws.com:9094'
```

```
SECRET_ARN 'arn:aws:secretsmanager:us-east-1:012345678910:secret:myMTLSSecret';
```

Important parameters:

- IAM_ROLE – The IAM role associated with the cluster, for streaming ingestion.
- URI – The bootstrap broker URI for the cluster. Note that for Amazon MSK, port 9094 is specified for communicating with brokers for TLS encryption.
- SECRET_ARN – The ARN of the secret from Secrets Manager, containing the certificate to use for mTLS.

Enabling mTLS authentication for an existing external schema

If you have an existing external schema that you use for streaming ingestion and you want to implement mutual TLS for authentication, you can run a command such as the following, which specifies mTLS authentication and the ACM certificate ARN in ACM.

```
ALTER EXTERNAL SCHEMA schema_name
AUTHENTICATION mtls
AUTHENTICATION_ARN 'arn:aws:acm:Region:444455556666:certificate/certificate_ID';
```

Or you can specify mTLS authentication, with reference to the secret ARN in AWS Secrets Manager.

```
ALTER EXTERNAL SCHEMA schema_name
AUTHENTICATION mtls
SECRET_ARN 'arn:aws:secretsmanager:us-east-1:012345678910:secret:myMTLSSecret';
```

For information about the ALTER EXTERNAL SCHEMA command, see ALTER EXTERNAL SCHEMA.

Ingesting streaming data using Kinesis

This procedure demonstrates how to ingest data from a Kinesis stream named *ev_station_data*, which contains consumption data from different EV charging stations, in JSON format. The schema is well defined. The example shows how to store the data as raw JSON and also how to convert the JSON data to Amazon Redshift data types as it's ingested.

Producer setup

1. Using Amazon Kinesis Data Streams, follow the steps to create a stream named `ev_station_data`. Choose **On-demand** for the **Capacity mode**. For more information, see [Creating a Stream via the AWS Management Console](#).

2. The [Amazon Kinesis Data Generator](#) can help you generate test data for use with your stream. Follow the steps detailed in the tool to get started, and use the following data template for generating your data:

```
{

   "_id" : "{{random.uuid}}",
   "clusterID": "{{random.number(
        {   "min":1,
            "max":50
        }
    )}}",
    "connectionTime": "{{date.now("YYYY-MM-DD HH:mm:ss")}}",
    "kWhDelivered": "{{commerce.price}}",
    "stationID": "{{random.number(
        {   "min":1,
            "max":467
        }
    )}}",
      "spaceID": "{{random.word}}-{{random.number(
        {   "min":1,
            "max":20
        }
    )}}",

   "timezone": "America/Los_Angeles",
   "userID": "{{random.number(
        {   "min":1000,
            "max":500000
        }
    )}}"
}
```

   Each JSON object in the stream data has the following properties:

```
{
    "_id": "12084f2f-fc41-41fb-a218-8cc1ac6146eb",
    "clusterID": "49",
```

```
    "connectionTime": "2022-01-31 13:17:15",
    "kWhDelivered": "74.00",
    "stationID": "421",
    "spaceID": "technologies-2",
    "timezone": "America/Los_Angeles",
    "userID": "482329"
}
```

Amazon Redshift setup

These steps show you how to configure the materialized view to ingest data.

1. Create an external schema to map the data from Kinesis to a Redshift object.

```
CREATE EXTERNAL SCHEMA evdata FROM KINESIS
IAM_ROLE 'arn:aws:iam::0123456789:role/redshift-streaming-role';
```

   For information about how to configure the IAM role, see Getting started with streaming ingestion from Amazon Kinesis Data Streams.

2. Create a materialized view to consume the stream data. The following example shows how to define a materialized view to ingest the JSON formatted data from a Kinesis stream.

   First, store stream records in semi-structured SUPER format. In this example, the JSON source is stored in Redshift without converting to Redshift types.

```
CREATE MATERIALIZED VIEW ev_station_data AS
    SELECT approximate_arrival_timestamp,
    partition_key,
    shard_id,
    sequence_number,
    case when can_json_parse(kinesis_data) then json_parse(kinesis_data) else null
 end as payload,
    case when not can_json_parse(kinesis_data) then kinesis_data else null end as
 failed_payload
    FROM evdata."ev_station_data" ;
```

Query the stream

1. Enable case sensitive SUPER attributes using the command below. Amazon Redshift is case insensitive by default, so in order to access case sensitive SUPER attributes, you need to enable this functionality.

```
SET enable_case_sensitive_super_attribute to TRUE;
```

2. Refresh the materialized view with the following command in order to pull data from the stream.

```
REFRESH MATERIALIZED VIEW ev_station_data;
```

3. Query the refreshed materialized view to get usage statistics.

```
SELECT e.payload.connectionTime::date as connectiontime
,SUM(e.payload.kWhDelivered::decimal(10,2)) AS Energy_Consumed
,count(distinct e.payload.userID) AS #Users
from ev_station_data as e
group by connectiontime
order by 1 desc;
```

4. View results.

```
connectiontime          energy_consumed    #users
2022-02-08                   4139          10
2022-02-09                   5571          10
2022-02-10                   8697          20
2022-02-11                   4408          10
2022-02-12                   4257          10
2022-02-23                   6861          10
```

AWS Glue Data Catalog views

This topic describes how to create views in the AWS Glue Data Catalog. You can use views in the Data Catalog to access data in different data sources using the same schema.

By creating views in the Data Catalog, you can create a single common view schema and metadata object to use across engines such as Amazon Athena and Amazon EMR Spark. Doing so lets you use the same views across your data lakes and data warehouses to fit your use cases. Views in the Data Catalog are special in that they are categorized as definer views, where access permissions are defined by the user who created the view instead of the user querying the view. The following are some use cases and benefits of creating views in the Data Catalog:

- Create a view that restricts data access based on the permissions the user needs. For example, you can use views in the Data Catalog to prevent employees who don't work in the HR department from seeing personally identifiable information (PII).
- Make sure that users can't access incomplete records. By applying certain filters onto your view in the Data Catalog, you make sure that data records inside a view in the Data Catalog are always complete.
- Data Catalog views have an included security benefit of making sure that the query definition used to create the view must complete to create the view. This security benefit means that views in the Data Catalog are not susceptible to SQL commands from malicious players.
- Views in the Data Catalog support the same advantages as normal views, such as letting users access a view without making the underlying table available to users.

To create a view in the Data Catalog, you must have a Spectrum external table, an object that's contained within a Lake Formation-managed datashare, or an Apache Iceberg table.

Definitions of Data Catalog views are stored in the AWS Glue Data Catalog. Use AWS Lake Formation to grant access through resource grants, column grants, or tag-based access controls. For more information about granting and revoking access in Lake Formation, see Granting and revoking permissions on Data Catalog resources.

When you use Amazon Redshift to run a query referencing such AWS Glue Data Catalog views, Amazon Redshift automatically masks fields in certain system table and view columns when logging metadata about that query. For more information, see Secure logging in the *Amazon Redshift Management Guide*.

Prerequisites

Before you can create a view in the Data Catalog, make sure that you have the following prerequisites completed:

- Make sure that your IAM role has the following trust policy.

  JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
               "Service": [
                    "glue.amazonaws.com",
                    "lakeformation.amazonaws.com"
                ]
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

- You also need the following pass role policy.

  JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "Stmt1",
            "Action": [
                "iam:PassRole"
            ],
            "Effect": "Allow",
            "Resource": "*",
            "Condition": {
                "StringEquals": {
                    "iam:PassedToService": [
                        "glue.amazonaws.com",
```

```
                                "lakeformation.amazonaws.com"
                            ]
                        }
                    }
                }
            ]
}
```

- Finally, you also need the following permissions.
  - `Glue:GetDatabase`
  - `Glue:GetDatabases`
  - `Glue:CreateTable`
  - `Glue:GetTable`
  - `Glue:UpdateTable`
  - `Glue:DeleteTable`
  - `Glue:GetTables`
  - `Glue:SearchTables`
  - `Glue:BatchGetPartition`
  - `Glue:GetPartitions`
  - `Glue:GetPartition`
  - `Glue:GetTableVersion`
  - `Glue:GetTableVersions`

End-to-end example

Start by creating an external schema based on your Data Catalog database.

```
CREATE EXTERNAL SCHEMA IF NOT EXISTS external_schema FROM DATA CATALOG DATABASE
 'external_data_catalog_db'
IAM_ROLE 'arn:aws:iam::123456789012:role/sample-role';
```

You can now create a Data Catalog view.

```
CREATE EXTERNAL PROTECTED VIEW external_schema.remote_view
AS SELECT * FROM external_schema.remote_table;
```

You can then start querying your view.

```
SELECT * FROM external_schema.remote_view;
```

For more information about the SQL commands related to views in the Data Catalog, see CREATE EXTERNAL VIEW, ALTER EXTERNAL VIEW, and DROP EXTERNAL VIEW.

Considerations and limitations

The following are considerations and limitations that apply to views created in the Data Catalog.

- AWS Glue Data Catalog views are only supported on RA3 provisioned clusters or Redshift Serverless workgroups.
- You can’t create a Data Catalog view that is based off of another view.
- You can only have 10 base tables in a Data Catalog view.
- The definer of the view must have full `SELECT GRANTABLE` permissions on the base tables.
- Views can only contain Lake Formation objects and built-ins. The following objects are not permitted inside of a view.
  - System tables
  - User-defined functions (UDFs)
  - Redshift tables, views, materialized views, and late binding views that aren’t in a Lake Formation managed data share.
- Views can’t contain nested Redshift Spectrum tables.
- AWS Glue representations of the base objects of a view must be in the same AWS account and Region as the view.

Querying spatial data in Amazon Redshift

Spatial data describes the position and shape of a geometry in a defined space (a spatial reference system). Amazon Redshift supports spatial data with the GEOMETRY and GEOGRAPHY data types, which contain spatial data and optionally the data's spatial reference system identifier (SRID).

Spatial data contains geometric data that you can use to represent geographic features. Examples of this type of data include weather reports, map directions, tweets with geographic positions, store locations, and airline routes. Spatial data plays an important role in business analytics, reporting, and forecasting.

You can query spatial data with Amazon Redshift SQL functions. Spatial data contains geometric values for an object.

The GEOMETRY data type operations work on the Cartesian plane. Although the spatial reference system identifier (SRID) is stored inside the object, this SRID is merely an identifier of the coordinate system and plays no role in the algorithms used to process the GEOMETRY objects. Conversely, the operations on the GEOGRAPHY data type treat the coordinates inside objects as spherical coordinates on a spheroid. This spheroid is defined by the SRID, which references a geographic spatial reference system. By default, GEOGRAPHY data types are created with spatial reference (SRID) 4326, referencing the World Geodetic System (WGS) 84. For more information about SRIDs, see [Spatial reference system](https://en.wikipedia.org/wiki/Spatial_reference_system) in Wikipedia.

You can use the ST_Transform function to transform the coordinates from various spatial reference systems. After the transformation of the coordinates is done, you can also use a simple cast between the two, as long as the input GEOMETRY is encoded with the geographic SRID. This cast simply copies coordinates without any further transformation. For example:

```
SELECT ST_AsEWKT(ST_GeomFromEWKT('SRID=4326;POINT(10 20)')::geography);
```

```
st_asewkt
------------------------
 SRID=4326;POINT(10 20)
```

To better understand the difference between GEOMETRY and GEOGRAPHY data types, consider calculating the distance between the Berlin airport (BER) and the San Francisco airport (SFO) using the World Geodetic System (WGS) 84. Using the GEOGRAPHY data type, the result is in meters.

When using `GEOMETRY` data type with SRID 4326, the result is in degrees, which can't convert to meters because the distance of one degree depends on where on the globe geometries are located.

Calculations on the `GEOGRAPHY` data type are mostly used for realistic round earth calculations such as the precise area of a country without distortion. But they are far more expensive to compute. Therefore, ST_Transform can transform your coordinates to an appropriate local projected coordinate system and do the calculation on the `GEOMETRY` data type faster.

Using spatial data, you can run queries to do the following:

- Find the distance between two points.
- Check whether one area (polygon) contains another.
- Check whether one linestring intersects another linestring or polygon.

You can use the `GEOMETRY` data type to hold the values of spatial data. A `GEOMETRY` value in Amazon Redshift can define two-dimensional (2D), three-dimensional (3DZ), two-dimensional with a measure (3DM), and four-dimensional (4D) geometry primitive data types:

- A two-dimensional (2D) geometry is specified by two Cartesian coordinates (x, y) in a plane.
- A three-dimensional (3DZ) geometry is specified by three Cartesian coordinates (x, y, z) in space.
- A two-dimensional with measure (3DM) geometry is specified by three coordinates (x, y, m), where the first two are Cartesian coordinates in a plane and the third is a measurement.
- A four-dimensional (4D) geometry is specified by four coordinates (x, y, z, m), where the first three are Cartesian coordinates in a space and the fourth is a measurement.

For more information about geometry primitive data types, see [Well-known text representation of geometry](#) in Wikipedia.

You can use the `GEOGRAPHY` data type to hold the values of spatial data. A `GEOGRAPHY` value in Amazon Redshift can define two-dimensional (2D), three-dimensional (3DZ), two-dimensional with a measure (3DM), and four-dimensional (4D) geometry primitive data types:

- A two-dimensional (2D) geometry is specified by longitude and latitude coordinates on a spheroid.
- A three-dimensional (3DZ) geometry is specified by longitude, latitude, and altitude coordinates on a spheroid.

- A two-dimensional with measure (3DM) geometry is specified by three coordinates (longitude, latitude, measure), where the first two are angular coordinates on a sphere and the third is a measurement.
- A four-dimensional (4D) geometry is specified by four coordinates (longitude, latitude, altitude, measure), where the first three are longitude, latitude and altitude, and the fourth is a measurement.

For more information about geographic coordinate systems, see Geographic coordinate system and Spherical coordinate system in Wikipedia.

The `GEOMETRY` and `GEOGRAPHY` data types have the following subtypes:

- `POINT`
- `LINESTRING`
- `POLYGON`
- `MULTIPOINT`
- `MULTILINESTRING`
- `MULTIPOLYGON`
- `GEOMETRYCOLLECTION`

There are Amazon Redshift SQL functions that support the following representations of geometric data:

- GeoJSON
- Well-known text (WKT)
- Extended well-known text (EWKT)
- Well-known binary (WKB) representation
- Extended well-known binary (EWKB)

You can cast between `GEOMETRY` and `GEOGRAPHY` data types.

The following SQL casts a linestring from a `GEOMETRY` to a `GEOGRAPHY`.

```
SELECT ST_AsEWKT(ST_GeomFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)')::geography);
```

```
 st_asewkt
-----------------------------------------------
 SRID=4326;LINESTRING(110 40,2 3,-10 80,-7 9)
```

The following SQL casts a linestring from a GEOGRAPHY to a GEOMETRY.

```
SELECT ST_AsEWKT(ST_GeogFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)')::geometry);
```

```
 st_asewkt
-----------------------------------------------
 SRID=4326;LINESTRING(110 40,2 3,-10 80,-7 9)
```

Amazon Redshift provides many SQL functions to query spatial data. Except for the ST_IsValid function, spatial functions that accept a GEOMETRY object as an argument expect this GEOMETRY object to be a valid geometry. If the GEOMETRY or GEOGRAPHY object isn't valid, then the behavior of the spatial function is undefined. For more information about validity, see Geometric validity.

For details about SQL functions to query spatial data, see Spatial functions.

For details about loading spatial data, see Loading a column of the GEOMETRY or GEOGRAPHY data type.

Topics

- Tutorial: Using spatial SQL functions with Amazon Redshift
- Loading a shapefile into Amazon Redshift
- Terminology for Amazon Redshift spatial data
- Considerations when using spatial data with Amazon Redshift

Tutorial: Using spatial SQL functions with Amazon Redshift

This tutorial demonstrates how to use some of the spatial SQL functions with Amazon Redshift.

To do this, you query two tables using spatial SQL functions. The tutorial uses data from public datasets that correlate location data of rental accommodations with postal codes in Berlin, Germany.

Topics

Prerequisites

For this tutorial, you need the following resources:

- An existing Amazon Redshift cluster and database that you can access and update. In the existing cluster, you create tables, load sample data, and run SQL queries to demonstrate spatial functions. Your cluster should have at least two nodes. To learn how to create a cluster, follow the steps in Amazon Redshift Getting Started Guide.
- To use the Amazon Redshift query editor, make sure that your cluster is in an AWS Region that supports the query editor. For more information, see Querying a database using the query editor in the *Amazon Redshift Management Guide*.
- AWS credentials for your Amazon Redshift cluster that allow it to load test data from Amazon S3. For information about how to access other AWS services like Amazon S3, see Authorizing Amazon Redshift to access AWS services.
- The AWS Identity and Access Management (IAM) role named `mySpatialDemoRole`, which has the managed policy `AmazonS3ReadOnlyAccess` attached to read Amazon S3 data. To create a role with permission to load data from an Amazon S3 bucket, see Authorizing COPY, UNLOAD, and CREATE EXTERNAL SCHEMA operations using IAM roles in the *Amazon Redshift Management Guide*.
- After you create the IAM role `mySpatialDemoRole`, that role needs an association with your Amazon Redshift cluster. For more information on how to create that association, see Authorizing COPY, UNLOAD, and CREATE EXTERNAL SCHEMA operations using IAM roles in the *Amazon Redshift Management Guide*.

Step 1: Create tables and load test data

The source data used by this tutorial is in files named `accommodations.csv` and `zipcodes.csv`.

The `accommodations.csv` file is open-source data from insideairbnb.com. The `zipcodes.csv` file provides postal codes that are open-source data from the national statistics institute of Berlin-Brandenburg in Germany (Amt für Statistik Berlin-Brandenburg). Both data sources are provided under a Creative Commons license. The data is limited to the Berlin, Germany, region. These files are located in an Amazon S3 public bucket to use with this tutorial.

You can optionally download the source data from the following Amazon S3 links:

- Source data for the `accommodations` table.
- Source data for the `zipcode` table.

Use the following procedure to create tables and load test data.

To create tables and load test data

1. Open the Amazon Redshift query editor. For more information on working with the query editor, see Querying a database using the query editor in the *Amazon Redshift Management Guide*.
2. Drop any tables used by this tutorial if they already exist in your database. For more information, see Step 3: Clean up your resources.
3. Create the `accommodations` table to store each accommodation's geographical location (longitude and latitude), the name of the listing, and other business data.

   This tutorial explores room rentals in Berlin, Germany. The `shape` column stores geographic points of the location of accommodations. The other columns contain information about the rental.

   To create the `accommodations` table, run the following SQL statement in the Amazon Redshift query editor.

```
CREATE TABLE public.accommodations (
  id INTEGER PRIMARY KEY,
  shape GEOMETRY,
  name VARCHAR(100),
  host_name VARCHAR(100),
  neighbourhood_group VARCHAR(100),
  neighbourhood VARCHAR(100),
  room_type VARCHAR(100),
  price SMALLINT,
```

```
  minimum_nights SMALLINT,
  number_of_reviews SMALLINT,
  last_review DATE,
  reviews_per_month NUMERIC(8,2),
  calculated_host_listings_count SMALLINT,
  availability_365 SMALLINT
);
```

4. Create the `zipcode` table in the query editor to store Berlin postal codes.

   A *postal code* is defined as a polygon in the `wkb_geometry` column. The rest of the columns describe additional spatial metadata about the postal code.

   To create the `zipcode` table, run the following SQL statement in the Amazon Redshift query editor.

```
CREATE TABLE public.zipcode (
  ogc_field INTEGER PRIMARY KEY NOT NULL,
  wkb_geometry GEOMETRY,
  gml_id VARCHAR(256),
  spatial_name VARCHAR(256),
  spatial_alias VARCHAR(256),
  spatial_type VARCHAR(256)
 );
```

5. Load the tables using sample data.

   The sample data for this tutorial is provided in an Amazon S3 bucket that allows read access to all authenticated AWS users. Make sure that you provide valid AWS credentials that permit access to Amazon S3.

   To load test data to your tables, run the following COPY commands. Replace *`account-number`* with your own AWS account number. The segment of the credentials string that is enclosed in single quotation marks can't contain any spaces or line breaks.

```
COPY public.accommodations
FROM 's3://redshift-downloads/spatial-data/accommodations.csv'
DELIMITER ';'
IGNOREHEADER 1 REGION 'us-east-1'
CREDENTIALS 'aws_iam_role=arn:aws:iam::account-number:role/mySpatialDemoRole';
```

```
COPY public.zipcode
FROM 's3://redshift-downloads/spatial-data/zipcode.csv'
DELIMITER ';'
IGNOREHEADER 1 REGION 'us-east-1'
CREDENTIALS 'aws_iam_role=arn:aws:iam::account-number:role/mySpatialDemoRole';
```

6. Verify that each table loaded correctly by running the following commands.

```
select count(*) from accommodations;
```

```
select count(*) from zipcode;
```

The following results show the number of rows in each table of test data.

Table name	Rows
accommodations	22,248
zipcode	190

Step 2: Query spatial data

After your tables are created and loaded, you can query them using SQL SELECT statements. The following queries demonstrate some of the information that you can retrieve. You can write many other queries that use spatial functions to satisfy your needs.

To query spatial data

1. Query to get the count of the total number of listings stored in the `accommodations` table, as shown following. The spatial reference system is World Geodetic System (WGS) 84, which has the unique spatial reference identifier 4326.

```
SELECT count(*) FROM public.accommodations WHERE ST_SRID(shape) = 4326;
```

```
 count
-------
```

```
22248
```

2. Fetch the geometry objects in well-known text (WKT) format with some additional attributes. Additionally, you can validate if this postal code data is also stored in World Geodetic System (WGS) 84, which uses the spatial reference ID (SRID) 4326. Spatial data must be stored in the same spatial reference system to be interoperable.

```
SELECT ogc_field, spatial_name, spatial_type, ST_SRID(wkb_geometry),
 ST_AsText(wkb_geometry)
FROM public.zipcode
ORDER BY spatial_name;
```

```

ogc_field  spatial_name  spatial_type  st_srid  st_astext
---------------------------------------------------------------
0           10115        Polygon        4326     POLYGON((...))
4           10117        Polygon        4326     POLYGON((...))
8           10119        Polygon        4326     POLYGON((...))
...
(190 rows returned)
```

3. Select the polygon of Berlin Mitte (10117), a borough of Berlin, in GeoJSON format, its dimension, and the number of points in this polygon.

```
SELECT ogc_field, spatial_name, ST_AsGeoJSON(wkb_geometry),
 ST_Dimension(wkb_geometry), ST_NPoints(wkb_geometry)
FROM public.zipcode
WHERE spatial_name='10117';
```

```

ogc_field  spatial_name  spatial_type
 st_dimension  st_npoint
-----------------------------------------------------------------------------------------------------
4           10117         {"type":"Polygon", "coordinates":[[[...]]]}    2
    331
```

4. Run the following SQL command to view how many accommodations are within 500 meters of the Brandenburg Gate.

```
SELECT count(*)
FROM public.accommodations
```

```
WHERE ST_DistanceSphere(shape, ST_GeomFromText('POINT(13.377704 52.516431)', 4326))
 < 500;
```

```
count
------
  29
```

5. Get the rough location of the Brandenburg Gate from data stored in the accommodations that are listed as nearby by running the following query.

   This query requires a subselect. It leads to a different count because the requested location is not the same as the previous query because it is closer to the accommodations.

```
WITH poi(loc) as (
  SELECT st_astext(shape) FROM accommodations WHERE name LIKE '%brandenburg gate%'
)
SELECT count(*)
FROM accommodations a, poi p
WHERE ST_DistanceSphere(a.shape, ST_GeomFromText(p.loc, 4326)) < 500;
```

```
count
------
  60
```

6. Run the following query to show the details of all accommodations around the Brandenburg Gate, ordered by price in descending order.

```
SELECT name, price, ST_AsText(shape)
FROM public.accommodations
WHERE ST_DistanceSphere(shape, ST_GeomFromText('POINT(13.377704 52.516431)', 4326))
 < 500
ORDER BY price DESC;
```

```
name                                                     price  st_astext
-------------------------------------------------------------------------------------
DUPLEX APARTMENT/PENTHOUSE in 5* LOCATION! 7583        300
 POINT(13.3826510209548 52.5159819722552)
```

```
DUPLEX-PENTHOUSE IN FIRST LOCATION! 7582               300
 POINT(13.3799997083855 52.5135918444834)
...
(29 rows returned)
```

7. Run the following query to retrieve the most expensive accommodation with its postal code.

```
SELECT
  a.price, a.name, ST_AsText(a.shape),
  z.spatial_name, ST_AsText(z.wkb_geometry)
FROM accommodations a, zipcode z
WHERE price = 9000 AND ST_Within(a.shape, z.wkb_geometry);
```

```

price   name                                 st_astext
     spatial_name      st_astext
-------------------------------------------------------------------------------------------------
9000    Ueber den Dächern Berlins Zentrum    POINT(13.334436985013
 52.4979779501538)    10777             POLYGON((13.3318284987227
 52.4956021172799,...
```

8. Calculate the maximum, minimum, or median price of accommodations by using a subquery.

   The following query lists the median price of accommodations by postal code.

```
SELECT
  a.price, a.name, ST_AsText(a.shape),
  z.spatial_name, ST_AsText(z.wkb_geometry)
FROM accommodations a, zipcode z
WHERE
  ST_Within(a.shape, z.wkb_geometry) AND
  price = (SELECT median(price) FROM accommodations)
ORDER BY a.price;
```

```

price name                            st_astext
 spatial_name   st_astext
-------------------------------------------------------------------------------------------------

45    "Cozy room Berlin-Mitte"        POINT(13.3864349535358 52.5292016386514)
 10115          POLYGON((13.3658598465795 52.535659581048,...
...
```

```
(723 rows returned)
```

9. Run the following query to retrieve the number of accommodations listed in Berlin. To find the hot spots, these are grouped by postal code and sorted by the amount of supply.

```
SELECT z.spatial_name as zip, count(*) as numAccommodations
FROM public.accommodations a, public.zipcode z
WHERE ST_Within(a.shape, z.wkb_geometry)
GROUP BY zip
ORDER BY numAccommodations DESC;
```

```

zip   numaccommodations
----------------------------
10245 872
10247 832
10437 733
10115 664
...
(187 rows returned)
```

Step 3: Clean up your resources

Your cluster continues to accrue charges as long as it's running. When you have completed this tutorial, you can delete your sample cluster.

If you want to keep the cluster but recover the storage used by the test data tables, run the following commands to delete the tables.

```
drop table public.accommodations cascade;
```

```
drop table public.zipcode cascade;
```

Loading a shapefile into Amazon Redshift

You can use the COPY command to ingest Esri shapefiles stored in Amazon S3 into Amazon Redshift tables. A *shapefile* stores the geometric location and attribute information of geographic features in a vector format. The shapefile format can spatially describe spatial objects such as points, lines, and polygons. For more information about a shapefile, see Shapefile in Wikipedia.

The COPY command supports the data format parameter `SHAPEFILE`. By default, the first column of the shapefile is either a `GEOMETRY` or `IDENTITY` column. All subsequent columns follow the order specified in the shapefile. However, the target table doesn't need to be in this exact layout because you can use COPY column mapping to define the order. For information about the COPY command shapefile support, see SHAPEFILE.

In some cases, the resulting geometry size might be greater than the maximum for storing a geometry in Amazon Redshift. If so, you can use the COPY option `SIMPLIFY` or `SIMPLIFY AUTO` to simplify the geometries during ingestion as follows:

- Specify `SIMPLIFY tolerance` to simplify all geometries during ingestion using the Ramer-Douglas-Peucker algorithm and the given tolerance.
- Specify `SIMPLIFY AUTO` without tolerance to simplify only geometries that are larger than the maximum size using the Ramer-Douglas-Peucker algorithm. This approach calculates the minimum tolerance that is large enough to store the object within the maximum size limit.
- Specify `SIMPLIFY AUTO max_tolerance` to simplify only geometries that are larger than the maximum size using the Ramer-Douglas-Peucker algorithm and the automatically calculated tolerance. This approach makes sure that the tolerance doesn't exceed the maximum tolerance.

For information about the maximum size of a `GEOMETRY` data value, see Considerations when using spatial data with Amazon Redshift.

In some cases, the tolerance is low enough that the record can't shrink below the maximum size of a `GEOMETRY` data value. In these cases, you can use the `MAXERROR` option of the COPY command to ignore all or up to a certain number of ingestion errors.

The COPY command also supports loading GZIP shapefiles. To do this, specify the COPY GZIP parameter. With this option, all shapefile components must be independently compressed and share the same compression suffix.

If a projection description file (.prj) exists with the shapefile, Redshift uses it to determine the spatial reference system id (SRID). If the SRID is valid, the resulting geometry has this SRID assigned. If the SRID value associated with the input geometry does not exist, the resulting geometry has the SRID value zero. You can disable automatic detection of the spatial reference system id at the session level by using `SET read_srid_on_shapefile_ingestion` to `OFF`.

Query the `SYS_SPATIAL_SIMPLIFY` or `SVL_SPATIAL_SIMPLIFY` system views to view which records have been simplified, along with the calculated tolerance. When you specify `SIMPLIFY` *`tolerance`*, this view contains a record for each COPY operation. Otherwise, it contains a record for each simplified geometry. For more information, see SYS_SPATIAL_SIMPLIFY or SVL_SPATIAL_SIMPLIFY.

For examples of loading a shapefile, see Loading a shapefile into Amazon Redshift.

Terminology for Amazon Redshift spatial data

The following terms are used to describe some Amazon Redshift spatial functions.

Bounding box

A bounding box of a geometry or geography is defined as the cross product (across dimensions) of the extents of the coordinates of all points in the geometry or geography. For two-dimensional geometries, the bounding box is a rectangle that completely includes all points in the geometry. For example, a bounding box of the polygon `POLYGON((0 0,1 0,0 2,0 0))` is the rectangle that is defined by the points (0, 0) and (1, 2) as its bottom-left and top-right corners. Amazon Redshift precomputes and stores a bounding box inside a geometry to speed up geometric predicates and spatial joins. For example if the bounding boxes of two geometries don't intersect, then these two geometries can't intersect, and they can't be in the result set of a spatial join using the ST_Intersects predicate.

You can use spatial functions to add (AddBBox), drop (DropBBox), and determine support (SupportsBBox) for a bounding box. Amazon Redshift supports the precomputaton of bounding boxes for all geometry subtypes.

The following example shows how to update existing geometries in a table to store them with a bounding box. If your cluster is at cluster version 1.0.26809 or later, then all new geometries are created with a precomputed bounding box by default.

```
UPDATE my_table SET geom = AddBBox(geom) WHERE SupportsBBox(geom) = false;
```

After you update existing geometries, we recommend you run the VACUUM command on the updated table. For more information, see VACUUM.

To set whether geometries are encoded with a bounding box during a session, see default_geometry_encoding.

Geometric validity

Geometric algorithms used by Amazon Redshift assume that the input geometry is a valid geometry. If an input to an algorithm is not valid, then the result is undefined. The following section describes the geometric validity definitions used by Amazon Redshift for each geometry subtype.

Point

A point is considered to be valid if one of the following conditions is true:

- The point is the empty point.
- All point coordinates are finite floating point numbers.

A point can be the empty point.

Linestring

A linestring is considered to be valid if any of the following conditions are true:

- The linestring is empty; that is, it contains no points.
- All points in a nonempty linestring have coordinates that are finite floating point numbers.
- The linestring, if not empty, must be one-dimensional; that is, it can't degenerate to a point.

A linestring can't contain empty points.

A linestring can have duplicate consecutive points.

A linestring can have self-intersections.

Polygon

A polygon is considered to be valid if any of the following conditions are true:

- The polygon is empty; that is, it contains no rings.
- If not empty, a polygon is valid if all of the following conditions are true:
  - All rings of the polygon are valid. A ring is considered to be valid if all the following conditions are true:
    - All points of the ring have coordinates that are finite floating point numbers.
    - The ring is closed; that is, its first point and its last point coincide.
    - The ring doesn't have any self-intersections.
    - The ring is two-dimensional.

  - The rings of the polygon must have consistent orientations. That is, if you traverse any ring, the interior of the polygon is either to your right or to your left.
  - All interior rings must be within the exterior ring of the polygon.
  - All interior rings must have the same orientation, and it must be the opposite orientation of the exterior ring.
  - Interior rings can't be nested; that is, an interior ring can't be within another interior ring.
  - Interior and exterior rings can only intersect at a finite number of points.
  - The interior of the polygon must be simply connected.

A polygon can't contain empty points.

Multipoint

A multipoint is considered to be valid if any of the following conditions are true:

- The multipoint is empty; that is, it contains no points.
- A multipoint is not empty, and all points are valid according to the point validity definition.

A multipoint can contain one or more empty points.

A multipoint can have duplicate points.

Multilinestring

A multilinestring is considered to be valid if any of the following conditions are true:

- The multilinestring is empty; that is, it contains no linestrings.
- All linestrings in a nonempty multilinestring are valid according to the linestring validity definition.

A nonempty multilinestring that consists of only empty linestrings is considered to be valid.

An empty linestring in a multilinestring doesn't affect its validity.

A multilinestring can have linestrings with duplicate consecutive points.

A multilinestring can have self-intersections.

A multilinestring can't contain empty points.

Multipolygon

A multipolygon is considered to be valid if any of the following conditions are true:

- The multipolygon doesn't contain any polygons (it is empty).
- The multipolygon is not empty and all of the following are true:
  - All polygons in the multipolygon are valid.
  - No two polygons in the multipolygon can intersect at an infinite number of points. In particular, this implies that the interior of any two polygons can't intersect and that they can only touch at a finite number of points.

An empty polygon in a multipolygon doesn't invalidate a multipolygon.

A multipolygon can't contain empty points.

Geometry collection

A geometry collection is considered to be valid if any of the following conditions are true:

- The geometry collection is empty; that is, it doesn't contain any geometries.
- All geometries in a nonempty geometry collection are valid.

This definition still applies, although in a recursive manner, for nested geometry collections.

A geometry collection can contain empty points and multipoints with empty points.

Geometric simplicity

Geometric algorithms used by Amazon Redshift assume that the input geometry is a valid geometry. If an input to an algorithm is not valid, then the simplicity check is undefined. The following section describes the geometric simplicity definitions used by Amazon Redshift for each geometry subtype.

Point

A valid point is considered to be simple if any of the following conditions are true:

- A valid point is always considered to be simple.
- An empty point is considered to be simple.

Linestring

A valid linestring is considered to be simple if any of the following conditions are true:

- The linestring is empty.
- The linestring is not empty and all of the following conditions are true:

  - It has no duplicate consecutive points.
  - It has no self-intersections, except possibly for its first point and last point, which can coincide. In other words, the linestring can't have self-intersections except at boundary points.

Polygon

A valid polygon is considered to be simple if it doesn't contain any duplicate consecutive points.

Multipoint

A valid multipoint is considered to be simple if any of the following conditions are true:

- The multipoint is empty; that is, it contains no points.
- No two nonempty points of the multipoint coincide.

Multilinestring

A valid multilinestring is considered to be simple if any of the following conditions are true:

- The multilinestring is empty.
- The multilinestring is nonempty and all of the following conditions are true:
  - All its linestrings are simple.
  - Any two linestrings of the multilinestring don't intersect, except at points that are boundary points of the two linestrings.

A nonempty multilinestring that consists of empty linestrings only is considered to be empty.

An empty linestring in a multilinestring doesn't affect its simplicity.

A closed linestring in a multilinestring can't intersect with any other linestring in the multilinestring.

A multilinestring can't have linestrings with duplicate consecutive points.

Multipolygon

A valid multipolygon is considered to be simple if it doesn't contain any duplicate consecutive points.

Geometry collection

A valid geometry collection is considered to be simple if any of the following conditions are true:

- The geometry collection is empty; that is, it doesn't contain any geometries.

- All geometries in a nonempty geometry collection are simple.

  This definition still applies, although in a recursive manner, for nested geometry collections.

H3

H3 is a hierarchical geospatial indexing grid system, which offers a way to index spatial coordinates down to square meter resolution. Indexed data can be joined across disparate datasets and aggregated at different levels of precision. H3 enables a range of algorithms and optimizations based on the grid, including nearest neighbors, shortest path, gradient smoothing, and more. H3 indexes refer to cells that can be either hexagons or pentagons. The space is subdivided hierarchically given a resolution. H3 supports 16 resolutions from 0–15, inclusive. With `0` being the coarsest and 15 being the finest.

Amazon Redshift provides the following H3 spatial functions:

- H3_Boundary
- H3_Center
- H3_FromLongLat
- H3_FromPoint
- H3_Polyfill

Considerations when using spatial data with Amazon Redshift

The following are considerations when using spatial data with Amazon Redshift:

- The maximum size of a `GEOMETRY` or `GEOGRAPHY` object is 1,048,447 bytes.
- Amazon Redshift Spectrum doesn't natively support spatial data. Therefore, you can't create or alter an external table with a `GEOMETRY` or `GEOGRAPHY` column.
- Data types for Python user-defined functions (UDFs) don't support the `GEOMETRY` or `GEOGRAPHY` data type.
- You can't use a `GEOMETRY` or `GEOGRAPHY` column as a sort key or a distribution key for an Amazon Redshift table.
- You can't use `GEOMETRY` or `GEOGRAPHY` columns in SQL ORDER BY, GROUP BY, or DISTINCT clauses.

- You can't use GEOMETRY or GEOGRAPHY columns in many SQL functions.
- You can't perform an UNLOAD operation on GEOMETRY or GEOGRAPHY columns into every format. You can UNLOAD GEOMETRY or GEOGRAPHY columns to text or comma-separated value (CSV) files. Doing this writes GEOMETRY or GEOGRAPHY data in hexadecimal EWKB format. If the size of the EWKB data is more than 4 MB, then a warning occurs because the data can't later be loaded into a table.
- The supported compression encoding of GEOMETRY or GEOGRAPHY data is RAW.
- When using JDBC or ODBC drivers, use customized type mappings. In this case, the client application must have information on which parameters of a `ResultSet` object are GEOMETRY or GEOGRAPHY objects. The `ResultSetMetadata` operation returns type VARCHAR.
- To copy geographic date from a SHAPEFILE, first ingest into a GEOMETRY column, and then cast the objects to GEOGRAPHY objects. .

The following nonspatial functions can accept an input of type GEOMETRY or GEOGRAPHY, or columns of type GEOMETRY or GEOGRAPHY:

- The aggregate function COUNT
- The conditional expressions COALESCE and NVL
- CASE expressions
- The default encoding for GEOMETRY and GEOGRAPHY is RAW. For more information, see Compression encodings.

Querying data with federated queries in Amazon Redshift

By using *federated queries* in Amazon Redshift, you can query and analyze data across operational databases, data warehouses, and data lakes. With the Federated Query feature, you can integrate queries from Amazon Redshift on live data in external databases with queries across your Amazon Redshift and Amazon S3 environments. Federated queries can work with external databases in Amazon RDS for PostgreSQL, Amazon Aurora PostgreSQL-Compatible Edition, Amazon RDS for MySQL, and Amazon Aurora MySQL-Compatible Edition.

You can use federated queries to incorporate live data as part of your business intelligence (BI) and reporting applications. For example, to make data ingestion to Amazon Redshift easier you can use federated queries to do the following:

- Query operational databases directly.
- Apply transformations quickly.
- Load data into the target tables without the need for complex extract, transform, load (ETL) pipelines.

To reduce data movement over the network and improve performance, Amazon Redshift distributes part of the computation for federated queries directly into the remote operational databases. Amazon Redshift also uses its parallel processing capacity to support running these queries, as needed.

When running federated queries, Amazon Redshift first makes a client connection to the RDS or Aurora DB cluster DB instance from the leader node to retrieve table metadata. From a compute node, Amazon Redshift issues subqueries with a predicate pushed down and retrieves the result rows. Amazon Redshift then distributes the result rows among the compute nodes for further processing.

Details about queries sent to the Amazon Aurora PostgreSQL database or Amazon RDS for PostgreSQL database are logged in the system view SVL_FEDERATED_QUERY.

Topics

Getting started with using federated queries to PostgreSQL

To create a federated query, you follow this general approach:

1. Set up connectivity from your Amazon Redshift cluster to your Amazon RDS or Aurora PostgreSQL DB instance.

   To do this, make sure that your RDS PostgreSQL or Aurora PostgreSQL DB instance can accept connections from your Amazon Redshift cluster. We recommend that your Amazon Redshift cluster and Amazon RDS or Aurora PostgreSQL instance be in the same virtual private cloud (VPC) and subnet group. This way, you can add the security group for the Amazon Redshift cluster to the inbound rules of the security group for your RDS or Aurora PostgreSQL DB instance.

   You can also set up VPC peering or other networking that allows Amazon Redshift to make connections to your RDS or Aurora PostgreSQL instance. For more information about VPC networking, see the following.

   - What is VPC peering? in the *Amazon VPC Peering Guide*
   - Working with a DB instance in a VPC in the *Amazon RDS User Guide*

   > **Note**
   >
   > There are cases where you must enable enhanced VPC routing: For example, if your Amazon Redshift cluster is in a different VPC than your RDS or Aurora PostgreSQL instance, or if they're in the same VPC and your routes require it. Otherwise, you might receive timeout errors when you run a federated query.

2. Set up secrets in AWS Secrets Manager for your RDS PostgreSQL and Aurora PostgreSQL databases. Then reference the secrets in AWS Identity and Access Management (IAM) access

policies and roles. For more information, see Creating a secret and an IAM role to use federated queries.

> **Note**
>
> If your cluster uses enhanced VPC routing, you might need to configure an interface VPC endpoint for AWS Secrets Manager. This is necessary when the VPC and subnet of your Amazon Redshift cluster don't have access to the public AWS Secrets Manager endpoint. When you use a VPC interface endpoint, communication between the Amazon Redshift cluster in your VPC and AWS Secrets Manager is routed privately from your VPC to the endpoint interface. For more information, see Creating an interface endpoint in the *Amazon VPC User Guide*.

3. Apply the IAM role that you previously created to the Amazon Redshift cluster. For more information, see Creating a secret and an IAM role to use federated queries.
4. Connect to your RDS PostgreSQL and Aurora PostgreSQL databases with an external schema. For more information, see CREATE EXTERNAL SCHEMA. For examples on how to use federated query, see Examples of using a federated query.
5. Run your SQL queries referencing the external schema that references your RDS PostgreSQL and Aurora PostgreSQL databases.

Getting started using federated queries to PostgreSQL with AWS CloudFormation

You can use federated queries to query across operational databases. In this getting-started guide, you can automate setup by using a sample AWS CloudFormation stack to enable a federated query from an Amazon Redshift cluster to an Aurora PostgreSQL serverless database. You can get up and running quickly without having to run SQL statements to provision your resources.

The stack creates an external schema, referencing your Aurora PostgreSQL instance, which includes tables with sample data. You can query tables in the external schema from your Redshift cluster.

If instead you want to get started with federated queries by running SQL statements to set up an external schema, without using CloudFormation, see Getting started with using federated queries to PostgreSQL.

Before running the CloudFormation stack for federated queries, make sure that you have an Amazon Aurora PostgreSQL-Compatible Edition serverless database with the Data API turned on. You can turn on the Data API in the database properties. If you can't find the setting, double-check that you are running a serverless instance of Aurora PostgreSQL. Also make sure that you have a Amazon Redshift cluster that uses RA3 nodes. We recommend that both the Redshift cluster and serverless Aurora PostgreSQL instance are in the same virtual private cloud (VPC) and subnet group. This way, you can add the security group for the Amazon Redshift cluster to the inbound rules of the security group for your Aurora PostgreSQL database instance.

For more information about getting started setting up an Amazon Redshift cluster, see Get started with Amazon Redshift provisioned data warehouses. For more information about setting up resources with CloudFormation, see What is AWS CloudFormation?. For more information about setting up an Aurora DB cluster database, see Creating an Aurora DB cluster Serverless v1 DB cluster.

Launching a CloudFormation stack for Redshift federated queries

Use the following procedure to launch your CloudFormation stack for Amazon Redshift to enable federated queries. Before doing so, make sure you have your Amazon Redshift cluster and your serverless Aurora PostgreSQL instance set up.

To launch your CloudFormation stack for federated queries

1. Click **Launch CFN stack** here to launch the CloudFormation service in the AWS Management Console.

   If you are prompted, sign in.

   The stack creation process starts, referencing a CloudFormation template file, which is stored in Amazon S3. A CloudFormation *template* is a text file in JSON format that declares AWS resources that make up a stack.
2. Choose **Next** to enter the stack details.
3. Under **Parameters**, for the cluster, enter the following:
   - The Amazon Redshift cluster name, for example **`ra3-consumer-cluster`**
   - A specific database name, for example **`dev`**
   - The name of a database user, for example **`consumeruser`**

Also enter the parameters for the Aurora DB cluster database, including the user, database name, port, and endpoint. We recommend using a test cluster and test serverless database, because the stack creates several database objects.

Choose **Next**.

The stack options appear.

4. Choose **Next** to accept the default settings.
5. Under **Capabilities**, choose **I acknowledge that AWS CloudFormation might create IAM resources.**
6. Choose **Create stack**.

Choose **Create stack**. CloudFormation provisions the template resources, which takes about 10 minutes, and creates an external schema.

If an error occurs while the stack is created, do the following:

- View the CloudFormation **Events** tab for information that can help you resolve the error.
- Make sure that you entered the correct name, database name, and database user name for the Redshift cluster. Also check the parameters for the Aurora PostgreSQL instance.
- Make sure that your cluster has RA3 nodes.
- Make sure that your database and Redshift cluster are in the same subnet and security group.

Querying data from the external schema

To use the following procedure, make sure that you have the required permissions for running queries on the cluster and the database described.

To query an external database with federated query

1. Connect to the Redshift database that you entered when you created the stack, using a client tool such as the Redshift query editor.
2. Query for the external schema created by the stack.

```
select * from svv_external_schemas;
```

The SVV_EXTERNAL_SCHEMAS view returns information about available external schemas. In this case, the external schema created by the stack is returned, `myfederated_schema`. You might also have other external schemas returned, if you have any set up. The view also returns the schema's associated database. The database is the Aurora DB cluster database that you entered when you created the stack. The stack adds a table to the Aurora DB cluster database, called `category`, and another table called `sales`.

3. Run SQL queries on tables in the external schema that references your Aurora PostgreSQL database. The following example shows a query.

```
SELECT count(*) FROM myfederated_schema.category;
```

The `category` table returns several records. You can also return records from the `sales` table.

```
SELECT count(*) FROM myfederated_schema.sales;
```

For more examples, see Examples of using a federated query.

Getting started with using federated queries to MySQL

To create a federated query to MySQL databases, you follow this general approach:

1. Set up connectivity from your Amazon Redshift cluster to your Amazon RDS or Aurora MySQL DB instance.

   To do this, make sure that your RDS MySQL or Aurora MySQL DB instance can accept connections from your Amazon Redshift cluster. We recommend that your Amazon Redshift cluster and Amazon RDS or Aurora MySQL instance be in the same virtual private cloud (VPC) and subnet group. This way, you can add the security group for the Amazon Redshift cluster to the inbound rules of the security group for your RDS or Aurora MySQL DB instance.

   You can also set up VPC peering or other networking that allows Amazon Redshift to make connections to your RDS or Aurora MySQL instance. For more information about VPC networking, see the following.

   - What is VPC peering? in the *Amazon VPC Peering Guide*
   - Working with a DB instance in a VPC in the *Amazon RDS User Guide*

> **Note**
>
> If your Amazon Redshift cluster is in a different VPC than your RDS or Aurora MySQL instance, then enable enhanced VPC routing. Otherwise, you might receive timeout errors when you run a federated query.

2. Set up secrets in AWS Secrets Manager for your RDS MySQL and Aurora MySQL databases. Then reference the secrets in AWS Identity and Access Management (IAM) access policies and roles. For more information, see Creating a secret and an IAM role to use federated queries.

> **Note**
>
> If your cluster uses enhanced VPC routing, you might need to configure an interface VPC endpoint for AWS Secrets Manager. This is necessary when the VPC and subnet of your Amazon Redshift cluster don't have access to the public AWS Secrets Manager endpoint. When you use a VPC interface endpoint, communication between the Amazon Redshift cluster in your VPC and AWS Secrets Manager is routed privately from your VPC to the endpoint interface. For more information, see Creating an interface endpoint in the *Amazon VPC User Guide*.

3. Apply the IAM role that you previously created to the Amazon Redshift cluster. For more information, see Creating a secret and an IAM role to use federated queries.
4. Connect to your RDS MySQL and Aurora MySQL databases with an external schema. For more information, see CREATE EXTERNAL SCHEMA. For examples on how to use federated queries, see Example of using a federated query with MySQL.
5. Run your SQL queries referencing the external schema that references your RDS MySQL and Aurora MySQL databases.

Creating a secret and an IAM role to use federated queries

The following steps show how to create a secret and an IAM role to use with federated queries.

Prerequisites

Make sure that you have the following prerequisites to create a secret and an IAM role to use with federated queries:

- An RDS PostgreSQL, Aurora PostgreSQL DB instance, RDS MySQL, or Aurora MySQL DB instance with user name and password authentication.
- An Amazon Redshift cluster with a cluster maintenance version that supports federated queries.

To create a secret (user name and password) with AWS Secrets Manager

1. Sign in to the Secrets Manager console with the account that owns your RDS or Aurora DB cluster instance.
2. Choose **Store a new secret**.
3. Choose the **Credentials for RDS database** tile. For **User name** and **Password**, enter values for your instance. Confirm or choose a value for **Encryption key**. Then choose the RDS database that your secret will access.

   Note

   We recommend using the default encryption key (`DefaultEncryptionKey`). If you use a custom encryption key, the IAM role that is used to access the secret must be added as a key user.
4. Enter a name for the secret, continue with the creation steps with the default choices, and then choose **Store**.
5. View your secret and note the **Secret ARN** value that you created to identify the secret.

To create a security policy using the secret

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. Create a policy with JSON similar to the following.

   JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AccessSecret",
            "Effect": "Allow",
```

```
            "Action": [
                "secretsmanager:GetResourcePolicy",
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret",
                "secretsmanager:ListSecretVersionIds"
            ],
            "Resource": "arn:aws:secretsmanager:us-
west-2:123456789012:secret:my-rds-secret-VNenFy"
        },
        {
            "Sid": "VisualEditor1",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetRandomPassword",
                "secretsmanager:ListSecrets"
            ],
            "Resource": "*"
        }
    ]
}
```

To retrieve the secret, you need list and read actions. We recommend that you restrict the resource to the specific secret that you created. To do this, use the Amazon Resource Name (ARN) of the secret to limit the resource. You can also specify the permissions and resources using the visual editor on the IAM console.

3. Give the policy a name and finish creating it.
4. Navigate to **IAM roles**.
5. Create an IAM role for **Redshift - Customizable**.
6. Either attach the IAM policy you just created to an existing IAM role, or create a new IAM role and attach the policy.
7. On the **Trust relationships** tab of your IAM role, confirm that the role contains the trust entity `redshift.amazonaws.com`.
8. Note the **Role ARN** you created. This ARN has access to the secret.

To attach the IAM role to your Amazon Redshift cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.

2. On the navigation menu, choose **Clusters**. The clusters for your account in the current AWS Region are listed.
3. Choose the cluster name in the list to view more details about a cluster.
4. For **Actions**, choose **Manage IAM roles**. The **Manage IAM roles** page appears.
5. Add your IAM role to the cluster.

Examples of using a federated query

The following examples show how to run a federated query. Run the SQL using your SQL client connected to the Amazon Redshift database.

Example of using a federated query with PostgreSQL

The following example shows how to set up a federated query that references an Amazon Redshift database, an Aurora PostgreSQL database, and Amazon S3. This example illustrates how federated queries work. To run it on your own environment, change it to fit your environment. For prerequisites for doing this, see Getting started with using federated queries to PostgreSQL.

Create an external schema that references an Aurora PostgreSQL database.

```
CREATE EXTERNAL SCHEMA apg
FROM POSTGRES
DATABASE 'database-1' SCHEMA 'myschema'
URI 'endpoint to aurora hostname'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-SecretsManager-RO'
SECRET_ARN 'arn:aws:secretsmanager:us-west-2:123456789012:secret:federation/test/
dataplane-apg-creds-YbVKQw';
```

Create another external schema that references Amazon S3, which uses Amazon Redshift Spectrum. Also, grant permission to use the schema to `public`.

```
CREATE EXTERNAL SCHEMA s3
FROM DATA CATALOG
DATABASE 'default' REGION 'us-west-2'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-S3';

GRANT USAGE ON SCHEMA s3 TO public;
```

Show the count of rows in the Amazon Redshift table.

```
SELECT count(*) FROM public.lineitem;

  count
----------
25075099
```

Show the count of rows in the Aurora PostgreSQL table.

```
SELECT count(*) FROM apg.lineitem;

count
-------
11760
```

Show the count of rows in Amazon S3.

```
SELECT count(*) FROM s3.lineitem_1t_part;

   count
------------
6144008876
```

Create a view of the tables from Amazon Redshift, Aurora PostgreSQL, and Amazon S3. This view is used to run your federated query.

```
CREATE VIEW lineitem_all AS
  SELECT
 l_orderkey,l_partkey,l_suppkey,l_linenumber,l_quantity,l_extendedprice,l_discount,l_tax,l_retu
         l_shipdate::date,l_commitdate::date,l_receiptdate::date,
 l_shipinstruct ,l_shipmode,l_comment
  FROM s3.lineitem_1t_part
  UNION ALL SELECT * FROM public.lineitem
  UNION ALL SELECT * FROM apg.lineitem
     with no schema binding;
```

Show the count of rows in the view `lineitem_all` with a predicate to limit the results.

```
SELECT count(*) from lineitem_all WHERE l_quantity = 10;
```

```
   count
-----------
123373836
```

Find out how many sales of one item there were in January of each year.

```
SELECT extract(year from l_shipdate) as year,
       extract(month from l_shipdate) as month,
       count(*) as orders
FROM lineitem_all
WHERE extract(month from l_shipdate) = 1
AND l_quantity < 2
GROUP BY 1,2
ORDER BY 1,2;

 year | month | orders
------+-------+---------
 1992 |     1 |  196019
 1993 |     1 | 1582034
 1994 |     1 | 1583181
 1995 |     1 | 1583919
 1996 |     1 | 1583622
 1997 |     1 | 1586541
 1998 |     1 | 1583198
 2016 |     1 |   15542
 2017 |     1 |   15414
 2018 |     1 |   15527
 2019 |     1 |     151
```

Example of using a mixed-case name

To query a supported PostgreSQL remote database that has a mixed-case name of a database, schema, table, or column, then set `enable_case_sensitive_identifier` to `true`. For more information about this session parameter, see enable_case_sensitive_identifier.

```
SET enable_case_sensitive_identifier TO TRUE;
```

Typically, the database and schema names are in lowercase. The following example shows how you can connect to a supported PostgreSQL remote database that has lowercase names for database and schema and mixed-case names for table and column.

Create an external schema that references an Aurora PostgreSQL database that has a lowercase database name (`dblower`) and lowercase schema name (`schemalower`).

```
CREATE EXTERNAL SCHEMA apg_lower
FROM POSTGRES
DATABASE 'dblower' SCHEMA 'schemalower'
URI 'endpoint to aurora hostname'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-SecretsManager-RO'
SECRET_ARN 'arn:aws:secretsmanager:us-west-2:123456789012:secret:federation/test/
dataplane-apg-creds-YbVKQw';
```

In the session where the query runs, set `enable_case_sensitive_identifier` to `true`.

```
SET enable_case_sensitive_identifier TO TRUE;
```

Run a federated query to select all data from the PostgreSQL database. The table (`MixedCaseTab`) and column (`MixedCaseName`) have mixed-case names. The result is one row (`Harry`).

```
select * from apg_lower."MixedCaseTab";
```

```


 MixedCaseName
-------
 Harry
```

The following example shows how you can connect to a supported PostgreSQL remote database that has a mixed-case name for the database, schema, table, and column.

Set `enable_case_sensitive_identifier` to `true` before you create the external schema. If `enable_case_sensitive_identifier` is not set to `true` before creating the external schema, then a database does not exist error occurs.

Create an external schema that references an Aurora PostgreSQL database that has a mixed-case database (`UpperDB`) and schema (`UpperSchema`) name.

```
CREATE EXTERNAL SCHEMA apg_upper
FROM POSTGRES
DATABASE 'UpperDB' SCHEMA 'UpperSchema'
URI 'endpoint to aurora hostname'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-SecretsManager-RO'
```

```
SECRET_ARN 'arn:aws:secretsmanager:us-west-2:123456789012:secret:federation/test/
dataplane-apg-creds-YbVKQw';
```

Run a federated query to select all data from the PostgreSQL database. The table (`MixedCaseTab`) and column (`MixedCaseName`) have mixed-case names. The result is one row (`Harry`).

```
select * from apg_upper."MixedCaseTab";
```

```


 MixedCaseName
-------
 Harry
```

Example of using a federated query with MySQL

The following example shows how to set up a federated query that references an Aurora MySQL database. This example illustrates how federated queries works. To run it on your own environment, change it to fit your environment. For prerequisites for doing this, see Getting started with using federated queries to MySQL.

This example depends on the following prerequisites:

- A secret that was set up in Secrets Manager for the Aurora MySQL database. This secret is referenced in IAM access policies and roles. For more information, see Creating a secret and an IAM role to use federated queries.
- A security group that is set up linking Amazon Redshift and Aurora MySQL.

Create an external schema that references an Aurora MySQL database.

```
CREATE EXTERNAL SCHEMA amysql
FROM MYSQL
DATABASE 'functional'
URI 'endpoint to remote hostname'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-SecretsManager-RO'
SECRET_ARN 'arn:aws:secretsmanager:us-west-2:123456789012:secret:federation/test/
dataplane-apg-creds-YbVKQw';
```

Run an example SQL select of the Aurora MySQL table to display one row from the employees table in Aurora MySQL.

```
SELECT level FROM amysql.employees LIMIT 1;

 level
-------
     8
```

Data type differences between Amazon Redshift and supported PostgreSQL and MySQL databases

The following table shows the mapping of an Amazon Redshift data type to a corresponding Amazon RDS PostgreSQL or Aurora PostgreSQL data type.

Amazon Redshift data type	RDS PostgreSQL or Aurora PostgreSQL data type	Description
SMALLINT	SMALLINT	Signed two-byte integer
INTEGER	INTEGER	Signed four-byte integer
BIGINT	BIGINT	Signed eight-byte integer
DECIMAL	DECIMAL	Exact numeric of selectable precision
REAL	REAL	Single precision floating-point number
DOUBLE PRECISION	DOUBLE PRECISION	Double precision floating-point number
BOOLEAN	BOOLEAN	Logical Boolean (true/false)

Amazon Redshift data type	RDS PostgreSQL or Aurora PostgreSQL data type	Description
CHAR	CHAR	Fixed-length character string
VARCHAR	VARCHAR	Variable-length character string with a user-defined limit
DATE	DATE	Calendar date (year, month, day)
TIMESTAMP	TIMESTAMP	Date and time (without time zone)
TIMESTAMPTZ	TIMESTAMPTZ	Date and time (with time zone)
GEOMETRY	PostGIS GEOMETRY	Spatial data

The following RDS PostgreSQL and Aurora PostgreSQL data types are converted to VARCHAR(64K) in Amazon Redshift:

- JSON, JSONB
- Arrays
- BIT, BIT VARYING
- BYTEA
- Composite types
- Date and time types INTERVAL, TIME, TIME WITH TIMEZONE
- Enumerated types
- Monetary types
- Network address types
- Numeric types SERIAL, BIGSERIAL, SMALLSERIAL, and MONEY
- Object identifier types

- pg_lsn type
- Pseudotypes
- Range types
- Text search types
- TXID_SNAPSHOT
- UUID
- XML type

The following table shows the mapping of an Amazon Redshift data type to a corresponding Amazon RDS MySQL or Aurora MySQL data type.

Amazon Redshift data type	RDS MySQL or Aurora MySQL data type	Description
BOOLEAN	TINYINT(1)	Logical Boolean (true or false)
SMALLINT	TINYINT(UNSIGNED)	Signed two-byte integer
SMALLINT	SMALLINT	Signed two-byte integer
INTEGER	SMALLINT UNSIGNED	Signed four-byte integer
INTEGER	MEDIUMINT (UNSIGNED)	Signed four-byte integer
INTEGER	INT	Signed four-byte integer
BIGINT	INT UNSIGNED	Signed eight-byte integer
BIGINT	BIGINT	Signed eight-byte integer

Amazon Redshift data type	RDS MySQL or Aurora MySQL data type	Description
DECIMAL	BIGINT UNSIGNED	Exact numeric of selectable precision
DECIMAL	DECIMAL(M,D)	Exact numeric of selectable precision
REAL	FLOAT	Single precision floating-point number
DOUBLE PRECISION	DOUBLE	Double precision floating-point number
CHAR	CHAR	Fixed-length character string
VARCHAR	VARCHAR	Variable-length character string with a user-defined limit
DATE	DATE	Calendar date (year, month, day)
TIME	TIME	Time (without time zone)
TIMESTAMP	TIMESTAMP	Date and time (without time zone)
TIMESTAMP	DATETIME	Time (without time zone)
VARCHAR(4)	YEAR	Variable length character represent ing year

An error results when TIME data is out of range (00:00:00 – 24:00:00).

The following RDS MySQL and Aurora MySQL data types are converted to VARCHAR(64K) in Amazon Redshift:

- BIT
- BINARY
- VARBINARY
- TINYBLOB, BLOB, MEDIUMBLOB, LONGBLOB
- TINYTEXT, TEXT, MEDIUMTEXT, LONGTEXT
- ENUM
- SET
- SPATIAL

Considerations when accessing federated data with Amazon Redshift

Some Amazon Redshift features don't support access to federated data. You can find related limitations and considerations following.

The following are limitations and considerations when using federated queries with Amazon Redshift:

- Federated queries support read access to external data sources. You can't write or create database objects in the external data source.
- In some cases, you might access an Amazon RDS or Aurora DB cluster database in a different AWS Region than Amazon Redshift. In these cases, you typically incur network latency and billing charges for transferring data across AWS Regions. We recommend using an Aurora global database with a local endpoint in the same AWS Region as your Amazon Redshift cluster. Aurora global databases use dedicated infrastructure for storage-based replication across any two AWS Regions with typical latency of less than 1 second.
- Consider the cost of accessing Amazon RDS or Aurora DB cluster. For example, when using this feature to access Aurora DB cluster, Aurora DB cluster charges are based on IOPS.
- Federated queries don't enable access to Amazon Redshift from RDS or Aurora DB cluster.

- Federated queries are only available in AWS Regions where both Amazon Redshift and Amazon RDS or Aurora DB cluster are available.
- Federated queries currently don't support `ALTER SCHEMA`. To change a schema, use `DROP` and then `CREATE EXTERNAL SCHEMA`.
- Federated queries don't work with concurrency scaling.
- Federated queries currently don't support access through a PostgreSQL foreign data wrapper.
- Federated queries to RDS MySQL or Aurora MySQL support transaction isolation at the READ COMMITTED level.
- If not specified, Amazon Redshift connects to RDS for MySQL or Aurora MySQL on port 3306. Confirm the MySQL port number before creating an external schema for MySQL.
- If not specified, Amazon Redshift connects to RDS PostgreSQL or Aurora PostgreSQL on port 5432. Confirm the PostgreSQL port number before creating an external schema for PostgreSQL.
- When fetching TIMESTAMP and DATE data types from MySQL, zero values are treated as NULL.
- If an Aurora DB cluster database reader endpoint is used, an "invalid snapshot" error can occur. This can be avoided by one of the following methods:
  - Use a specific Aurora DB cluster instance endpoint (instead of using the Aurora DB cluster cluster endpoint). This method uses REPEATABLE READ transaction isolation for the results from the PostgreSQL database.
  - Use an Aurora DB cluster reader endpoint and set `pg_federation_repeatable_read` to false for the session. This method uses READ COMMITTED transaction isolation for the results from the PostgreSQL database. For more information about Aurora DB cluster reader endpoints, see Types of Aurora DB cluster endpoints in the *Amazon Aurora User Guide*. For information about `pg_federation_repeatable_read`, see pg_federation_repeatable_read.

The following are considerations for transactions when working with federated queries to PostgreSQL databases:

- If a query consists of federated tables, the leader node starts a READ ONLY REPEATABLE READ transaction on the remote database. This transaction remains for the duration of the Amazon Redshift transaction.
- The leader node creates a snapshot of the remote database by calling `pg_export_snapshot` and makes a read lock on the affected tables.
- A compute node starts a transaction and uses the snapshot created at the leader node to issue queries to the remote database.

Supported versions of federated databases

An Amazon Redshift external schema can reference a database in an external RDS PostgreSQL or Aurora PostgreSQL. When it does, these limitations apply:

- When creating an external schema referencing Aurora DB cluster, the Aurora PostgreSQL database must be at version 9.6, or later.
- When creating an external schema referencing Amazon RDS, the Amazon RDS PostgreSQL database must be at version 9.6, or later.

An Amazon Redshift external schema can reference a database in an external RDS MySQL or Aurora MySQL. When it does, these limitations apply:

- When creating an external schema referencing Aurora DB cluster, the Aurora MySQL database must be at version 5.6 or later.
- When creating an external schema referencing Amazon RDS, the RDS MySQL database must be at version 5.6 or later.

Amazon Redshift Spectrum

This section describes how to use Redshift Spectrum to efficiently read data from Amazon S3.

Using Amazon Redshift Spectrum, you can efficiently query and retrieve structured and semi-structured data from files in Amazon S3 without having to load the data into Amazon Redshift tables. Redshift Spectrum queries employ massive parallelism to run very fast against large datasets. Much of the processing occurs in the Redshift Spectrum layer, and most of the data remains in Amazon S3. Multiple clusters can concurrently query the same dataset in Amazon S3 without the need to make copies of the data for each cluster.

Topics

Amazon Redshift Spectrum overview

This topic describes details for using Redshift Spectrum to efficiently read from Amazon S3.

Amazon Redshift Spectrum resides on dedicated Amazon Redshift servers that are independent of your cluster. Amazon Redshift pushes many compute-intensive tasks, such as predicate filtering and aggregation, down to the Redshift Spectrum layer. Thus, Redshift Spectrum queries use much less of your cluster's processing capacity than other queries. Redshift Spectrum also scales intelligently. Based on the demands of your queries, Redshift Spectrum can potentially use thousands of instances to take advantage of massively parallel processing.

You create Redshift Spectrum tables by defining the structure for your files and registering them as tables in an external data catalog. The external data catalog can be AWS Glue, the data catalog that comes with Amazon Athena, or your own Apache Hive metastore. You can create and manage external tables either from Amazon Redshift using data definition language (DDL) commands or using any other tool that connects to the external data catalog. Changes to the external data catalog are immediately available to any of your Amazon Redshift clusters.

Optionally, you can partition the external tables on one or more columns. Defining partitions as part of the external table can improve performance. The improvement occurs because the Amazon Redshift query optimizer eliminates partitions that don't contain data for the query.

Materialized views on Spectrum tables can greatly improve cost and performance. For more information, see Materialized views on external data lake tables in Amazon Redshift Spectrum.

After your Redshift Spectrum tables have been defined, you can query and join the tables just as you do any other Amazon Redshift table. Redshift Spectrum doesn't support update operations on external tables. You can add Redshift Spectrum tables to multiple Amazon Redshift clusters and query the same data on Amazon S3 from any cluster in the same AWS Region. When you update Amazon S3 data files, the data is immediately available for query from any of your Amazon Redshift clusters.

The AWS Glue Data Catalog that you access might be encrypted to increase security. If the AWS Glue catalog is encrypted, you need the AWS Key Management Service (AWS KMS) key for AWS Glue to access the AWS Glue catalog. AWS Glue catalog encryption is not available in all AWS Regions. For a list of supported AWS Regions, see Encryption and Secure Access for AWS Glue in the *AWS Glue Developer Guide*. For more information about AWS Glue Data Catalog encryption, see Encrypting Your AWS Glue Data Catalog in the *AWS Glue Developer Guide*.

> **Note**
>
> You can't view details for Redshift Spectrum tables using the same resources that you use for standard Amazon Redshift tables, such as PG_TABLE_DEF, STV_TBL_PERM, PG_CLASS, or information_schema. If your business intelligence or analytics tool doesn't recognize Redshift Spectrum external tables, configure your application to query SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS.

Amazon Redshift Spectrum Regions

Redshift Spectrum is available in AWS Regions where Amazon Redshift is available, unless otherwise specified in Region specific documentation. For AWS Region availability in commercial Regions, see Service endpoints for the **Redshift API** in the *Amazon Web Services General Reference*.

Amazon Redshift Spectrum limitations

This topic describes limitations for using Redshift Spectrum.

Note the following considerations when you use Redshift Spectrum:

- The Amazon Redshift cluster and the Amazon S3 bucket must be in the same AWS Region.
- Redshift Spectrum doesn't support enhanced VPC routing with provisioned clusters. To access your Amazon S3 data, you might need to perform additional configuration steps. For more information, see Redshift Spectrum and enhanced VPC routing in the *Amazon Redshift Management Guide*.
- Redshift Spectrum supports Amazon S3 access point aliases. For more information, see Using a bucket–style alias for your access point in the *Amazon Simple Storage Service User Guide*. However, Redshift Spectrum doesn't support VPC with Amazon S3 access point aliases. For more information, see Redshift Spectrum and enhanced VPC routing in the *Amazon Redshift Management Guide*.
- You can't perform update or delete operations on external tables. To create a new external table in the specified schema, you can use CREATE EXTERNAL TABLE. For more information about CREATE EXTERNAL TABLE, see CREATE EXTERNAL TABLE. To insert the results of a SELECT query into existing external tables on external catalogs, you can use INSERT (external table). For more information about INSERT (external table), see INSERT (external table).
- Unless you are using an AWS Glue Data Catalog that is enabled for AWS Lake Formation, you can't control user permissions on an external table. Instead, you can grant and revoke permissions on the external schema. For more information about working with AWS Lake Formation, see Redshift Spectrum and AWS Lake Formation.
- To run Redshift Spectrum queries, the database user must have permission to create temporary tables in the database. The following example grants temporary permission on the database `spectrumdb` to the `spectrumusers` user group.

```
grant temp on database spectrumdb to group spectrumusers;
```

For more information, see GRANT.

- When using the Athena Data Catalog or AWS Glue Data Catalog as a metadata store, see Quotas and Limits in the *Amazon Redshift Management Guide*.
- Redshift Spectrum doesn't support Amazon EMR with Kerberos.

Getting started with Amazon Redshift Spectrum

In this tutorial, you learn how to use Amazon Redshift Spectrum to query data directly from files on Amazon S3. If you already have a cluster and a SQL client, you can complete this tutorial with minimal setup.

> **Note**
>
> Redshift Spectrum queries incur additional charges. The cost of running the sample queries in this tutorial is nominal. For more information about pricing, see Amazon Redshift Spectrum pricing.

Prerequisites

To use Redshift Spectrum, you need an Amazon Redshift cluster and a SQL client that's connected to your cluster so that you can run SQL commands. The cluster and the data files in Amazon S3 must be in the same AWS Region.

For information about how to create an Amazon Redshift cluster, see Get started with Amazon Redshift provisioned data warehouses in the *Amazon Redshift Getting Started Guide*. For information about ways to connect to a cluster, see Connecting to Amazon Redshift data warehouses in the *Amazon Redshift Getting Started Guide*.

In some of the examples that follow, the sample data is in the US East (N. Virginia) Region (`us-east-1`), so you need a cluster that is also in `us-east-1`. Or, you can use Amazon S3 to copy data objects from the following buckets and folders to your bucket in the AWS Region where your cluster is located:

- `s3://redshift-downloads/tickit/spectrum/customers/*`
- `s3://redshift-downloads/tickit/spectrum/sales_partition/*`

- `s3://redshift-downloads/tickit/spectrum/sales/*`
- `s3://redshift-downloads/tickit/spectrum/salesevent/*`

Run an Amazon S3 command similar to the following to copy sample data that is located in the US East (N. Virginia) to your AWS Region. Before running the command create your bucket and folders in your bucket to match your Amazon S3 copy command. The output of the Amazon S3 copy command confirms that the files are copied to the *bucket-name* in your desired AWS Region.

```
aws s3 cp s3://redshift-downloads/tickit/spectrum/ s3://bucket-name/tickit/spectrum/ --
copy-props none --recursive
```

Getting started with Redshift Spectrum using AWS CloudFormation

As an alternative to the following steps, you can access the Redshift Spectrum DataLake AWS CloudFormation template to create a stack with an Amazon S3 bucket that you can query. For more information, see Launch your AWS CloudFormation stack and then query your data in Amazon S3.

Getting started with Redshift Spectrum step by step

To get started using Amazon Redshift Spectrum, follow these steps:

- Step 1. Create an IAM role for Amazon Redshift
- Step 2: Associate the IAM role with your cluster
- Step 3: Create an external schema and an external table
- Step 4: Query your data in Amazon S3

Step 1. Create an IAM role for Amazon Redshift

Your cluster needs authorization to access your external Data Catalog in AWS Glue or Amazon Athena and your data files in Amazon S3. To provide that authorization, you reference an AWS Identity and Access Management (IAM) role that is attached to your cluster. For more information about using roles with Amazon Redshift, see Authorizing COPY and UNLOAD Operations Using IAM Roles.

> **Note**
>
> In certain cases, you can migrate your Athena Data Catalog to an AWS Glue Data Catalog. You can do this if your cluster is in an AWS Region where AWS Glue is supported and you have Redshift Spectrum external tables in the Athena Data Catalog. To use the AWS Glue Data Catalog with Redshift Spectrum, you might need to change your IAM policies. For more information, see Upgrading to the AWS Glue Data Catalog in the *Athena User Guide*.

When you create a role for Amazon Redshift, choose one of the following approaches:

- If you are using Redshift Spectrum with either an Athena Data Catalog or AWS Glue Data Catalog, follow the steps outlined in To create an IAM role for Amazon Redshift.
- If you are using Redshift Spectrum with an AWS Glue Data Catalog that is enabled for AWS Lake Formation, follow the steps outlined in these procedures:
  - To create an IAM role for Amazon Redshift using an AWS Glue Data Catalog enabled for AWS Lake Formation
  - To grant SELECT permissions on the table to query in the Lake Formation database

To create an IAM role for Amazon Redshift

1. Open the IAM console.
2. In the navigation pane, choose **Roles**.
3. Choose **Create role**.
4. Choose **AWS service** as the trusted entity, and then choose **Redshift** as the use case.
5. Under **Use case for other AWS services**, choose **Redshift - Customizable** and then choose **Next**.
6. The **Add permissions policy** page appears. Choose `AmazonS3ReadOnlyAccess` and `AWSGlueConsoleFullAccess`, if you're using the AWS Glue Data Catalog. Or choose `AmazonAthenaFullAccess` if you're using the Athena Data Catalog. Choose **Next**.

   > **Note**
   >
   > The `AmazonS3ReadOnlyAccess` policy gives your cluster read-only access to all Amazon S3 buckets. To grant access to only the AWS sample data bucket, create a new policy and add the following permissions.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "s3:Get*",
                "s3:List*"
            ],
            "Resource": "arn:aws:s3:::redshift-downloads/*"
        }
    ]
}
```

7. For **Role name**, enter a name for your role, for example **`myspectrum_role`**.
8. Review the information, and then choose **Create role**.
9. In the navigation pane, choose **Roles**. Choose the name of your new role to view the summary, and then copy the **Role ARN** to your clipboard. This value is the Amazon Resource Name (ARN) for the role that you just created. You use that value when you create external tables to reference your data files on Amazon S3.

To create an IAM role for Amazon Redshift using an AWS Glue Data Catalog enabled for AWS Lake Formation

1. Open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Policies**.

   If this is your first time choosing **Policies**, the **Welcome to Managed Policies** page appears. Choose **Get Started**.
3. Choose **Create policy**.
4. Choose to create the policy on the **JSON** tab.
5. Paste in the following JSON policy document, which grants access to the Data Catalog but denies the administrator permissions for Lake Formation.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "RedshiftPolicyForLF",
            "Effect": "Allow",
            "Action": [
                "glue:*",
                "lakeformation:GetDataAccess"
            ],
            "Resource": "*"
        }
    ]
}
```

6. When you are finished, choose **Review** to review the policy. The policy validator reports any syntax errors.
7. On the **Review policy** page, for **Name** enter **`myspectrum_policy`** to name the policy that you are creating. Enter a **Description** (optional). Review the policy **Summary** to see the permissions that are granted by your policy. Then choose **Create policy** to save your work.

   After you create a policy, you can provide access to your users.

To provide access, add permissions to your users, groups, or roles:

- Users and groups in AWS IAM Identity Center:

  Create a permission set. Follow the instructions in Create a permission set in the *AWS IAM Identity Center User Guide*.
- Users managed in IAM through an identity provider:

  Create a role for identity federation. Follow the instructions in Create a role for a third-party identity provider (federation) in the *IAM User Guide*.
- IAM users:
  - Create a role that your user can assume. Follow the instructions in Create a role for an IAM user in the *IAM User Guide*.

- (Not recommended) Attach a policy directly to a user or add a user to a user group. Follow the instructions in Adding permissions to a user (console) in the *IAM User Guide*.

To grant SELECT permissions on the table to query in the Lake Formation database

1. Open the Lake Formation console at https://console.aws.amazon.com/lakeformation/.
2. In the navigation pane, choose **Data lake permissions**, and then choose **Grant**.
3. Follow the instructions in Granting table permissions using the named resource method in the *AWS Lake Formation Developer Guide*. Provide the following information:

   - For **IAM role**, choose the IAM role you created, `myspectrum_role`. When you run the Amazon Redshift Query Editor, it uses this IAM role for permission to the data.

   > **Note**
   >
   > To grant SELECT permission on the table in a Lake Formation–enabled Data Catalog to query, do the following:
   >
   > - Register the path for the data in Lake Formation.
   > - Grant users permission to that path in Lake Formation.
   > - Created tables can be found in the path registered in Lake Formation.

4. Choose **Grant**.

> **Important**
>
> As a best practice, allow access only to the underlying Amazon S3 objects through Lake Formation permissions. To prevent unapproved access, remove any permission granted to Amazon S3 objects outside of Lake Formation. If you previously accessed Amazon S3 objects before setting up Lake Formation, remove any IAM policies or bucket permissions that previously were set up. For more information, see Upgrading AWS Glue Data Permissions to the AWS Lake Formation Model and Lake Formation Permissions.

Step 2: Associate the IAM role with your cluster

Now you have an IAM role that authorizes Amazon Redshift to access the external Data Catalog and Amazon S3 for you. At this point, you must associate that role with your Amazon Redshift cluster.

To associate an IAM role with a cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose the name of the cluster that you want to update.
3. For **Actions**, choose **Manage IAM roles**. The **IAM roles** page appears.
4. Either choose **Enter ARN** and then enter an ARN or an IAM role, or choose an IAM role from the list. Then choose **Add IAM role** to add it to the list of **Attached IAM roles**.
5. Choose **Done** to associate the IAM role with the cluster. The cluster is modified to complete the change.

Step 3: Create an external schema and an external table

Create external tables in an external schema. The external schema references a database in the external data catalog and provides the IAM role ARN that authorizes your cluster to access Amazon S3 on your behalf. You can create an external database in an Amazon Athena Data Catalog, AWS Glue Data Catalog, or an Apache Hive metastore, such as Amazon EMR. For this example, you create the external database in an Amazon Athena Data Catalog when you create the external schema Amazon Redshift. For more information, see External schemas in Amazon Redshift Spectrum.

To create an external schema and an external table

1. To create an external schema, replace the IAM role ARN in the following command with the role ARN you created in step 1. Then run the command in your SQL client.

```
create external schema myspectrum_schema
from data catalog
database 'myspectrum_db'
iam_role 'arn:aws:iam::123456789012:role/myspectrum_role'
```

```
create external database if not exists;
```

2. To create an external table, run the following CREATE EXTERNAL TABLE command.

> **Note**
>
> Your cluster and the Amazon S3 bucket must be in the same AWS Region. For this example CREATE EXTERNAL TABLE command, the Amazon S3 bucket with the sample data is located in the US East (N. Virginia) AWS Region. To see the source data, download the `sales_ts.000` file.
>
> You can modify this example to run in a different AWS Region. Create an Amazon S3 bucket in your desired AWS Region. Copy the sales data with an Amazon S3 copy command. Then update the location option in the example `CREATE EXTERNAL TABLE` command to your bucket.
>
> ```
> aws s3 cp s3://redshift-downloads/tickit/spectrum/sales/ s3://bucket-name/
> tickit/spectrum/sales/ --copy-props none --recursive
> ```
>
> The output of the Amazon S3 copy command confirms that the file was copied to the *bucket-name* in your desired AWS Region.
>
> ```
> copy: s3://redshift-downloads/tickit/spectrum/sales/sales_ts.000 to
>  s3://bucket-name/tickit/spectrum/sales/sales_ts.000
> ```

```
create external table myspectrum_schema.sales(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
row format delimited
fields terminated by '\t'
stored as textfile
```

```
location 's3://redshift-downloads/tickit/spectrum/sales/'
table properties ('numRows'='172000');
```

Step 4: Query your data in Amazon S3

After your external tables are created, you can query them using the same SELECT statements that you use to query other Amazon Redshift tables. These SELECT statement queries include joining tables, aggregating data, and filtering on predicates.

To query your data in Amazon S3

1. Get the number of rows in the MYSPECTRUM_SCHEMA.SALES table.

```
select count(*) from myspectrum_schema.sales;
```

```
count
------
172462
```

2. Keep your larger fact tables in Amazon S3 and your smaller dimension tables in Amazon Redshift, as a best practice. If you loaded the sample data in Load data, you have a table named EVENT in your database. If not, create the EVENT table by using the following command.

```
create table event(
eventid integer not null distkey,
venueid smallint not null,
catid smallint not null,
dateid smallint not null sortkey,
eventname varchar(200),
starttime timestamp);
```

3. Load the EVENT table by replacing the IAM role ARN in the following COPY command with the role ARN you created in Step 1. Create an IAM role for Amazon Redshift. You can optionally download and view the `source data for the allevents_pipe.txt` from an Amazon S3 bucket in AWS Region `us-east-1`.

```
copy event from 's3://redshift-downloads/tickit/allevents_pipe.txt'
iam_role 'arn:aws:iam::123456789012:role/myspectrum_role'
```

```
delimiter '|' timeformat 'YYYY-MM-DD HH:MI:SS' region 'us-east-1';
```

The following example joins the external Amazon S3 table MYSPECTRUM_SCHEMA.SALES with the local Amazon Redshift table EVENT to find the total sales for the top 10 events.

```
select top 10 myspectrum_schema.sales.eventid,
 sum(myspectrum_schema.sales.pricepaid) from myspectrum_schema.sales, event
where myspectrum_schema.sales.eventid = event.eventid
and myspectrum_schema.sales.pricepaid > 30
group by myspectrum_schema.sales.eventid
order by 2 desc;
```

```
eventid | sum
--------+---------
    289 | 51846.00
   7895 | 51049.00
   1602 | 50301.00
    851 | 49956.00
   7315 | 49823.00
   6471 | 47997.00
   2118 | 47863.00
    984 | 46780.00
   7851 | 46661.00
   5638 | 46280.00
```

4. View the query plan for the previous query. Notice the `S3 Seq Scan`, `S3 HashAggregate`, and `S3 Query Scan` steps that were run against the data on Amazon S3.

```
explain
select top 10 myspectrum_schema.sales.eventid,
 sum(myspectrum_schema.sales.pricepaid)
from myspectrum_schema.sales, event
where myspectrum_schema.sales.eventid = event.eventid
and myspectrum_schema.sales.pricepaid > 30
group by myspectrum_schema.sales.eventid
order by 2 desc;
```

```
QUERY PLAN
```

```
-----------------------------------------------------------------------------
XN Limit  (cost=1001055770628.63..1001055770628.65 rows=10 width=31)


  ->  XN Merge  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)


        Merge Key: sum(sales.derived_col2)


        ->  XN Network  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)


              Send to leader


              ->  XN Sort  (cost=1001055770628.63..1001055770629.13 rows=200
 width=31)

                    Sort Key: sum(sales.derived_col2)


                    ->  XN HashAggregate  (cost=1055770620.49..1055770620.99
 rows=200 width=31)

                          ->  XN Hash Join DS_BCAST_INNER
 (cost=3119.97..1055769620.49 rows=200000 width=31)

                                Hash Cond: ("outer".derived_col1 = "inner".eventid)


                                ->  XN S3 Query Scan sales  (cost=3010.00..5010.50
 rows=200000 width=31)

                                      ->  S3 HashAggregate  (cost=3010.00..3010.50
 rows=200000 width=16)

                                            ->  S3 Seq Scan myspectrum_schema.sales
 location:"s3://redshift-downloads/tickit/spectrum/sales" format:TEXT
 (cost=0.00..2150.00 rows=172000 width=16)
                                                  Filter: (pricepaid > 30.00)
```

```
                                          ->  XN Hash  (cost=87.98..87.98 rows=8798 width=4)


                                                ->  XN Seq Scan on event  (cost=0.00..87.98
rows=8798 width=4)
```

Launch your AWS CloudFormation stack and then query your data in Amazon S3

After you create an Amazon Redshift cluster and connect to the cluster, you can install your Redshift Spectrum DataLake AWS CloudFormation template and then query your data.

CloudFormation installs the Redshift Spectrum Getting Started DataLake template and creates a stack that includes the following:

- A role named `myspectrum_role` associated with your Redshift cluster
- An external schema named `myspectrum_schema`
- An external table named `sales` in an Amazon S3 bucket
- A Redshift table named `event` loaded with data

To launch your Redshift Spectrum Getting Started DataLake CloudFormation stack

1. Choose **Launch CFN stack**. The CloudFormation console opens with the DataLake.yml template selected.

   You can also download and customize the Redshift Spectrum Getting Started DataLake CloudFormation CFN template, then open CloudFormation console (https://console.aws.amazon.com/cloudformation) and create a stack with the customized template.
2. Choose **Next**.
3. Under **Parameters**, enter the Amazon Redshift cluster name, database name, and your database user name.
4. Choose **Next**.

   The stack options appear.
5. Choose **Next** to accept the default settings.

6. Review the information and under **Capabilities**, and choose **I acknowledge that AWS CloudFormation might create IAM resources**.
7. Choose **Create stack**.

If an error occurs while the stack is being created, see the following information:

- View the CloudFormation **Events** tab for information that can help you resolve the error.
- Delete the DataLake CloudFormation stack before trying the operation again.
- Make sure that you are connected to your Amazon Redshift database.
- Make sure that you entered the correct information for the Amazon Redshift cluster name, database name, and database user name.

Query your data in Amazon S3

You query external tables using the same SELECT statements that you use to query other Amazon Redshift tables. These SELECT statement queries include joining tables, aggregating data, and filtering on predicates.

The following query returns the number of rows in the `myspectrum_schema.sales` external table.

```
select count(*) from myspectrum_schema.sales;
```

```
count
------
172462
```

Join an external table with a local table

The following example joins the external table `myspectrum_schema.sales` with the local table `event` to find the total sales for the top 10 events.

```
select top 10 myspectrum_schema.sales.eventid, sum(myspectrum_schema.sales.pricepaid)
 from myspectrum_schema.sales, event
where myspectrum_schema.sales.eventid = event.eventid
and myspectrum_schema.sales.pricepaid > 30
group by myspectrum_schema.sales.eventid
```

```
order by 2 desc;
```

```
eventid | sum
--------+---------
    289 | 51846.00
   7895 | 51049.00
   1602 | 50301.00
    851 | 49956.00
   7315 | 49823.00
   6471 | 47997.00
   2118 | 47863.00
    984 | 46780.00
   7851 | 46661.00
   5638 | 46280.00
```

View the query plan

View the query plan for the previous query. Note the `S3 Seq Scan`, `S3 HashAggregate`, and `S3 Query Scan` steps that were run on the data on Amazon S3.

```
explain
select top 10 myspectrum_schema.sales.eventid, sum(myspectrum_schema.sales.pricepaid)
from myspectrum_schema.sales, event
where myspectrum_schema.sales.eventid = event.eventid
and myspectrum_schema.sales.pricepaid > 30
group by myspectrum_schema.sales.eventid
order by 2 desc;
```

```


QUERY PLAN



-----------------------------------------------------------------------------
XN Limit  (cost=1001055770628.63..1001055770628.65 rows=10 width=31)



  ->  XN Merge  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)



        Merge Key: sum(sales.derived_col2)


```

```
      ->  XN Network  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)

            Send to leader

            ->  XN Sort  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)

                  Sort Key: sum(sales.derived_col2)

                  ->  XN HashAggregate  (cost=1055770620.49..1055770620.99 rows=200
 width=31)

                        ->  XN Hash Join DS_BCAST_INNER  (cost=3119.97..1055769620.49
 rows=200000 width=31)

                              Hash Cond: ("outer".derived_col1 = "inner".eventid)

                              ->  XN S3 Query Scan sales  (cost=3010.00..5010.50
 rows=200000 width=31)

                                    ->  S3 HashAggregate  (cost=3010.00..3010.50
 rows=200000 width=16)

                                          ->  S3 Seq Scan spectrum.sales
 location:"s3://redshift-downloads/tickit/spectrum/sales" format:TEXT
 (cost=0.00..2150.00 rows=172000 width=16)
                                                Filter: (pricepaid > 30.00)

                              ->  XN Hash  (cost=87.98..87.98 rows=8798 width=4)

                                    ->  XN Seq Scan on event  (cost=0.00..87.98
 rows=8798 width=4)
```

IAM policies for Amazon Redshift Spectrum

This topic describes the required IAM permissions for using Redshift Spectrum.

By default, Amazon Redshift Spectrum uses the AWS Glue Data Catalog in AWS Regions that support AWS Glue. In other AWS Regions, Redshift Spectrum uses the Athena Data Catalog. Your cluster needs authorization to access your external data catalog in AWS Glue or Athena and your data files in Amazon S3. You provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster. If you use an Apache Hive metastore to manage your data catalog, you don't need to provide access to Athena.

You can chain roles so that your cluster can assume other roles not attached to the cluster. For more information, see Chaining IAM roles in Amazon Redshift Spectrum.

The AWS Glue catalog that you access might be encrypted to increase security. If the AWS Glue catalog is encrypted, you need the AWS KMS key for AWS Glue to access the AWS Glue Data Catalog. For more information, see Encrypting Your AWS Glue Data Catalog in the *AWS Glue Developer Guide*.

Topics

Amazon S3 permissions

At a minimum, your cluster needs GET and LIST access to your Amazon S3 bucket. If your bucket is not in the same AWS account as your cluster, your bucket must also authorize your cluster to access the data. For more information, see Authorizing Amazon Redshift to Access Other AWS Services on Your Behalf.

> **Note**
>
> The Amazon S3 bucket can't use a bucket policy that restricts access only from specific VPC endpoints.

The following policy grants GET and LIST access to any Amazon S3 bucket. The policy allows access to Amazon S3 buckets for Redshift Spectrum as well as COPY operations.

JSON

```
{
 "Version": "2012-10-17",
 "Statement": [{
  "Effect": "Allow",
  "Action": ["s3:Get*", "s3:List*"],
  "Resource": "*"
 }]
}
```

The following policy grants GET and LIST access to your Amazon S3 bucket named `amzn-s3-demo-bucket`.

JSON

```
{
 "Version": "2012-10-17",
 "Statement": [{
  "Effect": "Allow",
  "Action": ["s3:Get*", "s3:List*"],
  "Resource": "arn:aws:s3:::amzn-s3-demo-bucket/*"
 }]
}
```

Cross-account Amazon S3 permissions

To grant Redshift Spectrum permission to access data in an Amazon S3 bucket that belongs to another AWS account, add the following policy to the Amazon S3 bucket. For more information, see Granting Cross-Account Bucket Permissions.

JSON

```
{
```

```
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "Example permissions",
            "Effect": "Allow",
            "Principal": {
                "AWS": "arn:aws:iam::111122223333:role/spectrumrole"
            },
            "Action": [
                "s3:GetBucketLocation",
                "s3:GetObject",
                "s3:ListMultipartUploadParts",
                "s3:ListBucket",
                "s3:ListBucketMultipartUploads"
            ],
            "Resource": [
                "arn:aws:s3:::bucketname",
                "arn:aws:s3:::bucketname/*"
            ]
        }
    ]
}
```

Policies to grant or restrict access using Redshift Spectrum

The following example policy allows access to Amazon S3 buckets for Amazon Redshift. When adding this policy to an IAM role, we recommend using an IAM role that is only used for Amazon Redshift. We also recommend that you don't reuse existing roles or add extra permissions to this IAM role.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "s3:GetObject",
                "s3:ListBucketVersions",
                "s3:ListBucket"
```

```
            ],
            "Resource": [
                "arn:aws:s3:::amzn-s3-demo-bucket",
                "arn:aws:s3:::amzn-s3-demo-bucket/*"
            ]
        }
    ]
}
```

Policies to grant minimum permissions

The following policy grants the minimum permissions required to use Redshift Spectrum with Amazon S3, AWS Glue, and Athena.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "s3:ListBucketVersions",
                "s3:ListBucket",
                "s3:GetObject"
            ],
            "Resource": [
                "arn:aws:s3:::bucketname",
                "arn:aws:s3:::bucketname/folder1/folder2/*"
             ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "glue:CreateDatabase",
                "glue:DeleteDatabase",
                "glue:GetDatabase",
                "glue:GetDatabases",
                "glue:UpdateDatabase",
                "glue:CreateTable",
                "glue:DeleteTable",
```

```
                "glue:BatchDeleteTable",
                "glue:UpdateTable",
                "glue:GetTable",
                "glue:GetTables",
                "glue:BatchCreatePartition",
                "glue:CreatePartition",
                "glue:DeletePartition",
                "glue:BatchDeletePartition",
                "glue:UpdatePartition",
                "glue:GetPartition",
                "glue:GetPartitions",
                "glue:BatchGetPartition"
            ],
            "Resource": "*"
        }
    ]
}
```

If you use Athena for your data catalog instead of AWS Glue, the policy requires full Athena access. The following policy grants access to Athena resources. If your external database is in a Hive metastore, you don't need Athena access.

JSON

```
{
 "Version": "2012-10-17",
 "Statement": [{
  "Effect": "Allow",
  "Action": ["athena:*"],
  "Resource": ["*"]
 }]
}
```

Chaining IAM roles in Amazon Redshift Spectrum

When you attach a role to your cluster, your cluster can assume that role to access Amazon S3, Athena, and AWS Glue on your behalf. If a role attached to your cluster doesn't have access to the necessary resources, you can chain another role, possibly belonging to another account. Your cluster then temporarily assumes the chained role to access the data. You can also grant cross-account access by chaining roles. You can chain a maximum of 10 roles. Each role in the chain assumes the next role in the chain, until the cluster assumes the role at the end of chain.

To chain roles, you establish a trust relationship between the roles. A role that assumes another role must have a permissions policy that allows it to assume the specified role. In turn, the role that passes permissions must have a trust policy that allows it to pass its permissions to another role. For more information, see Chaining IAM Roles in Amazon Redshift.

When you run the CREATE EXTERNAL SCHEMA command, you can chain roles by including a comma-separated list of role ARNs.

> **Note**
>
> The list of chained roles must not include spaces.

In the following example, `MyRedshiftRole` is attached to the cluster. `MyRedshiftRole` assumes the role `AcmeData`, which belongs to account `111122223333`.

```
create external schema acme from data catalog
database 'acmedb' region 'us-west-2'
iam_role 'arn:aws:iam::123456789012:role/MyRedshiftRole,arn:aws:iam::111122223333:role/
AcmeData';
```

Controlling access to the AWS Glue Data Catalog

If you use AWS Glue for your data catalog, you can apply fine-grained access control to the AWS Glue Data Catalog with your IAM policy. For example, you might want to expose only a few databases and tables to a specific IAM role.

The following sections describe the IAM policies for various levels of access to data stored in the AWS Glue Data Catalog.

Topics

Policy for database operations

If you want to give users permissions to view and create a database, they need access rights to both the database and the AWS Glue Data Catalog.

The following example query creates a database.

```
CREATE EXTERNAL SCHEMA example_db
FROM DATA CATALOG DATABASE 'example_db' region 'us-west-2'
IAM_ROLE 'arn:aws:iam::redshift-account:role/spectrumrole'
CREATE EXTERNAL DATABASE IF NOT EXISTS
```

The following IAM policy gives the minimum permissions required for creating a database.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetDatabase",
                "glue:CreateDatabase"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:catalog"
            ]
        }
    ]
}
```

The following example query lists the current databases.

```
SELECT * FROM SVV_EXTERNAL_DATABASES WHERE
databasename = 'example_db1' or databasename = 'example_db2';
```

The following IAM policy gives the minimum permissions required to list the current databases.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetDatabases"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:database/example_db1",
                "arn:aws:glue:us-west-2:111122223333:database/example_db2",
                "arn:aws:glue:us-west-2:111122223333:catalog"
            ]
        }
    ]
}
```

Policy for table operations

If you want to give users permissions to view, create, drop, alter, or take other actions on tables, they need several types of access. They need access to the tables themselves, the databases they belong to, and the catalog.

The following example query creates an external table.

```
CREATE EXTERNAL TABLE example_db.example_tbl0(
    col0 INT,
    col1 VARCHAR(255)
) PARTITIONED BY (part INT) STORED AS TEXTFILE
LOCATION 's3://test/s3/location/';
```

The following IAM policy gives the minimum permissions required to create an external table.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:CreateTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

The following example queries each list the current external tables.

```
SELECT * FROM svv_external_tables
WHERE tablename = 'example_tbl0' OR
tablename = 'example_tbl1';
```

```
SELECT * FROM svv_external_columns
WHERE tablename = 'example_tbl0' OR
tablename = 'example_tbl1';
```

```
SELECT parameters FROM svv_external_tables
WHERE tablename = 'example_tbl0' OR
tablename = 'example_tbl1';
```

The following IAM policy gives the minimum permissions required to list the current external tables.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetTables"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl1"
            ]
        }
    ]
}
```

The following example query alters an existing table.

```
ALTER TABLE example_db.example_tbl0
SET TABLE PROPERTIES ('numRows' = '100');
```

The following IAM policy gives the minimum permissions required to alter an existing table.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
```

```
            "Effect": "Allow",
            "Action": [
                "glue:GetTable",
                "glue:UpdateTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

The following example query drops an existing table.

```
DROP TABLE example_db.example_tbl0;
```

The following IAM policy gives the minimum permissions required to drop an existing table.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:DeleteTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
```

```
}
```

Policy for partition operations

If you want to give users permissions to perform partition-level operations (view, create, drop, alter, and so on), they need permissions to the tables that the partitions belong to. They also need permissions to the related databases and the AWS Glue Data Catalog.

The following example query creates a partition.

```
ALTER TABLE example_db.example_tbl0
ADD PARTITION (part=0) LOCATION 's3://test/s3/location/part=0/';
ALTER TABLE example_db.example_t
ADD PARTITION (part=1) LOCATION 's3://test/s3/location/part=1/';
```

The following IAM policy gives the minimum permissions required to create a partition.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetTable",
                "glue:BatchCreatePartition"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

The following example query lists the current partitions.

```
SELECT * FROM svv_external_partitions
WHERE schemname = 'example_db' AND
tablename = 'example_tbl0'
```

The following IAM policy gives the minimum permissions required to list the current partitions.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetPartitions",
                "glue:GetTables",
                "glue:GetTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

The following example query alters an existing partition.

```
ALTER TABLE example_db.example_tbl0 PARTITION(part='0')
SET LOCATION 's3://test/s3/new/location/part=0/';
```

The following IAM policy gives the minimum permissions required to alter an existing partition.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetPartition",
                "glue:UpdatePartition"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

The following example query drops an existing partition.

```
ALTER TABLE example_db.example_tbl0 DROP PARTITION(part='0');
```

The following IAM policy gives the minimum permissions required to drop an existing partition.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:DeletePartition"
```

```
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:111122223333:catalog",
                "arn:aws:glue:us-west-2:111122223333:database/example_db",
                "arn:aws:glue:us-west-2:111122223333:table/example_db/
example_tbl0"
            ]
        }
    ]
}
```

Redshift Spectrum and AWS Lake Formation

This topic describes how to use Redshift Spectrum with Lake Formation. Lake Formation is a service for sharing analytics data.

You can use AWS Lake Formation to centrally define and enforce database, table, and column-level access policies to data stored in Amazon S3. After your data is registered with an AWS Glue Data Catalog enabled with Lake Formation, you can query it by using several services, including Redshift Spectrum.

Lake Formation provides the security and governance of the Data Catalog. Within Lake Formation, you can grant and revoke permissions to the Data Catalog objects, such as databases, tables, columns, and underlying Amazon S3 storage.

> **Important**
>
> You can only use Redshift Spectrum with a Lake Formation enabled Data Catalog in AWS Regions where Lake Formation is available. For a list of available Regions, see AWS Lake Formation endpoints and quotas in the *AWS General Reference*.

By using Redshift Spectrum with Lake Formation, you can do the following:

- Use Lake Formation as a centralized place where you grant and revoke permissions and access control policies on all of your data in the data lake. Lake Formation provides a hierarchy of permissions to control access to databases and tables in a Data Catalog. For more information, see Overview of Lake Formation permissions in the *AWS Lake Formation Developer Guide*.

- Create external tables and run queries on data in the data lake. Before users in your account can run queries, a data lake account administrator registers your existing Amazon S3 paths containing source data with Lake Formation. The administrator also creates tables and grants permissions to your users. Access can be granted on databases, tables, or columns. The administrator can use data filters in Lake Formation to grant granular access control over your sensitive data stored in Amazon S3. For more information, see Using data filters for row-level and cell-level security.

  After the data is registered in the Data Catalog, each time users try to run queries, Lake Formation verifies access to the table for that specific principal. Lake Formation vends temporary credentials to Redshift Spectrum, and the query runs.
- Run Redshift Spectrum queries against an automounted AWS Glue Data Catalog using IAM credentials obtained with `GetCredentials` or `GetClusterCredentials`, and manage Lake Formation permissions by database user (IAMR:username or IAM:username).

When you use Redshift Spectrum with a Data Catalog enabled for Lake Formation, one of the following must be in place:

- An IAM role associated with the cluster that has permission to the Data Catalog.
- A federated IAM identity configured to manage access to external resources. For more information, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift external tables.

> **Important**
>
> You can't chain IAM roles when using Redshift Spectrum with a Data Catalog enabled for Lake Formation.

To learn more about the steps required to set up AWS Lake Formation to use with Redshift Spectrum, see Tutorial: Creating a data lake from a JDBC source in Lake Formation in the *AWS Lake Formation Developer Guide*. Specifically, see Query the data in the data lake using Amazon Redshift Spectrum for details about integration with Redshift Spectrum. The data and AWS resources used in this topic depend on previous steps in the tutorial.

Using data filters for row-level and cell-level security

You can define data filters in AWS Lake Formation to control your Redshift Spectrum queries' row-level and cell-level access to data defined in your Data Catalog. To set this up, you perform the following tasks:

- Create a data filter in Lake Formation with the following information:
  - A column specification with a list of columns to include or exclude from query results.
  - A row filter expression that specifies the rows to include in the query results.

  For more information about how to create a data filter, see Data filters in Lake Formation in the *AWS Lake Formation Developer Guide*.
- Create an external table in Amazon Redshift that references a table in your Lake Formation enabled Data Catalog. For details on how to query a Lake Formation table using Redshift Spectrum, see Query the data in the data lake using Amazon Redshift Spectrum in the *AWS Lake Formation Developer Guide*.

After the table is defined in Amazon Redshift, you can query the Lake Formation table and access only the rows and columns that are allowed by the data filter.

For a detailed guide on how to set up row-level and cell-level security in Lake Formation, and then query using Redshift Spectrum, see Use Amazon Redshift Spectrum with row-level and cell-level security policies defined in AWS Lake Formation.

Data files for queries in Amazon Redshift Spectrum

This section describes how to create data files in Amazon S3 in a format that Redshift Spectrum supports.

The data files that you use for queries in Amazon Redshift Spectrum are commonly the same types of files that you use for other applications. For example, the same types of files are used with Amazon Athena, Amazon EMR, and QuickSight. You can query the data in its original format directly from Amazon S3. To do this, the data files must be in a format that Redshift Spectrum supports and be located in an Amazon S3 bucket that your cluster can access.

The Amazon S3 bucket with the data files and the Amazon Redshift cluster must be in the same AWS Region. For information about supported AWS Regions, see Amazon Redshift Spectrum Regions.

Data formats for Redshift Spectrum

Redshift Spectrum supports the following structured and semi-structured data formats.

File format	Columnar	Supports parallel reads	Split unit
Parquet	Yes	Yes	Row group
ORC	Yes	Yes	Stripe
RCFile	Yes	Yes	Row group
TextFile	No	Yes	Row
SequenceFile	No	Yes	Row or block
RegexSerde	No	Yes	Row
OpenCSV	No	Yes	Row
AVRO	No	Yes	Block
Ion	No	No	N/A
JSON	No	No	N/A

In the preceding table, the headings indicate the following:

- **Columnar –** Whether the file format physically stores data in a column-oriented structure as opposed to a row-oriented one.
- **Supports parallel reads –** Whether the file format supports reading individual blocks within the file. Reading individual blocks enables the distributed processing of a file across multiple independent Redshift Spectrum requests instead of having to read the full file in a single request.
- **Split unit –** For file formats that can be read in parallel, the split unit is the smallest chunk of data that a single Redshift Spectrum request can process.

Note

Timestamp values in text files must be in the format `yyyy-MM-dd HH:mm:ss.SSSSSS`, as the following timestamp value shows: `2017-05-01 11:30:59.000000`.

We recommend using a columnar storage file format, such as Apache Parquet. Amazon Redshift supports the Apache Parquet v1 data file format. With a columnar storage file format, you can minimize data transfer out of Amazon S3 by selecting only the columns that you need.

Compression types for Redshift Spectrum

To reduce storage space, improve performance, and minimize costs, we strongly recommend that you compress your data files. Redshift Spectrum recognizes file compression types based on the file extension.

Redshift Spectrum supports the following compression types and extensions.

Compression Algorithm	File Extension	Supports Parallel Reads
Gzip	.gz	No
Bzip2	.bz2	Yes
Snappy	.snappy	No

You can apply compression at different levels. Most commonly, you compress a whole file or compress individual blocks within a file. Compressing columnar formats at the file level doesn't yield performance benefits.

For Redshift Spectrum to be able to read a file in parallel, the following must be true:

- The file format supports parallel reads.
- The file-level compression, if any, supports parallel reads.

It doesn't matter whether the individual split units within a file are compressed using a compression algorithm that can be read in parallel, because each split unit is processed by a single

Redshift Spectrum request. An example of this is Snappy-compressed Parquet files. Individual row groups within the Parquet file are compressed using Snappy, but the top-level structure of the file remains uncompressed. In this case, the file can be read in parallel because each Redshift Spectrum request can read and process individual row groups from Amazon S3.

Encryption for Redshift Spectrum

Redshift Spectrum transparently decrypts data files that are encrypted using the following encryption options:

- Server-side encryption (SSE-S3) using an AES-256 encryption key managed by Amazon S3.
- Server-side encryption with keys managed by AWS Key Management Service (SSE-KMS).

Redshift Spectrum doesn't support Amazon S3 client-side encryption. For more information on server-side encryption, see Protecting Data Using Server-Side Encryption in the *Amazon Simple Storage Service User Guide*.

Amazon Redshift uses massively parallel processing (MPP) to achieve fast execution of complex queries operating on large amounts of data. Redshift Spectrum extends the same principle to query external data, using multiple Redshift Spectrum instances as needed to scan files. Place the files in a separate folder for each table.

You can optimize your data for parallel processing by doing the following:

- If your file format or compression doesn't support reading in parallel, break large files into many smaller files. We recommend using file sizes between 64 MB and 1 GB.
- Keep all the files about the same size. If some files are much larger than others, Redshift Spectrum can't distribute the workload evenly.

External schemas in Amazon Redshift Spectrum

This topic describes how to create and use external schemas with Redshift Spectrum. External schemas are collections of tables that you use as references to access data outside your Amazon Redshift cluster. These tables contain metadata about the external data that Redshift Spectrum reads.

All external tables must be created in an external schema, which you create using a CREATE EXTERNAL SCHEMA statement.

> **Note**
>
> Some applications use the term *database* and *schema* interchangeably. In Amazon Redshift, we use the term *schema*.

An Amazon Redshift external schema references an external database in an external data catalog. You can create the external database in Amazon Redshift, in Amazon Athena, in AWS Glue Data Catalog, or in an Apache Hive metastore, such as Amazon EMR. If you create an external database in Amazon Redshift, the database resides in the Athena Data Catalog. To create a database in a Hive metastore, you need to create the database in your Hive application.

Amazon Redshift needs authorization to access the Data Catalog in Athena and the data files in Amazon S3 on your behalf. To provide that authorization, you first create an AWS Identity and Access Management (IAM) role. Then you attach the role to your cluster and provide Amazon Resource Name (ARN) for the role in the Amazon Redshift `CREATE EXTERNAL SCHEMA` statement. For more information about authorization, see IAM policies for Amazon Redshift Spectrum.

To create an external database at the same time you create an external schema, specify `FROM DATA CATALOG` and include the `CREATE EXTERNAL DATABASE` clause in your `CREATE EXTERNAL SCHEMA` statement.

The following example creates an external schema named `spectrum_schema` using the external database `spectrum_db`.

```
create external schema spectrum_schema from data catalog
database 'spectrum_db'
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole'
create external database if not exists;
```

If you manage your data catalog using Athena, specify the Athena database name and the AWS Region in which the Athena Data Catalog is located.

The following example creates an external schema using the default `sampledb` database in the Athena Data Catalog.

```
create external schema athena_schema from data catalog
database 'sampledb'
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole'
```

```
region 'us-east-2';
```

Note

The `region` parameter references the AWS Region in which the Athena Data Catalog is located, not the location of the data files in Amazon S3.

If you manage your data catalog using a Hive metastore, such as Amazon EMR, your security groups must be configured to allow traffic between the clusters.

In the CREATE EXTERNAL SCHEMA statement, specify `FROM HIVE METASTORE` and include the metastore's URI and port number. The following example creates an external schema using a Hive metastore database named `hive_db`.

```
create external schema hive_schema
from hive metastore
database 'hive_db'
uri '172.10.10.10' port 99
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole'
```

To view external schemas for your cluster, query the PG_EXTERNAL_SCHEMA catalog table or the SVV_EXTERNAL_SCHEMAS view. The following example queries SVV_EXTERNAL_SCHEMAS, which joins PG_EXTERNAL_SCHEMA and PG_NAMESPACE.

```
select * from svv_external_schemas
```

For the full command syntax and examples, see CREATE EXTERNAL SCHEMA.

Working with external catalogs in Amazon Redshift Spectrum

The metadata for Amazon Redshift Spectrum external databases and external tables is stored in an external data catalog. By default, Redshift Spectrum metadata is stored in an Athena Data Catalog. You can view and manage Redshift Spectrum databases and tables in your Athena console.

You can also create and manage external databases and external tables using Hive data definition language (DDL) using Athena or a Hive metastore, such as Amazon EMR.

> **Note**
>
> We recommend using Amazon Redshift to create and manage external databases and external tables in Redshift Spectrum.

Viewing Redshift Spectrum databases in Athena and AWS Glue

You can create an external database by including the CREATE EXTERNAL DATABASE IF NOT EXISTS clause as part of your CREATE EXTERNAL SCHEMA statement. In such cases, the external database metadata is stored in your Data Catalog. The metadata for external tables that you create qualified by the external schema is also stored in your Data Catalog.

Athena and AWS Glue maintain a Data Catalog for each supported AWS Region. To view table metadata, log on to the Athena or AWS Glue console. In Athena, choose **Data sources**, your AWS Glue, then view the details of your database. In AWS Glue, choose **Databases**, your external database, then view the details of your database.

If you create and manage your external tables using Athena, register the database using CREATE EXTERNAL SCHEMA. For example, the following command registers the Athena database named `sampledb`.

```
create external schema athena_sample
from data catalog
database 'sampledb'
iam_role 'arn:aws:iam::123456789012:role/mySpectrumRole'
region 'us-east-1';
```

When you query the SVV_EXTERNAL_TABLES system view, you see tables in the Athena `sampledb` database and also tables that you created in Amazon Redshift.

```
select * from svv_external_tables;
```

```
schemaname    | tablename        | location

--------------+-----------------
+--------------------------------------------------------
athena_sample | elb_logs         | s3://athena-examples/elb/plaintext
athena_sample | lineitem_1t_csv  | s3://myspectrum/tpch/1000/lineitem_csv
```

```
athena_sample | lineitem_1t_part | s3://myspectrum/tpch/1000/lineitem_partition

spectrum      | sales            | s3://redshift-downloads/tickit/spectrum/sales

spectrum      | sales_part       | s3://redshift-downloads/tickit/spectrum/sales_part
```

Registering an Apache Hive metastore database

If you create external tables in an Apache Hive metastore, you can use CREATE EXTERNAL SCHEMA to register those tables in Redshift Spectrum.

In the CREATE EXTERNAL SCHEMA statement, specify the FROM HIVE METASTORE clause and provide the Hive metastore URI and port number. The IAM role must include permission to access Amazon S3 but doesn't need any Athena permissions. The following example registers a Hive metastore.

```
create external schema if not exists hive_schema
from hive metastore
database 'hive_database'
uri 'ip-10-0-111-111.us-west-2.compute.internal' port 9083
iam_role 'arn:aws:iam::123456789012:role/mySpectrumRole';
```

Enabling your Amazon Redshift cluster to access your Amazon EMR cluster

If your Hive metastore is in Amazon EMR, you must give your Amazon Redshift cluster access to your Amazon EMR cluster. To do so, you create an Amazon EC2 security group. You then allow all inbound traffic to the EC2 security group from your Amazon Redshift cluster's security group and your Amazon EMR cluster's security group. Then you add the EC2 security to both your Amazon Redshift cluster and your Amazon EMR cluster.

View your Amazon Redshift cluster's security group name

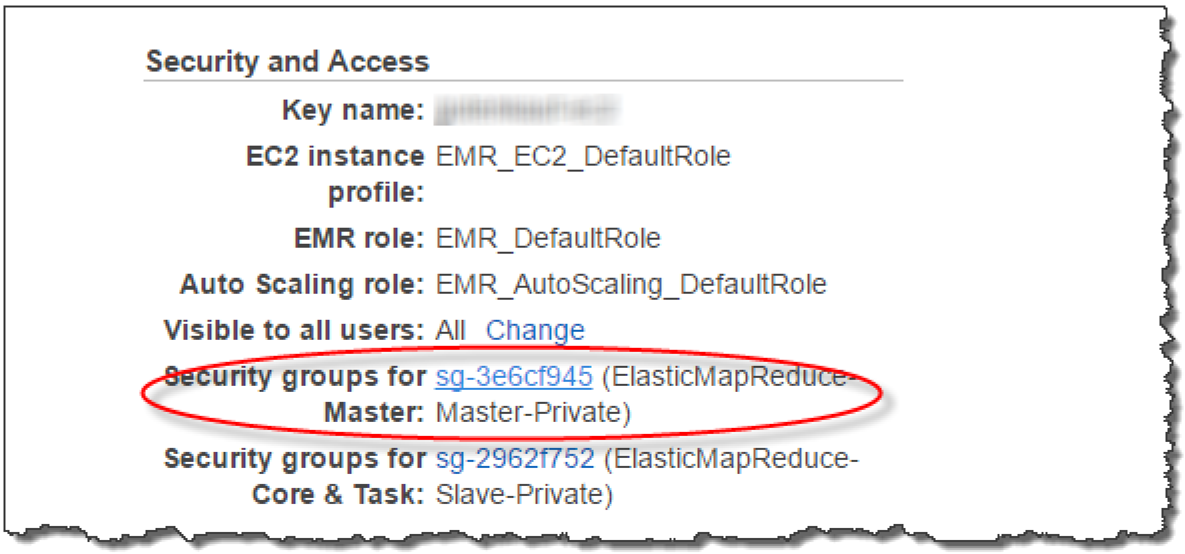
To display the security group, do the following:

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose the cluster from the list to open its details.
3. Choose **Properties** and view the **Network and security settings** section.

4. Find your security group in **VPC security group** and take note of it.

View the Amazon EMR master node security group name

1. Open your Amazon EMR cluster. For more information, see [Use security configurations to set up cluster security]() in the *Amazon EMR Management Guide*.
2. Under **Security and access**, make a note of the Amazon EMR master node security group name.



To create or modify an Amazon EC2 security group to allow connection between Amazon Redshift and Amazon EMR

1. In the Amazon EC2 dashboard, choose **Security groups**. For more information, see [Security group rules]() in the *Amazon EC2 User Guide*
2. Choose **Create security group**.
3. If you are using VPC, choose the VPC that your Amazon Redshift and Amazon EMR clusters are in.
4. Add an inbound rule.
   1. For **Type**, choose **Custom TCP**.
   2. For **Source**, choose **Custom**.
   3. Enter the name of your Amazon Redshift security group.
5. Add another inbound rule.

   1. For **Type**, choose **TCP**.
   2. For **Port Range**, enter **9083**.

   > **Note**
   >
   > The default port for an EMR HMS is 9083. If your HMS uses a different port, specify that port in the inbound rule and in the external schema definition.

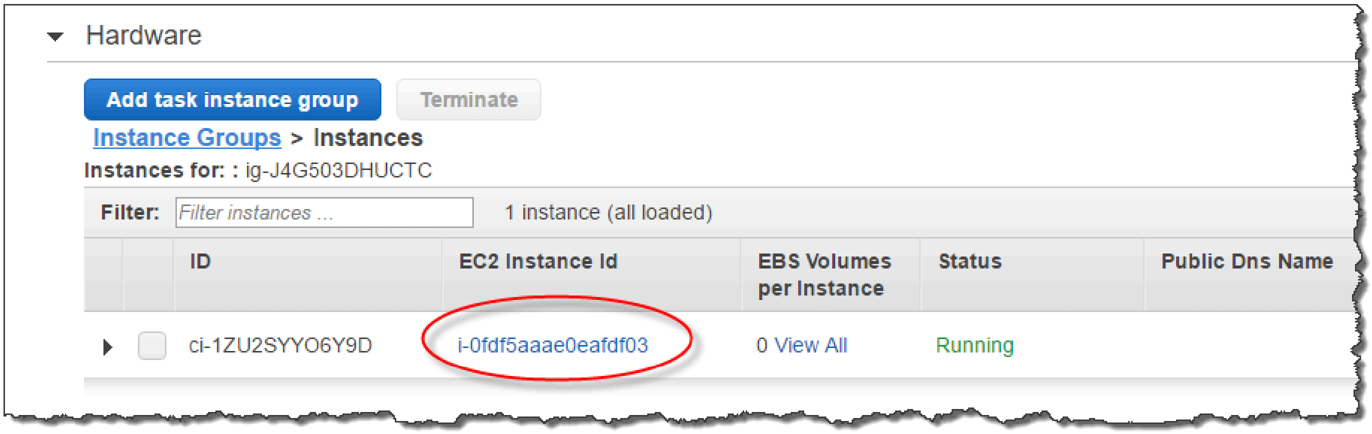
   3. For **Source**, choose **Custom**.
6. Enter a security group name and description.
7. Choose **Create security group**.

To add the Amazon EC2 security group you created in the previous procedure to your Amazon Redshift cluster

1. In Amazon Redshift, choose your cluster.
2. Choose **Properties**.
3. View the **Network and security settings** and choose **Edit**.
4. In **VPC security group**, choose the new security group name.
5. Choose **Save changes**.

To add the Amazon EC2 security group to your Amazon EMR cluster

1. In Amazon EMR, choose your cluster. For more information, see Use security configurations to set up cluster security in the *Amazon EMR Management Guide*.
2. Under **Hardware**, choose the link for the Master node.
3. Choose the link in the **EC2 instance ID** column.



4. For **Actions**, choose **Security**, **Change security groups**.
5. In **Associated sercurity groups**, choose the new security group, and choose **Add security group**.
6. Choose **Save**.

External tables for Redshift Spectrum

This topic describes how to create and use external tables with Redshift Spectrum. External tables are tables that you use as references to access data outside your Amazon Redshift cluster. These tables contain metadata about the external data that Redshift Spectrum reads.

You create an external table in an external schema. To create external tables, you must be the owner of the external schema or a superuser. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner. The following example changes the owner of the `spectrum_schema` schema to `newowner`.

```
alter schema spectrum_schema owner to newowner;
```

To run a Redshift Spectrum query, you need the following permissions:

- Usage permission on the schema
- Permission to create temporary tables in the current database

The following example grants usage permission on the schema `spectrum_schema` to the `spectrumusers` user group.

```
grant usage on schema spectrum_schema to group spectrumusers;
```

The following example grants temporary permission on the database `spectrumdb` to the `spectrumusers` user group.

```
grant temp on database spectrumdb to group spectrumusers;
```

You can create an external table in Amazon Redshift, AWS Glue, Amazon Athena, or an Apache Hive metastore. For more information, see Getting Started Using AWS Glue in the *AWS Glue Developer Guide*, Getting Started in the *Amazon Athena User Guide*, or Apache Hive in the *Amazon EMR Developer Guide*.

If your external table is defined in AWS Glue, Athena, or a Hive metastore, you first create an external schema that references the external database. Then you can reference the external table in your SELECT statement by prefixing the table name with the schema name, without needing to create the table in Amazon Redshift. For more information, see External schemas in Amazon Redshift Spectrum.

To allow Amazon Redshift to view tables in the AWS Glue Data Catalog, add `glue:GetTable` to the Amazon Redshift IAM role. Otherwise you might get an error similar to the following.

```
RedshiftIamRoleSession is not authorized to perform: glue:GetTable on resource: *;
```

For example, suppose that you have an external table named `lineitem_athena` defined in an Athena external catalog. In this case, you can define an external schema named `athena_schema`, then query the table using the following SELECT statement.

```
select count(*) from athena_schema.lineitem_athena;
```

To define an external table in Amazon Redshift, use the CREATE EXTERNAL TABLE command. The external table statement defines the table columns, the format of your data files, and the location of your data in Amazon S3. Redshift Spectrum scans the files in the specified folder and any subfolders. Redshift Spectrum ignores hidden files and files that begin with a period, underscore, or hash mark (. , _, or #) or end with a tilde (~).

The following example creates a table named SALES in the Amazon Redshift external schema named `spectrum`. The data is in tab-delimited text files.

```
create external table spectrum.sales(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
row format delimited
fields terminated by '\t'
stored as textfile
location 's3://redshift-downloads/tickit/spectrum/sales/'
table properties ('numRows'='172000');
```

To view external tables, query the SVV_EXTERNAL_TABLES system view.

Pseudocolumns

By default, Amazon Redshift creates external tables with the pseudocolumns `$path`, `$size`, and `$spectrum_oid`. Select the `$path` column to view the path to the data files on Amazon S3, and select the `$size` column to view the size of the data files for each row returned by a query. The `$spectrum_oid` column provides the ability to perform correlated queries with Redshift Spectrum. For an example, see Example: Performing correlated subqueries in Redshift Spectrum. You must delimit the `$path`, `$size`, and `$spectrum_oid` column names with double quotation marks. A SELECT * clause doesn't return the pseudocolumns. You must explicitly include the `$path`, `$size`, and `$spectrum_oid` column names in your query, as the following example shows.

```
select "$path", "$size", "$spectrum_oid"
from spectrum.sales_part where saledate = '2008-12-01';
```

You can disable the creation of pseudocolumns for a session by setting the `spectrum_enable_pseudo_columns` configuration parameter to `false`. For more information, see spectrum_enable_pseudo_columns. You can also disable only the `$spectrum_oid` pseudocolumn by setting the `enable_spectrum_oid` to `false`. For more information, see enable_spectrum_oid. However, disabling the `$spectrum_oid` pseudocolumn also disables support for correlated queries with Redshift Spectrum.

> **Important**
>
> Selecting `$size`, `$path`, or `$spectrum_oid` incurs charges because Redshift Spectrum scans the data files on Amazon S3 to determine the size of the result set. For more information, see Amazon Redshift Pricing.

Pseudocolumns example

The following example returns the total size of related data files for an external table.

```
select distinct "$path", "$size"
from spectrum.sales_part;

 $path                                                                 | $size
-----------------------------------------------------------------------+-------
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/ |  1616
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-02/ |  1444
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-03/ |  1644
```

Partitioning Redshift Spectrum external tables

When you partition your data, you can restrict the amount of data that Redshift Spectrum scans by filtering on the partition key. You can partition your data by any key.

A common practice is to partition the data based on time. For example, you might choose to partition by year, month, date, and hour. If you have data coming from multiple sources, you might partition by a data source identifier and date.

The following procedure describes how to partition your data.

To partition your data

1. Store your data in folders in Amazon S3 according to your partition key.

   Create one folder for each partition value and name the folder with the partition key and value. For example, if you partition by date, you might have folders named `saledate=2017-04-01`, `saledate=2017-04-02`, and so on. Redshift Spectrum scans the files in the partition folder and any subfolders. Redshift Spectrum ignores hidden files and files that begin with a period, underscore, or hash mark (. , _, or #) or end with a tilde (~).

2. Create an external table and specify the partition key in the PARTITIONED BY clause.

   The partition key can't be the name of a table column. The data type can be SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, or TIMESTAMP data type.

3. Add the partitions.

   Using ALTER TABLE … ADD PARTITION, add each partition, specifying the partition column and key value, and the location of the partition folder in Amazon S3. You can add multiple partitions in a single ALTER TABLE … ADD statement. The following example adds partitions for `'2008-01'` and `'2008-03'`.

```
alter table spectrum.sales_part add
partition(saledate='2008-01-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/
saledate=2008-01/'
partition(saledate='2008-03-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/
saledate=2008-03/';
```

   Note

   If you use the AWS Glue catalog, you can add up to 100 partitions using a single ALTER TABLE statement.

Partitioning data examples

In this example, you create an external table that is partitioned by a single partition key and an external table that is partitioned by two partition keys.

The sample data for this example is located in an Amazon S3 bucket that gives read access to all authenticated AWS users. Your cluster and your external data files must be in the same AWS Region. The sample data bucket is in the US East (N. Virginia) Region (us-east-1). To access the data using Redshift Spectrum, your cluster must also be in us-east-1. To list the folders in Amazon S3, run the following command.

```
aws s3 ls s3://redshift-downloads/tickit/spectrum/sales_partition/
```

```
PRE saledate=2008-01/
PRE saledate=2008-03/
PRE saledate=2008-04/
PRE saledate=2008-05/
PRE saledate=2008-06/
PRE saledate=2008-12/
```

If you don't already have an external schema, run the following command. Substitute the Amazon Resource Name (ARN) for your AWS Identity and Access Management (IAM) role.

```
create external schema spectrum
from data catalog
database 'spectrumdb'
iam_role 'arn:aws:iam::123456789012:role/myspectrumrole'
create external database if not exists;
```

Example 1: Partitioning with a single partition key

In the following example, you create an external table that is partitioned by month.

To create an external table partitioned by month, run the following command.

```
create external table spectrum.sales_part(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
partitioned by (saledate char(10))
row format delimited
fields terminated by '|'
stored as textfile
location 's3://redshift-downloads/tickit/spectrum/sales_partition/'
table properties ('numRows'='172000');
```

To add the partitions, run the following ALTER TABLE command.

```
alter table spectrum.sales_part add
partition(saledate='2008-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/'

partition(saledate='2008-03')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-03/'

partition(saledate='2008-04')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-04/';
```

To select data from the partitioned table, run the following query.

```
select top 5 spectrum.sales_part.eventid, sum(spectrum.sales_part.pricepaid)
from spectrum.sales_part, event
where spectrum.sales_part.eventid = event.eventid
  and spectrum.sales_part.pricepaid > 30
  and saledate = '2008-01'
group by spectrum.sales_part.eventid
order by 2 desc;
```

```
eventid | sum
--------+---------
   4124 | 21179.00
   1924 | 20569.00
   2294 | 18830.00
   2260 | 17669.00
   6032 | 17265.00
```

To view external table partitions, query the SVV_EXTERNAL_PARTITIONS system view.

```
select schemaname, tablename, values, location from svv_external_partitions
where tablename = 'sales_part';
```

```
schemaname | tablename  | values      | location

-----------+------------+-------------
+-------------------------------------------------------------------------
spectrum   | sales_part | ["2008-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-01
spectrum   | sales_part | ["2008-03"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-03
```

```
spectrum   | sales_part | ["2008-04"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-04
```

Example 2: Partitioning with a multiple partition key

To create an external table partitioned by `date` and `eventid`, run the following command.

```
create external table spectrum.sales_event(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
partitioned by (salesmonth char(10), event integer)
row format delimited
fields terminated by '|'
stored as textfile
location 's3://redshift-downloads/tickit/spectrum/salesevent/'
table properties ('numRows'='172000');
```

To add the partitions, run the following ALTER TABLE command.

```
alter table spectrum.sales_event add
partition(salesmonth='2008-01', event='101')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-01/
event=101/'

partition(salesmonth='2008-01', event='102')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-01/
event=102/'

partition(salesmonth='2008-01', event='103')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-01/
event=103/'

partition(salesmonth='2008-02', event='101')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-02/
event=101/'
```

```
partition(salesmonth='2008-02', event='102')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-02/
event=102/'

partition(salesmonth='2008-02', event='103')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-02/
event=103/'

partition(salesmonth='2008-03', event='101')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-03/
event=101/'

partition(salesmonth='2008-03', event='102')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-03/
event=102/'

partition(salesmonth='2008-03', event='103')
location 's3://redshift-downloads/tickit/spectrum/salesevent/salesmonth=2008-03/
event=103/';
```

Run the following query to select data from the partitioned table.

```
select spectrum.sales_event.salesmonth, event.eventname,
 sum(spectrum.sales_event.pricepaid)
from spectrum.sales_event, event
where spectrum.sales_event.eventid = event.eventid
  and salesmonth = '2008-02'
 and (event = '101'
 or event = '102'
 or event = '103')
group by event.eventname, spectrum.sales_event.salesmonth
order by 3 desc;
```

```
salesmonth | eventname       | sum
-----------+-----------------+--------
2008-02    | The Magic Flute | 5062.00
2008-02    | La Sonnambula   | 3498.00
2008-02    | Die Walkure     |  534.00
```

Mapping external table columns to ORC columns

You use Amazon Redshift Spectrum external tables to query data from files in ORC format. Optimized row columnar (ORC) format is a columnar storage file format that supports nested data structures. For more information about querying nested data, see Querying Nested Data with Amazon Redshift Spectrum.

When you create an external table that references data in an ORC file, you map each column in the external table to a column in the ORC data. To do so, you use one of the following methods:

- Mapping by position
- Mapping by column name

Mapping by column name is the default.

Mapping by position

With position mapping, the first column defined in the external table maps to the first column in the ORC data file, the second to the second, and so on. Mapping by position requires that the order of columns in the external table and in the ORC file match. If the order of the columns doesn't match, then you can map the columns by name.

> **Important**
>
> In earlier releases, Redshift Spectrum used position mapping by default. If you need to continue using position mapping for existing tables, set the table property `orc.schema.resolution` to `position`, as the following example shows.
>
> ```
> alter table spectrum.orc_example
> set table properties('orc.schema.resolution'='position');
> ```

For example, the table `SPECTRUM.ORC_EXAMPLE` is defined as follows.

```
create external table spectrum.orc_example(
int_col int,
float_col float,
nested_col struct<
```

```
  "int_col" : int,
  "map_col" : map<int, array<float >>
   >
) stored as orc
location 's3://example/orc/files/';
```

The table structure can be abstracted as follows.

```
• 'int_col' : int
• 'float_col' : float
• 'nested_col' : struct
   o 'int_col' : int
   o 'map_col' : map
      - key : int
      - value : array
         - value : float
```

The underlying ORC file has the following file structure.

```
• ORC file root(id = 0)
   o 'int_col' : int (id = 1)
   o 'float_col' : float (id = 2)
   o 'nested_col' : struct (id = 3)
      - 'int_col' : int (id = 4)
      - 'map_col' : map (id = 5)
         - key : int (id = 6)
         - value : array (id = 7)
            - value : float (id = 8)
```

In this example, you can map each column in the external table to a column in ORC file strictly by position. The following shows the mapping.

External table column name	ORC column ID	ORC column name
int_col	1	int_col
float_col	2	float_col
nested_col	3	nested_col
nested_col.int_col	4	int_col

External table column name	ORC column ID	ORC column name
nested_col.map_col	5	map_col
nested_col.map_col.key	6	NA
nested_col.map_col.value	7	NA
nested_col.map_col.value.item	8	NA

Mapping by column name

Using name mapping, you map columns in an external table to named columns in ORC files on the same level, with the same name.

For example, suppose that you want to map the table from the previous example, `SPECTRUM.ORC_EXAMPLE`, with an ORC file that uses the following file structure.

```
• ORC file root(id = 0)
   o 'nested_col' : struct (id = 1)
      - 'map_col' : map (id = 2)
         - key : int (id = 3)
         - value : array (id = 4)
            - value : float (id = 5)
      - 'int_col' : int (id = 6)
   o 'int_col' : int (id = 7)
   o 'float_col' : float (id = 8)
```

Using position mapping, Redshift Spectrum attempts the following mapping.

External table column name	ORC column ID	ORC column name
int_col	1	struct
float_col	7	int_col
nested_col	8	float_col

When you query a table with the preceding position mapping, the SELECT command fails on type validation because the structures are different.

You can map the same external table to both file structures shown in the previous examples by using column name mapping. The table columns `int_col`, `float_col`, and `nested_col` map by column name to columns with the same names in the ORC file. The column named `nested_col` in the external table is a `struct` column with subcolumns named `map_col` and `int_col`. The subcolumns also map correctly to the corresponding columns in the ORC file by column name.

Creating external tables for data managed in Apache Hudi

To query data in Apache Hudi Copy On Write (CoW) format, you can use Amazon Redshift Spectrum external tables. A Hudi Copy On Write table is a collection of Apache Parquet files stored in Amazon S3. You can read Copy On Write (CoW) tables in Apache Hudi versions 0.5.2, 0.6.0, 0.7.0, 0.8.0, 0.9.0, 0.10.0, 0.10.1, 0.11.0, and 0.11.1 that are created and modified with insert, delete, and upsert write operations. For example, bootstrap tables are not supported. For more information, see Copy On Write Table in the open source Apache Hudi documentation.

When you create an external table that references data in Hudi CoW format, you map each column in the external table to a column in the Hudi data. Mapping is done by column.

The data definition language (DDL) statements for partitioned and unpartitioned Hudi tables are similar to those for other Apache Parquet file formats. For Hudi tables, you define `INPUTFORMAT` as `org.apache.hudi.hadoop.HoodieParquetInputFormat`. The `LOCATION` parameter must point to the Hudi table base folder that contains the `.hoodie` folder, which is required to establish the Hudi commit timeline. In some cases, a SELECT operation on a Hudi table might fail with the message No valid Hudi commit timeline found. If so, check if the `.hoodie` folder is in the correct location and contains a valid Hudi commit timeline.

> **Note**
>
> Apache Hudi format is only supported when you use an AWS Glue Data Catalog. It's not supported when you use an Apache Hive metastore as the external catalog.

The DDL to define an unpartitioned table has the following format.

```
CREATE EXTERNAL TABLE tbl_name (columns)
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
```

```
STORED AS
INPUTFORMAT 'org.apache.hudi.hadoop.HoodieParquetInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
LOCATION 's3://s3-bucket/prefix'
```

The DDL to define a partitioned table has the following format.

```
CREATE EXTERNAL TABLE tbl_name (columns)
PARTITIONED BY(pcolumn1 pcolumn1-type[,...])
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS
INPUTFORMAT 'org.apache.hudi.hadoop.HoodieParquetInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
LOCATION 's3://s3-bucket/prefix'
```

To add partitions to a partitioned Hudi table, run an ALTER TABLE ADD PARTITION command where the `LOCATION` parameter points to the Amazon S3 subfolder with the files that belong to the partition.

The DDL to add partitions has the following format.

```
ALTER TABLE tbl_name
ADD IF NOT EXISTS PARTITION(pcolumn1=pvalue1[,...])
LOCATION 's3://s3-bucket/prefix/partition-path'
```

Creating external tables for data managed in Delta Lake

To query data in Delta Lake tables, you can use Amazon Redshift Spectrum external tables.

To access a Delta Lake table from Redshift Spectrum, generate a manifest before the query. A Delta Lake *manifest* contains a listing of files that make up a consistent snapshot of the Delta Lake table. In a partitioned table, there is one manifest per partition. A Delta Lake table is a collection of Apache Parquet files stored in Amazon S3. For more information, see Delta Lake in the open source Delta Lake documentation.

When you create an external table that references data in Delta Lake tables, you map each column in the external table to a column in the Delta Lake table. Mapping is done by column name.

The DDL for partitioned and unpartitioned Delta Lake tables is similar to that for other Apache Parquet file formats. For Delta Lake tables, you define `INPUTFORMAT` as org.apache.hadoop.hive.ql.io.SymlinkTextInputFormat and OUTPUTFORMAT as org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat. The LOCATION parameter must point to the manifest folder in the table base folder. If a SELECT operation on a Delta Lake table fails, for possible reasons see Limitations and troubleshooting for Delta Lake tables.

The DDL to define an unpartitioned table has the following format.

```
CREATE EXTERNAL TABLE tbl_name (columns)
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS
INPUTFORMAT 'org.apache.hadoop.hive.ql.io.SymlinkTextInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://s3-bucket/prefix/_symlink_format_manifest'
```

The DDL to define a partitioned table has the following format.

```
CREATE EXTERNAL TABLE tbl_name (columns)
PARTITIONED BY(pcolumn1 pcolumn1-type[,...])
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS
INPUTFORMAT 'org.apache.hadoop.hive.ql.io.SymlinkTextInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://s3-bucket>/prefix/_symlink_format_manifest'
```

To add partitions to a partitioned Delta Lake table, run an ALTER TABLE ADD PARTITION command where the LOCATION parameter points to the Amazon S3 subfolder that contains the manifest for the partition.

The DDL to add partitions has the following format.

```
ALTER TABLE tbl_name
ADD IF NOT EXISTS PARTITION(pcolumn1=pvalue1[,...])
LOCATION
's3://s3-bucket/prefix/_symlink_format_manifest/partition-path'
```

Or run DDL that points directly to the Delta Lake manifest file.

```
ALTER TABLE tbl_name
ADD IF NOT EXISTS PARTITION(pcolumn1=pvalue1[,...])
```

```
LOCATION
's3://s3-bucket/prefix/_symlink_format_manifest/partition-path/manifest'
```

Limitations and troubleshooting for Delta Lake tables

Consider the following when querying Delta Lake tables from Redshift Spectrum:

- If a manifest points to a snapshot or partition that no longer exists, queries fail until a new valid manifest has been generated. For example, this might result from a VACUUM operation on the underlying table,
- Delta Lake manifests only provide partition-level consistency.

The following table explains some potential reasons for certain errors when you query a Delta Lake table.

Error message	Possible reason
Delta Lake manifest in bucket *s3-bucket-1* cannot contain entries in bucket *s3-bucket-2*.	The manifest entries point to files in a different Amazon S3 bucket than the specified one.
Delta Lake files are expected to be in the same folder.	The manifest entries point to files that have a different Amazon S3 prefix than the specified one.
File *filename* listed in Delta Lake manifest *manifest-path* was not found.	A file listed in the manifest wasn't found in Amazon S3.
Error fetching Delta Lake manifest.	The manifest wasn't found in Amazon S3.
Invalid S3 Path.	An entry in the manifest file isn't a valid Amazon S3 path, or the manifest file has been corrupted.

Using Apache Iceberg tables with Amazon Redshift

> **Note**
>
> To achieve the best performance when using Apache Iceberg tables with Amazon Redshift, you must generate column statistics for the tables using AWS Glue. For more information, see Generating column statistics for Iceberg tables in the *AWS Glue Developer Guide*.

This topic describes how to use tables in Apache Iceberg format with Redshift Spectrum or Redshift Serverless. Apache Iceberg is a high-performance format for huge analytic tables.

You can use Redshift Spectrum or Redshift Serverless to query Apache Iceberg tables cataloged in the AWS Glue Data Catalog. Apache Iceberg is an open-source table format for data lakes. For more information, see Apache Iceberg in the Apache Iceberg documentation.

Amazon Redshift provides transactional consistency for querying Apache Iceberg tables. You can manipulate the data in your tables using ACID (atomicity, consistency, isolation, durability) compliant services such as Amazon Athena and Amazon EMR while running queries using Amazon Redshift. Amazon Redshift can use the table statistics stored in Apache Iceberg metadata to optimize query plans and reduce file scans during query processing. With Amazon Redshift SQL, you can join Redshift tables with data lake tables.

To get started using Iceberg tables with Amazon Redshift:

1. Create an Apache Iceberg table on an AWS Glue Data Catalog database using a compatible service such as Amazon Athena or Amazon EMR. To create an Iceberg table using Athena, see Using Apache Iceberg tables in the *Amazon Athena User Guide*.
2. Create an Amazon Redshift cluster or Redshift Serverless workgroup with an associated IAM role that allows access to your data lake. For information on how to create clusters or workgroups, see Get started with Amazon Redshift provisioned data warehouses and Get started with Redshift Serverless data warehouses in the *Amazon Redshift Getting Started Guide*.
3. Connect to your cluster or workgroup using query editor v2 or a third-party SQL client. For information about how to connect using query editor v2, see Connecting to an Amazon Redshift data warehouse using SQL client tools in the *Amazon Redshift Management Guide*.
4. Create an external schema in your Amazon Redshift database for a specific Data Catalog database that includes your Iceberg tables. For information about creating an external schema, see External schemas in Amazon Redshift Spectrum.

5. Run SQL queries to access the Iceberg tables in the external schema you created.

Considerations when using Apache Iceberg tables with Amazon Redshift

Consider the following when using Amazon Redshift with Iceberg tables:

- **Iceberg version support –** Amazon Redshift supports running queries against the following versions of Iceberg tables:
  - Version 1 defines how large analytic tables are managed using immutable data files.
  - Version 2 adds the ability to support row-level updates and deletes while keeping the existing data files unchanged, and handling table data changes using delete files.

  For the difference between version 1 and version 2 tables, see Format version changes in the Apache Iceberg documentation.
- **Queries only –** Amazon Redshift supports read-only access to Apache Iceberg tables. It supports transactional consistent select queries. You can use a service like Amazon Athena to define and update the schema of Iceberg tables in the AWS Glue Data Catalog.
- **Adding partitions –** You don't need to manually add partitions for your Apache Iceberg tables. New partitions in Apache Iceberg tables are automatically detected by Amazon Redshift and no manual operation is needed to update partitions in the table definition. Any changes in partition specification are also automatically applied to your queries without any user intervention.
- **Ingesting Iceberg data into Amazon Redshift –** You can use INSERT INTO or CREATE TABLE AS commands to import data from your Iceberg table into a local Amazon Redshift table. You currently cannot use the COPY command to ingest the contents of an Apache Iceberg table into a local Amazon Redshift table.
- **Materialized views –** You can create materialized views on Apache Iceberg tables like any other external table in Amazon Redshift. The same considerations for other data lake table formats apply to Apache Iceberg tables. Automatic refreshes, automatic query rewriting, and automatic MVs on data lake tables are currently not supported.
- **AWS Lake Formation fine-grained access control –** Amazon Redshift supports AWS Lake Formation fine-grained access control on Apache Iceberg tables.
- **User-defined data handling parameters –** Amazon Redshift supports user-defined data handling parameters on Apache Iceberg tables. You use user-defined data handling parameters on existing files to tailor the data being queried in external tables to avoid scan errors. These

parameters provide capabilities to handle mismatches between the table schema and the actual data on files. You can use user-defined data handling parameters on Apache Iceberg tables as well.

- **Time travel queries** – Time travel queries are currently not supported with Apache Iceberg tables.
- **Pricing** – When you access Iceberg tables from a cluster, you are charged Redshift Spectrum pricing. When you access Iceberg tables from a workgroup, you are charged Redshift Serverless pricing. For information about Redshift Spectrum and Redshift Serverless pricing, see Amazon Redshift pricing.

Supported data types with Apache Iceberg tables

This topic describes the supported data types that Redshift Spectrum can read from tables in Apache Iceberg format.

Amazon Redshift can query Iceberg tables that contain the following data types:

```
binary
boolean
date
decimal
double
float
int
list
long
map
string
struct
timestamp without time zone
```

For more information about Iceberg data types, see the Schemas for Iceberg in the Apache Iceberg documentation.

The following table shows the relationship between Amazon Redshift data types and Iceberg table data types.

Iceberg type	Amazon Redshift type	Notes
boolean	boolean	
-	tinyint	Not supported for Iceberg tables in Amazon Redshift.
-	smallint	Not supported for Iceberg tables in Amazon Redshift.
int	int	In Amazon Redshift SQL statements, this type is INTEGER.
long	bigint	
double	double precision	
float	real	
decimal(P , S)	decimal(P , S)	P is precision, S is scale.
-	char	Not supported for Iceberg tables in Redshift Spectrum.
string	string	In Amazon Redshift SQL statements, this type is VARCHAR.
binary	binary	
date	date	
time	-	
timestamp	timestamp	
timestamp tz	-	
list<E>	array	

Iceberg type	Amazon Redshift type	Notes
`map<K,V>`	`map`	
`struct<...>`	`struct`	
`fixed(L)`	`-`	The `fixed(L)` type is not currently supported in Redshift Spectrum.

For more information about data types in Amazon Redshift, see Data types.

Amazon Redshift Spectrum query performance

This topic describes how to improve Redshift Spectrum query performance.

Look at the query plan to find what steps have been pushed to the Amazon Redshift Spectrum layer.

The following steps are related to the Redshift Spectrum query:

- S3 Seq Scan
- S3 HashAggregate
- S3 Query Scan
- Seq Scan PartitionInfo
- Partition Loop

The following example shows the query plan for a query that joins an external table with a local table. Note the S3 Seq Scan and S3 HashAggregate steps that were run against the data on Amazon S3.

```
explain
select top 10 spectrum.sales.eventid, sum(spectrum.sales.pricepaid)
from spectrum.sales, event
```

```
where spectrum.sales.eventid = event.eventid
and spectrum.sales.pricepaid > 30
group by spectrum.sales.eventid
order by 2 desc;
```

```
QUERY PLAN


-----------------------------------------------------------------------------
XN Limit  (cost=1001055770628.63..1001055770628.65 rows=10 width=31)


  ->  XN Merge  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)


        Merge Key: sum(sales.derived_col2)


        ->  XN Network  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)


              Send to leader


              ->  XN Sort  (cost=1001055770628.63..1001055770629.13 rows=200 width=31)


                    Sort Key: sum(sales.derived_col2)


                    ->  XN HashAggregate  (cost=1055770620.49..1055770620.99 rows=200
 width=31)

                          ->  XN Hash Join DS_BCAST_INNER  (cost=3119.97..1055769620.49
 rows=200000 width=31)

                                Hash Cond: ("outer".derived_col1 = "inner".eventid)


                                ->  XN S3 Query Scan sales  (cost=3010.00..5010.50
 rows=200000 width=31)
```

```
                                              ->  S3 HashAggregate  (cost=3010.00..3010.50
rows=200000 width=16)

                                                    ->  S3 Seq Scan spectrum.sales
location:"s3://redshift-downloads/tickit/spectrum/sales" format:TEXT
(cost=0.00..2150.00 rows=172000 width=16)
                                                          Filter: (pricepaid > 30.00)


                                        ->  XN Hash  (cost=87.98..87.98 rows=8798 width=4)


                                              ->  XN Seq Scan on event  (cost=0.00..87.98
rows=8798 width=4)
```

Note the following elements in the query plan:

- The `S3 Seq Scan` node shows the filter `pricepaid > 30.00` was processed in the Redshift Spectrum layer.

  A filter node under the `XN S3 Query Scan` node indicates predicate processing in Amazon Redshift on top of the data returned from the Redshift Spectrum layer.
- The `S3 HashAggregate` node indicates aggregation in the Redshift Spectrum layer for the group by clause (`group by spectrum.sales.eventid`).

Following are ways to improve Redshift Spectrum performance:

- Use Apache Parquet formatted data files. Parquet stores data in a columnar format, so Redshift Spectrum can eliminate unneeded columns from the scan. When data is in text-file format, Redshift Spectrum needs to scan the entire file.
- Use multiple files to optimize for parallel processing. Keep your file sizes larger than 64 MB. Avoid data size skew by keeping files about the same size. For information about Apache Parquet files and configuration recommendations, see File Format: Configurations in the *Apache Parquet Documentation*.
- Use the fewest columns possible in your queries.
- Put your large fact tables in Amazon S3 and keep your frequently used, smaller dimension tables in your local Amazon Redshift database.

- Update external table statistics by setting the TABLE PROPERTIES numRows parameter. Use CREATE EXTERNAL TABLE or ALTER TABLE to set the TABLE PROPERTIES numRows parameter to reflect the number of rows in the table. Amazon Redshift doesn't analyze external tables to generate the table statistics that the query optimizer uses to generate a query plan. If table statistics aren't set for an external table, Amazon Redshift generates a query execution plan. Amazon Redshift generates this plan based on the assumption that external tables are the larger tables and local tables are the smaller tables.
- The Amazon Redshift query planner pushes predicates and aggregations to the Redshift Spectrum query layer whenever possible. When large amounts of data are returned from Amazon S3, the processing is limited by your cluster's resources. Redshift Spectrum scales automatically to process large requests. Thus, your overall performance improves whenever you can push processing to the Redshift Spectrum layer.
- Write your queries to use filters and aggregations that are eligible to be pushed to the Redshift Spectrum layer.

  The following are examples of some operations that can be pushed to the Redshift Spectrum layer:

  - GROUP BY clauses
  - Comparison conditions and pattern-matching conditions, such as LIKE.
  - Aggregate functions, such as COUNT, SUM, AVG, MIN, and MAX.
  - String functions.

  Operations that can't be pushed to the Redshift Spectrum layer include DISTINCT and ORDER BY.
- Use partitions to limit the data that is scanned. Partition your data based on your most common query predicates, then prune partitions by filtering on partition columns. For more information, see Partitioning Redshift Spectrum external tables.

  Query SVL_S3PARTITION to view total partitions and qualified partitions.
- Use AWS Glue's statistics generator to compute column-level statistics for AWS Glue Data Catalog tables. Once AWS Glue generates statistics for tables in the Data Catalog, Amazon Redshift Spectrum automatically uses those statistics to optimize the query plan. For more information about computing column-level statistics using AWS Glue, see Working with column statistics in the *AWS Glue Developer Guide*.

Data handling options

This topic describes how to configure how Redshift Spectrum handles data in unexpected formats.

You can set table parameters when you create external tables to tailor the data being queried in external tables. Otherwise, scan errors can occur. For more information, see TABLE PROPERTIES in CREATE EXTERNAL TABLE. For examples, see Data handling examples. For a list of errors, see SVL_SPECTRUM_SCAN_ERROR.

You can set the following TABLE PROPERTIES when you create external tables to specify input handling for data being queried in external tables.

- `column_count_mismatch_handling` to identify if the file contains less or more values for a row than the number of columns specified in the external table definition.
- `invalid_char_handling` to specify input handling for invalid characters in columns containing VARCHAR, CHAR, and string data. When you specify REPLACE for `invalid_char_handling`, you can specify the replacement character to use.
- `numeric_overflow_handling` to specify cast overflow handling in columns containing integer and decimal data.
- `surplus_bytes_handling` to specify input handling for surplus bytes in columns containing VARBYTE data.
- `surplus_char_handling` to specify input handling for surplus characters in columns containing VARCHAR, CHAR, and string data.

You can set a configuration option to cancel queries that exceed a maximum number of errors. For more information, see spectrum_query_maxerror.

Example: Performing correlated subqueries in Redshift Spectrum

This topic describes how to perform correlated subqueries in Redshift Spectrum. A correlated subquery is a query that uses values from the outer query.

You can perform correlated subqueries in Redshift Spectrum. The `$spectrum_oid` pseudocolumn provides the ability to perform correlated queries with Redshift Spectrum. To perform a correlated subquery, the pseudocolumn `$spectrum_oid` must be enabled but doesn't appear in the SQL statement. For more information, see Pseudocolumns.

To create the external schema and external tables for this example, see Getting started with Amazon Redshift Spectrum.

Following is an example of a correlated subquery in Redshift Spectrum.

```
select *
from myspectrum_schema.sales s
where exists
( select *
from myspectrum_schema.listing l
where l.listid = s.listid )
order by salesid
limit 5;
```

```

salesid  listid   sellerid   buyerid   eventid   dateid  qtysold  pricepaid
 commission   saletime
1        1        36861      21191     7872      1875    4        728          109.2
    2008-02-18 02:36:48
2        4        8117       11498     4337      1983    2        76           11.4
    2008-06-06 05:00:16
3        5        1616       17433     8647      1983    2        350          52.5
    2008-06-06 08:26:17
4        5        1616       19715     8647      1986    1        175          26.25
    2008-06-09 08:38:52
5        6        47402      14115     8240      2069    2        154          23.1
    2008-08-31 09:17:02
```

Metrics in Amazon Redshift Spectrum

This topic describes system views that you can use to monitor Redshift Spectrum queries.

You can monitor Amazon Redshift Spectrum queries using the following system views:

- SVL_S3QUERY

  Use the SVL_S3QUERY view to get details about Redshift Spectrum queries (S3 queries) at the segment and node slice level.

- SVL_S3QUERY_SUMMARY

  Use the SVL_S3QUERY_SUMMARY view to get a summary of all Amazon Redshift Spectrum queries (S3 queries) that have been run on the system.

The following are some things to look for in SVL_S3QUERY_SUMMARY:

- The number of files that were processed by the Redshift Spectrum query.
- The number of bytes scanned from Amazon S3. The cost of a Redshift Spectrum query is reflected in the amount of data scanned from Amazon S3.
- The number of bytes returned from the Redshift Spectrum layer to the cluster. A large amount of data returned might affect system performance.
- The maximum duration and average duration of Redshift Spectrum requests. Long-running requests might indicate a bottleneck.

Query troubleshooting in Amazon Redshift Spectrum

This topic is a reference for common issues you might encounter with Amazon Redshift Spectrum queries.

To view errors generated by Redshift Spectrum queries, query the SVL_S3LOG system table.

Topics

- Required field missing from external partition information

Retries exceeded

If an Amazon Redshift Spectrum request times out, the request is canceled and resubmitted. After five failed retries, the query fails with the following error.

```
error:  Spectrum Scan Error: Retries exceeded
```

Possible causes include the following:

- Large file sizes (greater than 1 GB). Check your file sizes in Amazon S3 and look for large files and file size skew. Break up large files into smaller files, between 100 MB and 1 GB. Try to make files about the same size.
- Slow network throughput. Try your query later.

Access throttled

Amazon Redshift Spectrum is subject to the service quotas of other AWS services. Under high usage, Redshift Spectrum requests might be required to slow down, resulting in the following error.

```
error:  Spectrum Scan Error: Access throttled
```

Two types of throttling can happen:

- Access throttled by Amazon S3.
- Access throttled by AWS KMS.

The error context provides more details about the type of throttling. Following, you can find causes and possible resolutions for this throttling.

Access throttled by Amazon S3

Amazon S3 might throttle a Redshift Spectrum request if the read request rate on a prefix is too high. For information about a GET/HEAD request rate that you can achieve in Amazon S3, see Optimizing Amazon S3 Performance in *Amazon Simple Storage Service User Guide.* The Amazon

S3 GET/HEAD request rate takes into account all GET/HEAD requests on a prefix so different applications accessing the same prefix share the total requests rate.

If your Redshift Spectrum requests frequently get throttled by Amazon S3, reduce the number of Amazon S3 GET/HEAD requests that Redshift Spectrum makes to Amazon S3. To do this, try merging small files into larger files. We recommend using file sizes of 64 MB or larger.

Also consider partitioning your Redshift Spectrum tables to benefit from early filtering and to reduce the number of files accessed in Amazon S3. For more information, see Partitioning Redshift Spectrum external tables.

Access throttled by AWS KMS

If you store your data in Amazon S3 using server-side encryption (SSE-S3 or SSE-KMS), Amazon S3 calls an API operation to AWS KMS for each file that Redshift Spectrum accesses. These requests count toward your cryptographic operations quota; for more information, see AWS KMS Request Quotas. For more information on SSE-S3 and SSE-KMS, see Protecting Data Using Server-Side Encryption and Protecting Data Using Server-Side Encryption with KMS keys Stored in AWS KMS in *Amazon Simple Storage Service User Guide.*

A first step to reduce the number of requests that Redshift Spectrum makes to AWS KMS is to reduce the number of files accessed. To do this, try merging small files into larger files. We recommend using file sizes of 64 MB or larger.

If your Redshift Spectrum requests frequently get throttled by AWS KMS, consider requesting a quota increase for your AWS KMS request rate for cryptographic operations. To request a quota increase, see AWS Service Limits in the *Amazon Web Services General Reference*.

Resource limit exceeded

Redshift Spectrum enforces an upper bound on the amount of memory a request can use. A Redshift Spectrum request that requires more memory fails, resulting in the following error.

```
error:  Spectrum Scan Error: Resource limit exceeded
```

There are two common reasons that can cause a Redshift Spectrum request to overrun its memory allowance:

- Redshift Spectrum processes a large chunk of data that can't be split in smaller chunks.
- A large aggregation step is processed by Redshift Spectrum.

We recommend using a file format that supports parallel reads with split sizes of 128 MB or less. See Data files for queries in Amazon Redshift Spectrum for supported file formats and generic guidelines for data file creation. When using file formats or compression algorithms that don't support parallel reads, we recommend keeping file sizes between 64 MB and 128 MB.

No rows returned for a partitioned table

If your query returns zero rows from a partitioned external table, check whether a partition has been added for this external table. Redshift Spectrum only scans files in an Amazon S3 location that has been explicitly added using `ALTER TABLE … ADD PARTITION`. Query the SVV_EXTERNAL_PARTITIONS view to find existing partitions. Run `ALTER TABLE … ADD PARTITION` for each missing partition.

Not authorized error

Verify that the IAM role for the cluster allows access to the Amazon S3 file objects. If your external database is on Amazon Athena, verify that the IAM role allows access to Athena resources. For more information, see IAM policies for Amazon Redshift Spectrum.

Incompatible data formats

For a columnar file format, such as Apache Parquet, the column type is embedded with the data. The column type in the CREATE EXTERNAL TABLE definition must match the column type of the data file. If there is a mismatch, you receive an error similar to the following:

```
File 'https://s3bucket/location/file has an incompatible Parquet schema
for column ‘s3://s3bucket/location.col1'. Column type: VARCHAR, Par
```

The error message might be truncated due to the limit on message length. To retrieve the complete error message, including column name and column type, query the SVL_S3LOG system view.

The following example queries SVL_S3LOG for the last query completed.

```
select message
from svl_s3log
where query = pg_last_query_id()
order by query,segment,slice;
```

The following is an example of a result that shows the full error message.

```
                              message
----------------------------------------------------------------------------------------------
Spectrum Scan Error. File 'https://s3bucket/location/file has an incompatible
Parquet schema for column ' s3bucket/location.col1'.
Column type: VARCHAR, Parquet schema:\noptional int64 l_orderkey [i:0 d:1 r:0]\n
```

To correct the error, alter the external table to match the column type of the Parquet file.

Syntax error when using Hive DDL in Amazon Redshift

Amazon Redshift supports data definition language (DDL) for CREATE EXTERNAL TABLE that is similar to Hive DDL. However, the two types of DDL aren't always exactly the same. If you copy Hive DDL to create or alter Amazon Redshift external tables, you might encounter syntax errors. The following are examples of differences between Amazon Redshift and Hive DDL:

- Amazon Redshift requires single quotation marks (') where Hive DDL supports double quotation marks (").
- Amazon Redshift doesn't support the STRING data type. Use VARCHAR instead.

Permission to create temporary tables

To run Redshift Spectrum queries, the database user must have permission to create temporary tables in the database. The following example grants temporary permission on the database `spectrumdb` to the `spectrumusers` user group.

```
grant temp on database spectrumdb  to group spectrumusers;
```

For more information, see GRANT.

Invalid range

Redshift Spectrum expects that files in Amazon S3 that belong to an external table are not overwritten during a query. If this happens, it can result in the following error.

```
Error: HTTP response error code: 416 Message: InvalidRange The requested range is not
 satisfiable
```

To avoid the error, make sure Amazon S3 files are not overwritten while they are queried with Redshift Spectrum.

Invalid Parquet version number

Redshift Spectrum checks the metadata of each Apache Parquet file it accesses. If the check fails, it can result in an error similar to the following:

```
File 'https://s3.region.amazonaws.com/s3bucket/location/file has an invalid version
 number
```

There are two common reasons that can cause the check to fail:

- The Parquet file has been overwritten during the query (see Invalid range).
- The Parquet file is corrupt.

Required field missing from external partition information

When you try to add a partition to an external table in an external catalog, you might get the following error:

```
Error: The required field (<field_name>) is missing from the external partition
 information. Add missing field in partition and retry. Partition location:
 <partition_path>
```

This error means that one of the partitions in the external table that was used in your query has missing partition metadata information. This can happen in the following cases:

- You added a partition to an external table in an external catalog, such as the AWS Glue Data Catalog, with partial information.
- You queried a partitioned table in Amazon Redshift while adding or updating partitions for the corresponding table in an external catalog, such as the AWS Glue Data Catalog.

Following are the fields that must be filled when retrieving a partition from the AWS Glue Data Catalog:

- StorageDescriptor
  - InputFormat

  - OutputFormat
  - SerDeInfo
- Values

You can query SVV_EXTERNAL_PARTITIONS to find existing partitions and see details on their fields.

For a full list of AWS Glue Data Catalog partition fields, see Partition in the *AWS Glue Web API Reference*.

Tutorial: Querying nested data with Amazon Redshift Spectrum

This tutorial demonstrates how to query nested data with Redshift Spectrum. Nested data is data that contains nested fields. Nested fields are fields that are joined together as a single entity, such as arrays, structs, or objects.

Topics

Overview

Amazon Redshift Spectrum supports querying nested data in Parquet, ORC, JSON, and Ion file formats. Redshift Spectrum accesses the data using external tables. You can create external tables that use the complex data types `struct`, `array`, and `map`.

For example, suppose that your data file contains the following data in Amazon S3 in a folder named `customers`. Although there isn't a single root element, each JSON object in this sample data represents a row in a table.

```
{"id": 1,
```

```
 "name": {"given": "John", "family": "Smith"},
 "phones": ["123-457789"],
 "orders": [{"shipdate": "2018-03-01T11:59:59.000Z", "price": 100.50},
            {"shipdate": "2018-03-01T09:10:00.000Z", "price": 99.12}]
}
{"id": 2,
 "name": {"given": "Jenny", "family": "Doe"},
 "phones": ["858-8675309", "415-9876543"],
 "orders": []
}
{"id": 3,
 "name": {"given": "Andy", "family": "Jones"},
 "phones": [],
 "orders": [{"shipdate": "2018-03-02T08:02:15.000Z", "price": 13.50}]
}
```

You can use Amazon Redshift Spectrum to query nested data in files. The following tutorial shows you how to do so with Apache Parquet data.

Prerequisites

If you are not using Redshift Spectrum yet, follow the steps in the Getting started with Amazon Redshift Spectrum before continuing.

To create an external schema, replace the IAM role ARN in the following command with the role ARN you created in Create an IAM role. Then run the command in your SQL client.

```
create external schema spectrum
from data catalog
database 'myspectrum_db'
iam_role 'arn:aws:iam::123456789012:role/myspectrum_role'
create external database if not exists;
```

Step 1: Create an external table that contains nested data

You can view the source data by downloading it from Amazon S3.

To create the external table for this tutorial, run the following command.

```
CREATE EXTERNAL TABLE spectrum.customers (
  id     int,
  name   struct<given:varchar(20), family:varchar(20)>,
```

```
  phones array<varchar(20)>,
  orders array<struct<shipdate:timestamp, price:double precision>>
)
STORED AS PARQUET
LOCATION 's3://redshift-downloads/tickit/spectrum/customers/';
```

In the example preceding, the external table `spectrum.customers` uses the `struct` and `array` data types to define columns with nested data. Amazon Redshift Spectrum supports querying nested data in Parquet, ORC, JSON, and Ion file formats. The `STORED AS` parameter is `PARQUET` for Apache Parquet files. The `LOCATION` parameter has to refer to the Amazon S3 folder that contains the nested data or files. For more information, see CREATE EXTERNAL TABLE.

You can nest `array` and `struct` types at any level. For example, you can define a column named `toparray` as shown in the following example.

```
toparray array<struct<nestedarray:
         array<struct<morenestedarray:
         array<string>>>>>
```

You can also nest `struct` types as shown for column `x` in the following example.

```
x struct<a: string,
         b: struct<c: integer,
                   d: struct<e: string>
                  >
        >
```

Step 2: Query your nested data in Amazon S3 with SQL extensions

Redshift Spectrum supports querying `array`, `map`, and `struct` complex types through extensions to the Amazon Redshift SQL syntax.

Extension 1: Access to columns of structs

You can extract data from `struct` columns using a dot notation that concatenates field names into paths. For example, the following query returns given and family names for customers. The given name is accessed by the long path `c.name.given`. The family name is accessed by the long path `c.name.family`.

```
SELECT c.id, c.name.given, c.name.family
```

```
FROM   spectrum.customers c;
```

The preceding query returns the following data.

```
id | given | family
---|-------|-------
1  | John  | Smith
2  | Jenny | Doe
3  | Andy  | Jones
(3 rows)
```

A `struct` can be a column of another `struct`, which can be a column of another `struct`, at any level. The paths that access columns in such deeply nested `structs` can be arbitrarily long. For example, see the definition for the column `x` in the following example.

```
x struct<a: string,
         b: struct<c: integer,
                      d: struct<e: string>
                  >
        >
```

You can access the data in `e` as `x.b.d.e`.

Extension 2: Ranging over arrays in a FROM clause

You can extract data from `array` columns (and, by extension, `map` columns) by specifying the `array` columns in a `FROM` clause in place of table names. The extension applies to the `FROM` clause of the main query, and also the `FROM` clauses of subqueries.

You can reference `array` elements by position, such as `c.orders[0]`. (preview)

By combining ranging over `arrays` with joins, you can achieve various kinds of unnesting, as explained in the following use cases.

Unnesting using inner joins

The following query selects customer IDs and order ship dates for customers that have orders. The SQL extension in the FROM clause `c.orders o` depends on the alias `c`.

```
SELECT c.id, o.shipdate
FROM   spectrum.customers c, c.orders o
```

For each customer c that has orders, the FROM clause returns one row for each order o of the customer c. That row combines the customer row c and the order row o. Then the SELECT clause keeps only the `c.id` and `o.shipdate`. The result is the following.

```
id|      shipdate
--|----------------------
1 |2018-03-01  11:59:59
1 |2018-03-01  09:10:00
3 |2018-03-02  08:02:15
(3 rows)
```

The alias c provides access to the customer fields, and the alias o provides access to the order fields.

The semantics are similar to standard SQL. You can think of the FROM clause as running the following nested loop, which is followed by SELECT choosing the fields to output.

```
for each customer c in spectrum.customers
  for each order o in c.orders
     output c.id and o.shipdate
```

Therefore, if a customer doesn't have an order, the customer doesn't appear in the result.

You can also think of this as the FROM clause performing a JOIN with the `customers` table and the `orders` array. In fact, you can also write the query as shown in the following example.

```
SELECT c.id, o.shipdate
FROM   spectrum.customers c INNER JOIN c.orders o ON true
```

> **Note**
>
> If a schema named c exists with a table named `orders`, then `c.orders` refers to the table `orders`, and not the array column of `customers`.

Unnesting using left joins

The following query outputs all customer names and their orders. If a customer hasn't placed an order, the customer's name is still returned. However, in this case, the order columns are NULL, as shown in the following example for Jenny Doe.

```
SELECT c.id, c.name.given, c.name.family, o.shipdate, o.price
FROM   spectrum.customers c LEFT JOIN c.orders o ON true
```

The preceding query returns the following data.

```
id  |  given   | family  |    shipdate          | price
----|---------|---------|----------------------|--------
 1  |  John    | Smith   | 2018-03-01  11:59:59 | 100.5
 1  |  John    | Smith   | 2018-03-01  09:10:00 |  99.12
 2  |  Jenny   | Doe     |                      |
 3  |  Andy    | Jones   | 2018-03-02  08:02:15 |  13.5
 (4 rows)
```

Extension 3: Accessing an array of scalars directly using an alias

When an alias p in a `FROM` clause ranges over an array of scalars, the query refers to the values of p as p. For example, the following query produces pairs of customer names and phone numbers.

```
SELECT c.name.given, c.name.family, p AS phone
FROM   spectrum.customers c LEFT JOIN c.phones p ON true
```

The preceding query returns the following data.

```
given  |  family  |  phone
-------|----------|-----------
John   | Smith    | 123-4577891
Jenny  | Doe      | 858-8675309
Jenny  | Doe      | 415-9876543
Andy   | Jones    |
(4 rows)
```

Extension 4: Accessing elements of maps

Redshift Spectrum treats the `map` data type as an `array` type that contains `struct` types with a `key` column and a `value` column. The `key` must be a `scalar`; the value can be any data type.

For example, the following code creates an external table with a `map` for storing phone numbers.

```
CREATE EXTERNAL TABLE spectrum.customers2 (
  id     int,
  name   struct<given:varchar(20), family:varchar(20)>,
```

```
  phones map<varchar(20), varchar(20)>,
  orders array<struct<shipdate:timestamp, price:double precision>>
)
STORED AS PARQUET
LOCATION 's3://redshift-downloads/tickit/spectrum/customers/';
```

Because a `map` type behaves like an `array` type with columns `key` and `value`, you can think of the preceding schemas as if they were the following.

```
CREATE EXTERNAL TABLE spectrum.customers3 (
  id     int,
  name   struct<given:varchar(20), family:varchar(20)>,
  phones array<struct<key:varchar(20), value:varchar(20)>>,
  orders array<struct<shipdate:timestamp, price:double precision>>
)
STORED AS PARQUET
LOCATION 's3://redshift-downloads/tickit/spectrum/customers/';
```

The following query returns the names of customers with a mobile phone number and returns the number for each name. The map query is treated as the equivalent of querying a nested `array` of `struct` types. The following query only returns data if you have created the external table as described previously.

```
SELECT c.name.given, c.name.family, p.value
FROM   spectrum.customers c, c.phones p
WHERE  p.key = 'mobile';
```

Note

The `key` for a `map` is a `string` for Ion and JSON file types.

Nested data use cases

This topic describes use cases for nested data. Nested data is data that contains nested fields. Nested fields are fields that are joined together as a single entity, such as arrays, structs, or objects.

You can combine the extensions described previously with the usual SQL features. The following use cases illustrate some common combinations. These examples help demonstrate how you can use nested data. They aren't part of the tutorial.

Topics

Ingesting nested data

You can use a `CREATE TABLE AS` statement to ingest data from an external table that contains complex data types. The following query extracts all customers and their phone numbers from the external table, using `LEFT JOIN`, and stores them in the Amazon Redshift table `CustomerPhones`.

```
CREATE TABLE CustomerPhones AS
SELECT  c.name.given, c.name.family, p AS phone
FROM    spectrum.customers c LEFT JOIN c.phones p ON true;
```

Aggregating nested data with subqueries

You can use a subquery to aggregate nested data. The following example illustrates this approach.

```
SELECT c.name.given, c.name.family, (SELECT COUNT(*) FROM c.orders o) AS ordercount
FROM   spectrum.customers c;
```

The following data is returned.

```
given   |  family  |  ordercount
--------|----------|--------------
 Jenny  |  Doe     |       0
 John   |  Smith   |       2
 Andy   |  Jones   |       1
 (3 rows)
```

> **Note**
>
> When you aggregate nested data by grouping by the parent row, the most efficient way is the one shown in the previous example. In that example, the nested rows of `c.orders` are grouped by their parent row `c`. Alternatively, if you know that `id` is unique for each

customer and o.shipdate is never null, you can aggregate as shown in the following example. However, this approach generally isn't as efficient as the previous example.

```
SELECT    c.name.given, c.name.family, COUNT(o.shipdate) AS ordercount
FROM      spectrum.customers c LEFT JOIN c.orders o ON true
GROUP BY  c.id, c.name.given, c.name.family;
```

You can also write the query by using a subquery in the FROM clause that refers to an alias (c) of the ancestor query and extracts array data. The following example demonstrates this approach.

```
SELECT c.name.given, c.name.family, s.count AS ordercount
FROM   spectrum.customers c, (SELECT count(*) AS count FROM c.orders o) s;
```

Joining Amazon Redshift and nested data

You can also join Amazon Redshift data with nested data in an external table. For example, suppose that you have the following nested data in Amazon S3.

```
CREATE EXTERNAL TABLE spectrum.customers2 (
  id      int,
  name    struct<given:varchar(20), family:varchar(20)>,
  phones  array<varchar(20)>,
  orders  array<struct<shipdate:timestamp, item:int>>
);
```

Suppose also that you have the following table in Amazon Redshift.

```
CREATE TABLE prices (
  id int,
  price double precision
);
```

The following query finds the total number and amount of each customer's purchases based on the preceding. The following example is only an illustration. It only returns data if you have created the tables described previously.

```
SELECT   c.name.given, c.name.family, COUNT(o.date) AS ordercount, SUM(p.price) AS
 ordersum
FROM     spectrum.customers2 c, c.orders o, prices p ON o.item = p.id
```

```
GROUP BY c.id, c.name.given, c.name.family;
```

Nested data limitations (preview)

This topic describes limitations for reading nested data with Redshift Spectrum. Nested data is data that contains nested fields. Nested fields are fields that are joined together as a single entity, such as arrays, structs, or objects.

> **Note**
>
> The limitations marked (preview) in the following list only apply to preview clusters created in the following Regions.
>
> - US East (Ohio) (us-east-2)
> - US East (N. Virginia) (us-east-1)
> - US West (N. California) (us-west-1)
> - Asia Pacific (Tokyo) (ap-northeast-1)
> - Europe (Ireland) (eu-west-1)
> - Europe (Stockholm) (eu-north-1)
>
> For information about setting up Preview clusters, see Creating a preview cluster in the *Amazon Redshift Management Guide*.

The following limitations apply to nested data:

- An `array` or `map` type can contain other `array` or `map` types as long as queries on the nested `arrays` or `maps` don't return `scalar` values. (preview)
- Amazon Redshift Spectrum supports complex data types only as external tables.
- Subquery result columns must be top-level. (preview)
- If an `OUTER JOIN` expression refers to a nested table, it can refer only to that table and its nested arrays (and maps). If an `OUTER JOIN` expression doesn't refer to a nested table, it can refer to any number of non-nested tables.
- If a `FROM` clause in a subquery refers to a nested table, it can't refer to any other table.
- If a subquery depends on a nested table that refers to a parent table, the subquery can only use the parent table in the `FROM` clause. You can't use the parent in any other clauses, such as a

SELECT or WHERE clause. For example, the following query doesn't run because the subquery's SELECT clause refers to the parent table c.

```
SELECT c.name.given
FROM   spectrum.customers c
WHERE (SELECT COUNT(c.id) FROM c.phones p WHERE p LIKE '858%') > 1;
```

The following query works because the parent c is used only in the FROM clause of the subquery.

```
SELECT c.name.given
FROM   spectrum.customers c
WHERE (SELECT COUNT(*) FROM c.phones p WHERE p LIKE '858%') > 1;
```

- A subquery that accesses nested data anywhere other than the FROM clause must return a single value. The only exceptions are (NOT) EXISTS operators in a WHERE clause.
- (NOT) IN is not supported.
- The maximum nesting depth for all nested types is 100. This restriction applies to all file formats (Parquet, ORC, Ion, and JSON).
- Aggregation subqueries that access nested data can only refer to arrays and maps in their FROM clause, not to an external table.
- Querying the pseudocolumns of nested data in a Redshift Spectrum table is not supported. For more information, see Pseudocolumns.
- When extracting data from array or map columns by specifying them in a FROM clause, you can only select values from those columns if the values are scalar. For example, the following queries both try to SELECT elements from inside an array. The query that selects arr.a works because arr.a is a scalar value. The second query doesn't work because array is an array extracted from s3.nested table in the FROM clause. (preview)

```
SELECT array_column FROM s3.nested_table;

array_column
-----------------
[{"a":1},{"b":2}]

SELECT arr.a FROM s3.nested_table t, t.array_column arr;

arr.a
-----
```

```
1

--This query fails to run.
SELECT array FROM s3.nested_table tab, tab.array_column array;
```

You can't use an array or map in the FROM clause that itself comes from another array or map. To select arrays or other complex structures that are nested inside other arrays, consider using indexes in the SELECT statement.

Serializing complex nested JSON

This topic demonstrates how to serialize nested data in JSON format. Nested data is data that contains nested fields. Nested fields are fields that are joined together as a single entity, such as arrays, structs, or objects.

An alternate to methods demonstrated in this tutorial is to query top-level nested collection columns as serialized JSON. You can use the serialization to inspect, convert, and ingest nested data as JSON with Redshift Spectrum. This method is supported for ORC, JSON, Ion, and Parquet formats. Use the session configuration parameter `json_serialization_enable` to configure the serialization behavior. When set, complex JSON data types are serialized to VARCHAR(65535). The nested JSON can be accessed with JSON functions. For more information, see json_serialization_enable.

For example, without setting `json_serialization_enable`, the following queries that access nested columns directly fail.

```
SELECT * FROM spectrum.customers LIMIT 1;

=> ERROR:  Nested tables do not support '*' in the SELECT clause.

SELECT name FROM spectrum.customers LIMIT 1;

=> ERROR:  column "name" does not exist in customers
```

Setting `json_serialization_enable` enables querying top-level collections directly.

```
SET json_serialization_enable TO true;

SELECT * FROM spectrum.customers order by id LIMIT 1;
```

```
id | name                                       | phones           | orders
---+--------------------------------------------+-----------------
+-------------------------------------------------------------------------------------------------------
1  | {"given": "John", "family": "Smith"} | ["123-457789"] | [{"shipdate":
 "2018-03-01T11:59:59.000Z", "price": 100.50}, {"shipdate": "2018-03-01T09:10:00.000Z",
 "price": 99.12}]

SELECT name FROM spectrum.customers order by id LIMIT 1;

name
---------
{"given": "John", "family": "Smith"}
```

Consider the following items when serializing nested JSON.

- When collection columns are serialized as VARCHAR(65535), their nested subfields can't be accessed directly as part of the query syntax (for example, in the filter clause). However, JSON functions can be used to access nested JSON.
- The following specialized representations are not supported:
  - ORC unions
  - ORC maps with complex type keys
  - Ion datagrams
  - Ion SEXP
- Timestamps are returned as ISO serialized strings.
- Primitive map keys are promoted to string (for example, 1 to `"1"`).
- Top-level null values are serialized as NULLs.
- If the serialization overflows the maximum VARCHAR size of 65535, the cell is set to NULL.

Serializing complex types containing JSON strings

By default, string values contained in nested collections are serialized as escaped JSON strings. Escaping might be undesirable when the strings are valid JSON. Instead you might want to write nested subelements or fields that are VARCHAR directly as JSON. Enable this behavior with the `json_serialization_parse_nested_strings` session-level configuration. When both `json_serialization_enable` and `json_serialization_parse_nested_strings` are set, valid JSON values are serialized inline without escape characters. When the value is not valid JSON, it is escaped as if the `json_serialization_parse_nested_strings` configuration value was not set. For more information, see json_serialization_parse_nested_strings.

For example, assume the data from the previous example contained JSON as a `structs` complex type in the `name` VARCHAR(20) field:

```
name
---------
{"given": "{\"first\":\"John\",\"middle\":\"James\"}", "family": "Smith"}
```

When `json_serialization_parse_nested_strings` is set, the `name` column is serialized as follows:

```
SET json_serialization_enable TO true;
SET json_serialization_parse_nested_strings TO true;
SELECT name FROM spectrum.customers order by id LIMIT 1;

name
---------
{"given": {"first":"John","middle":"James"}, "family": "Smith"}
```

Instead of being escaped like this:

```
SET json_serialization_enable TO true;
SELECT name FROM spectrum.customers order by id LIMIT 1;

name
---------
{"given": "{\"first\":\"John\",\"middle\":\"James\"}", "family": "Smith"}
```

HyperLogLog sketches

This topic describes how to use HyperLogLog sketches in Amazon Redshift. HyperLogLog is an algorithm for the count-distinct problem, approximating the number of distinct elements in a data set. HyperLogLog sketches are arrays of uniqueness data about a data set.

HyperLogLog is an algorithm used for estimating the cardinality of a multiset. *Cardinality* refers to the number of distinct values in a multiset. For example, in the set of {4,3,6,2,2,6,4,3,6,2,2,3}, the cardinality is 4 with distinct values of 4, 3, 6, and 2.

The precision of the HyperLogLog algorithm (also known as m value) can affect the accuracy of the estimated cardinality. During the cardinality estimation, Amazon Redshift uses a default precision value of 15. This value can be up to 26 for smaller datasets. Thus, the average relative error ranges between 0.01–0.6%.

When calculating the cardinality of a multiset, the HyperLogLog algorithm generates a construct called an HLL sketch. An *HLL sketch* encapsulates information about the distinct values in a multiset. The Amazon Redshift data type HLLSKETCH represents such sketch values. This data type can be used to store sketches in an Amazon Redshift table. Additionally, Amazon Redshift supports operations that can be applied to HLLSKETCH values as aggregate and scalar functions. You can use these functions to extract the cardinality of an HLLSKETCH and combine multiple HLLSKETCH values.

The HLLSKETCH data type offers significant query performance benefits when extracting the cardinality from large datasets. You can preaggregate these datasets using HLLSKETCH values and store them in tables. Amazon Redshift can extract the cardinality directly from the stored HLLSKETCH values without accessing the underlying datasets.

When processing HLL sketches, Amazon Redshift performs optimizations that minimize the memory footprint of the sketch and maximize the precision of the extracted cardinality. Amazon Redshift uses two representations for HLL sketches, sparse and dense. An HLLSKETCH starts in sparse format. As new values are inserted into it, its size increases. After its size reaches the size of the dense representation, Amazon Redshift automatically converts the sketch from sparse to dense.

Amazon Redshift imports, exports, and prints an HLLSKETCH as JSON when the sketch is in a sparse format. Amazon Redshift imports, exports, and prints an HLLSKETCH as a Base64 string when the sketch is in a dense format. For more information about UNLOAD, see Unloading the

HLLSKETCH data type. To import text or comma-separated value (CSV) data into Amazon Redshift, use the COPY command. For more information, see Loading the HLLSKETCH data type.

For information about functions used with HyperLogLog, see HyperLogLog functions.

Topics

- Considerations
- Limitations
- Examples

Considerations

This topic describes usage details for HyperLogLog in Amazon Redshift.

The following are considerations for using HyperLogLog in Amazon Redshift:

- The following non-HyperLogLog functions can accept an input of type HLLSKETCH or columns of type HLLSKETCH:
  - The aggregate function COUNT
  - The conditional expressions COALESCE and NVL
  - CASE expressions
- The supported encoding is RAW.
- You can perform an UNLOAD operation on table with HLLSKETCH columns into text or CSV. You can use the UNLOAD HLLSKETCH columns to write HLLSKETCH data. Amazon Redshift shows the data in a JSON format for a sparse representation or a Base64 format for a dense representation. For more information about UNLOAD, see Unloading the HLLSKETCH data type.

  The following shows the format used for a sparse HyperLogLog sketch represented in a JSON format.

  ```
  {"version":1,"logm":15,"sparse":{"indices":
  [15099259,33107846,37891580,50065963],"values":[2,3,2,1]}}
  ```
- You can import text or CSV data into Amazon Redshift using the COPY command. For more information, see Loading the HLLSKETCH data type.
- The default encoding for HLLSKETCH is RAW. For more information, see Compression encodings.

Limitations

This topic describes limitations for HyperLogLog in Amazon Redshift.

The following are limitations for using HyperLogLog in Amazon Redshift:

- Amazon Redshift tables don't support an HLLSKETCH column as a sort key or a distribution key for an Amazon Redshift table.
- Amazon Redshift doesn't support HLLSKETCH columns in ORDER BY, GROUP BY, or DISTINCT clauses.
- You can only UNLOAD HLLSKETCH columns to text or CSV format. Amazon Redshift then writes the HLLSKETCH data in either a JSON format or a Base64 format. For more information about UNLOAD, see UNLOAD.
- Amazon Redshift only supports HyperLogLog sketches with a precision (logm value) of 15.
- JDBC and ODBC drivers don't support the HLLSKETCH data type. Therefore, the result set uses VARCHAR to represent the HLLSKETCH values.
- Amazon Redshift Spectrum doesn't natively support the HLLSKETCH data. Therefore, you can't create or alter an external table with an HLLSKETCH column.
- Data types for Python user-defined functions (UDFs) don't support the HLLSKETCH data type. For more information about Python UDFs, see Scalar Python UDFs.

> **Note**
>
> Starting November 1, 2025, Amazon Redshift will no longer support the creation of new Python UDFs. Existing Python UDFs will continue to function until June 30, 2026. Starting July 1, 2026, Amazon Redshift will no longer support Python UDFs. We recommend that you migrate your existing Python UDFs to Lambda UDFs before November 1, 2025. For information on creating and using Lambda UDFs, see Scalar Lambda UDFs. For information on converting existing Python UDFs to Lambda UDFs, see the blog post .

Examples

This section contains examples for using HyperLogLog with Amazon Redshift.

Topics

Example: Return cardinality in a subquery

The following example returns the cardinality for each sketch in a subquery for a table named *Sales*.

```
CREATE TABLE Sales (customer VARCHAR, country VARCHAR, amount BIGINT);
INSERT INTO Sales VALUES ('David Joe', 'Greece', 14.5),  ('David Joe', 'Greece',
 19.95), ('John Doe', 'USA', 29.95), ('John Doe', 'USA', 19.95), ('George Spanos',
 'Greece', 9.95), ('George Spanos', 'Greece', 2.95);
```

The following query generates an HLL sketch for the customers of each country and extracts the cardinality. This shows unique customers from each country.

```
SELECT hll_cardinality(sketch), country
FROM (SELECT hll_create_sketch(customer) AS sketch, country
        FROM Sales
        GROUP BY country) AS hll_subquery;

hll_cardinality | country
----------------+---------
            1   | USA
            2   | Greece
 ...
```

Example: Return an HLLSKETCH type from combined sketches in a subquery

The following example returns a single HLLSKETCH type that represents the combination of individual sketches from a subquery. The sketches are combined by using the HLL_COMBINE aggregate function.

```
SELECT hll_combine(sketch)
FROM (SELECT hll_create_sketch(customer) AS sketch
        FROM Sales
```

```
        GROUP BY country) AS hll_subquery

                                        hll_combine
---------------------------------------------------------------------------------------------------
 {"version":1,"logm":15,"sparse":{"indices":[29808639,35021072,47612452],"values":
[1,1,1]}}
(1 row)
```

Example: Return a HyperLogLog sketch from combining multiple sketches

For the following example, suppose that the table `page-users` stores preaggregated sketches for each page that users visited on a given website. Each row in this table contains a HyperLogLog sketch that represents all user IDs that show the visited pages.

```
page_users
-- +----------------+-------------+--------------+
-- | _PARTITIONTIME | page        | sketch |
-- +----------------+-------------+--------------+
-- | 2019-07-28     | homepage    | CHAQkAQYA... |
-- | 2019-07-28     | Product A   | CHAQxPnYB... |
-- +----------------+-------------+--------------+
```

The following example unions the preaggregated multiple sketches and generates a single sketch. This sketch encapsulates the collective cardinality that each sketch encapsulates.

```
SELECT hll_combine(sketch) as sketch
FROM page_users
```

The output looks similar to the following.

```
-- +-----------------------------------------+
-- | sketch |
-- +-----------------------------------------+
-- | CHAQ3sGoCxgCIAuCB4iAIBgTIBgqgIAgAwY.... |
-- +-----------------------------------------+
```

When a new sketch is created, you can use the HLL_CARDINALITY function to get the collective distinct values, as shown following.

```
SELECT hll_cardinality(sketch)
FROM (
  SELECT
  hll_combine(sketch) as sketch
  FROM page_users
) AS hll_subquery
```

The output looks similar to the following.

```
-- +-------+
-- | count |
-- +-------+
-- | 54356 |
-- +-------+
```

Example: Generate HyperLogLog sketches over S3 data using external tables

The following examples cache HyperLogLog sketches to avoid directly accessing Amazon S3 for cardinality estimation.

You can preaggregate and cache HyperLogLog sketches in external tables defined to hold Amazon S3 data. By doing this, you can extract cardinality estimates without accessing the underlying base data.

For example, suppose that you have unloaded a set of tab-delimited text files into Amazon S3. You run the following query to define an external table named `sales` in the Amazon Redshift external schema named `spectrum`. The Amazon S3 bucket for this example is in the US East (N. Virginia) AWS Region.

```
create external table spectrum.sales(
salesid integer,
listid integer,
sellerid smallint,
buyerid smallint,
eventid integer,
dateid integer,
qtysold integer,
pricepaid decimal(8,2),
```

```
commission decimal(8,2),
saletime timestamp)
row format delimited
fields terminated by '\t' stored as textfile
location 's3://redshift-downloads/tickit/spectrum/sales/';
```

Suppose that you want to compute the distinct buyers who purchased an item on arbitrary dates. To do so, the following example generates sketches for the buyer IDs for each day of the year and stores the result in the Amazon Redshift table `hll_sales`.

```
CREATE TABLE hll_sales AS
SELECT saletime, hll_create_sketch(buyerid) AS sketch
FROM spectrum.sales
GROUP BY saletime;

SELECT TOP 5 * FROM hll_sales;
```

The output looks similar to the following.

```
-- hll_sales

-- | saletime        | sketch
    |
-- +-----------------
+--------------------------------------------------------------------+
-- | 7/22/2008 8:30  | {"version":1,"logm":15,"sparse":{"indices":[9281416],"values":
[1]}}
-- | 2/19/2008 0:38  | {"version":1,"logm":15,"sparse":{"indices":[48735497],"values":
[3]}}
-- | 11/5/2008 4:49  | {"version":1,"logm":15,"sparse":{"indices":[27858661],"values":
[1]}}
-- | 10/27/2008 4:08 | {"version":1,"logm":15,"sparse":{"indices":[65295430],"values":
[2]}}
-- | 2/16/2008 9:37  | {"version":1,"logm":15,"sparse":{"indices":[56869618],"values":
[2]}}
-- +----------------
 +--------------------------------------------------------------------+
```

The following query shows the estimated number of distinct buyers that purchased an item during the Friday after Thanksgiving in 2008.

```
SELECT hll_cardinality(hll_combine(sketch)) as distinct_buyers
```

```
FROM hll_sales
WHERE trunc(saletime) = '2008-11-28';
```

The output looks similar to the following.

```
distinct_buyers
---------------
386
```

Suppose that you want the number of distinct users who bought an item on a certain range of dates. An example might be from the Friday after Thanksgiving to the following Monday. To get this, the following query uses the `hll_combine` aggregate function. This function enables you to avoid double-counting buyers who purchased an item on more than one day of the selected range.

```
SELECT hll_cardinality(hll_combine(sketch)) as distinct_buyers
FROM hll_sales
WHERE saletime BETWEEN '2008-11-28' AND '2008-12-01';
```

The output looks similar to the following.

```
distinct_buyers
---------------
1166
```

To keep the `hll_sales` table up-to-date, run the following query at the end of each day. Doing this generates an HyperLogLog sketch based on the IDs of buyers that purchased an item today and adds it to the `hll_sales` table.

```
INSERT INTO hll_sales
SELECT saletime, hll_create_sketch(buyerid)
FROM spectrum.sales
WHERE TRUNC(saletime) = to_char(GETDATE(), 'YYYY-MM-DD')
GROUP BY saletime;
```

Cross-database queries

This topic describes *cross-database queries*, which are queries that operate on multiple Amazon Redshift databases within a single Amazon Redshift cluster.

By using cross-database queries in Amazon Redshift, you can query and write across databases in an Amazon Redshift cluster. With cross-database queries, you can query and write data from any database in the Amazon Redshift cluster, regardless of which database you are connected to. Cross-database queries eliminate data copies and simplify your data organization to support multiple business groups from the same data warehouse.

With cross-database queries, you can do the following:

- **Query data across databases in your Amazon Redshift cluster**.

  Not only can you query from databases that you are connected to, you can also read from any other databases that you have permissions to.

  When you query database objects on any other unconnected databases, you have read access only to those database objects. You can use cross-database queries to access data from any of the databases on your Amazon Redshift cluster without having to connect to that specific database. Doing this can help you query and join data that is spread across multiple databases in your Amazon Redshift cluster quickly and easily.

  You can also join datasets from multiple databases in a single query and analyze the data using business intelligence (BI) or analytics tools. You can continue to set up granular table-level read access controls for users by using standard Amazon Redshift SQL commands. By doing so, you can help ensure that users see only the relevant subsets of the data that they have permissions for.
- **Write data across databases in your Amazon Redshift cluster.**.

  You can write from databases that you are connected to, and also write from any other database that you have permissions to.

  When you have write permissions on database objects on any other unconnected databases, you can use cross-database queries to write data from any database on your Amazon Redshift cluster without having to connect to that specific database. Doing this can help you with complex write operations while quickly and easily joining data that is spread across multiple databases in your Amazon Redshift cluster.

You can also join datasets from multiple databases in a single query and write the data using different extract-transform-load (ETL) or analytics tools. You can continue to set up granular table-level write access controls for users by using standard Amazon Redshift SQL commands. This ensures that users see only the relevant subsets of the data that they have permissions for.

- **Query objects**.

  You can query other database objects using fully qualified object names expressed with the three-part notation. The full path to any database object consists of three components: database name, schema, and name of the object. You can access any object from any other database using the full path notation, `database_name.schema_name.object_name`. To access a particular column, use `database_name.schema_name.object_name.column_name`.

  You can also create an alias for a schema in another database using the external schema notation. This external schema references to another database and schema pair. Query can access the other database object using the external schema notation, `external_schema_name.object_name`.

  In the same read-only query, you can query various database objects, such as user tables, regular views, materialized views, and late-binding views from other databases.

- **Manage permissions**.

  Users with access privileges for objects in any databases in an Amazon Redshift cluster can query and write data to those objects. You grant privileges to users and user groups using the GRANT command. You can also revoke privileges using the REVOKE command when a user no longer requires the access to specific database objects.

- **Work with metadata and BI tools.**

  You can create an external schema to refer to a schema in another Amazon Redshift database within the same Amazon Redshift cluster. For information, see CREATE EXTERNAL SCHEMA command.

  After external schema references are created, Amazon Redshift shows the tables under the schema of the other database in SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS for the tools to explore the metadata.

To integrate cross-database query with BI tools, you can use the following system views. These help you view information about the metadata of objects in the connected and other databases on the Amazon Redshift cluster.

Following are system views that show all Amazon Redshift objects and external objects of all databases in your Amazon Redshift cluster:

- SVV_ALL_COLUMNS
- SVV_ALL_SCHEMAS
- SVV_ALL_TABLES

Following are system views that show all Amazon Redshift objects of all databases in your Amazon Redshift cluster:

- SVV_REDSHIFT_COLUMNS
- SVV_REDSHIFT_DATABASES
- SVV_REDSHIFT_FUNCTIONS
- SVV_REDSHIFT_SCHEMAS
- SVV_REDSHIFT_TABLES

Topics

Considerations

This topic describes usage details for cross-database queries in Amazon Redshift.

When you work with the cross-database query feature in Amazon Redshift, consider the following:

- Amazon Redshift supports cross-database query on all ra3 node types and serverless namespaces.
- Amazon Redshift supports joining data from tables or views across one or more databases in the same Amazon Redshift cluster.

- All queries in a transaction on the connected database read data in the same state of the other database as the data was at the beginning of the transaction. This approach helps to provide query transactional consistency across databases. Amazon Redshift supports transactional consistency for cross-database queries.
- To get metadata across databases, use SVV_ALL* and SVV_REDSHIFT* metadata views. You can't use the three-part notation or external schemas to query cross-database metadata tables or views under information_schema and pg_catalog.

Limitations

This topic describes limitations for cross-database queries in Amazon Redshift.

When you work with the cross-database query feature in Amazon Redshift, be aware of the limitations following:

- You can't query views that are created on other databases that refer to objects of yet another database.
- You can't write to external schemas to database objects on any other unconnected databases.
- You can only create late-binding and materialized views on objects of other databases in the cluster. You can't create regular views on objects of other databases in the cluster.
- Amazon Redshift doesn't support tables with column-level privileges for cross-database queries.
- Running cross-database queries on tables with interleaved sort keys isn't supported.

Cross-database query examples

This topic contains examples for how to use cross-database queries. Cross-database queries are queries that operate on multiple databases within a single Amazon Redshift cluster.

Use the following examples to help learn how to set up a cross-database query that references an Amazon Redshift database.

To start, create databases db1 and db2 and users `user1` and `user2` in your Amazon Redshift cluster. For more information, see CREATE DATABASE and CREATE USER.

```
--As user1 on db1
CREATE DATABASE db1;
```

```
CREATE DATABASE db2;

CREATE USER user1 PASSWORD 'Redshift01';

CREATE USER user2 PASSWORD 'Redshift01';
```

As `user1` on db1, create a table, grant access privileges to `user2`, and insert values into `table1`. For more information, see GRANT and INSERT.

```
--As user1 on db1
CREATE TABLE table1 (c1 int, c2 int, c3 int);

GRANT SELECT ON table1 TO user2;

INSERT INTO table1 VALUES (1,2,3),(4,5,6),(7,8,9);
```

As `user2` on db2, run a cross-database query in db2 using the three-part notation.

```
--As user2 on db2
SELECT * from db1.public.table1 ORDER BY c1;

c1 | c2  | c3
---+-----+----
1  |  2  | 3
4  |  5  | 6
7  |  8  | 9
(3 rows)
```

Now grant write privileges to `user2`, and insert values into `table1` in db1 as `user2` .

```
--As user1 on db1
GRANT INSERT ON table1 TO user2;
```

As `user2` on db2, run a cross-database query in db2 using the three-part notation to insert data into `table1` in db1.

```
--As user2 on db2
INSERT INTO db1.public.table1 VALUES (10,11,12);
SELECT * from db1.public.table1 ORDER BY c1;
```

```
c1  | c2   | c3
----+------+----
1   |  2   | 3
4   |  5   | 6
7   |  8   | 9
10  |  11  | 12
(4 rows)
```

As `user2` on db2, create an external schema and run a cross-database query in db2 using the external schema notation.

```
--As user2 on db2
CREATE EXTERNAL SCHEMA db1_public_sch
FROM REDSHIFT DATABASE 'db1' SCHEMA 'public';

SELECT * FROM db1_public_sch.table1 ORDER BY c1;

c1  | c2 | c3
----+----+----
1   | 2  | 3
4   | 5  | 6
7   | 8  | 9
10  | 11 | 12
(4 rows)
```

To create different views and grant permissions to those views, as `user1` on db1, do the following.

```
--As user1 on db1
CREATE VIEW regular_view AS SELECT c1 FROM table1;

GRANT SELECT ON regular_view TO user2;


CREATE MATERIALIZED VIEW mat_view AS SELECT c2 FROM table1;

GRANT SELECT ON mat_view TO user2;


CREATE VIEW late_bind_view AS SELECT c3 FROM public.table1 WITH NO SCHEMA BINDING;

GRANT SELECT ON late_bind_view TO user2;
```

As `user2` on db2, run the following cross-database query using the three-part notation to view the particular view.

```
--As user2 on db2
SELECT * FROM db1.public.regular_view;

c1
----
1
4
7
10
(4 rows)

SELECT * FROM db1.public.mat_view;

c2
----
2
5
8
11
(4 rows)

SELECT * FROM db1.public.late_bind_view;

c3
----
3
6
9
12
(4 rows)
```

As `user2` on db2, run the following cross-database query using the external schema notation to query the late-binding view.

```
--As user2 on db2
SELECT * FROM db1_public_sch.late_bind_view;

c3
----
3
```

```
6
9
12
(4 rows)
```

As `user2` on db2, run the following command using connected tables in a single query.

```
--As user2 on db2
CREATE TABLE table1 (a int, b int, c int);

INSERT INTO table1 VALUES (1,2,3), (4,5,6), (7,8,9);

SELECT a AS col_1, (db1.public.table1.c2 + b) AS sum_col2, (db1.public.table1.c3 + c)
 AS sum_col3 FROM db1.public.table1, table1 WHERE db1.public.table1.c1 = a;
col_1 | sum_col2 | sum_col3
------+----------+----------
1     | 4        | 6
4     | 10       | 12
7     | 16       | 18
(3 rows)
```

The following example lists all databases on the cluster.

```
select database_name, database_owner, database_type
from svv_redshift_databases
where database_name in ('db1', 'db2');

 database_name | database_owner | database_type
---------------+----------------+---------------
 db1           |            100 | local
 db2           |            100 | local
(2 rows)
```

The following example lists all Amazon Redshift schemas of all databases on the cluster.

```
select database_name, schema_name, schema_owner, schema_type
from svv_redshift_schemas
where database_name in ('db1', 'db2');

 database_name |    schema_name     | schema_owner | schema_type
---------------+--------------------+--------------+-------------
 db1           | pg_catalog         |            1 | local
```

```
 db1           | public             |            1 | local
 db1           | information_schema |            1 | local
 db2           | pg_catalog         |            1 | local
 db2           | public             |            1 | local
 db2           | information_schema |            1 | local
(6 rows)
```

The following example lists all Amazon Redshift tables or views of all databases on the cluster.

```
select database_name, schema_name, table_name, table_type
from svv_redshift_tables
where database_name in ('db1', 'db2') and schema_name in ('public');

 database_name | schema_name |     table_name      | table_type
---------------+-------------+---------------------+------------
 db1           | public      | late_bind_view      | VIEW
 db1           | public      | mat_view            | VIEW
 db1           | public      | mv_tbl__mat_view__0 | TABLE
 db1           | public      | regular_view        | VIEW
 db1           | public      | table1              | TABLE
 db2           | public      | table2              | TABLE
(6 rows)
```

The following example lists all Amazon Redshift and external schemas of all databases on the cluster.

```
select database_name, schema_name, schema_owner, schema_type
from svv_all_schemas where database_name in ('db1', 'db2') ;

 database_name |    schema_name     | schema_owner | schema_type
---------------+--------------------+--------------+-------------
 db1           | pg_catalog         |            1 | local
 db1           | public             |            1 | local
 db1           | information_schema |            1 | local
 db2           | pg_catalog         |            1 | local
 db2           | public             |            1 | local
 db2           | information_schema |            1 | local
 db2           | db1_public_sch     |            1 | external
(7 rows)
```

The following example lists all Amazon Redshift and external tables of all databases on the cluster.

```
select database_name, schema_name, table_name, table_type
from svv_all_tables
where database_name in ('db1', 'db2') and schema_name in ('public');

 database_name | schema_name |     table_name      | table_type
---------------+-------------+---------------------+------------
 db1           | public      | regular_view        | VIEW
 db1           | public      | mv_tbl__mat_view__0 | TABLE
 db1           | public      | mat_view            | VIEW
 db1           | public      | late_bind_view      | VIEW
 db1           | public      | table1              | TABLE
 db2           | public      | table2              | TABLE
(6 rows)
```

Using cross-database queries with the query editor

This topic explains how to use cross-database queries with the query editor. Cross-database queries are queries that operate on multiple databases within a single Amazon Redshift cluster.

You can use cross-database queries to access data from any of the databases on your Amazon Redshift cluster without having to connect to that specific database. When you run cross-database queries on any other unconnected databases, you have read and write access only to those database objects.

You can query and write to other database objects using fully qualified object names expressed with three-part notation. The full path to any database object consists of three components: database name, schema, and name of the object. An example is *`database_name.schema_name.object_name`*.

To use cross-database queries with the query editor v2

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. Create a cluster to use cross-database queries in Amazon Redshift query editor v2. For more information, see [Creating a cluster](#) in the *Amazon Redshift Management Guide*.
3. Enable access to the query editor with the appropriate permissions. For more information, see [Querying a database using the query editor v2](#) in the *Amazon Redshift Management Guide*.
4. On the navigation menu, choose **Query editor v2**, then connect to a database in your cluster.

When you connect to the query editor v2 for the first time, Amazon Redshift shows the resources for the connected database by default.

5. Choose the other databases that you have access to view database objects for these other databases. To view objects, make sure that you have the appropriate permissions. After you choose a database, Amazon Redshift shows the list of schemas from the database.

   Select a schema to see the list of database objects within that schema.

   > **Note**
   >
   > Amazon Redshift doesn't directly support query catalog objects that are part of AWS Glue or federated databases. To query these, first create external schemas that refer to those external data sources in each database.
   > Amazon Redshift cross-database queries with three-part notation don't support metadata tables under the schemas `information_schema` and `pg_catalog` because these metadata views are specific to a database.

6. (Optional) Filter the list of tables or views for the schema that you selected.

Apache Iceberg compatibility for Amazon Redshift

You can register entire Amazon Redshift provisioned clusters or serverless namespaces to the AWS Glue Data Catalog to create catalogs that securely share live data across AWS accounts. You can access these catalogs from any SQL query engine that supports the Apache Iceberg REST API. AWS Lake Formation manages the permissions for the catalogs, letting you manage a single copy of data with a single set of permissions while leveraging Amazon Redshift features such as materialized views and zero-ETL integrations.

All catalogs created from registered Amazon Redshift provisioned clusters and serverless namespaces in the AWS Glue Data Catalog are automatically mounted as external databases on all provisioned clusters and serverless workgroups in the same AWS Region under the same account. Catalogs created in the AWS Glue Data Catalog to store data in Redshift Managed Storage (RMS) are similarly mounted as external databases. Once mounted, you can directly connect to these databases and query the objects using the three-part notation `database@namespace-catalog.schema.table`.

Regions where Apache Iceberg compatibility is available

Apache Iceberg compatibility with Amazon Redshift is available in the following AWS Regions:

- US East (N. Virginia)
- US East (Ohio)
- US West (N. California)
- Asia Pacific (Hong Kong)
- Asia Pacific (Seoul);
- Asia Pacific (Singapore)
- Asia Pacific (Sydney)
- Asia Pacific (Tokyo)
- Canada (Central)
- Europe (Frankfurt)
- Europe (Ireland)
- Europe (London)

- Europe (Stockholm)
- South America (São Paulo)

Considerations and limitations when using Amazon Redshift catalogs in the AWS Glue Data Catalog

When using Amazon Redshift catalogs in the AWS Glue Data Catalog, consider the following:

- Data warehouses registered to the AWS Glue Data Catalog follow the three-part syntax for accessing tables (`database@namespace-catalog.schema.table`). For example, if you registered an Amazon Redshift namespace named a, populated by a database named b, which held a schema named c, in which was a table named d, you would select from d using the following statement:

  ```
  SELECT * FROM b@a.c.d;
  ```

  Note that the combined length of the `database@namespace-catalog` part of the syntax must be 127 characters or less.
- When you register a cluster or namespace to the AWS Glue Data Catalog, Amazon Redshift registers all databases and relations in that cluster or namespace.
- You can register multiple Redshift clusters and namespaces to the AWS Glue Data Catalog.
- Registering a cluster or namespace only registers the internal schemas and relations in that cluster or namespace. The following aren't registered:
  - External schemas.
  - External tables. Note that late-binding views created from external tables will be registered.
  - User-created functions.
  - Procedures.
  - Tables with row-level security or dynamic data masking policies attached.
  - Database objects with uppercase or mixed-case names. Tables containing uppercase or mixed-case columns aren't registered. This applies even when enable_case_sensitive_identifier is disabled.
- Amazon Redshift database permissions, such as roles granted by role-based access control, don't transfer to catalogs in the AWS Glue Data Catalog. Use AWS Lake Formation to configure permissions for the AWS Glue Data Catalog. For more information on using Lake Formation to

configure permissions, see [Setting up permissions for Amazon Redshift datashares](#) in the *AWS Lake Formation Developer Guide*.

- When you create a catalog from a registered cluster or serverless namespace, the AWS Glue Data Catalog creates an Amazon Redshift managed workgroup using Amazon Redshift compute resources to handle compute requirements when querying that catalog. You can view the managed workgroup in the Amazon Redshift Serverless console and manage it in AWS Glue.
- When you register a paused cluster, the AWS Glue Data Catalog won't mount that cluster as a catalog until the cluster is resumed.
- When you register a serverless namespace that's not being actively used, the AWS Glue Data Catalog won't mount that namespace as a catalog until the namespace is used again.
- Your account must have a default VPC to create a managed workgroup.
- To access tables in data warehouses registered to the AWS Glue Data Catalog, the database's isolation level must be SNAPSHOT. Attempting to access tables with an isolation level of SERIALIZABLE will result in an error. For more information on serializable isolation, see Serializable isolation. For information on changing the isolation level of a database, see ALTER DATABASE.

  Note that the isolation level of the default `dev` database can't be altered. Consequently, this means that tables in the `dev` database won't be included in the accessible data when registering data warehouses to the AWS Glue Data Catalog.

IAM policy requirements for accessing clusters and namespaces registered to the Data Catalog

This topic describes the required IAM permissions for registering provisioned clusters and serverless namespaces to the Data Catalog and accessing them with Amazon Redshift.

After you register a provisioned cluster or serverless namespace to the AWS Glue Data Catalog, you need the following permissions to discover the creation of and changes to the subsequently created catalog.

- `glue:GetCatalog`
- `glue:GetCatalogs`
- `lakeformation:GetDataAccess`

These permissions are included in the service-linked role `AmazonRedshiftServiceLinkedRolePolicy`. For more information on this role, see [Using service-linked roles for Amazon Redshift](#) in the *Amazon Redshift Management Guide*.

Registering Amazon Redshift clusters and namespaces to the AWS Glue Data Catalog

You can add Amazon Redshift provisioned clusters and serverless namespaces to the AWS Glue Data Catalog to access them using the Apache Iceberg REST API. You do this by registering the Amazon Redshift data warehouse to the AWS Glue Data Catalog using the Amazon Redshift console or AWS CLI, then creating a Amazon Redshift federated catalog for the warehouse using AWS Lake Formation.

Amazon Redshift data warehouses registered to the Data Catalog act as producer datashares. Changes that you make to clusters or serverless namespaces from their catalogs are reflected in the cluster or namespace in Redshift, and vice versa.

Registering using the Amazon Redshift console

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. Navigate to the serverless namespace or provisioned cluster that you want to register and select it.
3. From the namespace or cluster's details page, select **Register to AWS Glue Data Catalog** from the **Actions** drop-down menu.
4. Enter the destination account ID that you want to register the namespace or cluster to and choose **Register**.
5. If you're registering from your account to the same account in AWS Glue, you'll be taken directly to the AWS Lake Formation console to finish the process. If you're registering to a different account, a link appears that takes you to Lake Formation.

Registering using the AWS CLI

To register a cluster or namespace to the AWS Glue Data Catalog using the AWS CLI, use the `register-namespace` command with the following options:

- `namespace-identifier`: An object with the unique identifier of the cluster or namespace you're registering. This object is different depending on whether you're registering a provisioned cluster or a serverless namespace. Consider the following:
  - For provisioned clusters, you provide a `ProvisionedIdentifier` object, which contains a `ClusterIdentifier` object with the unique identifier of the cluster you're registering.
  - or serverless namespaces, you provide a `ServerlessIdentifier` object, which contains a `NamespaceIdentifier` object with the unique identifier of the namespace you're registering, as well as a `WorkgroupIdentifier` object with the unique identifier of the workgroup associated with that namespace.
- `consumer-identifiers`: An array with a single element, containing the unique identifier of the account you're registering the cluster or namespace to.

The following example registers the `mySampleNamespace` serverless namespace to the account ID `012345678910`.

```
aws redshift register-namespace /
--namespace-identifier {ServerlessIdentifier: {NamespaceIdentifer:
 mySampleNamespace, WorkgroupIdentifier: mySampleWorkgroup}} /
--consumer-identifiers [012345678910]
```

Deregistering Amazon Redshift clusters and namespaces from the AWS Glue Data Catalog

You can deregister a provisioned cluster or serverless namespace from the AWS Glue Data Catalog using the Amazon Redshift console or the AWS CLI. Data warehouses that you deregister from the AWS Glue Data Catalog are only removed from the AWS Glue Data Catalog itself. The warehouses remain part of your Amazon Redshift account. Additionally, the catalog remains in AWS Glue and must be manually removed. When you remove the catalog from AWS Glue, the managed workgroup associated with it is also removed.

Deregistering using the Amazon Redshift console

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.

2. Navigate to the serverless namespace or provisioned cluster that you want to deregister and select it.
3. From the namespace or cluster's details page, select **Deregister from AWS Glue Data Catalog** from the **Actions** drop-down menu. This option only appears if you've chosen a data warehouse that's already been registered to the AWS Glue Data Catalog.
4. Enter the account ID that owns the catalog holding your cluster or namespace and choose **Deregister**.

Deregistering using the AWS CLI

To deregister a cluster or namespace from the AWS Glue Data Catalog using the AWS CLI, use the `deregister-namespace` command with the following options:

- `namespace-identifier`: An object with the unique identifier of the cluster or namespace you're deregistering. This object is different depending on whether you're deregistering a provisioned cluster or a serverless namespace. Consider the following:
  - For provisioned clusters, you provide a `ProvisionedIdentifier` object, which contains a `ClusterIdentifier` object with the unique identifier of the cluster you're deregistering.
  - or serverless namespaces, you provide a `ServerlessIdentifier` object, which contains a `NamespaceIdentifier` object with the unique identifier of the namespace you're deregistering, as well as a `WorkgroupIdentifier` object with the unique identifier of the workgroup associated with that namespace.
- `consumer-identifiers`: An array with a single element, containing the unique identifier of the account you're deregistering the cluster or namespace from.

The following example deregisters the `mySampleNamespace` serverless namespace from the account ID `012345678910`.

```
aws redshift deregister-namespace /
--namespace-identifier {ServerlessIdentifier: {NamespaceIdentifer:
 mySampleNamespace, WorkgroupIdentifier: mySampleWorkgroup}} /
--consumer-identifiers [012345678910]
```

Managed workgroups

When you register a provisioned cluster or serverless namespace to the AWS Glue Data Catalog and create a catalog from it, AWS Glue creates a managed workgroup to provide compute resources for any SQL query engine that accesses that catalog. For example, an Amazon Athena user querying a table in a catalog would have their compute requirements fulfilled by the managed workgroup's Amazon Redshift compute resources. Managed workgroups use Amazon Redshift compute resources, but are managed in AWS Glue. Your account must have a default VPC to create a managed workgroup.

Managed workgroups count toward the Amazon Redshift Serverless workgroup quota, which by default is 25. For more information, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

You can view general information, performance metrics, and query information for your managed workgroups in the Amazon Redshift Serverless console. For more information, see Viewing properties for a workgroup in the *Amazon Redshift Management Guide*.

Querying catalogs registered in the AWS Glue Data Catalog

After you register an Amazon Redshift data warehouse to the AWS Glue Data Catalog and set permissions for the resulting catalog in AWS Lake Formation, the catalog is automatically mounted in all Amazon Redshift instances with access to the source data warehouse in the same account and AWS Region. You can then query that catalog as you would a local cluster or workgroup. You can also query catalogs registered to the AWS Glue Data Catalog using any SQL engine that supports the Apache Iceberg REST Open API. For more information on querying catalogs in the AWS Glue Data Catalog using the Apache Iceberg REST API, see Accessing the Data Catalog in the *AWS Glue Developer Guide*. For information on the Apache Iceberg REST API, see the Apache Iceberg REST Open API specification.

To query a catalog, you must first set the permissions for the catalog using AWS Lake Formation. For more information on setting permissions for catalogs in AWS Lake Formation, see Setting up permissions for Amazon Redshift datashares in the *AWS Lake Formation Developer Guide*. You also need an IAM role with the `AmazonRedshiftServiceLinkedRolePolicy` managed policy attached. For information on service-linked roles, see Using service-linked roles for Amazon Redshift in the *Amazon Redshift Management Guide*.

Note that queries against catalogs must follow the following three-part syntax for accessing tables:

```
database@namespace.schema.table
```

For general information on querying Amazon Redshift data warehouses, see [Query a database] in the *Amazon Redshift Management Guide*.

Querying using the query editor v2

After setting permissions for an account to access a managed workgroup, that managed workgroup appears in the tree-view panel under the external databases section of your serverless database. You can query the managed workgroup the same way that you would query an internal Amazon Redshift provisioned cluster or serverless workgroup, using the three-part syntax format `database@namespace/cluster.schema.table`. See the following sample statement:

```
SELECT price FROM sales_db@mynamespace.sales_schema.inventory_table
```

Querying using the Data API

You can query managed workgroups using the Amazon Redshift Data API the same way that you would query an internal Amazon Redshift provisioned cluster or serverless workgroup, passing the Amazon Resource Name (ARN) of the catalog into the relevant `database` attribute. Consider the following example that creates a table in a catalog.

```
aws redshift-data execute-statement —sql 'CREATE TABLE IF NOT EXISTS "dev@test-
rms-catalog".public.t1 (c1 INT, c2 VARCHAR(10));' —database arn:aws:glue:us-
east-1:550022730026:catalog/test-rms-catalog
```

Data sharing in Amazon Redshift

With Amazon Redshift, you can securely share data across Amazon Redshift clusters or with other AWS services. Data sharing lets you share live data, without having to create a copy or move it. Database administrators and data engineers can use data sharing to provide secure, read-only access to data for analytics purposes, while maintaining control over the data. Data analysts, business intelligence professionals, and data scientists can leverage shared data to gain insights without duplicating or moving data. Common use cases include sharing data with partners, enabling cross-functional analysis, and facilitating data democratization within an organization. The following sections cover the details of configuring and managing data sharing in Amazon Redshift.

With Amazon Redshift *data sharing*, you can securely share access to live data across Amazon Redshift clusters, workgroups, AWS accounts, and AWS Regions without manually moving or copying the data. Since the data is live, all users can see the most up-to-date and consistent information in Amazon Redshift as soon as it's updated.

You can share data across provisioned clusters, serverless workgroups, Availability Zones, AWS accounts, and AWS Regions. You can share between cluster types as well as between provisioned clusters and serverless.

You can share database objects for both reads and writes across different Amazon Redshift clusters or Amazon Redshift Serverless workgroups within the same AWS account, or from one AWS account to another. You can read and write data across Regions as well. You can grant permissions such as SELECT, INSERT, and UPDATE for different tables and USAGE and CREATE for different schemas. The data is live and available to all warehouses as soon as a write transaction is committed.

Data sharing use cases for Amazon Redshift

Amazon Redshift data sharing is especially useful for these use cases:

- **Supporting different kinds of business-critical workloads** – Use a central extract, transform, and load (ETL) cluster that shares data with multiple business intelligence (BI) or analytic clusters. This approach provides read workload isolation and chargeback for individual workloads. You can size and scale your individual workload compute according to the workload-specific requirements of price and performance.

- **Enabling cross-group collaboration –** Enable seamless collaboration across teams and business groups for broader analytics, data science, and cross-product impact analysis.
- **Delivering data as a service –** Share data as a service across your organization.
- **Sharing data between environments –** Share data among development, test, and production environments. You can improve team agility by sharing data at different levels of granularity.
- **Licensing access to data in Amazon Redshift –** List Amazon Redshift data sets in the AWS Data Exchange catalog that customers can find, subscribe to, and query in minutes.

Data sharing write-access use cases

Data sharing for writes has several important use cases:

- **Update business source data on the producer –** You can share data as a service across your organization, but then consumers can also perform actions on the source data. For instance, they can communicate back up-to-date values or acknowledge receipt of data. These are just a couple possible business use cases.
- **Insert additional records on the producer –** Consumers can add records to the original source data. These can be marked as from the consumer, if needed.

For information specifically regarding how to perform write operations on a datashare, see Sharing write access to data.

Data sharing at different levels in Amazon Redshift

With Amazon Redshift, you can share data at different levels. These levels include databases, schemas, tables, views (including regular, late-binding, and materialized views), and SQL user-defined functions (UDFs). You can create multiple datashares for a given database. A datashare can contain objects from multiple schemas in the database on which sharing is created.

By having this flexibility in sharing data, you get fine-grained access control. You can tailor this control for different users and businesses that need access to Amazon Redshift data.

Consistency management for data sharing in Amazon Redshift

Amazon Redshift provides transactional consistency on all producer and consumer clusters and shares up-to-date and consistent views of the data with all consumers.

You can continuously update data on the producer cluster. All queries on a consumer cluster within a transaction read the same state of the shared data. Amazon Redshift doesn't consider the data that was changed by another transaction on the producer cluster that was committed after the beginning of the transaction on the consumer cluster. After the data change is committed on the producer cluster, new transactions on the consumer cluster can immediately query the updated data.

The strong consistency removes the risks of lower-fidelity business reports that might contain invalid results during sharing of data. This factor is especially important for financial analysis or where the results might be used to prepare datasets that are used to train machine learning models.

Considerations for data sharing in Amazon Redshift

With Amazon Redshift *data sharing*, you can securely share access to live data across Amazon Redshift clusters, workgroups, AWS accounts, and AWS Regions without manually moving or copying the data. Previously, objects in datashares were read only in all circumstances. Writing to an object in a datashare is a new feature. Objects in datashares are only write-enabled when a producer specifically grants write privileges like INSERT or CREATE on objects to the datashare. Additionally, for cross-account sharing, a producer has to authorize the datashare for writes and the consumer has to associate specific clusters and workgroups for writes.

This section covers considerations when working with Amazon Redshift data sharing.

Topics

General considerations for data sharing in Amazon Redshift

The following are general considerations when working with datashares in Amazon Redshift:

- *Default database* – When you read data from a datashare, you remain connected to your local cluster database. For more information about setting up and reading from a database created from a datashare, see Querying datashare objects and Materialized views on external data lake tables in Amazon Redshift Spectrum.
- *Connections* – You must be connected directly to a datashare database or run the USE command to write to datashares. You can also use three-part notation. The USE command is not supported on external tables.
- *Performance* – The performance of the queries on shared data depends on the compute capacity of the consumer clusters.
- *Data transfer charges* – Cross-Region data sharing includes additional cross-Region data-transfer charges.
  - These data-transfer charges don't apply within the same Region, only across Regions. For more information, see Managing cost control for cross-Region data sharing.
  - The consumer is charged for all compute and cross-region data transfer fees required to query the producer's data. The producer is charged for the underlying storage of data in their provisioned cluster or serverless namespace.
- *Data sharing within and between clusters* – You only need datashares when you are sharing data between different Amazon Redshift provisioned clusters or serverless workgroups. Within the same cluster, you can query another database using simple three-part notation `database.schema.table` as long as you have the required permissions on the objects in the other database.
- *Metadata Discovery* – When you're a consumer connected directly to a datashare database through the Redshift JDBC, ODBC, or Python drivers, you can view catalog data in the following ways:
  - SQL SHOW commands.
  - Querying information_schema tables and views.
  - Querying SVV metadata views.
- *Permissions visibility* – Consumers can see the permissions granted to the datashares through the SHOW GRANTS SQL command.
- *Cluster encryption management for data sharing* – To share data across an AWS account, both the producer and consumer cluster must be encrypted.

- If both the producer and consumer clusters and serverless namespaces are in the same account, they must have the same encryption type (either both unencrypted, or both encrypted). In every other case, including Lake Formation managed datashares, both the consumer and producer must be encrypted. This is for security purposes. However, they don't need to share the same encryption key.
- To protect data in transit, all data is encrypted in transit through the encryption schema of the producer cluster. The consumer cluster adopts this encryption schema when data is loaded. The consumer cluster then operates as a normal encrypted cluster. Communications between the producer and consumer are also encrypted using a shared key schema. For more information about encryption in transit, Encryption in transit.

Considerations for data sharing reads and writes in Amazon Redshift

> **Note**
>
> Amazon Redshift multi-warehouse writes using data sharing is only supported on Amazon Redshift patch 186 for provisioned clusters on current track version 1.0.78881 or greater, and for Amazon Redshift Serverless workgroups on version 1.0.78890 or greater.

The following are considerations when working with datashare reads and writes in Amazon Redshift:

- You can only share SQL UDFs through datashares. Python and Lambda UDFs aren't supported.
- If the producer database has specific collation, use the same collation settings for the consumer database.
- Amazon Redshift doesn't support nested SQL user-defined functions on producer clusters.
- Amazon Redshift doesn't support sharing tables with interleaved sort keys and views that refer to tables with interleaved sort keys.
- Amazon Redshift doesn't support accessing a datashare object which had a concurrent DDL occur between the Prepare and Execute of the access.
- Amazon Redshift doesn't support sharing stored procedures through datashares.
- Amazon Redshift doesn't support sharing metadata system views and system tables.
- *Compute type* – You must use Serverless workgroups, ra3.large clusters, ra3.xlplus clusters, ra3.4xl clusters, or ra3.16xl clusters to use this feature.

- *Isolation level* – Your database's isolation level must be snapshot isolation in order to allow other Serverless workgroups and provisioned clusters to write to it.
- *Multi-statement queries and transactions* – Multi-statement queries outside of a transaction block aren't currently supported. As a result, if you are using a query editor like dbeaver and you have multiple write queries, you need to wrap your queries in an explicit BEGIN...END transaction statement.

  When multi-command statements are used outside of transactions, if the first command is a write to a producer database, subsequent write commands in the statement are only allowed to that producer database. If the first command is a read, subsequent write commands are only allowed to the used database, if set, otherwise to the local database. Note that the writes in a transaction are only supported to a single database.
- *Consumer sizing* – Consumer clusters must have at least 64 slices or more to perform writes using data sharing.
- *Views and materialized views* – You can't create, update, or alter views or materialized views on a datashare database.
- *Security* – You can't attach or remove security policies such as column-level (CLS), row-level (RLS) and dynamic data masking (DDM) to datashare objects.
- *Manageability* – Consumers warehouses can't add datashare objects or views referencing datashare objects to another datashare. Consumers also can't modify or drop an existing datashare.
- *Truncate operations* – Datashare writes support transactional truncates for remote tables. This is different than truncates that you run locally on a cluster, which are auto-commit. For more information about the SQL command, see TRUNCATE.

Considerations for data sharing with data lake tables in Amazon Redshift

The following are considerations when working with data lake tables in Amazon Redshift:

- Data sharing of data lake tables does not support customer managed AWS KMS keys for Amazon S3 bucket encryption. You can use AWS managed keys for encryption. For more information, see Using server-side encryption with Amazon S3 managed keys (SSE-S3) .
- To data share data lake tables from an encrypted AWS Glue catalog, you must delegate AWS KMS operations to an IAM role by following the instructions in Encrypting your Data Catalog.

- External tables that explicitly specify manifest files in the `LOCATION` clause aren't supported for data sharing. This includes the following tables that Amazon Redshift Spectrum supports:
  - Delta Lake
  - Hudi

Considerations for data sharing with AWS Lake Formation in Amazon Redshift

The following are considerations and limitations for sharing Amazon Redshift data with Lake Formation. For information on data sharing considerations and limitations, see Considerations when using data sharing in Amazon Redshift. For information about Lake Formation limitations, see Notes on working with Amazon Redshift datashares in Lake Formation.

- Sharing a datashare to Lake Formation across Regions is currently unsupported.
- If column-level filters are defined for a user on a shared relation, performing a `SELECT *` operation returns only the columns the user has access to.
- Cell-level filters from Lake Formation are unsupported.
- If you created and shared a view and its tables to Lake Formation, you can configure filters to manage access of the tables, Amazon Redshift enforces Lake Formation defined policies when consumer cluster users access shared objects. When a user accesses a view shared with Lake Formation, Redshift enforces only the Lake Formation policies defined on the view and not the tables contained within the view. However, when users directly access the table, Redshift enforces the defined Lake Formation policies on the table.
- You can't create materialized views on the consumer based on a shared table if the table has Lake Formation filters configured.
- The Lake Formation administrator must have data lake administrator permissions and the required permissions to accept a datashare.
- The producer consumer cluster must be an RA3 cluster with the latest Amazon Redshift cluster version or a serverless workgroup to share datashares via Lake Formation.
- Both the producer and consumer clusters must be encrypted.
- Redshift row-level and column-level access control policies implemented in the producer cluster or workgroup are ignored when the datashare is shared to Lake Formation. The Lake Formation administrator must configure these policies in Lake Formation. The producer cluster or workgroup administrator can turn off RLS for a table by using the ALTER TABLE command.

- Sharing datashares via Lake Formation is only available to users who have access to both Redshift and Lake Formation.

Considerations for data sharing with AWS Data Exchange in Amazon Redshift

When using AWS Data Exchange for Amazon Redshift, consider the following:

- Both producers and consumers must use the RA3 instance types to use Amazon Redshift datashares. Producers must use the RA3 instance types with the latest Amazon Redshift cluster version.
- Both the producer and consumer clusters must be encrypted.
- You must be registered as an AWS Data Exchange provider to list products on AWS Data Exchange, including products that contain AWS Data Exchange datashares. For more information, see Getting started as a provider.
- You don't need to be a registered AWS Data Exchange provider to find, subscribe to, and query Amazon Redshift data through AWS Data Exchange.
- To control access to your data, create AWS Data Exchange datashares with the publicly accessible setting turned on. To alter an AWS Data Exchange datashare to turn off the publicly accessible setting, set the session variable to allow ALTER DATASHARE SET PUBLICACCESSIBLE FALSE. For more information, see ALTER DATASHARE usage notes.
- Producers can't manually add or remove consumers from AWS Data Exchange datashares because access to the datashares is granted based on having an active subscription to an AWS Data Exchange product that contains the AWS Data Exchange datashare.
- Producers can't view the SQL queries that consumers run. They can only view metadata, such as the number of queries or the objects consumers query, through Amazon Redshift tables that only the producer can access. For more information, see Monitoring and auditing data sharing in Amazon Redshift.
- We recommend that you make your datashares publicly accessible. If you don't, subscribers on AWS Data Exchange with publicly accessible consumer clusters won't be able to use your datashare.
- We recommend that you don't delete an AWS Data Exchange datashare shared to other AWS accounts using the DROP DATASHARE statement. If you do, the AWS accounts that have access to the datashare will lose access. This action is irreversible. Performing this type of alteration can

breach data product terms in AWS Data Exchange. If you want to delete an AWS Data Exchange datashare, see DROP DATASHARE usage notes.

- For cross-Region data sharing, you can create AWS Data Exchange datashares to share licensed data.
- When consuming data from a different Region, the consumer pays the Cross-Region data transfer fee from the producer Region to the consumer Region.

Permissions you can grant to datashares

Different object types and various permissions you can grant to them in a data sharing context.

Databases:

- CREATE
- USAGE
- ALTER
- DROP

Schemas:

- CREATE
- USAGE
- ALTER
- DROP

Tables:

- SELECT
- INSERT
- UPDATE
- DELETE
- TRUNCATE
- DROP

- ALTER
- REFERENCES

Functions:

- EXECUTE

Supported SQL statements for data sharing writes on consumers

The following Data Definition Language (DDL) statements are supported for data sharing with writes:

- ALTER TABLE RENAME TO
- ALTER TABLE RENAME COLUMN TO
- ALTER TABLE ADD/DROP COLUMN
- ALTER SCHEMA RENAME TO
- { CREATE | DROP } SCHEMA
- { CREATE | DROP | SHOW } TABLE
- CREATE TABLE table_name AS
- BEGIN | START TRANSACTION
- END | COMMIT | ROLLBACK
- TRUNCATE

The following Data Manipulation Language (DML) statements are supported for data sharing with writes:

- SELECT
- INSERT
- INSERT INTO SELECT
- UPDATE
- DELETE
- MERGE

- COPY without COMPUPDATE

The following analyze statements are supported for data sharing with writes:

- ANALYZE. The consumer runs USER ANALYZE and sends the stats to the producer.
- Analyze activated by CTAS/COPY running on the consumer. This iIncludes multiplexing for small consumers.
- Auto-analyze run on the producer after COPY.

The following permission statements are supported for data sharing with writes:

- { GRANT | REVOKE } privilege_name ON OBJECT_TYPE object_name TO consumer_user
- SHOW GRANTS. For more information, see SHOW GRANTS.

Unsupported SQL statements for data sharing writes on consumers

The following aren't supported:

- Multi-statement queries to consumer warehouses when writing to producers.
- Multi-statement queries to consumer warehouses in a different database, if the previous command is a read statement.
- Object references other than three-dot notations, such as one.dot or two.dot notations, if not connected to shared database.
- Concurrency scaling queries writing from consumers to producers.
- Auto-copy jobs writing from consumers to producers.
- Streaming jobs writing from consumers to producers.
- Consumers creating zero-ETL integration tables on producer clusters. For more information about zero-ETL integrations, see Working with zero-ETL integrations.
- Writing to a table with an interleaved sort key through a data share.
- Writing to a stored procedure through a data share.
- Writing to a SQL user-defined functions (UDF) through a data share. These include nested, Python, and Lambda UDFs.
- UPDATE, INSERT, or COPY statements on identity columns to consumer warehouses with more compute slices than producer.

- MERGE statements on non-RMS external tables to consumer warehouses, when writing to producers.
- CREATE TABLE statements with:
  - DEFAULT expression set to data type VARBYTE. The VARBYTE data type can't be implicitly converted to any other data type. For more information, see CAST function.
  - AS OF SELECT statements with NULL parameter to consumer warehouses, when writing to producers.
  - LIKE parameter to consumer warehouses, when writing to producers.

AWS Regions where data sharing is available

The following table lists availability for both data sharing read and write capabilities.

Region	Same-region data sharing	Cross-region data sharing	AWS Lake Formation governed datashares
US East (N. Virginia) (us-east-1)	Yes	Yes	Yes
US East (Ohio) (us-east-2)	Yes	Yes	Yes
US West (N. California) (us-west-1)	Yes	Yes	Yes
US West (Oregon) (us-west-2)	Yes	Yes	Yes
Asia Pacific (Hong Kong) (ap-east-1)	Yes	No	No
Asia Pacific (Mumbai) (ap-south-1)	Yes	Yes	Yes
Asia Pacific (Hyderabad) (ap-south-2)	Yes	No	No

Region	Same-region data sharing	Cross-region data sharing	AWS Lake Formation governed datashares
Asia Pacific (Tokyo) (ap-northeast-1)	Yes	Yes	Yes
Asia Pacific (Singapore) (ap-southeast-1)	Yes	Yes	Yes
Asia Pacific (Sydney) (ap-southeast-2)	Yes	Yes	Yes
Asia Pacific (Jakarta); (ap-southeast-3)	Yes	No	No
Asia Pacific (Melbourne) (ap-southeast-4)	Yes	No	No
Asia Pacific (Seoul) (ap-northeast-2)	Yes	Yes	Yes
Asia Pacific (Osaka) (ap-northeast-3)	Yes	Yes	Yes
China (Beijing) (cn-north-1)	Yes	Yes	Yes
China (Ningxia) (cn-northwest-1)	Yes	Yes	Yes
Africa (Cape Town) (af-south-1)	Yes	No	No
Canada West (Calgary) (ca-west-1)	Yes	No	No
Canada (Central) (ca-central-1)	Yes	Yes	Yes

Region	Same-region data sharing	Cross-region data sharing	AWS Lake Formation governed datashares
Europe (Frankfurt) (eu-central-1)	Yes	Yes	Yes
Europe (Zurich) (eu-central-2)	Yes	No	No
Europe (Ireland) (eu-west-1)	Yes	Yes	Yes
Europe (London) (eu-west-2)	Yes	Yes	Yes
Europe (Paris) (eu-west-3)	Yes	Yes	Yes
Europe (Milan) (eu-south-1)	Yes	No	No
Europe (Spain) (eu-south-2)	Yes	No	No
Europe (Stockholm) (eu-north-1)	Yes	Yes	Yes
Middle East (UAE) (me-central-1)	Yes	No	No
Middle East (Bahrain) (me-south-1)	Yes	No	No
Israel (Tel Aviv) (il-central-1)	Yes	No	No
South America (São Paulo) (sa-east-1)	Yes	Yes	Yes

Region	Same-region data sharing	Cross-region data sharing	AWS Lake Formation governed datashares
AWS GovCloud (US-East) (us-gov-east-1)	Yes	No	Yes
AWS GovCloud (US-West) (us-gov-west-1)	Yes	No	Yes

Getting started with data sharing in Amazon Redshift

You can get started with data sharing by following one of the guides in this section.

Topics

Getting started with read-only data sharing in the console

With Amazon Redshift, you can manage data sharing with writes using the console to control access and govern data across Amazon Redshift clusters and AWS accounts. The following sections provide step-by-step instructions on configuring and managing data sharing with writes using the Amazon Redshift console.

Use the Amazon Redshift console to manage datashares created in your account or shared from other accounts.

You need permissions to create, edit, or delete datashares. For information, see Managing permissions for a datashares in Amazon Redshift.

- If you are a producer administrator, you can create datashares, add data consumers, add datashare objects, create databases from datashares, edit datashares, or delete datashares from the **CLUSTERS** tab.

From the navigation menu, navigate the **Clusters** tab, choose a cluster from the cluster list. Then do one of the following:

- Choose the **Datashares** tab, choose a datashare from the **Datashares created in my namespace** section. Then do one of the following:
  - Create a datashare

    When a datashare is created, you can add datashare objects or data consumers. For more information, see Add datashare objects to datashares and Add data consumers to datashares.
  - Editing datashares created in your account
  - Deleting a datashare created in your account
- Choose **Datashares** and choose a datashare from the **Datashares from other clusters** section. Then do one of the following:
  - Create a datashare
  - Creating databases from datashares
- Choose **Databases** and choose a database from the **Databases** section. Then choose **Create datashare**. For more information, see Creating databases from datashares.

> **Note**
>
> To view databases and objects within databases or to view datashares in the cluster, connect to a database. For more information, see Connecting to a database.

Connecting to a database

With Amazon Redshift, you can establish a connection to your data warehouse cluster and execute SQL queries, load data, or perform administrative tasks. Connecting to a database refers to the process of creating a secure channel between a client application or tool and the Amazon Redshift cluster. The following sections will provide step-by-step instructions on how to connect to an Amazon Redshift database.

Connect to a database to view databases and objects within databases in this cluster or to view datashares.

The user credentials used to connect to a specified database must have the necessary permissions to view all datashares.

If there is no local connection, do one of the following:

- In the cluster details page, from the **Databases** tab, in the **Databases** or **Datashare objects** section, choose **Connect to database** to view database objects in the cluster.
- In the cluster details page, from the **Datashares** tab, do one of the following:
  - In the **Datashares from other clusters** section, choose **Connect to database** to view datashares from other clusters.
  - In the **Datashares created in my cluster** section, choose **Connect to database** to view datashares in your cluster.
- On the **Connect to database** window, do one of the following:
  - If you choose **Create a new connection**, choose **AWS Secrets Manager** to use a stored secret to authenticate access for the connection.

    Or, choose **Temporary credentials** to use database credentials to authenticate access for the connection. Specify values for **Database name** and **Database user**.

    Choose **Connect**.
  - Choose **Use a recent connection** to connect to another database that you have the necessary permissions.

    Amazon Redshift automatically makes the connection.

After a database connection is established, you can start creating datashares, querying datashares, or creating databases from datashares.

Creating datashares

With Amazon Redshift, you can share live data across Amazon Redshift clusters or AWS accounts using datashares. A datashare is a consumer-producer object that allows you to share live data from your Amazon Redshift cluster with other clusters or AWS accounts. Creating datashares enables secure data sharing while maintaining control over access and ensuring data remains up-to-date. The following sections provide details on creating datashares and adding database objects such as schemas, tables, and views to share live data securely.

Create a datashare

A datashare is a logical container of database objects, permissions, and consumers. Consumers are Amazon Redshift provisioned clusters or Amazon Redshift Serverless namespaces in your account and other AWS accounts. Each datashare is associated with the database it's created in and only objects from that database can be added. As a producer administrator, you can create datashares on the console and with SQL by following one of the below procedures.

Console

On the console, you can create datashares from the **Datashares** tabs in the cluster or namespace details page. After the datashare is created, you can create databases from the datashare on a consumer as a consumer administrator.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. In the cluster or namespace details page, from the **Datashares** tab, in the **Datashares** section, connect to a database if you don't have a database connection. In the **Datashares created in my account** section, choose **Create datashare**. The **Create datashare** page appears.
4. Choose **Create datashare**. You can only create a datashare from a local database. If you haven't connected to the database, the **Connect to database** page appears. Follow the steps in Connecting to a database to connect to a database. If there is a recent connection, the **Create datashare** page appears.
5. In the **Datashare information** section, choose one of the following:
   - Choose **Datashare** to create datashares to share data for read or write purpose across different Amazon Redshift data warehouses (provisioned clusters or Serverless endpoints) or in the same AWS account or different AWS accounts.
   - Choose **AWS Data Exchange datashare** to create datashares to license your data through AWS Data Exchange.
6. Specify values for **Datashare name**, **Database name**, and **Publicly accessible**. When you change the database name, make a new database connection.
7. Add objects to your datashare either using the **Scoped permissions** or **Direct permissions** sections. To add objects to a datashare, see Creating a datashare in Amazon Redshift.

8. In the **Data consumers** section, you can choose to publish to Amazon Redshift, or publish to the AWS Glue Data Catalog, which starts the process of sharing data with Lake Formation. Publishing your datashare to Amazon Redshift means sharing your data with another namespace or Amazon Redshift account that acts as the consumer.

> **Note**
>
> Once the datashare is created, you can't edit the configuration to publish to the other option.

9. Choose **Create datashare**.

SQL

The following command creates a datashare:

```
CREATE DATASHARE salesshare;
```

At the time of datashare creation, each datashare is associated with a database. Only objects from that database can be shared in that datashare. Multiple datashares can be created on the same database with the same or different granularity of objects. There is no limit on the number of datashares a cluster can create. You can also use the Amazon Redshift console to create datashares. For more information, see CREATE DATASHARE.

You can also control security restrictions to the datashare during creation. The following example shows that the consumer with a public IP access is allowed to read the datashare.

```
CREATE DATASHARE my_datashare [PUBLICACCESSIBLE = TRUE];
```

Setting PUBLICACCESSIBLE = TRUE allows consumers to query your datashare from publicly accessible clusters and provisioned workgroups. Leave this out or explicitly set it to false if you do not want to allow it.

You can modify properties about the type of consumers after you create a datashare. For example, you can define that clusters that want to consume data from a given datashare can't be publicly accessible. Queries from consumer clusters that don't meet security restrictions specified in datashare are rejected at query runtime. For more information, see ALTER DATASHARE.

Add datashare objects to datashares

You can add database objects of various types on the console and with SQL by following one of the below procedures.

Console

You can add objects to your datashare either using **Scoped permissions** or **Direct permissions** sections. Select either **Grant scoped permissions** or **Grant direct permissions** to add objects. Select the **Add** button to add objects. A dialog appears. Perform the following steps:

1. If you select **Grant scoped permissions**, the **Grant scoped permissions** page appears where you can grant scoped permissions at either a database or a schema level. Datashares with scoped permissions have the specified permissions on all current and future objects within the database or schema. For more details see, [Scoped permissions](#).

    1. Next, select **Database scoped permissions** to grant scoped permissions at the database level. When you grant scoped permissions, they apply to the current database while creating the datashare. These permissions can't be granted to individual objects and are applicable to both existing and new objects (schemas, tables, views, UDFs).
    2. Select the scoped permission(s) for the schemas, table or views or user-defined functions. This means all objects in the database have the selected permissions granted to consumers. Select **Grant** to complete granting database scoped permissions.
    3. Then, select **Schema scoped permissions** to grant scoped permissions at the schema level. When you grant schema-scoped permissions, all objects added to the schema have the specified datashare permissions.
    4. Select the schema you want to add to the datashare from the dropdown. You can select only a single schema at a time. Then, select direct permission(s) you want to grant on the selected schema.
    5. Select scoped permission(s) for your schema objects such as tables, views and user-defined functions. Permissions are granted on all matching objects in the schema. These can be either existing objects or those added in the future. When it's applied, you can't remove a permission from an object without revoking the scoped permissions.
    6. Select **Grant** to complete granting schema scoped permissions.

2. If you select **Grant direct permissions**, the **Grant direct permissions** page appears where you can grant direct permissions at each objects level such as schema, table, view or user-

defined function. To grant direct permissions, you must first add the relevant schemas to the datashare.

1. Next, select **Grant direct permissions** to schemas to apply direct permissions on specific schema. Then, select schema permission(s) for your schema objects such as tables, views and user-defined functions and select the schema you want added to the datashare. Select **Grant** to complete adding schema to the datashare.
2. After you have a schema added to your datashare, you can proceed with adding direct permissions for your schema objects. Select **Grant direct permissions** again. The **Grant direct permissions** page appears. Then, navigate to the direct permissions tabs for schema objects.
3. Select **Grant direct permissions to tables and views** to grant object level direct permissions on these objects. Select the required direct permission(s) and the required objects from the list. Use the search field to find datashare objects. Select Grant to complete adding tables and views to the datashare.
4. Select **Grant direct permissions to user-defined functions** to grant object level direct permissions on user-defined functions. Select the required direct permission(s) and the required objects from the list. Use the search field to find datashare objects. Select **Grant** to complete adding user-defined functions to the datashare.

3. You can also choose whether you want to **Add future objects**. When you choose to include datashare objects added to the schema, it means that objects added to the schema are added to the datashare automatically.
4. Choose **Add** to complete the section and add the objects. They're listed under the **Datashare objects**.
5. After you add objects, you can select individual objects and edit their permissions. If you select a schema, a dialog appears that asks if you would like to add **Scoped permissions**. This makes it so each existing or added object to the schema has a pre-selected set of permissions, appropriate for the object type. For instance, the administrator can set that all added tables have SELECT and UPDATE permissions, for instance.
6. All datashare objects are listed under the **Scoped permissions** or **Direct permissions** sections.
7. In the **Data consumers** section, you can add namespaces or add AWS accounts as consumers of the datashare.
8. Choose **Create datashare** to save your changes.

After you create the datashare, it appears in the list under **Datashares created in my namespace**. If you choose a datashare from the list, you can view its consumers, its objects, and other properties.

SQL

With SQL, the datashare owner must grant USAGE on the schemas they want to add to the datashare. The GRANT is used to grant various actions on the schema, including CREATE and USAGE. The schemas hold shared objects:

```
CREATE SCHEMA myshared_schema1;
CREATE SCHEMA myshared_schema2;

GRANT USAGE ON SCHEMA myshared_schema1 TO DATASHARE my_datashare;
GRANT CREATE, USAGE ON SCHEMA myshared_schema2 TO DATASHARE my_datashare;
```

Alternatively, the administrator can continue to run ALTER commands to add a schema to the datashare. Only USAGE permissions are granted when a schema is added this way.

```
ALTER DATASHARE my_datashare ADD SCHEMA myshared_schema1;
```

After the administrator adds schemas, they can grant datashare permissions on objects in the schema. These can be both read and write permissions. The GRANT ALL sample shows how to grant all permissions.

```
GRANT SELECT, INSERT ON TABLE myshared_schema1.table1, myshared_schema1.table2,
 myshared_schema2.table1
TO DATASHARE my_datashare;

GRANT ALL ON TABLE myshared_schema1.table4 TO DATASHARE my_datashare;
```

You can continue to run commands like ALTER DATASHARE to add tables. When you do, only SELECT permissions are granted on the objects added.

```
ALTER DATASHARE my_datashare ADD TABLE myshared_schema1.table1,
 myshared_schema1.table2, myshared_schema2.table1;
```

You can grant scoped permissions to a datashare on all objects of a type within a database or schema. Datashares with scoped permissions have the specified permissions on all current and future objects within the database or schema.

You can view the scope of database-level scoped permissions in SVV_DATABASE_PRIVILEGES. You can view the scope of schema-level scoped permissions in SVV_SCHEMA_PRIVILEGES.

The following is the syntax for granting scoped permissions to datashares. For more information about scoped permissions, see Scoped permissions.

```
GRANT { CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }FOR SCHEMAS IN
DATABASE db_name
TO DATASHARE { datashare_name}

GRANT { { SELECT | INSERT | UPDATE | DELETE | DROP | ALTER | TRUNCATE | REFERENCES }
 [, ...] } | ALL [PRIVILEGES] } }FOR TABLES IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO DATASHARE { datashare_name}

GRANT { EXECUTE | ALL [ PRIVILEGES ] }FOR FUNCTIONS IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO DATASHARE { datashare_name}
```

Add data consumers to datashares

You can add one or more data consumers to the datashares. Data consumers can be namespaces that uniquely identified Amazon Redshift clusters or AWS accounts.

You must explicitly choose to turn off or turn on sharing your datashare to clusters with public access.

- Choose **Add namespaces to the datashare**. Namespaces are globally unique identifier (GUID) for Amazon Redshift cluster.
- Choose **Add AWS accounts** to the datashare. The specified AWS accounts must have access permissions to the datashare.

Authorizing or removing authorization from datashares

As a producer administrator, choose which data consumers to authorize to access datashares or to remove authorization from. Authorized data consumers receive notifications to take actions on datashares. If you are adding a namespace as a data consumer, you don't have to perform authorization.

Prerequisite: To authorize or remove authorization for the datashare, there must be at least one data consumer added to the datashare.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Datashares**. The datashare list page appears.
3. Choose **In my account**.
4. In the **Datashares in my account** section, do one of the following:
   - Choose one or more consumer clusters that you want to authorize. The Authorize data consumers page appears. Then choose **Authorize**.

     If you chose **Publish to AWS Glue Data Catalog** when creating the datashare, you can only grant authorization of the datashare to a Lake Formation account.

     For AWS Data Exchange datashare, you can only authorize one datashare at a time.

     When you authorize an AWS Data Exchange datashare, you are sharing the datashare with the AWS Data Exchange service and allowing AWS Data Exchange to manage access to the datashare on your behalf. AWS Data Exchange allows access to consumers by adding consumer accounts as data consumers to the AWS Data Exchange datashare when they subscribe to the products. AWS Data Exchange doesn't have read access to the datashare.
   - Choose one or more consumer clusters that you want to remove authorization from. Then choose **Remove authorization**.

After data consumers are authorized, they can access datashare objects and create a consumer database to query the data.

After authorization is removed, data consumers lose access to the datashare immediately.

Managing datashares from other accounts as a consumer

Removing association of datashare from data consumers

As a consumer administrator, you can remove association of datashares from data consumers.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Datashares**. The datashare list page appears.

3. Choose **From other accounts**.
4. In the **Datashares from other accounts** section, choose the datashare to remove association from data consumers.
5. In the **Data consumers** section, choose one or more data consumers to remove association from. Then choose **Remove association**.
6. When the Remove association page appears, choose **Remove association**.

After association is removed, data consumers will lose access to the datashare. You can change the data consumer association at any time.

Declining datashares

As a consumer administrator, you can reject any datashare whose state is available or active. After you reject a datashare, consumer cluster users lose access to the datashare. Amazon Redshift doesn't return the rejected datashare if you call the `DescribeDataSharesForConsumer` API operation. If the producer administrator runs the `DescribeDataSharesForProducer` API operation, they will see that the datashare was rejected. Once a datashare is rejected, the producer administrator can authorize the datashare to a consumer cluster again, and the consumer administrator can choose to associate their AWS account with the datashare or reject it.

If your AWS account has an association to a datashare and a pending association to a datashare that's managed by Lake Formation, rejecting the datashare association that's managed by Lake Formation also rejects the original datashare. To reject a specific association, the producer administrator can remove authorization from a specified datashare. This action doesn't affect other datashares.

To reject a datashare, use the AWS console, the API operation `RejectDataShare`, or `reject-datashare` in the AWS CLI.

To reject a datashare using the AWS console:

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. In the navigation menu, choose **Datashares**.
3. Choose **From other accounts**.
4. In the **Datashares from other accounts** section, choose the datashare you want to decline. When the **Decline datashare** page appears, choose **Decline**.

After you decline the datashares, you can't revert the change. Amazon Redshift removes the datashares from the list. To see the datashare again, the producer administrator must authorize it again.

Managing existing datashares

With Amazon Redshift, you can manage existing datashares to control access to your data in an Amazon Redshift cluster. The following sections provide step-by-step guidance on managing datashares in your Amazon Redshift environment.

Viewing datashares

View datashares from the **DATASHARES** or **CLUSTERS** tab.

- Use the **DATASHARES** tab to list datashares in your account or from other accounts.
  - To view datashares created in your account, choose **In my account**, then choose the datashare you want to view.
  - To view datashares that are shared from other accounts, choose **From other accounts**, then choose the datashare you want to view.
- Use the **CLUSTERS** tab to list datashares in your cluster or from other clusters.

  Connect to a database. For more information, see Connecting to a database.

  Then choose a datashare either from the **Datashares from other clusters** or **Datashares created in my cluster** section to view its details.

Removing datashare objects from datashares

You can remove one or more objects from a datashare by using the following procedure.

To remove one or more objects from a datashare

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**.
4. In the **Datashares created in my account** section, choose **Connect to database**. For more information, see Connecting to a database.

5. Choose the datashare you want to edit, then choose **Edit**. The datashare details page appears.
6. To remove one or more datashare objects to the datashare, do one of the following:

   - To remove schemas from the datashare, choose one or more schemas. Then choose **Remove**. Amazon Redshift removes the specified schemas and all the objects of the specified schemas from the datashare.
   - To remove tables and views from the datashare, choose one or more tables and views. Then choose **Remove**. Alternatively, choose **Remove by schema** to remove all tables and views in the specified schemas.
   - To remove user-defined functions from the datashare, choose one or more user-defined functions. Then choose **Remove**. Alternatively, choose **Remove by schema** to remove all user-defined functions in the specified schemas.

Removing data consumers from datashares

You can remove one or more data consumers from a datashare. Data consumers can be namespaces that uniquely identified Amazon Redshift clusters or AWS accounts.

Choose one or more data consumers either from the namespace IDs or AWS account, then choose **Remove**.

Amazon Redshift removes the specified data consumers from the datashare. They lose access to the datashare immediately.

Editing datashares created in your account

Edit datashares created in your account using the console. Connect to a database first to see the list of datashares created in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**.
4. In the **Datashares created in my account** section, choose **Connect to database**. For more information, see [Connecting to a database](#).
5. Choose the datashare you want to edit, then choose **Edit**. The datashare details page appears.
6. Make any changes in the **Datashare objects** or **Data consumers** section.

Note

If you chose to publish your datashare to the AWS Glue Data Catalog, you can't edit the configuration to publish the datashare to other Amazon Redshift accounts.

7. Choose **Save changes**.

Amazon Redshift updates your datashare with the changes.

Deleting a datashare created in your account

Delete datashares created in your account using the console. Connect to a database first to see the list of datashares created in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**. The datashare list appears.
4. In the **Datashares created in my account** section, choose **Connect to database**. For more information, see Connecting to a database.
5. Choose one or more datashares you want to delete, then choose **Delete**. The Delete datashares page appears.

   Deleting a datashare shared with Lake Formation doesn't automatically remove the associated permissions in Lake Formation. To remove them, go to the Lake Formation console.
6. Type **Delete** to confirm deleting the specified datashares.
7. Choose **Delete**.

After datashares are deleted, datashare consumers lose access to the datashares.

Querying datashares

With Amazon Redshift, you can query data across datashares from producer clusters to securely access live data without copying or transferring it. The following sections cover the details of setting up and querying datashares in your Amazon Redshift environment.

Creating databases from datashares

To start querying data in the datashare, create a database from a datashare. You can create only one database from a specified datashare.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**. The datashare list appears.
4. In the **Datashares from other clusters** section, choose **Connect to database**. For more information, see Connecting to a database.
5. Choose a datashare that you want to create databases from, then choose **Create database from datashare**. The Create database from datashare page appears.
6. In the **Database name**, specify a database name. The database name must be 1–64 alphanumeric characters (lowercase only) and it can't be a reserved word.
7. Choose **Create**.

After the database is created, you can query data in the database.

Managing AWS Data Exchange datashares

With Amazon Redshift, you can securely share and receive live data from AWS Data Exchange without having to create and manage data extracts or pipelines. Managing AWS Data Exchange datashares allows you to subscribe to third-party data products and integrate live data streams directly into your Amazon Redshift data warehouse. The following sections demonstrate managing AWS Data Exchange datashares within your Amazon Redshift clusters.

Creating data sets on AWS Data Exchange

Create data sets on AWS Data Exchange.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**.

4. In the **Datashares created in my account** section, choose an AWS Data Exchange datashare.
5. Choose **Create data set on AWS Data Exchange**. For more information, see [Publishing a new product](#).

Editing AWS Data Exchange datashares

Edit AWS Data Exchange datashares using the console. Connect to a database first to see the list of datashares created in your account.

For AWS Data Exchange datashares, you can't make changes to data consumers.

To edit the publicly accessible setting for AWS Data Exchange datashares, use the Query editor v2. Amazon Redshift generates a random one-time value to set the session variable to allow turning this setting off. For more information, see [ALTER DATASHARE usage notes](#).

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. From the navigator menu, choose **Editor**, then **Query editor v2**.
4. If this is the first time you use the Query editor v2, configure your AWS account. By default, an AWS owned key is used to encrypt resources. For more information about configuring your AWS account, see [Configuring your AWS account](#) in the *Amazon Redshift Management Guide*.
5. To connect to the cluster that your AWS Data Exchange datashare is in, choose **Database** and the cluster name in the tree-view panel. If prompted, enter the connection parameters.
6. Copy the following SQL statement. The following example changes the publicly accessible setting of the salesshare datashare.

```
ALTER DATASHARE salesshare SET PUBLICACCESSIBLE FALSE;
```

7. To run the copied SQL statement, choose **Queries** and paste the copied SQL statement in the query area. Then choose **Run**.

   An error appears following:

```
ALTER DATASHARE salesshare SET PUBLICACCESSIBLE FALSE;
ERROR:  Alter of ADX-managed datashare salesshare requires session variable
 datashare_break_glass_session_var to be set to value 'c670ba4db22f4b'
```

The value 'c670ba4db22f4b' is a random one-time value that Amazon Redshift generates when an unrecommended operation occurs.

8. Copy and paste the following sample statement into the query area. Then run the command. The SET `datashare_break_glass_session_var` command applies a permission to allow an unrecommended operation for an AWS Data Exchange datashare.

```
SET datashare_break_glass_session_var to 'c670ba4db22f4b';
```

9. Run the ALTER DATASHARE statement again.

```
ALTER DATASHARE salesshare;
```

Amazon Redshift updates your datashare with the changes.

Deleting AWS Data Exchange datashares created in your account

Delete AWS Data Exchange datashares created in your account using the console. Connect to a database first to see the list of datashares created in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. From the navigator menu, choose **Editor**, then **Query editor v2**.
4. If this is the first time you use the Query editor v2, configure your AWS account. By default, an AWS owned key is used to encrypt resources. For more information about configuring your AWS account, see [Configuring your AWS account]() in the *Amazon Redshift Management Guide*.
5. To connect to the cluster that your AWS Data Exchange datashare is in, choose **Database** and the cluster name in the tree-view panel. If prompted, enter the connection parameters.
6. Copy the following SQL statement. The following example drops the salesshare datashare.

```
DROP DATASHARE salesshare
```

7. To run the copied SQL statement, choose **Queries** and paste the copied SQL statement in the query area. Then choose **Run**.

   An error appears following:

```
ERROR:  Drop of ADX-managed datashare salesshare requires session variable
 datashare_break_glass_session_var to be set to value '620c871f890c49'
```

The value '620c871f890c49' is a random one-time value that Amazon Redshift generates when an unrecommended operation occurs.

8. Copy and paste the following sample statement into the query area. Then run the command. The SET `datashare_break_glass_session_var` command applies a permission to allow an unrecommended operation for an AWS Data Exchange datashare.

```
SET datashare_break_glass_session_var to '620c871f890c49';
```

9. Run the DROP DATASHARE statement again.

```
DROP DATASHARE salesshare;
```

After the datashare is deleted, datashare consumers lose access to the datashare.

Deleting a shared AWS Data Exchange datashare can breach data product terms in AWS Data Exchange.

Getting started with read-only data sharing with the SQL interface

With Amazon Redshift, you can securely share data across Amazon Redshift clusters, enabling data consumers to query and access live data without copying or replicating it. Data sharing lets you create and configure datashares, which are producer-side objects that reference the database objects you want to share.

You can share data for read purposes across different Amazon Redshift clusters within or across AWS accounts, or across AWS Regions.

Topics

- Sharing read access to data within an AWS account
- Working with views in Amazon Redshift data sharing
- Adding data lake tables to a datashare
- Sharing data across AWS accounts
- Sharing data across AWS Regions

- Sharing licensed Amazon Redshift data on AWS Data Exchange
- Getting started with AWS Lake Formation-managed datashares

Sharing read access to data within an AWS account

With Amazon Redshift, you can share read access to data across different database users or groups within the same AWS account. This feature allows you to control data access privileges at a granular level, ensuring that only authorized users or groups can read specific data sets.

Share data for read purposes as a producer administrator or database owner

1. Create datashares in your cluster. For more information, see CREATE DATASHARE.

   ```
   CREATE DATASHARE salesshare;
   ```

   Cluster superuser and database owners can create datashares. Each datashare is associated with a database during creation. Only objects from that database can be shared in that datashare. Multiple datashares can be created on the same database with the same or different granularity of objects. There is no limit on the number of datashares a cluster can create.

   You can also use the Amazon Redshift console to create datashares. For more information, see Create a datashare.

2. Delegate permissions to operate on the datashare. For more information, see GRANT or REVOKE.

   The following example grants permissions to `dbuser` on `salesshare`.

   ```
   GRANT ALTER, SHARE ON DATASHARE salesshare TO dbuser;
   ```

   Cluster superusers and the owners of the datashare can grant or revoke modification permissions on the datashare to additional users.

3. Add objects to or remove objects from datashares. To add objects to a datashare, add the schema before adding objects. When you add a schema, Amazon Redshift doesn't add all the objects under it. Make sure to add these explicitly. For more information, see ALTER DATASHARE.

```
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD ALL TABLES IN SCHEMA PUBLIC;
```

You can also add views to a datashare.

```
CREATE VIEW public.sales_data_summary_view AS SELECT * FROM
 public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD VIEW public.sales_data_summary_view;
```

Use ALTER DATASHARE to share schemas, and tables, views, and functions in a given schema. Superusers, datashare owners, or users who have ALTER or ALL permission on the datashare can alter the datashare to add objects to or remove objects from it. Users should have the permissions to add or remove objects from the datashare. Users should also be the owners of the objects or have SELECT, USAGE, or ALL permissions on the objects.

You can also use GRANT to add objects to the datashare. This example shows how:

```
GRANT SELECT ON TABLE public.tickit_sales_redshift TO DATASHARE salesshare;
```

This syntax is functionally equivalent to `ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;`.

Use the INCLUDENEW clause to add any new tables, views, or SQL user-defined functions (UDFs) created in a specified schema to the datashare. Only superusers can change this property for each datashare-schema pair.

```
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
ALTER DATASHARE salesshare SET INCLUDENEW = TRUE FOR SCHEMA PUBLIC;
```

You can also use the Amazon Redshift console to add or remove objects from datashares. For more information, see Add datashare objects to datashares, Removing datashare objects from datashares, and Editing datashares created in your account.

4. Add consumers to or remove consumers from datashares. The following example adds the consumer namespace to `salesshare`. The namespace is the namespace globally unique identifier (GUID) of the consumer cluster in the account. For more information, see GRANT or REVOKE.

```
GRANT USAGE ON DATASHARE salesshare TO NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

You can only grant permissions to one datashare consumer in a GRANT statement.

Cluster superusers and the owners of datashare objects or users that have SHARE permission on the datashare can add consumers to or remove consumers from a datashare. To do so, they use GRANT USAGE or REVOKE USAGE.

To find the namespace of the cluster that you currently see, you can use the SELECT CURRENT_NAMESPACE command. To find the namespace of a different cluster within the same AWS account, go to the Amazon Redshift console cluster details page. On that page, find the newly added namespace field.

You can also use the Amazon Redshift console to add or remove data consumers for datashares. For more information, see Add data consumers to datashares and Removing data consumers from datashares.

5. (Optional) Add security restrictions to the datashare. The following example shows that the consumer cluster with a public IP access is allowed to read the datashare. For more information, see ALTER DATASHARE.

```
ALTER DATASHARE salesshare SET PUBLICACCESSIBLE = TRUE;
```

You can modify properties about the type of consumers after datashare creation. For example, you can define that clusters that want to consume data from a given datashare can't be publicly accessible. Queries from consumer clusters that don't meet security restrictions specified in datashare are rejected at query runtime.

You can also use the Amazon Redshift console to edit datashares. For more information, see Editing datashares created in your account.

6. List datashares created in the cluster and look into the contents of the datashare.

The following example displays the information of a datashare named `salesshare`.

```
DESC DATASHARE salesshare;

 producer_account  |          producer_namespace          | share_type | share_name
 | object_type |           object_name          |   include_new
```

```
-------------------+---------------------------------------+------------
+------------+-------------+---------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_users_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_venue_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_category_redshift|
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_date_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_event_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_listing_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | table        | public.tickit_sales_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | schema       | public                          |  t
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND    | salesshare
 | view         | public.sales_data_summary_view |
```

The following example displays the outbound datashares in a producer cluster.

```
SHOW DATASHARES LIKE 'sales%';
```

The output looks similar to the following.

```
share_name | share_owner  | source_database | consumer_database | share_type |
 createdate       | is_publicaccessible  | share_acl | producer_account |
 producer_namespace
-----------+--------------+-----------------+-------------------+------------
+---------------------+----------------------+-----------+------------------
+-------------------------------------
salesshare |    100       | dev             |                   |  OUTBOUND
 | 2020-12-09 02:27:08 |          True        |           |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

For more information, see DESC DATASHARE and SHOW DATASHARES.

You can also use SVV_DATASHARES, SVV_DATASHARE_CONSUMERS, and SVV_DATASHARE_OBJECTS to view the datashares, the objects within the datashare, and the datashare consumers.

7. Drop datashares. For more information, see DROP DATASHARE.

   You can delete the datashare objects at any point using DROP DATASHARE. Cluster superusers and owners of datashare can drop datashares.

   The following example drops a datashare named `salesshare`.

   ```
   DROP DATASHARE salesshare;
   ```

   You can also use the Amazon Redshift console to delete datashares. For more information, see Deleting a datashare created in your account.

8. Use ALTER DATASHARE to remove objects from datashares at any point from the datashare. Use REVOKE USAGE ON to revoke permissions on the datashare to certain consumers. It revokes USAGE permissions on objects within a datashare and instantly stops access to all consumer clusters. Listing datashares and the metadata queries, such as listing databases and tables, doesn't return the shared objects after access is revoked.

   ```
   ALTER DATASHARE salesshare REMOVE TABLE public.tickit_sales_redshift;
   ```

   You can also use the Amazon Redshift console to edit datashares. For more information, see Editing datashares created in your account.

9. Revoke access to the datashare from namespaces if you don't want to share the data with the consumers anymore.

   ```
   REVOKE USAGE ON DATASHARE salesshare FROM NAMESPACE
    '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
   ```

   You can also use the Amazon Redshift console to edit datashares. For more information, see Editing datashares created in your account.

Share data for read purposes as a consumer administrator

1. List the datashares that are made available to you and view the content of datashares. For more information, see DESC DATASHARE and SHOW DATASHARES.

   The following example displays the information of inbound datashares of a specified producer namespace. When you run DESC DATASHARE as a consumer administrator, you must specify the NAMESPACE option to view inbound datashares.

```
DESC DATASHARE salesshare OF NAMESPACE '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';


 producer_account  |          producer_namespace          | share_type | share_name
 | object_type |           object_name             |   include_new
-------------------+--------------------------------------+------------
+------------+-------------+-----------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_users_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_venue_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_category_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_date_redshift      |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_event_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_listing_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_sales_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | schema      | public                           |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | view        | public.sales_data_summary_view   |
```

   Only cluster superusers can do this. You can also use SVV_DATASHARES to view the datashares and SVV_DATASHARE_OBJECTS to view the objects within the datashare.

   The following example displays the inbound datashares in a consumer cluster.

```
SHOW DATASHARES LIKE 'sales%';
```

```
 share_name | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace
------------+-------------+-----------------+-------------------+------------
+------------+---------------------+-----------+------------------
+-------------------------------------
 salesshare |             |                 |                   | INBOUND
    |            |          t          |           |    123456789012    |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

2. As a database superuser, you can create local databases that reference to the datashares. For more information, see CREATE DATABASE.

```
CREATE DATABASE sales_db FROM DATASHARE salesshare OF NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

   If you want more granular control over access to the objects in the local database, use the WITH PERMISSIONS clause when creating the database. This lets you grant object-level permissions for objects in the database in step 4.

```
CREATE DATABASE sales_db WITH PERMISSIONS FROM DATASHARE salesshare OF NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

   You can see databases that you created from the datashare by querying the SVV_REDSHIFT_DATABASES view. You can connect to these databases directly, or you can connect to a local database on your consumer cluster and perform a cross-database query to query the data from the datashare databases. You can't create a datashare on top of database objects created from an existing datashare. However, you can copy the data into a separate table on the consumer cluster, perform any processing needed, and then share the new objects that were created.

   You can also use the Amazon Redshift console to create databases from datashares. For more information, see Creating databases from datashares.

3. (Optional) Create external schemas to refer to and assign granular permissions to specific schemas in the consumer database imported on the consumer cluster. For more information, see CREATE EXTERNAL SCHEMA.

```
CREATE EXTERNAL SCHEMA sales_schema FROM REDSHIFT DATABASE 'sales_db' SCHEMA
 'public';
```

4. Grant permissions on databases and schema references created from the datashares to users and roles in the consumer cluster as needed. For more information, see GRANT or REVOKE.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

```
GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

If you created your database without WITH PERMISSIONS, you can only assign permissions on the entire database created from the datashare to your users and roles. In some cases, you need fine-grained controls on a subset of database objects created from the datashare. If so, you can create an external schema reference that points to specific schemas in the datashare (as described in the previous step) and provide granular permissions at schema level.

You can also create late-binding views on top of shared objects and use these to assign granular permissions. You can also consider having producer clusters create additional datashares for you with the granularity required.

If you created your database with WITH PERMISSIONS in step 2, you must assign object-level permissions for objects in the shared database. A user with only the USAGE permission can't access any objects in a database created with WITH PERMISSIONS until they're granted additional object-level permissions..

```
GRANT SELECT ON sales_db.public.tickit_sales_redshift to Bob;
```

5. Query data in the shared objects in the datashares.

Users and roles with permissions on consumer databases and schemas on consumer clusters can explore and navigate the metadata of any shared objects. They can also explore and navigate local objects in a consumer cluster. To do this, they use JDBC or ODBC drivers or SVV_ALL and SVV_REDSHIFT views.

Producer clusters might have many schemas in the database, tables, and views within each schema. The users on the consumer side can see only the subset of objects that are made available through the datashare. These users can't see the entire metadata from the producer cluster. This approach helps provide granular metadata security control with data sharing.

You continue to connect to local cluster databases. But now, you can also read from the databases and schemas that are created from the datashare using the three-part database.schema.table notation. You can perform queries that span across any and all databases that are visible to you. These can be local databases on the cluster or databases created from the datashares. Consumer clusters can't connect to the databases created from the datashares.

You can access the data using full qualification. For more information, see Cross-database query examples.

```
SELECT * FROM sales_db.public.tickit_sales_redshift ORDER BY 1,2 LIMIT 5;

 salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime
---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------
       1 |      1 |    36861 |   21191 |    7872 |   1875 |       4 |    728.00 |
   109.20 | 2008-02-18 02:36:48
       2 |      4 |     8117 |   11498 |    4337 |   1983 |       2 |     76.00 |
    11.40 | 2008-06-06 05:00:16
       3 |      5 |     1616 |   17433 |    8647 |   1983 |       2 |    350.00 |
    52.50 | 2008-06-06 08:26:17
       4 |      5 |     1616 |   19715 |    8647 |   1986 |       1 |    175.00 |
    26.25 | 2008-06-09 08:38:52
       5 |      6 |    47402 |   14115 |    8240 |   2069 |       2 |    154.00 |
    23.10 | 2008-08-31 09:17:02
```

You can only use SELECT statements on shared objects. However, you can create tables in the consumer cluster by querying the data from the shared objects in a different local database.

In addition to queries, consumers can create views on shared objects. Only late-binding views or materialized views are supported. Amazon Redshift doesn't support regular views on shared data. Views that consumers create can span across multiple local databases or databases created from datashares. For more information, see CREATE VIEW.

```
// Connect to a local cluster database

// Create a view on shared objects and access it.
CREATE VIEW sales_data
AS SELECT *
```

```
FROM sales_db.public.tickit_sales_redshift
WITH NO SCHEMA BINDING;

SELECT * FROM sales_data;
```

Working with views in Amazon Redshift data sharing

A producer cluster can share regular, late-binding, and materialized views. When sharing regular or late-binding views, you don't have to share the base tables. The following table shows how views are supported with data sharing.

View name	Can this view be added to a datashare ?	Can a consumer create this view on datashare objects across clusters?
Regular view	Yes	No
Late-binding view	Yes	Yes
Materialized view	Yes	Yes, but only with a complete refresh

The following query shows the output of a regular view that is supported with data sharing. For information about regular view definition, see CREATE VIEW.

```
SELECT * FROM tickit_db.public.myevent_regular_vw
ORDER BY eventid LIMIT 5;

   eventid  |  eventname
  ----------+-------------
     3835   | LeAnn Rimes
     3967   | LeAnn Rimes
     4856   | LeAnn Rimes
     4948   | LeAnn Rimes
     5131   | LeAnn Rimes
```

The following query shows the output of a late-binding view that is supported with data sharing. For information about late-binding view definition, see CREATE VIEW.

```
SELECT * FROM tickit_db.public.event_lbv
ORDER BY eventid LIMIT 5;

 eventid | venueid | catid | dateid |          eventname           |      starttime
 --------+---------+-------+--------+------------------------------
+---------------------
     1   |   305   |   8   |  1851  |        Gotterdammerung       | 2008-01-25
 14:30:00
     2   |   306   |   8   |  2114  |           Boris Godunov      | 2008-10-15
 20:00:00
     3   |   302   |   8   |  1935  |              Salome          | 2008-04-19
 14:30:00
     4   |   309   |   8   |  2090  |  La Cenerentola (Cinderella) | 2008-09-21
 14:30:00
     5   |   302   |   8   |  1982  |          Il Trovatore        | 2008-06-05
 19:00:00
```

The following query shows the output of a materialized view that is supported with data sharing. For information about materialized view definition, see CREATE MATERIALIZED VIEW.

```
SELECT * FROM tickit_db.public.tickets_mv;

  catgroup | qtysold
 ----------+---------
  Concerts | 195444
    Shows  | 149905
```

You can maintain common tables across all tenants in a producer cluster. You can also share subsets of data filtered by dimension columns, such as `tenant_id` (`account_id` or `namespace_id`), to consumer clusters. To do this, you can define a view on the base table with a filter on these ID columns, for example `current_aws_account = tenant_id`. On the consumer side, when you query the view, you see only the rows that qualify for your account. To do this, you can use the Amazon Redshift context functions `current_aws_account` and `current_namespace`.

The following query returns the account ID in which the current Amazon Redshift cluster resides. You can run this query if you are connected to Amazon Redshift.

```
select current_user, current_aws_account;
```

```
current_user | current_aws_account
-------------+--------------------
dwuser       |    111111111111
(1row)
```

The following query returns the namespace of the current Amazon Redshift cluster. You can run this query if you are connected to the database.

```
select current_user, current_namespace;

current_user | current_namespace
-------------+--------------------------------------
dwuser       | 86b5169f-01dc-4a6f-9fbb-e2e24359e9a8
(1 row)
```

Incremental refresh for materialized views in a datashare

Amazon Redshift supports incremental refresh for materialized views in a consumer datashare when the base tables are shared. Incremental refresh is an operation where Amazon Redshift identifies changes in the base table or tables that happened after the previous refresh and updates only the corresponding records in the materialized view. For more information about this behavior, see CREATE MATERIALIZED VIEW.

Adding data lake tables to a datashare

With a datashare, a data *producer* can securely share database objects of fine granularity, such as schemas and tables, with *consumers* in the same AWS account or in different accounts. The producer can also share objects across regions. This topic describes how to add objects from a data lake, specifically, from the AWS Glue data catalog, to a datashare. It covers two use cases:

- *Adding a late-binding view to a datashare that references a table from a data lake* – This is convenient for a consumer, because preliminary configuration, such as defining permissions on the external source data, for example with Lake Formation, is likely already completed. An additional benefit is that a view added to a datashare can join tables from the data lake with Redshift native tables.
- *Adding a table from an external schema to a datashare directly* – This makes objects from the data lake available to consumers with no additional layers or logic. Consumers can query the table or join it with tables on the consumer.

These cases apply after you reference a table from the AWS data catalog in Redshift using CREATE EXTERNAL SCHEMA. Any table from the AWS data catalog can be the source.

> **Note**
>
> Data lake tables that you add to a datashare can include tables registered with Lake Formation and AWS Glue data catalog tables.

Create an external schema and an external table

You create an external schema and an external table in order to add them to the datashare in the sections that follow. These are preliminary steps. If you have already done this, you can skip this section.

1. On the producer, create an external schema that references the data lake data stored in Amazon S3. The external schema references the AWS Glue Data Catalog. The role and region in the sample are examples:

```
CREATE EXTERNAL SCHEMA external_schema_name FROM DATA CATALOG
DATABASE 'glue_database_name'
IAM_ROLE 'arn:aws:iam::123456789012:role/sample-role'
REGION 'us-east-1';
```

2. Create a data lake table in the external schema.

```
CREATE EXTERNAL TABLE external_schema_name.sales(
salesid INTEGER,
sellerid INTEGER,
buyerid INTEGER,
saledate DATE,
pricepaid DECIMAL(8,2))
ROW FORMAT delimited
FIELDS TERMINATED BY '\t'
STORED AS textfile
LOCATION 's3://redshift-downloads/tickit/spectrum/sales/';
```

   The sample includes the `LOCATION`. It must be in the form `s3://{bucket_name}/{folder}/`, where the folder is specified. The folder must have a length of at least one character. You can optionally include subfolders. To see additional examples for creating tables in a data lake, see Examples for CREATE EXTERNAL TABLE.

> **Note**
>
> Sharing is supported only for tables where the IAM role on the producer has SELECT access on the table.

Add a late-binding view that references a data lake table to a datashare

When you create tables based on an external schema from the AWS data catalog, and you want to add them to a datashare, the most common way to do it is to add a Redshift late-binding view that references the table you created, which contains data from the data lake. The following procedure shows the steps:

1. Create a late-binding view that references the external table you created previously:

```
CREATE VIEW lbv AS
select * from external_schema_name.sales, other_schema.t1
WITH NO SCHEMA BINDING;
```

2. Add the view schema to the datashare. This is the local schema that contains the late-binding view.

```
ALTER DATASHARE dsx_datashare ADD SCHEMA public;
```

3. Add the schema that contains the table referenced by the late-binding view to the datashare. Adding the schema is required for any base tables referenced in a view that's added to a datashare, whether the schema contains local database objects or objects from a data lake. Note that you must add this schema before you add the late-binding view.

```
ALTER DATASHARE dsx_datashare ADD SCHEMA external_schema_name;
ALTER DATASHARE dsx_datashare ADD SCHEMA other_schema;
```

4. Add the view to the datashare, using a SQL command. Note that the table name includes the schema prefix.

```
ALTER DATASHARE my_datashare ADD TABLE public.lbv;
```

5. Confirm that the view and schemas are successfully added to the datashare:

   ```
   SELECT * FROM svv_datashare_objects WHERE share_name = 'my_datashare';
   ```

6. The consumer administrator creates a database from the datashare and then grants usage to consumer users.

After you complete the steps, database consumer users with access to the datashare view can query the data.

Add a data lake table directly to a datashare

Adding a table in an external schema to a datashare is similar to adding a view. This works well for a case where a consumer wants to query the data lake table in its original state, or if a consumer wants to join it to tables in the consumer data warehouse. The steps that follow show you how to add a data lake table to a datashare, using SQL.

1. Create an external schema and an external table, as described in the first section of this topic.
2. Discover existing tables in the external schema, to confirm that the table you created is available:

   ```
   SELECT * FROM svv_external_tables WHERE schemaname = 'external_schema_name';
   ```

3. Add the external schema to the datashare:

   ```
   ALTER DATASHARE my_datashare ADD SCHEMA external_schema_name;
   ```

4. Add the external table to the datashare. Note that the table name includes the schema prefix:

   ```
   ALTER DATASHARE my_datashare ADD TABLE external_schema_name.sales;
   ```

5. Confirm that the table is successfully added to the datashare:

   ```
   SELECT * FROM svv_datashare_objects WHERE share_name = 'my_datashare';
   ```

   For more detailed instruction, see Sharing read access to data within an AWS account.

6. On the consumer, which is the database receiving the shared data, the administrator associates the datashare to make shared tables available for users to query. For more information

regarding how to perform this step, see Managing datashares from other accounts as a consumer.

After administrators complete the steps, database users on the consumer can write queries to retrieve data from the shared table and join it with other tables on the consumer.

Usage notes for adding data lake objects to a datashare

There are several items to note when you use tables and views from a data lake in a datashare:

- **Logging with AWS CloudTrail** – The data producer account can use AWS CloudTrail logs to audit when data lake tables shared through a datashare are accessed:
  - **Using log data to control data access** – The CloudTrail logs record details about who accesses shared tables, including both Redshift datashare producers and consumers. The identifiers are available in the `ExternalId` field under the `AssumeRole` CloudTrail logs. The data owner can configure additional limitations on data access in an IAM policy by means of actions. For more information about defining data access through policies, see Access to AWS accounts owned by third parties.
- **Security and consumer permissions** – For Lake Formation registered tables, Amazon S3 resources are secured by Lake Formation and made available using the credentials provided by Lake Formation.

Billing considerations for adding data lake objects to a datashare

The following details how costs are attributed for storing and scanning data lake objects in a datashare:

- When a consumer queries shared objects from a data lake, the cost of scanning is billed to the consumer.
  - When the consumer is a provisioned cluster, Redshift uses Redshift Spectrum to scan Amazon S3 data. Therefore, the Spectrum cost is billed to the consumer account.
  - When the consumer is an Amazon Redshift Serverless workgroup, there is no separate charge for Spectrum.
- Amazon S3 costs for storage and operations, such as listing buckets, is billed to the account that owns each Amazon S3 bucket.

For additional details regarding billing for Amazon Redshift Serverless, see Billing for Amazon Redshift Serverless. More billing and pricing information is available at Amazon Redshift pricing.

Sharing data across AWS accounts

You can share data for read purposes across AWS accounts. Sharing data across AWS accounts works similarly to sharing data within an account. The difference is that there is a two-way handshake required in sharing data across AWS accounts. A producer account administrators can either authorize consumer accounts to access datashares or choose not to authorize any access. To use an authorized datashare, a consumer account administrator can associate the datashare. The administrator can associate the datashare with an entire AWS account or with specific clusters in the consumer account, or decline the datashare. For more information about sharing data within an account, see Sharing read access to data within an AWS account.

A datashare can have data consumers that are either namespaces in the same account or different AWS accounts. You don't need to create separate datashares for sharing within an account and cross-account sharing.

For cross-account data sharing, both the producer and consumer cluster must be encrypted.

When sharing data with AWS accounts, producer administrators share with the AWS account as an entity. A consumer administrator can decide which namespaces in the consumer account get access to a datashare.

Topics

producer administrator actions

With Amazon Redshift, you can perform administrative tasks on producer clusters to manage data ingestion and load processing.

If you are a producer administrator or database owner – follow these steps:

1. Create datashares in your cluster and add datashare objects to the datashares. For more detailed steps on how to create datashares and add datashare objects to datashares, see Sharing read

access to data within an AWS account. For information about the CREATE DATASHARE and ALTER DATASHARE, see CREATE DATASHARE and ALTER DATASHARE.

The following example adds different datashare objects to the datashare `salesshare`.

```
-- Add schema to datashare
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;

-- Add table under schema to datashare
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;

-- Add view to datashare
ALTER DATASHARE salesshare ADD TABLE public.sales_data_summary_view;

-- Add all existing tables and views under schema to datashare (does not include
 future table)
ALTER DATASHARE salesshare ADD ALL TABLES in schema public;
```

You can also use the Amazon Redshift console to create or edit datashares. For more information, see Create a datashare and Editing datashares created in your account.

2. Delegate permissions to operate on the datashare. For more information, see GRANT or REVOKE.

   The following example grants permissions to `dbuser` on `salesshare`.

   ```
   GRANT ALTER, SHARE ON DATASHARE salesshare TO dbuser;
   ```

   Cluster superusers and the owners of the datashare can grant or revoke modification permissions on the datashare to additional users.

3. Add consumers to or remove consumers from datashares. The following example adds the AWS account ID to `salesshare`. For more information, see GRANT or REVOKE.

   ```
   GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '123456789012';
   ```

   You can only grant permissions to one data consumer in a GRANT statement.

   Cluster superusers and the owners of datashare objects, or users that have SHARE permissions on the datashare, can add consumers to or remove consumers from a datashare. To do so, they use GRANT USAGE or REVOKE USAGE.

You can also use the Amazon Redshift console to add or remove data consumers for datashares. For more information, see Add data consumers to datashares and Removing data consumers from datashares.

4. (Optional) Revoke access to the datashare from AWS accounts if you don't want to share the data with the consumers anymore.

```
REVOKE USAGE ON DATASHARE salesshare FROM ACCOUNT '123456789012';
```

If you are a producer account administrator – follow these steps:

After granting usage to the AWS account, the datashare status is `pending_authorization`. The producer account administrator should authorize datashares using the Amazon Redshift console and choose the data consumers.

Sign in to the https://console.aws.amazon.com/redshiftv2/. Then choose which data consumers to authorize to access datashares or to remove authorization from. Authorized data consumers receive notifications to take actions on datashares. If you are adding a namespace as a data consumer, you don't have to perform authorization. After data consumers are authorized, they can access datashare objects and create a consumer database to query the data. For more information, see Authorizing or removing authorization from datashares.

Sharing write permissions to data across accounts

With Amazon Redshift, you can share data across AWS accounts and grant write permissions, enabling collaboration and data sharing between teams or organizations. Cross-account data sharing allows you to establish a data provider account that creates and manages databases, schemas, and tables, which can then be securely shared with data consumer accounts. The following sections demonstrate the process of configuring cross-account data sharing and granting write access in Amazon Redshift.

Consumer account administrator actions

With Amazon Redshift, you can manage consumer accounts and control their access to your data warehousing resources.

If you are a consumer account administrator – follow these steps:

To associate one or more datashares that are shared from other accounts with your entire AWS account or specific namespaces in your account, use the Amazon Redshift console.

Sign in to the https://console.aws.amazon.com/redshiftv2/. Then, associate one or more datashares that are shared from other accounts with your entire AWS account or specific namespaces in your account. For more information, see Associating a datashare from a different AWS account in Amazon Redshift.

After the AWS account or specific namespaces are associated, the datashares become available for consumption. You can also change datashare association at any time. When changing association from individual namespaces to an AWS account, Amazon Redshift overwrites the namespaces with the AWS account information. When changing association from an AWS account to specific namespaces, Amazon Redshift overwrites the AWS account information with the namespace information. All namespaces in the account get access to the data.

consumer administrator actions

With Amazon Redshift, you can perform administrative tasks on consumer clusters to manage data ingestion and load processing.

If you are a consumer administrator – follow these steps:

1. List the datashares made available to you and view the content of datashares. The content of datashares is available only when the producer administrator has authorized the datashares and the consumer administrator has accepted and associated the datashares. For more information, see DESC DATASHARE and SHOW DATASHARES.

   The following example displays the information of inbound datashares of a specified producer namespace. When you run the DESC DATAHSARE as a consumer administrator, you must specify the NAMESPACE and account ID to view inbound datashares. For outbound datashares, specify the datashare name.

```
SHOW DATASHARES LIKE 'sales%';

share_name | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace
-----------+-------------+-----------------+-------------------+------------
+------------+---------------------+-----------+------------------
+---------------------------------------
salesshare |             |                 |                   | INBOUND    |
          |       t          |           | 123456789012    | 'dd8772e1-
d792-4fa4-996b-1870577efc0d'
```

```
DESC DATASHARE salesshare OF ACCOUNT '123456789012' NAMESPACE 'dd8772e1-
d792-4fa4-996b-1870577efc0d';


 producer_account |          producer_namespace          | share_type | share_name |
 object_type |           object_name
------------------+--------------------------------------+------------+------------
+-------------+---------------------------------
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_users_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_venue_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_category_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_date_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_event_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_listing_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 table       | public.tickit_sales_redshift
 123456789012     | dd8772e1-d792-4fa4-996b-1870577efc0d | INBOUND    | salesshare |
 schema      | public
(8 rows)
```

Only cluster superusers can do this. You can also use SVV_DATASHARES to view the datashares and SVV_DATASHARE_OBJECTS to view the objects within the datashare.

The following example displays the inbound datashares in a consumer cluster.

```
SELECT * FROM SVV_DATASHARES WHERE share_name LIKE 'sales%';

share_name | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace
-----------+-------------+-----------------+-------------------+------------
+------------+---------------------+-----------+------------------
+--------------------------------------
```

```
salesshare |               |                  |                    | INBOUND    |
            |        t            |            | 123456789012       | 'dd8772e1-
d792-4fa4-996b-1870577efc0d'
```

```
SELECT * FROM SVV_DATASHARE_OBJECTS WHERE share_name LIKE 'sales%';
 share_type | share_name | object_type |           object_name           |
 producer_account |          producer_namespace
------------+------------+-------------+---------------------------------
+-------------------+--------------------------------------
 INBOUND    | salesshare | table       | public.tickit_users_redshift    |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_venue_redshift    |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_category_redshift |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_date_redshift     |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_event_redshift    |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_listing_redshift  |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | table       | public.tickit_sales_redshift    |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
 INBOUND    | salesshare | schema      | public                          |
 123456789012      | dd8772e1-d792-4fa4-996b-1870577efc0d
(8 rows)
```

2. Create local databases that reference to the datashares. Specify the NAMESPACE and account ID when creating the database from the datashare. For more information, see CREATE DATABASE.

```
CREATE DATABASE sales_db FROM DATASHARE salesshare OF ACCOUNT '123456789012'
 NAMESPACE 'dd8772e1-d792-4fa4-996b-1870577efc0d';
```

If you want more granular control over access to the objects in the local database, use the WITH PERMISSIONS clause when creating the database. This lets you grant object-level permissions for objects in the database in step 4.

```
CREATE DATABASE sales_db WITH PERMISSIONS FROM DATASHARE salesshare OF ACCOUNT
 '123456789012' NAMESPACE 'dd8772e1-d792-4fa4-996b-1870577efc0d';
```

You can see databases that you created from the datashare by querying SVV_REDSHIFT_DATABASES view. You can connect to these databases directly, or you can connect to a local database on your consumer cluster and perform a cross-database query to query the data from the datashare databases. You can't create a datashare on top of database objects created from an existing datashare. However, you can copy the data into a separate table on the consumer cluster, perform any processing needed, and then share the new objects created.

3. (Optional) Create external schemas to refer and assign granular permissions to specific schemas in the consumer database imported on the consumer cluster. For more information, see CREATE EXTERNAL SCHEMA.

```
CREATE EXTERNAL SCHEMA sales_schema FROM REDSHIFT DATABASE 'sales_db' SCHEMA
 'public';
```

4. Grant permissions on databases and schema references created from the datashares to user or roles in the consumer cluster as needed. For more information, see GRANT or REVOKE.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

```
GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

If you created your database without WITH PERMISSIONS, you can only assign permissions on the entire database created from the datashare to your users or roles. In some cases, you need fine-grained controls on a subset of database objects created from the datashare. If so, you can create an external schema reference pointing to specific schemas in the datashare, as described in the previous step. You can then provide granular permissions at the schema level. You can also create late-binding views on top of shared objects and use these to assign granular permissions. You can also consider having producer clusters create additional datashares for you with the granularity required. You can create as many schema references to the database created from the datashare as you need.

If you created your database with WITH PERMISSIONS in step 2, you must assign object-level permissions for objects in the shared database. A user with only the USAGE permission can’t access any objects in a database created with WITH PERMISSIONS until they’re granted additional object-level permissions..

```
GRANT SELECT ON sales_db.public.tickit_sales_redshift to Bob;
```

5. Query data in the shared objects in the datashares.

   Users and roles with permissions on consumer databases and schemas on consumer clusters can explore and navigate the metadata of any shared objects. They can also explore and navigate local objects in a consumer cluster. To do this, use JDBC or ODBC drivers or SVV_ALL and SVV_REDSHIFT views.

   Producer clusters might have many schemas in the database, tables, and views within each schema. The users on the consumer side can see only the subset of objects that are made available through the datashare. These users can't see all the metadata from the producer cluster. This approach helps provide granular metadata security control with data sharing.

   You continue to connect to local cluster databases. But now, you can also read from the databases and schemas that are created from the datashare using the three-part database.schema.table notation. You can perform queries that span across any and all databases that are visible to you. These can be local databases on the cluster or databases created from the datashares. Consumer clusters can't connect to the databases created from the datashares.

   You can access the data using full qualification. For more information, see [Cross-database query examples](#).

   ```
   SELECT * FROM sales_db.public.tickit_sales_redshift;
   ```

   You can only use SELECT statements on shared objects. However, you can create tables in the consumer cluster by querying the data from the shared objects in a different local database.

   In addition to performing queries, consumers can create views on shared objects. Only late-binding views and materialized views are supported. Amazon Redshift doesn't support regular views on shared data. Views that consumers create can span across multiple local databases or databases created from datashares. For more information, see [CREATE VIEW](#).

   ```
   // Connect to a local cluster database

   // Create a view on shared objects and access it.
   CREATE VIEW sales_data
   AS SELECT *
   FROM sales_db.public.tickit_sales_redshift
   ```

```
WITH NO SCHEMA BINDING;

SELECT * FROM sales_data;
```

Sharing data across AWS Regions

You can share data for read purposes across Amazon Redshift clusters in AWS Regions. With cross-Region data sharing, you can share data across AWS Regions without the need to copy data manually. You don't have to unload your data into Amazon S3 and copy the data into a new Amazon Redshift cluster or perform cross-Region snapshot copy.

With cross-Region data sharing, you can share data across clusters in the same AWS account, or in different AWS accounts even when the clusters are in different Regions. When sharing data with Amazon Redshift clusters that are in the same AWS account but different AWS Regions, follow the same workflow as sharing data within an AWS account. For more information, see Sharing read access to data within an AWS account.

If clusters sharing data are in different AWS accounts and AWS Regions, you can follow the same workflow as sharing data across AWS accounts and include Region-level associations on the consumer cluster. Cross-Region data sharing supports datashare association with the entire AWS account, the entire AWS Region, or specific namespaces within an AWS Region. For more information about sharing data across AWS accounts, see Sharing data across AWS accounts.

When consuming data from a different Region, the consumer pays the Cross-Region data transfer fee from the producer region to the consumer Region.

To use the datashare, a consumer account administrator can associate the datashare in one of the following three ways.

- Association with an entire AWS account spanning all its AWS Regions
- Association with a specific AWS Region in an AWS account
- Association with specific namespaces within an AWS Region

When the administrator chooses the entire AWS account, all existing and future namespaces across different AWS Regions in the account have access to the datashares. A consumer account administrator can also choose specific AWS Regions or namespaces within a Region to grant them access to the datashares.

If you are a producer administrator or database owner, create a datashare, add database objects and data consumers to the datashare, and grant permissions to data consumers. For more information, see producer administrator actions.

If you are a producer account administrator, authorize datashares using the AWS Command Line Interface (AWS CLI) or the Amazon Redshift console and choose the data consumers.

If you are a consumer account administrator – follow these steps:

To associate one or more datashares that are shared from other accounts to your entire AWS account or specific AWS Regions or namespaces within an AWS Region, use the Amazon Redshift console.

With cross-Region data sharing, you can add clusters in a specific AWS Region using the AWS Command Line Interface (AWS CLI) or Amazon Redshift console.

To specify one or more AWS Regions, you can use the `associate-data-share-consumer` CLI command with the optional `consumer-region` option.

With the CLI, the following example associates the `Salesshare` with the entire AWS account with the `associate-entire-account` option. You can only associate one Region at a time.

```
aws redshift associate-data-share-consumer
--region {PRODUCER_REGION}
--data-share-arn arn:aws:redshift:{PRODUCER_REGION}:{PRODUCER_ACCOUNT}:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/Salesshare
--associate-entire-account
```

The following example associates the `Salesshare` with the US East (Ohio) Region (`us-east-2`).

```
aws redshift associate-data-share-consumer
--region {PRODUCER_REGION}
--data-share-arn arn:aws:redshift:{PRODUCER_REGION}:0123456789012:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/Salesshare
--consumer-region 'us-east-2'
```

The following example associates the `Salesshare` with a specific consumer namespace in another AWS account in the Asia Pacific (Sydney) Region (`ap-southeast-2`).

```
aws redshift associate-data-share-consumer
--data-share-arn arn:aws:redshift:{PRODUCER_REGION}:{PRODUCER_ACCOUNT}:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/Salesshare
```

```
--consumer-arn 'arn:aws:redshift:ap-southeast-2:{CONSUMER_ACCOUNT}:namespace:
{ConsumerImmutableClusterId}'
```

You can use the Amazon Redshift console to associate datashares with your entire AWS account or specific AWS Regions or namespaces within an AWS Region. To do this, sign in to the https://console.aws.amazon.com/redshiftv2/. Then associate one or more datashares that are shared from other accounts with your entire AWS account, the entire AWS Region, or a specific namespace within an AWS Region. For more information, see Associating a datashare from a different AWS account in Amazon Redshift.

After the AWS account or specific namespaces are associated, the datashares become available for consumption. You can also change datashare association at any time. When changing association from individual namespaces to an AWS account, Amazon Redshift overwrites the namespaces with the AWS account information. When changing association from an AWS account to specific namespaces, Amazon Redshift overwrites the AWS account information with the namespace information. When changing association from an entire AWS account to specific AWS Regions and namespaces, Amazon Redshift overwrites the AWS account information with the specific Region and namespace information.

If you are a consumer administrator, you can create local databases that reference to the datashares and grant permissions on databases created from the datashares to user or roles in the consumer cluster as needed. You can also create views on shared objects and create external schemas to refer and assign granular permissions to specific schemas in the consumer database imported on the consumer cluster. For more information, see consumer administrator actions.

Managing cost control for cross-Region data sharing

With Amazon Redshift, you can manage cost control for cross-Region data sharing by configuring data sharing to limit the amount of data that is transferred between AWS Regions. Managing cost control for cross-Region data sharing allows you to set data transfer limits, monitor data transfer usage, and receive notifications when approaching or exceeding those limits.

When consuming data from a different Region, the consumer pays the Cross-Region data transfer fee from the producer Region to the consumer Region. The price of data transfer is different for different Regions. The charge is based on the bytes of data scanned for every successful query run. For more information about Amazon Redshift pricing, see Amazon Redshift pricing.

You are charged for the number of bytes, rounded up to the next megabyte, with a 10MB minimum per query. You can set cost controls on your query usage and view the amount of data being transferred per query on your cluster.

To monitor and control your usage and associated cost of using cross-Region data sharing, you can create daily, weekly, monthly usage limits, and define actions that Amazon Redshift automatically takes if those limits are reached to help maintain your budget with predictability.

Depending on the usage limits you set, actions that Amazon Redshift takes can be to log an event to a system table, send a CloudWatch alarm and notify an administrator with an Amazon SNS, or to turn off cross-Region data sharing for further usage.

To create usage limits in the Amazon Redshift console, choose **Configure usage limit** under **Actions** for your cluster. You can monitor your usage trends and get alerts on usage exceeding your defined limits with automatically generated CloudWatch metrics from the **Cluster performance** or **Monitoring** tabs. You can also create, modify, and delete usage limits programmatically by using the AWS CLI or Amazon Redshift API operations.

Sharing licensed Amazon Redshift data on AWS Data Exchange

When creating AWS Data Exchange datashares and adding them to an AWS Data Exchange product, providers can license data in Amazon Redshift that consumers can discover, subscribe to, and query up-to-date data in Amazon Redshift when they have active AWS Data Exchange subscriptions.

With AWS Data Exchange datashares added to an AWS Data Exchange product, consumers automatically have access to a product's datashares when their subscription starts and retain their access as long as their subscription is active.

Topics

Working with AWS Data Exchange datashares as a producer

With Amazon Redshift, you can share live data products with AWS Data Exchange as a producer by creating and managing datashares.

If you are a producer administrator, follow these steps to manage AWS Data Exchange datashares on the Amazon Redshift console:

1. Create datashares in your cluster to share data on AWS Data Exchange and grant access to AWS Data Exchange to the datashares.

Cluster superuser and database owners can create datashares. Each datashare is associated with a database during creation. Only objects from that database can be shared in that datashare. Multiple datashares can be created on the same database with the same or different granularity of objects. There is no limit on the number of datashares you can create on a cluster.

You can also use the Amazon Redshift console to create datashares. For more information, see [Create a datashare](#).

Use the MANAGEDBY ADX option to implicitly grant access of the datashare to AWS Data Exchange when running the CREATE DATASHARE statement. This indicates that AWS Data Exchange manages this datashare. You can only use the MANAGEDBY ADX option when you create a new datashare. You can't use the ALTER DATASHARE statement to modify an existing datashare to add the MANAGEDBY ADX option. Once a datashare is created with the MANAGEDBY ADX option, only AWS Data Exchange can access and manage the datashare.

```
CREATE DATASHARE salesshare
[[SET] MANAGEDBY [=] {ADX} ];
```

2. Add objects to the datashares. Producer administrator continues to manage datashare objects that are available in an AWS Data Exchange datashare.

   To add objects to a datashare, add the schema before adding objects. When you add a schema, Amazon Redshift doesn't add all the objects under it. You must add them explicitly. For more information, see ALTER DATASHARE.

```
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD ALL TABLES IN SCHEMA PUBLIC;
```

   You can also add views to a datashare.

```
CREATE VIEW public.sales_data_summary_view AS SELECT * FROM
 public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD TABLE public.sales_data_summary_view;
```

   Use ALTER DATASHARE to share schemas, and tables, views, and functions in a given schema. Superusers, datashare owners, or users who have ALTER or ALL permissions on the datashare can alter the datashare to add objects to or remove objects from it. Users should have the permissions to add or remove objects from the datashare. Users should also be the owners of the objects or have SELECT, USAGE, or ALL permissions on the objects.

Use the INCLUDENEW clause to add any new tables, views, or SQL user-defined functions (UDFs) created in a specified schema to the datashare. Only superusers can change this property for each datashare-schema pair.

```
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
ALTER DATASHARE salesshare SET INCLUDENEW = TRUE FOR SCHEMA PUBLIC;
```

You can also use the Amazon Redshift console to add or remove objects from datashares. For more information, see Add datashare objects to datashares, Removing datashare objects from datashares, and Editing AWS Data Exchange datashares.

3. To authorize access to the datashares for AWS Data Exchange, do one of the following:

   - Explicitly authorize access to the datashare for AWS Data Exchange by using the `ADX` keyword in the `aws redshift authorize-data-share` API. This allows AWS Data Exchange to recognize the datashare in the service account and manage associating consumers to the datashare.

     ```
     aws redshift authorize-data-share
     --data-share-arn arn:aws:redshift:us-east-1:{PRODUCER_ACCOUNT}:datashare:
     {PRODUCER_CLUSTER_NAMESPACE}/salesshare
     --consumer-identifier ADX
     ```

     You can use a conditional key `ConsumerIdentifier` for the `AuthorizeDataShare` and `DeauthorizeDataShare` APIs to explicitly allow or deny AWS Data Exchange to make calls to the two APIs in the IAM policy.

     JSON

     ```
     {
         "Version": "2012-10-17",
         "Statement": [
             {
                 "Sid": "VisualEditor0",
                 "Effect": "Deny",
                 "Action": [
                     "redshift:AuthorizeDataShare",
     ```

```
                "redshift:DeauthorizeDataShare"
            ],
            "Resource": "*",
            "Condition": {
                "StringEqualsIgnoreCase": {
                    "redshift:ConsumerIdentifier": "ADX"
                }
            }
        }
    ]
}
```

- Use the Amazon Redshift console to authorize or remove authorization of AWS Data Exchange datashares. For more information, see Authorizing or removing authorization from datashares.
- Optionally, you can implicitly authorize access to the AWS Data Exchange datashare when importing the datashare into an AWS Data Exchange dataset.

To remove authorization for access to the AWS Data Exchange datashares, use the ADX keyword in the `aws redshift deauthorize-data-share` API operation. By doing this, you allow AWS Data Exchange to recognize the datashare in the service account and manage removing association from the datashare.

```
aws redshift deauthorize-data-share
--data-share-arn arn:aws:redshift:us-east-1:{PRODUCER_ACCOUNT}:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/salesshare
--consumer-identifier ADX
```

4. List datashares created in the cluster and look into the contents of the datashare.

   The following example displays the information of a datashare named salesshare. For more information, see DESC DATASHARE and SHOW DATASHARES.

```
DESC DATASHARE salesshare;

 producer_account  |          producer_namespace          | share_type | share_name
 | object_type |           object_name            |   include_new
-------------------+--------------------------------------+------------
+-------------+-------------+---------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_users_redshift   |
```

```
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_venue_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_category_redshift|
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_date_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_event_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_listing_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table        | public.tickit_sales_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | schema       | public                         |  t
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | view         | public.sales_data_summary_view |
```

The following example displays the outbound datashares in a producer cluster.

```
SHOW DATASHARES LIKE 'sales%';
```

The output looks similar to the following.

```
share_name | share_owner  | source_database | consumer_database | share_type |
 createdate      | is_publicaccessible  | share_acl | producer_account |
 producer_namespace
-----------+--------------+-----------------+-------------------+------------
+---------------------+---------------------+-----------+------------------
+---------------------------------------
salesshare |    100       | dev             |                   |  OUTBOUND
 | 2020-12-09 02:27:08 |          True       |           |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

For more information, see DESC DATASHARE and SHOW DATASHARES.

You can also use SVV_DATASHARES, SVV_DATASHARE_CONSUMERS, and SVV_DATASHARE_OBJECTS to view the datashares, the objects within the datashare, and the datashare consumers.

5. Drop datashares. We recommend that you don't delete an AWS Data Exchange datashare shared to other AWS accounts using the DROP DATASHARE statement. Those accounts will lose access to the datashare. This action is irreversible. This might breach data product offer

terms in AWS Data Exchange. If you want to delete an AWS Data Exchange datashare, see DROP DATASHARE usage notes.

The following example drops a datashare named salesshare.

```
DROP DATASHARE salesshare;
ERROR:  Drop of ADX-managed datashare salesshare requires session variable
 datashare_break_glass_session_var to be set to value '620c871f890c49'
```

To allow dropping an AWS Data Exchange datashare, set the datashare_break_glass_session_var variable and run the DROP DATASHARE statement again. If you want to delete an AWS Data Exchange datashare, see DROP DATASHARE usage notes.

You can also use the Amazon Redshift console to delete datashares. For more information, see Deleting AWS Data Exchange datashares created in your account.

6. Use ALTER DATASHARE to remove objects from datashares at any point from the datashare. Use REVOKE USAGE ON to revoke permissions on the datashare to certain consumers. It revokes USAGE permissions on objects within a datashare and instantly stops access to all consumer clusters. Listing datashares and the metadata queries, such as listing databases and tables, doesn't return the shared objects after access is revoked.

```
ALTER DATASHARE salesshare REMOVE TABLE public.tickit_sales_redshift;
```

You can also use the Amazon Redshift console to edit datashares. For more information, see Editing AWS Data Exchange datashares.

7. Grant or revoke GRANT USAGE from AWS Data Exchange datashares. You can't grant or revoke GRANT USAGE for AWS Data Exchange datashare. The following example shows an error when the GRANT USAGE permission is granted to an AWS account for a datashare that AWS Data Exchange manages.

```
CREATE DATASHARE salesshare MANAGEDBY ADX;
```

```
GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '012345678910';
ERROR:  Permission denied to add/remove consumer to/from datashare salesshare.
 Datashare consumers are managed by ADX.
```

For more information, see GRANT or REVOKE.

If you are a producer administrator, follow these steps to create and publish a datashare product on the AWS Data Exchange console:

- When the AWS Data Exchange datashare has been created, the producer creates a new dataset, imports assets, creates a revision, and creates and publishes a new product.

  Use the Amazon Redshift console to create datasets. For more information, see Creating data sets on AWS Data Exchange.

  For more information, see Providing data products on AWS Data Exchange.

Working with AWS Data Exchange datashares as a consumer

With Amazon Redshift, you can access and analyze datasets from AWS Data Exchange without having to store or manage copies of the data.

If you are a consumer, follow these steps to discover data products that contain AWS Data Exchange datashares and query Amazon Redshift data:

1. On the AWS Data Exchange console, discover and subscribe to data products that contains AWS Data Exchange datashares.

   Once your subscription starts, you can access licensed Amazon Redshift data that is imported as assets to datasets that contain AWS Data Exchange datashares.

   For more information on how to get started with using data products that contain AWS Data Exchange datashares, see Subscribing to data products on AWS Data Exchange.
2. On the Amazon Redshift console, create an Amazon Redshift cluster, if needed.

   For information on how to create a cluster, see Creating a cluster.
3. List the datashares that are made available to you and view the content of datashares. For more information, see DESC DATASHARE and SHOW DATASHARES.

   The following example displays the information of inbound datashares of a specified producer namespace. When you run DESC DATASHARE as a consumer administrator, you must specify the ACCOUNT and NAMESPACE option to view inbound datashares.

   ```
   DESC DATASHARE salesshare of ACCOUNT '123456789012' NAMESPACE
    '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
   ```

```
 producer_account  |          producer_namespace          | share_type | share_name
 | object_type |           object_name          |   include_new
-------------------+--------------------------------------+------------
+------------+-------------+-----------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_users_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_venue_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_category_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_date_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_event_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_listing_redshift  |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | table       | public.tickit_sales_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | schema      | public                          |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare
 | view        | public.sales_data_summary_view  |
```

Only cluster superusers can do this. You can also use SVV_DATASHARES to view the datashares and SVV_DATASHARE_OBJECTS to view the objects within the datashare.

The following example displays the inbound datashares in a consumer cluster.

```
SHOW DATASHARES LIKE 'sales%';


 share_name | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace
------------+-------------+-----------------+-------------------+------------
+------------+---------------------+-----------+------------------
+-------------------------------------
 salesshare |             |                 |                   | INBOUND
    |            |         t           |           |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

4. Create local databases that reference to the datashares. You must specify the ACCOUNT and NAMESPACE option to create local databases for AWS Data Exchange datashares. For more information, see CREATE DATABASE.

```
CREATE DATABASE sales_db FROM DATASHARE salesshare OF ACCOUNT '123456789012'
 NAMESPACE '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

   If you want more granular control over access to the objects in the local database, use the WITH PERMISSIONS clause when creating the database. This lets you grant object-level permissions for objects in the database in step 6.

```
CREATE DATABASE sales_db WITH PERMISSIONS FROM DATASHARE salesshare OF ACCOUNT
 '123456789012' NAMESPACE '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

   You can see databases that you created from the datashare by querying the SVV_REDSHIFT_DATABASES view. You can connect to these databases directly, or you can connect to a local database on your consumer cluster and perform a cross-database query to query the data from the datashare databases. You can't create a datashare on top of database objects created from an existing datashare. However, you can copy the data into a separate table on the consumer cluster, perform any processing needed, and then share the new objects that were created.

   You can also use the Amazon Redshift console to create databases from datashares. For more information, see Creating databases from datashares.

5. (Optional) Create external schemas to refer to and assign granular permissions to specific schemas in the consumer database imported on the consumer cluster. For more information, see CREATE EXTERNAL SCHEMA.

```
CREATE EXTERNAL SCHEMA sales_schema FROM REDSHIFT DATABASE 'sales_db' SCHEMA
 'public';
```

6. Grant permissions on databases and schema references created from the datashares to user or roles in the consumer cluster as needed. For more information, see GRANT or REVOKE.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

```
GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

If you created your database without WITH PERMISSIONS, you can only assign permissions on the entire database created from the datashare to your users and roles. In some cases, you need fine-grained controls on a subset of database objects created from the datashare. If so, you can create an external schema reference that points to specific schemas in the datashare (as described in the previous step) and provide granular permissions at schema level.

You can also create late-binding views on top of shared objects and use these to assign granular permissions. You can also consider having producer clusters create additional datashares for you with the granularity required. You can create as many schema references to the database created from the datashare as you need.

If you created your database with WITH PERMISSIONS in step 4, you must assign object-level permissions for objects in the shared database. A user with only the USAGE permission can’t access any objects in a database created with WITH PERMISSIONS until they’re granted additional object-level permissions..

```
GRANT SELECT ON sales_db.public.tickit_sales_redshift to Bob;
```

7. Query data in the shared objects in the datashares.

   Users and roles with permissions on consumer databases and schemas on consumer clusters can explore and navigate the metadata of any shared objects. They can also explore and navigate local objects in a consumer cluster. To do this, they use JDBC or ODBC drivers, the SHOW commands, or SVV_ALL and SVV_REDSHIFT views.

   Producer clusters might have many schemas in the database, tables, and views within each schema. The users on the consumer side can see only the subset of objects that are made available through the datashare. These users can't see the entire metadata from the producer cluster. This approach helps provide granular metadata security control with data sharing.

   You continue to connect to local cluster databases. But now, you can also read from the databases and schemas that are created from the datashare using the three-part database.schema.table notation. You can perform queries that span across any and all databases that are visible to you. These can be local databases on the cluster or databases created from the datashares. Or, you can directly connect to these consumer databases and run queries against the shared objects with partial notation.

You can access the data using full qualification. For more information, see Cross-database query examples.

```
SELECT * FROM sales_db.public.tickit_sales_redshift ORDER BY 1,2 LIMIT 5;

 salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime
---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------
       1 |      1 |    36861 |   21191 |    7872 |   1875 |       4 |    728.00 |
   109.20 | 2008-02-18 02:36:48
       2 |      4 |     8117 |   11498 |    4337 |   1983 |       2 |     76.00 |
    11.40 | 2008-06-06 05:00:16
       3 |      5 |     1616 |   17433 |    8647 |   1983 |       2 |    350.00 |
    52.50 | 2008-06-06 08:26:17
       4 |      5 |     1616 |   19715 |    8647 |   1986 |       1 |    175.00 |
    26.25 | 2008-06-09 08:38:52
       5 |      6 |    47402 |   14115 |    8240 |   2069 |       2 |    154.00 |
    23.10 | 2008-08-31 09:17:02
```

You can only use SELECT statements on shared objects. However, you can create tables in the consumer cluster by querying the data from the shared objects in a different local database.

In addition to queries, consumers can create views on shared objects. Only late-binding views or materialized views are supported. Amazon Redshift doesn't support regular views on shared data. Views that consumers create can span across multiple local databases or databases created from datashares. For more information, see CREATE VIEW.

```
// Connect to a local cluster database

// Create a view on shared objects and access it.
CREATE VIEW sales_data
AS SELECT *
FROM sales_db.public.tickit_sales_redshift
WITH NO SCHEMA BINDING;

SELECT * FROM sales_data;
```

Getting started with AWS Lake Formation-managed datashares

With Amazon Redshift, you can access and share live data across AWS accounts and Amazon Redshift clusters through AWS Lake Formation-managed datashares. AWS Lake Formation datashares enable data providers to securely share live data from their Amazon S3 data lake with any consumer, including other AWS accounts and Amazon Redshift clusters.

Working with Lake Formation-managed datashares as a producer

With Amazon Redshift, you can access and analyze data shared through AWS Lake Formation datashares. AWS Lake Formation datashares enable secure data sharing across AWS accounts and Amazon Redshift clusters without having to copy or move the underlying data.

Sharing data to AWS Lake Formation lets you centrally define AWS Lake Formation permissions of Amazon Redshift datashares and restrict user access to objects within a datashare.

With Amazon Redshift, you can securely share live data across AWS accounts and Amazon Redshift clusters using AWS Lake Formation-managed datashares as a producer. A Lake Formation-managed datashare is an object that allows you to share live data from your Amazon Redshift cluster with other AWS accounts and services.

As a producer cluster or workgroup administrator, follow these steps to share datashares to Lake Formation:

1. Create datashares in your cluster and authorize AWS Lake Formation to access the datashares.

   Only cluster superuser and database owners can create datashares. Each datashare is associated with a database during creation. Only objects from that database can be shared in that datashare. Multiple datashares can be created on the same database with the same or different granularity of objects. There is no limit on the number of datashares you can create on a cluster.

   ```
   CREATE DATASHARE salesshare;
   ```

2. Add objects to the datashare. The producer cluster or workgroup administrator continues to manage datashare objects that are available. To add objects to a datashare, add the schema before adding objects. When you add a schema, Amazon Redshift doesn't add all the objects under it. You must add them explicitly. For more information, see ALTER DATASHARE.

   ```
   ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
   ```

```
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD ALL TABLES IN SCHEMA PUBLIC;
```

You can also add views to a datashare. Supported views are standard views, late binding views, and materialized views.

```
CREATE VIEW public.sales_data_summary_view AS SELECT * FROM
 public.tickit_sales_redshift;
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;
```

Use ALTER DATASHARE to share schemas, tables, and views, in a given schema. Superusers, datashare owners, or users who have ALTER or ALL permissions on the datashare can alter the datashare to add objects to or remove objects from it. Database users should be the owners of the objects or have SELECT, USAGE, or ALL permissions on the objects.

Use the INCLUDENEW clause to add any new tables and views created in a specified schema to the datashare. Only superusers can change this property for each datashare-schema pair.

```
ALTER DATASHARE salesshare ADD SCHEMA PUBLIC;
ALTER DATASHARE salesshare SET INCLUDENEW = TRUE FOR SCHEMA PUBLIC;
```

3. Grant access of the datashare to a Lake Formation administrator account.

```
GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '012345678910' VIA DATA CATALOG;
```

To revoke usage, use the following command.

```
REVOKE USAGE ON DATASHARE salesshare FROM ACCOUNT '012345678910' VIA DATA CATALOG;
```

4. Authorize access to the datashare for Lake Formation by using the `aws redshift authorize-data-share` API operation. Doing so lets Lake Formation recognize the datashare in the service account and manage associating consumers to the datashare.

```
aws redshift authorize-data-share
--data-share-arn arn:aws:redshift:us-east-1:{PRODUCER_ACCOUNT}:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/salesshare
--consumer-identifier {"DataCatalog/<consumer-account-id>"}
```

To remove authorization from Lake Formation-managed datashares, use the `aws redshift deauthorize-data-share` API operation. By doing so, you allow AWS Lake Formation to recognize the datashare in the service account and remove authorization.

```
aws redshift deauthorize-data-share
--data-share-arn arn:aws:redshift:us-east-1:{PRODUCER_ACCOUNT}:datashare:
{PRODUCER_CLUSTER_NAMESPACE}/salesshare
--consumer-identifier {"DataCatalog/<consumer-account-id>"}
```

At any time, if the producer cluster or workgroup administrator decides that there is no longer a need to share data with the consumer cluster or workgroup, they can use DROP DATASHARE to delete the datashare, deauthorize the datashare, or revoke datashare permissions. The associated permissions and objects in Lake Formation are not automatically deleted.

```
DROP DATASHARE salesshare;
```

After authorizing the Lake Formation account to manage the datashare, the Lake Formation administrator can discover the shared datashare, associate the dateshare with an Data Catalog ARN, and create a database in the AWS Glue Data Catalog linking to the datashare. To associate datashares using the AWS CLI, use the command [associate-data-share-consumer](). To share a datashare across AWS Regions, specify the `--region` parameter in the `associate-data-share-consumer` command or use the AWS console to choose your data consumers. The following example demonstrates how to share a Lake Formation-managed datashare across Regions.

```
aws redshift associate-data-share-consumer --region <region-1>
--data-share-arn 'arn:aws:redshift:us-
east-1:12345678912:datashare:035c45ea-61ce-86f0-8b75-19ac6102c3b7/sample_share'
--consumer-arn 'arn:aws:glue:<region-1>:111912345678:catalog'
```

The Lake Formation administrator must also create local resources that define how objects within the datashare should map to objects within Lake Formation. For more information about discovering datashares and creating local resources, see [Managing permissions for data in an Amazon Redshift datashare]().

Working with Lake Formation-managed datashares as a consumer

With Amazon Redshift, you can access and analyze data shared with you through AWS Lake Formation datashares. A datashare is a data product that contains a collection of data objects, such as tables or databases, from different data sources.

After the AWS Lake Formation administrator discovers the datashare invitation and creates a database in the AWS Glue Data Catalog that links to the datashare, the consumer cluster or workgroup administrator can associate the cluster with the datashare and the database in the AWS Glue Data Catalog, create a database local to the consumer cluster or workgroup, and grant access to users and roles in the Amazon Redshift consumer cluster or workgroup to start querying. Follow these steps to set up querying permissions.

1. On the Amazon Redshift console, create an Redshift cluster to serve as the consumer cluster or workgroup, if needed. For information on how to create a cluster, see Creating a cluster.
2. To list which databases in the AWS Glue Data Catalog consumer cluster or workgroup users have access to, run the SHOW DATABASES command.

   ```
   SHOW DATABASES FROM DATA CATALOG [ACCOUNT <account-id>,<account-id2>] [LIKE
    <expression>]
   ```

   Doing so lists the resources that are available from the Data Catalog, such as the AWS Glue database's ARN, database name, and information about the datashare.
3. Using the AWS Glue database ARN from SHOW DATABASES, create a local database in the consumer cluster or workgroup. For more information, see CREATE DATABASE.

   ```
   CREATE DATABASE lf_db FROM ARN <lake-formation-database-ARN> WITH [NO] DATA CATALOG
    SCHEMA [<schema>];
   ```
4. Grant access on databases and schema references created from the datashares to users and roles in the consumer cluster or workgroup as needed. For more information, see GRANT or REVOKE. Note that users created from the CREATE USER command cannot access objects in datashare that have been shared to Lake Formation. Only users with access to both Redshift and Lake Formation can access datashares that have been shared with Lake Formation.

   ```
   GRANT USAGE ON DATABASE sales_db TO IAM:Bob;
   ```

As a consumer cluster or workgroup administrator, you can only assign permissions on the entire database created from the datashare to your users and roles. In some cases, you need fine-grained controls on a subset of database objects created from the datashare.

You can also create late-binding views on top of shared objects and use these to assign granular permissions. You can also consider having producer clusters or workgroups create additional datashares for you with the granularity required. You can create as many schema references to the database created from the datashare.

5. Database users can use the views SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS to find all of the shared tables or columns within the AWS Glue database

```
SELECT * from svv_external_tables WHERE redshift_database_name = 'lf_db';

SELECT * from svv_external_columns WHERE redshift_database_name = 'lf_db';
```

6. Query data in the shared objects in the datashares.

   Users and roles with permissions on consumer databases and schemas on consumer clusters or workgroups can explore and navigate the metadata of any shared objects. They can also explore and navigate local objects in a consumer cluster or workgroup. To do so, they can use the JDBC or ODBC drivers or the SVV_ALL and SVV_EXTERNAL views.

```
SELECT * FROM lf_db.schema.table;
```

   You can only use SELECT statements on shared objects. However, you can create tables in the consumer cluster by querying the data from the shared objects in a different local database.

```
// Connect to a local cluster database

// Create a view on shared objects and access it.

CREATE VIEW sales_data
AS SELECT *
FROM sales_db.public.tickit_sales_redshift
WITH NO SCHEMA BINDING;

SELECT * FROM sales_data;
```

Getting started with multi-warehouse writes using data sharing in Amazon Redshift

You can share database objects for both reads and writes across different Amazon Redshift clusters or Amazon Redshift Serverless workgroups within the same AWS account, across accounts, and across regions. The procedures in this topic show how to set up data sharing that includes write permissions. You can grant permissions such as SELECT, INSERT, and UPDATE for different tables and USAGE and CREATE for schemas.

Data is live and available to all warehouses as soon as you commit a write transaction Producer account administrators can determine whether or not specific namespaces or regions get read-only, read-and-write, or any access to the data. The procedures assume you're working in a database in a provisioned cluster or Amazon Redshift Serverless workgroup.

With Amazon Redshift, you can manage data sharing with writes using the console or the SQL interface to control access and govern data across Amazon Redshift clusters and AWS accounts. The following sections provide step-by-step instructions on configuring and managing data sharing with writes using Amazon Redshift.

For a list of Regions where data sharing is available, see AWS Regions where data sharing is available. For considerations and limitations for writes, see Considerations for data sharing in Amazon Redshift.

> **Note**
>
> Amazon Redshift multi-warehouse writes using data sharing is only supported on Amazon Redshift patch 186 for provisioned clusters on current track version 1.0.78881 or greater, and for Amazon Redshift Serverless workgroups on version 1.0.78890 or greater.

Topics

- Connecting to a database in Amazon Redshift
- Producer actions for new datashares in Amazon Redshift
- Consumer actions for new datashares in Amazon Redshift
- Producer actions for existing datashares in Amazon Redshift
- Consumer actions for existing datashares in Amazon Redshift

Connecting to a database in Amazon Redshift

With Amazon Redshift, you can establish a connection to your data warehouse cluster and execute SQL queries, load data, or perform administrative tasks. Connecting to a database refers to the process of creating a secure channel between a client application or tool and the Amazon Redshift cluster. The following sections provide step-by-step instructions on how to connect to an Amazon Redshift database.

Console

Connect to a database to view databases and objects within databases or to view datashares in the Amazon Redshift data warehouse. The user credentials used to connect to a specified database must have the necessary permissions to view all datashares.

If there is no local connection, do one of the following:

- If you are a producer administrator, go to the **Clusters** tab for provisioned clusters, or the **Namespaces configuration** tab for Serverless endpoints. Select the respective cluster or namespace from the list.
- In the cluster or namespace details page, from the **Datashares** tab, choose **Connect to database** and do one of the following:
  - In the **Datashares from other namespaces and AWS accounts** section, view datashares from other clusters, namespaces, or accounts.
  - In the **Datashares created in my cluster** section, view datashares in your cluster.
- On the **Connect to database** window, do one of the following:
  - If you choose **Create a new connection**, choose **AWS Secrets Manager** to use a stored secret to authenticate access for the connection.

    Or, choose **Temporary credentials** to use database credentials to authenticate access for the connection. Specify values for **Database name** and **Database user**.

    Choose **Connect**.
  - Choose **Use a recent connection** to connect to another database that you have the necessary permissions.

    Amazon Redshift automatically makes the connection.

After a database connection is established, you can start creating datashares, querying datashares, or creating databases from datashares.

Producer actions for new datashares in Amazon Redshift

With Amazon Redshift, you can share live data across Amazon Redshift clusters or AWS accounts using datashares. A datashare is a consumer-producer object that allows you to share live data from your Amazon Redshift cluster with other clusters or AWS accounts. Creating datashares enables secure data sharing while maintaining control over access and ensuring data remains up-to-date. The following sections provide details on creating datashares and adding database objects such as schemas, tables, and views to share live data securely.

Topics

Creating a datashare in Amazon Redshift

A datashare is a logical container of database objects, permissions, and consumers. Consumers are Amazon Redshift provisioned clusters or Amazon Redshift Serverless namespaces in your account and other AWS accounts. Each datashare is associated with the database it's created in and only objects from that database can be added. As a producer administrator, you can create datashares on the console and with SQL by following one of the below procedures.

Console

On the console, you can create datashares from the **Datashares** tabs in the cluster or namespace details page. After the datashare is created, you can create databases from the datashare on a consumer as a consumer administrator.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.

3. In the cluster or namespace details page, from the **Datashares** tab, in the **Datashares** section, connect to a database if you don't have a database connection. In the **Datashares created in my account** section, choose **Create datashare**. The **Create datashare** page appears.
4. Choose **Create datashare**. You can only create a datashare from a local database. If you haven't connected to the database, the **Connect to database** page appears. Follow the steps in Connecting to a database to connect to a database. If there is a recent connection, the **Create datashare** page appears.
5. In the **Datashare information** section, choose one of the following:
   - Choose **Datashare** to create datashares to share data for read or write purpose across different Amazon Redshift data warehouses (provisioned clusters or Serverless endpoints) or in the same AWS account or different AWS accounts.
   - Choose **AWS Data Exchange datashare** to create datashares to license your data through AWS Data Exchange.
6. Specify values for **Datashare name**, **Database name**, and **Publicly accessible**. When you change the database name, make a new database connection.
7. Add objects to your datashare either using the **Scoped permissions** or **Direct permissions** sections. To add objects to a datashare, see Creating a datashare in Amazon Redshift.
8. In the **Data consumers** section, you can choose to publish to Amazon Redshift, or publish to the AWS Glue Data Catalog, which starts the process of sharing data with Lake Formation. Publishing your datashare to Amazon Redshift means sharing your data with another namespace or Amazon Redshift account that acts as the consumer.

   > **Note**
   >
   > Once the datashare is created, you can't edit the configuration to publish to the other option.

9. Choose **Create datashare**.

SQL

The following command creates a datashare:

```
CREATE DATASHARE salesshare;
```

At the time of datashare creation, each datashare is associated with a database. Only objects from that database can be shared in that datashare. Multiple datashares can be created on the same database with the same or different granularity of objects. There is no limit on the number of datashares a cluster can create. You can also use the Amazon Redshift console to create datashares. For more information, see [CREATE DATASHARE](#).

You can also control security restrictions to the datashare during creation. The following example shows that the consumer with a public IP access is allowed to read the datashare.

```
CREATE DATASHARE my_datashare [PUBLICACCESSIBLE = TRUE];
```

Setting PUBLICACCESSIBLE = TRUE allows consumers to query your datashare from publicly accessible clusters and provisioned workgroups. Leave this out or explicitly set it to false if you do not want to allow it.

You can modify properties about the type of consumers after you create a datashare. For example, you can define that clusters that want to consume data from a given datashare can't be publicly accessible. Queries from consumer clusters that don't meet security restrictions specified in datashare are rejected at query runtime. For more information, see [ALTER DATASHARE](#).

Adding objects to a datashare in Amazon Redshift

You can add database objects of various types on the console and with SQL by following one of the below procedures.

Console

You can add objects to your datashare either using **Scoped permissions** or **Direct permissions** sections. Select either **Grant scoped permissions** or **Grant direct permissions** to add objects. Select the **Add** button to add objects. A dialog appears. Perform the following steps:

1. If you select **Grant scoped permissions**, the **Grant scoped permissions** page appears where you can grant scoped permissions at either a database or a schema level. Datashares with scoped permissions have the specified permissions on all current and future objects within the database or schema. For more details see, [Scoped permissions](#).

   1. Next, select **Database scoped permissions** to grant scoped permissions at the database level. When you grant scoped permissions, they apply to the current database while

creating the datashare. These permissions can't be granted to individual objects and are applicable to both existing and new objects (schemas, tables, views, UDFs).

2. Select the scoped permission(s) for the schemas, table or views or user-defined functions. This means all objects in the database have the selected permissions granted to consumers. Select **Grant** to complete granting database scoped permissions.
3. Then, select **Schema scoped permissions** to grant scoped permissions at the schema level. When you grant schema-scoped permissions, all objects added to the schema have the specified datashare permissions.
4. Select the schema you want to add to the datashare from the dropdown. You can select only a single schema at a time. Then, select direct permission(s) you want to grant on the selected schema.
5. Select scoped permission(s) for your schema objects such as tables, views and user-defined functions. Permissions are granted on all matching objects in the schema. These can be either existing objects or those added in the future. When it's applied, you can't remove a permission from an object without revoking the scoped permissions.
6. Select **Grant** to complete granting schema scoped permissions.

2. If you select **Grant direct permissions**, the **Grant direct permissions** page appears where you can grant direct permissions at each objects level such as schema, table, view or user-defined function. To grant direct permissions, you must first add the relevant schemas to the datashare.

    1. Next, select **Grant direct permissions** to schemas to apply direct permissions on specific schema. Then, select schema permission(s) for your schema objects such as tables, views and user-defined functions and select the schema you want added to the datashare. Select **Grant** to complete adding schema to the datashare.
    2. After you have a schema added to your datashare, you can proceed with adding direct permissions for your schema objects. Select **Grant direct permissions** again. The **Grant direct permissions** page appears. Then, navigate to the direct permissions tabs for schema objects.
    3. Select **Grant direct permissions to tables and views** to grant object level direct permissions on these objects. Select the required direct permission(s) and the required objects from the list. Use the search field to find datashare objects. Select Grant to complete adding tables and views to the datashare.
    4. Select **Grant direct permissions to user-defined functions** to grant object level direct permissions on user-defined functions. Select the required direct permission(s) and the

required objects from the list. Use the search field to find datashare objects. Select **Grant** to complete adding user-defined functions to the datashare.

3. You can also choose whether you want to **Add future objects**. When you choose to include datashare objects added to the schema, it means that objects added to the schema are added to the datashare automatically.
4. Choose **Add** to complete the section and add the objects. They're listed under the **Datashare objects**.
5. After you add objects, you can select individual objects and edit their permissions. If you select a schema, a dialog appears that asks if you would like to add **Scoped permissions**. This makes it so each existing or added object to the schema has a pre-selected set of permissions, appropriate for the object type. For instance, the administrator can set that all added tables have SELECT and UPDATE permissions, for instance.
6. All datashare objects are listed under the **Scoped permissions** or **Direct permissions** sections.
7. In the **Data consumers** section, you can add namespaces or add AWS accounts as consumers of the datashare.
8. Choose **Create datashare** to save your changes.

After you create the datashare, it appears in the list under **Datashares created in my namespace**. If you choose a datashare from the list, you can view its consumers, its objects, and other properties.

SQL

With SQL, the datashare owner must grant USAGE on the schemas they want to add to the datashare. The GRANT is used to grant various actions on the schema, including CREATE and USAGE. The schemas hold shared objects:

```
CREATE SCHEMA myshared_schema1;
CREATE SCHEMA myshared_schema2;

GRANT USAGE ON SCHEMA myshared_schema1 TO DATASHARE my_datashare;
GRANT CREATE, USAGE ON SCHEMA myshared_schema2 TO DATASHARE my_datashare;
```

Alternatively, the administrator can continue to run ALTER commands to add a schema to the datashare. Only USAGE permissions are granted when a schema is added this way.

```
ALTER DATASHARE my_datashare ADD SCHEMA myshared_schema1;
```

After the administrator adds schemas, they can grant datashare permissions on objects in the schema. These can be both read and write permissions. The GRANT ALL sample shows how to grant all permissions.

```
GRANT SELECT, INSERT ON TABLE myshared_schema1.table1, myshared_schema1.table2,
 myshared_schema2.table1
TO DATASHARE my_datashare;

GRANT ALL ON TABLE myshared_schema1.table4 TO DATASHARE my_datashare;
```

You can continue to run commands like ALTER DATASHARE to add tables. When you do, only SELECT permissions are granted on the objects added.

```
ALTER DATASHARE my_datashare ADD TABLE myshared_schema1.table1,
 myshared_schema1.table2, myshared_schema2.table1;
```

You can grant scoped permissions to a datashare on all objects of a type within a database or schema. Datashares with scoped permissions have the specified permissions on all current and future objects within the database or schema.

You can view the scope of database-level scoped permissions in SVV_DATABASE_PRIVILEGES. You can view the scope of schema-level scoped permissions in SVV_SCHEMA_PRIVILEGES.

The following is the syntax for granting scoped permissions to datashares. For more information about scoped permissions, see Scoped permissions.

```
GRANT { CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }FOR SCHEMAS IN
DATABASE db_name
TO DATASHARE { datashare_name}

GRANT { { SELECT | INSERT | UPDATE | DELETE | DROP | ALTER | TRUNCATE | REFERENCES }
 [, ...] } | ALL [PRIVILEGES] } }FOR TABLES IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO DATASHARE { datashare_name}

GRANT { EXECUTE | ALL [ PRIVILEGES ] }FOR FUNCTIONS IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO DATASHARE { datashare_name}
```

Adding data consumers to a datashare in Amazon Redshift

You can add one or more data consumers to the datashares on the console or with SQL. Data consumers can be namespaces that uniquely identified Amazon Redshift clusters or AWS accounts.

Console

You must explicitly choose to turn off or turn on sharing your datashare to clusters with public access.

- Choose **Add namespaces to the datashare**. Namespaces are globally unique identifier (GUID) for Amazon Redshift cluster.
- Choose **Add AWS accounts** to the datashare. The specified AWS accounts must have access permissions to the datashare.

SQL

With SQL, the administrator grants usage on the datashare to a specific namespace in the account. You can find the namespace ID as part of the ARN in the cluster details page, in the Amazon Redshift Serverless namespace details page, or by running the command `SELECT current_namespace;`. For more information, see CURRENT_NAMESPACE.

```
GRANT USAGE ON DATASHARE my_datashare TO NAMESPACE '86b5169f-012a-234b-9fbb-
e2e24359e9a8';
```

The following is an example of how to grant usage of a datashare to an AWS account.

```
GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '123456789012';
```

The following is an example of how to grant usage of a datashare to a Lake Formation account.

```
GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '123456789012' VIA DATA CATALOG;
```

Authorizing a datashare in Amazon Redshift

With Amazon Redshift, you can control access to datashares by authorizing specified consumers. Datashares allow you to share live data across Amazon Redshift clusters in the same or different

AWS accounts, providing a seamless way to distribute and consume analytical data. This section provides step-by-step instructions for authorizing and revoking consumer access to your datashares in Amazon Redshift.

> **Note**
>
> If you are adding a namespace as a data consumer, you don't have to perform authorization. To authorize a datashare, there must be at least one data consumer added to the datashare.

Console

As a producer administrator on the console, you can choose which data consumers to authorize to access datashares or to remove authorization from. Authorized data consumers receive notifications to take actions on datashares. If you are adding a namespace as a data consumer, you don't have to perform authorization.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Datashares**. From here you can see a list called **Datashares consumers**. Choose one or more consumer clusters that you want to authorize. Then choose **Authorize**.
3. The **Authorize account** dialog appears. You can choose among a couple authorization types.
   - **Read-only on [cluster name or workgroup name]** – This means that no write permissions are available on the consumer, even if the datashare creator granted write permissions.
   - **Read and write on [cluster name or workgroup name]** – This means that all permissions granted by the creator, including write permissions, are available on the consumer.
4. Choose **Save**.

You can also authorize AWS Data Exchange as a consumer.

1. If you chose **Publish to AWS Glue Data Catalog** when creating the datashare, you can only grant authorization of the datashare to a Lake Formation account.

For AWS Data Exchange datashare, you can only authorize one datashare at a time.

When you authorize an AWS Data Exchange datashare, you are sharing the datashare with the AWS Data Exchange service and allowing AWS Data Exchange to manage access to the datashare on your behalf. AWS Data Exchange allows access to consumers by adding consumer accounts as data consumers to the AWS Data Exchange datashare when they subscribe to the products. AWS Data Exchange doesn't have read access to the datashare.

2. Choose **Save**.

After data consumers are authorized, they can access datashare objects and create a consumer database to query the data.

API

The producer security administrator determines the following:

- Whether or not another account can have access to the datashare.
- If an account has access to the datashare, whether or not that account has write permissions.

The following IAM permissions are required to authorize a datashare:

redshift:AuthorizeDataShare

You can authorize usage and writes using either a CLI call or with the API:

```
authorize-data-share
--data-share-arn <value>
--consumer-identifier <value>
[--allow-writes | --no-allow-writes]
```

For more information about the command, see authorize-data-share.

The consumer identifier can be either:

- A twelve digit AWS account ID.
- The namespace identifier ARN.

> **Note**
>
> Write permissions aren't granted at the authorizing step. Authorizing a datashare for writes just allows the account to have write permissions that were granted by the datashare administrator. If an administrator does not allow writes, the only permissions available to the specific consumer are SELECT, USAGE, and EXECUTE.

You can change the authorization of a datashare consumer by calling `authorize-data-share` again, but with a different value. The old authorization is overwritten by the new authorization. So if you originally authorize and allow writes, but re-authorize and specify `no-allow-writes` or simply do not specify a value, the consumer will have their write permissions revoked.

Consumer actions for new datashares in Amazon Redshift

With Amazon Redshift, you can consume datashares from other AWS accounts, enabling cross-account data sharing and collaboration. A datashare is a secure way to share live data across Amazon Redshift clusters, even if they are in different AWS accounts. The following sections provide detailed steps for configuring access, creating databases from datashares, granting object level permissions, and querying shared data.

Topics

Associating a datashare from a different AWS account in Amazon Redshift

With Amazon Redshift, you can associate datashares shared by other AWS accounts, enabling seamless and secure data sharing across organizational boundaries. Datashares are shareable database objects that encapsulate data from one or more Amazon Redshift databases. The following sections demonstrate the process of associating datashares.

Console

As a consumer administrator, you can associate one or more datashares that are shared from other accounts to your entire AWS account or specific namespaces in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Datashares**. The datashare list page appears. Choose **From other accounts**.
3. In the **Datashares from other accounts** section, choose the datashare that you want to associate and choose **Associate**. When the **Associate** datashare page appears, choose one of the following association types:

   - Choose **Entire AWS account** to associate all existing and future namespaces across different AWS Regions in your AWS account with the datashare.
   - If the datashare is published to the AWS Glue Data Catalog, you can only associate the datashare with the entire AWS account.
4. From here you can choose **Allowed permissions**. The choices are:

   - **Read-only –** If you choose read only, write permissions like UPDATE or INSERT aren't available on the consumer, even if these permissions were granted and authorized on the producer.
   - **Read and write –** Consumer datashare users will have all of the permissions, both read and write, that were granted and authorized by the producer.
5. Alternatively, choose **Specific AWS Regions and namespaces** to associate one or more AWS Regions and specific namespaces with the datashare. Choose **Add Region** to add specific AWS Regions and namespaces to the datashare. The **Add AWS Region** page appears.
6. Choose an **AWS Region**.
7. Do one of the following:

   - Choose **Add all namespaces** to add all existing and future namespaces in this Region to the datashare.
   - Choose **Add specific namespaces** to add one or more specific namespaces in this Region to the datashare.
   - Choose one or more namespaces and choose **Add AWS Region**.
8. Choose **Associate**.

It's possible for the producer to go back and change settings for an authorization, which can affect association settings on consumers.

If you're associating the datashare with a Lake Formation account, go to the Lake Formation console to create a database, then define permissions over the database. For more information, see [Setting up permissions for Amazon Redshift datashares](#) in the AWS Lake Formation Developer Guide. Once you create a AWS Glue database or a federated database, you can use query editor v2 or any preferred SQL client with your consumer cluster to query the data.

After the datashare is associated, the datashares become available.

> **Note**
>
> You can also change datashare association at any time. When changing association from specific AWS Regions and namespaces to the entire AWS account, Amazon Redshift overwrites the specific Region and namespaces information with AWS account information. All the AWS Regions and namespaces in the AWS account then have access to the datashare.

API

> **Note**
>
> The steps in this section are performed after the producer administrator grants specific actions on the shared database objects and, if the datashare is being shared with another account, the producer security administrator authorizes access.

The consumer security administrator determines the following:

- Whether or not all namespaces in an account, namespaces in specific regions in the account, or specific namespaces have access to the datashare.
- If namespaces have access to the datashare, whether or not those namespace have write permissions.

The consumer security administrator can associate the datashare with the following command:

```
associate-data-share-consumer
```

```
--data-share-arn <value>
--consumer-identifier <value>
[--allow-writes | --no-allow-writes]
```

For more information about the command, see associate-data-share-consumer.

The consumer security administrator must explicitly set `allow-writes` to true when associating a datashare with a namespace, to allow use of INSERT and UPDATE commands. If they don't, the users can perform only read operations, such as SELECT, USAGE, or EXECUTE privileges.

You can change the association of a namespace for a datashare by calling `associate-data-share-consumer` again, with a different value. The old association is overwritten by the new association, so if you originally associate and set `allow-writes`, but associate and specify `no-allow-writes`, or simply do not specify a value, the consumer will have their write permissions revoked.

Creating a database from a datashare in Amazon Redshift

With Amazon Redshift, you can use a datashare to create a database, and then query data across datashares from producer clusters to securely access live data without copying or transferring it. The following steps cover the details of setting up a database in your Amazon Redshift environment.

Console

Before you can query data in the datashare, you must create a database from a datashare. You can create only one database from a specified datashare.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**. The datashare list appears.
4. In the **Datashares from other clusters** section, choose **Connect to database**. For more information, see Connecting to a database.
5. Choose a datashare that you want to create databases from, then choose **Create database from datashare**. The Create database from datashare page appears.

6. In the **Database name**, specify a database name. The database name must be 1–64 alphanumeric characters (lowercase only) and it can't be a reserved word.
7. Choose **Create**.

After the database is created, you can query data in the database or perform write operations, if they have been granted, authorized, and associated by the consumer administrator.

API

To share data for read purposes as a consumer administrator, perform the following steps.

1. List the datashares that are made available to you and view the content of datashares. For more information, see DESC DATASHARE and SHOW DATASHARES.

   The following example displays the information of inbound datashares of a specified producer namespace. When you run DESC DATASHARE as a consumer administrator, you must specify the NAMESPACE option to view inbound datashares.

```
DESC DATASHARE salesshare OF NAMESPACE '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';


 producer_account  |          producer_namespace          | share_type |
 share_name | object_type |           object_name           |   include_new
-------------------+--------------------------------------+------------
+------------+-------------+---------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_users_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_venue_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_category_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_date_redshift     |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_event_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_listing_redshift  |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | table       | public.tickit_sales_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | schema      | public                          |
```

```
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    |
 salesshare | view        | public.sales_data_summary_view  |
```

Only cluster superusers can do this. You can also use SVV_DATASHARES to view the datashares and SVV_DATASHARE_OBJECTS to view the objects within the datashare.

The following example displays the inbound datashares in a consumer cluster.

```
SHOW DATASHARES LIKE 'sales%';


 share_name | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace
------------+-------------+-----------------+-------------------+------------
+------------+---------------------+-----------+-----------------
+-------------------------------------
 salesshare |             |                 |                   | INBOUND
    |            |         t           |           |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

2. As a database superuser, you can create local databases that reference to the datashares. For more information, see CREATE DATABASE.

```
CREATE DATABASE sales_db FROM DATASHARE salesshare OF NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

If you want more granular control over access to the objects in the local database, use the WITH PERMISSIONS clause when creating the database. This lets you grant object-level permissions for objects in the database in step 4.

```
CREATE DATABASE sales_db WITH PERMISSIONS FROM DATASHARE salesshare OF NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

You can see databases that you created from the datashare by querying the SVV_REDSHIFT_DATABASES view. You can connect to these databases directly, or you can connect to a local database on your consumer cluster and perform a cross-database query to query the data from the datashare databases.

> **Note**
>
> You can't create a datashare on top of database objects created from an existing datashare. However, you can copy the data into a separate table on the consumer cluster, perform any processing needed, and then share the new objects that were created.

You can also use the Amazon Redshift console to create databases from datashares. For more information, see Creating databases from datashares.

Granting object level permissions to consumer users and roles in Amazon Redshift

As a consumer administrator, you can grant permissions to consumer users and roles at the object level by completing the following steps.

SQL

If you created your database without WITH PERMISSIONS, you can only assign permissions on the entire database created from the datashare to your users and roles.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

```
GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

You can also create late-binding views on top of shared objects and use these to assign granular permissions. You can also consider having producer clusters create additional datashares for you with the granularity required.

If you created your database with WITH PERMISSIONS, you must assign object-level permissions for objects in the shared database. A user with only the USAGE permission can't access any objects in a database created with WITH PERMISSIONS until they're granted additional object-level permissions..

```
GRANT SELECT ON sales_db.public.tickit_sales_redshift to Bob;
```

For more information about granting permissions with multi-warehouse writes, see Managing permissions for a datashares in Amazon Redshift.

Querying data in a datashare in Amazon Redshift

With Amazon Redshift, you can query data across datashares from producer clusters to securely access live data without copying or transferring it. The following section covers querying datashares in your Amazon Redshift environment.

Users and roles with permissions on consumer databases and schemas on consumer clusters can explore and navigate the metadata of any shared objects. They can also explore and navigate local objects in a consumer cluster. To do this, they use JDBC or ODBC drivers or SVV_ALL and SVV_REDSHIFT views.

Producer clusters might have many schemas in the database, tables, and views within each schema. The users on the consumer side can see only the subset of objects that are made available through the datashare. These users can't see the entire metadata from the producer cluster. This approach helps provide granular metadata security control with data sharing.

You continue to connect to local cluster databases. But now, you can also read from the databases and schemas that are created from the datashare using the three-part database.schema.table notation. You can perform queries that span across any and all databases that are visible to you. These can be local databases on the cluster or databases created from the datashares. Consumer clusters can't connect to the databases created from the datashares.

You can access the data using full qualification. For more information, see Cross-database query examples.

SQL

```
SELECT * FROM sales_db.public.tickit_sales_redshift ORDER BY 1,2 LIMIT 5;

 salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime
---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------
       1 |      1 |    36861 |   21191 |    7872 |   1875 |       4 |    728.00 |
  109.20 | 2008-02-18 02:36:48
       2 |      4 |     8117 |   11498 |    4337 |   1983 |       2 |     76.00 |
   11.40 | 2008-06-06 05:00:16
       3 |      5 |     1616 |   17433 |    8647 |   1983 |       2 |    350.00 |
   52.50 | 2008-06-06 08:26:17
```

```
      4 |       5 |      1616 |    19715 |     8647 |    1986 |         1 |     175.00 |
   26.25 | 2008-06-09 08:38:52
      5 |       6 |     47402 |    14115 |     8240 |    2069 |         2 |     154.00 |
   23.10 | 2008-08-31 09:17:02
```

You can only use SELECT statements on shared objects. However, you can create tables in the consumer cluster by querying the data from the shared objects in a different local database.

Producer actions for existing datashares in Amazon Redshift

With Amazon Redshift, you can manage existing datashares to control access to your data in an Amazon Redshift cluster. The following sections provide step-by-step guidance on modifying datashare objects, managing datashare permissions, and updating datashare properties to effectively control and audit data access in your Amazon Redshift environment.

Topics

Viewing a datashare in Amazon Redshift

You can view datashares from the console or with SQL.

Console

You can view datashares from the **Datashares** or **Clusters** tab.

- Use the **Datashares** tab to list datashares in your account or from other accounts.
  - To view datashares created in your account, choose **In my account**, then choose the datashare you want to view.
  - To view datashares that are shared from other accounts, choose **From other accounts**, then choose the datashare you want to view.

- Use the **Clusters** tab to list datashares in your cluster or from other clusters.

  First, connect to a database. Then, choose a datashare either from the **Datashares from other clusters** or **Datashares created in my cluster** section to view its details.

SQL

You can list datashares created in the cluster and look into the contents of the datashare.

The following example displays the information of a datashare named `salesshare`.

```
DESC DATASHARE salesshare;

 producer_account  |          producer_namespace          | share_type | share_name
 | object_type |           object_name          |   include_new
-------------------+--------------------------------------+------------+------------
+-------------+---------------------------------+------------------
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_users_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_venue_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_category_redshift|
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_date_redshift    |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_event_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_listing_redshift |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | table       | public.tickit_sales_redshift   |
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | schema      | public                         |  t
 123456789012      | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | OUTBOUND   | salesshare
 | view        | public.sales_data_summary_view |
```

The following example displays the outbound datashares in a producer cluster.

```
SHOW DATASHARES LIKE 'sales%';
```

The output looks similar to the following.

```
share_name | share_owner  | source_database | consumer_database | share_type |
  createdate      | is_publicaccessible  | share_acl | producer_account |
 producer_namespace
-----------+--------------+-----------------+-------------------+------------
+---------------------+---------------------+-----------+------------------
+---------------------------------------
salesshare |    100       | dev             |                   |  OUTBOUND
 | 2020-12-09 02:27:08 |          True        |           |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

For more information, see DESC DATASHARE and SHOW DATASHARES.

You can also use SVV_DATASHARES, SVV_DATASHARE_CONSUMERS, and SVV_DATASHARE_OBJECTS to view the datashares, the objects within the datashare, and the datashare consumers.

Editing datashares created in your account in Amazon Redshift

You can edit a datashare created in your account using the console and with SQL.

Console

On the console, take the following steps to connect to a database first to see the list of datashares created in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**.
4. In the **Datashares created in my account** section, choose **Connect to database**.
5. Choose the datashare you want to edit, then choose **Edit**. The datashare details page appears.
6. Make any changes in the **Datashare objects** or **Data consumers** section.
7. Choose **Save changes**. Amazon Redshift updates your datashare with the changes.

> **Note**
>
> If you chose to publish your datashare to the AWS Glue Data Catalog, you can't edit the configuration to publish the datashare to other Amazon Redshift accounts.

SQL

Use ALTER DATASHARE to remove objects from datashares at any point from the datashare. To remove a schema, use the following command:

```
ALTER DATASHARE salesshare REMOVE SCHEMA PUBLIC;
```

To remove a table, use the following command:

```
ALTER DATASHARE salesshare REMOVE TABLE public.tickit_sales_redshift;
```

Use REVOKE USAGE ON to revoke permissions on the datashare to certain consumers. It revokes USAGE permissions on objects within a datashare and instantly stops access to all consumer clusters. Listing datashares and the metadata queries, such as listing databases and tables, doesn't return the shared objects after access is revoked. Revoke access to the datashare from namespaces if you don't want to share the data with the consumers anymore.

```
REVOKE USAGE ON DATASHARE salesshare FROM NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

If you don't want to share the data with the consumers anymore, revoke access to the datashare from AWS accounts:

```
REVOKE USAGE ON DATASHARE salesshare FROM ACCOUNT '123456789012';
```

Removing authorization from a datashare in Amazon Redshift

With Amazon Redshift, you can control access to datashares by revoking authorization for specified consumers. This sections provides instructions for revoking consumer access to your datashares in Amazon Redshift.

> **Note**
>
> To remove authorization for the datashare, there must be at least one data consumer added to the datashare.

Console

Choose one or more consumer clusters that you want to remove authorization from. Then, choose **Remove authorization**.

After authorization is removed, data consumers lose access to the datashare immediately.

API

The producer security administrator determines the following:

- Whether or not another account can have access to the datashare.
- If an account has access to the datashare, whether or not that account has write permissions.

The following IAM permissions are required to deauthorize a datashare:

redshift:DeauthorizeDataShare

You can deauthorize usage and writes using either a CLI call or with the API:

```
deauthorize-data-share
--data-share-arn <value>
--consumer-identifier <value>
```

For more information about the command, see deauthorize-data-share.

Removing datashare objects from a datashare in Amazon Redshift

You can remove one or more objects from a datashare by using the following procedure.

Console

To remove one or more objects from a datashare on the consoe, follow these steps.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**.
4. In the **Datashares created in my account** section, choose **Connect to database**. For more information, see Connecting to a database.
5. Choose the datashare you want to edit, then choose **Edit**. The datashare details page appears.
6. To remove one or more datashare objects to the datashare, do one of the following:

   - To remove schemas from the datashare, choose one or more schemas. Then choose **Remove**. Amazon Redshift removes the specified schemas and all the objects of the specified schemas from the datashare.
   - To remove tables and views from the datashare, choose one or more tables and views. Then choose **Remove**. Alternatively, choose **Remove by schema** to remove all tables and views in the specified schemas.
   - To remove user-defined functions from the datashare, choose one or more user-defined functions. Then choose **Remove**. Alternatively, choose **Remove by schema** to remove all user-defined functions in the specified schemas.

SQL

Use ALTER DATASHARE to remove objects from datashares at any point from the datashare. To remove a schema, use the following command:

```
ALTER DATASHARE salesshare REMOVE SCHEMA PUBLIC;
```

To remove a table, use the following command:

```
ALTER DATASHARE salesshare REMOVE TABLE public.tickit_sales_redshift;
```

Removing data consumers from a datashare in Amazon Redshift

You can remove one or more data consumers from a datashare. Data consumers can be namespaces that uniquely identified Amazon Redshift clusters or AWS accounts.

Console

To remove one or more data consumers from a datashare on the console, choose one or more data consumers either from the namespace IDs or AWS account. Then, choose **Remove**.

Amazon Redshift removes the specified data consumers from the datashare. They lose access to the datashare immediately.

SQL

Use REVOKE USAGE ON to revoke permissions on the datashare to certain consumers. It revokes USAGE permissions on objects within a datashare and instantly stops access to all consumer clusters. Listing datashares and the metadata queries, such as listing databases and tables, doesn't return the shared objects after access is revoked. Revoke access to the datashare from namespaces if you don't want to share the data with the consumers anymore.

```
REVOKE USAGE ON DATASHARE salesshare FROM NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

Deleting a datashare created in your account in Amazon Redshift

You can delete a datashare created in your account using the console or with SQL.

Console

To delete a datashare created in your account using the console, first connect to a database to see the list of datashares created in your account.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose your cluster. The cluster details page appears.
3. Choose **Datashares**. The datashare list appears.
4. In the **Datashares created in my account** section, choose **Connect to database**.
5. Choose one or more datashares you want to delete, then choose **Delete**. The Delete datashares page appears.

Deleting a datashare shared with Lake Formation doesn't automatically remove the associated permissions in Lake Formation. To remove them, go to the Lake Formation console.

6. Type **Delete** to confirm deleting the specified datashares.
7. Choose **Delete**.

After datashares are deleted, datashare consumers lose access to the datashares.

SQL

You can use SQL to delete the datashare objects at any point using DROP DATASHARE. Cluster superusers and owners of datashare can drop datashares.

The following example drops a datashare named `salesshare`.

```
DROP DATASHARE salesshare;
```

Consumer actions for existing datashares in Amazon Redshift

With Amazon Redshift, you can manage existing datashares to control access to your data in an Amazon Redshift cluster. The following sections provide step-by-step guidance on managing datashares in your Amazon Redshift environment as a consumer administrator.

Topics

Managing permissions for a datashares in Amazon Redshift

As a producer administrator, you retain control for the datasets you are sharing. You can add new objects to or remove them from the datashare. You can also grant or revoke access to datashares as a whole for the consumer clusters, AWS accounts, or AWS Regions. When permissions are revoked, consumer clusters immediately lose access to the shared objects and stop seeing them in the list of INBOUND datashares in SVV_DATASHARES.

The following example creates the datashare `salesshare`, adds the schema `public`, and adds the table `public.tickit_sales_redshift` to `salesshare`. It also grants usage permissions on `salesshare` to the specified namespace.

```
CREATE DATASHARE salesshare;

ALTER DATASHARE salesshare ADD SCHEMA public;

ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;

GRANT USAGE ON DATASHARE salesshare TO NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

For CREATE DATASHARE, superusers and database owners can create datashares. For more information, see CREATE DATASHARE. For ALTER DATASHARE, the owner of the datashare with the required permissions on the datashare objects to be added or removed can alter the datashare. For information, see ALTER DATASHARE.

As a producer administrator, when you drop a datashare, it stops being listed on consumer clusters. The databases and schema references created on the consumer cluster from the dropped datashare continue to exist with no objects in them. The consumer administrator must delete these databases manually.

On the consumer side, a consumer administrator can determine which users and roles should get access to the shared data by creating a database from the datashare. Depending on the options you choose when creating the database, you can control access to it as follows. For more information about creating a database from a datashare, see CREATE DATABASE.

For more information about setting up a datashare and reading data from a consumer, see Sharing read access to data within an AWS account.

Creating the database without the WITH PERMISSIONS clause

An administrator can control access at the database or schema level. To control access at the schema level, the administrator must create an external schema from the Amazon Redshift database created from the datashare.

The following example grants permissions to access a shared table at the database level and schema level.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

```
CREATE EXTERNAL SCHEMA sales_schema FROM REDSHIFT DATABASE sales_db SCHEMA 'public';

GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

To further restrict access, you can create views on top of shared objects, exposing only the necessary data. You can then use these views to give access to the users and roles.

After the users are granted access to the database or schema, they will have access to all shared objects in that database or schema.

Creating the database with the WITH PERMISSIONS clause

After granting usage rights on the database or schema, an administrator can further control access using the same permission granting process as they would on a local database or schema. Without individual object permissions, users can't access any objects in the datashared database or schema even after being granted the USAGE permission.

The following example grants permissions to access a shared table at the database level.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
GRANT USAGE FOR SCHEMAS IN DATABASE sales_db TO Bob;
GRANT SELECT ON sales_db.public.tickit_sales_redshift TO Bob;
```

After being granted access to the database or schema, users still need to be given the relevant permissions for any objects in the database or schema that you want them to access.

Granular sharing using WITH PERMISSIONS

You can use granular sharing using WITH PERMISSIONS to enable clusters or Serverless workgroups to query the datashare. This process assumes the datashare is originating from another cluster or Amazon Redshift Serverless namespace in your account, or it is coming from another account and has been associated with the namespace you are using.

1. The consumer database administrator can create a database from the datashare.

   ```
   CREATE DATABASE my_ds_db [WITH PERMISSIONS] FROM DATASHARE my_datashare OF
    NAMESPACE 'abc123def';
   ```

   If you create a database WITH PERMISSIONS, you can grant granular permissions on datashare objects to different users and roles. Without this, all users and roles granted USAGE permission on the datashare database are granted all permissions on all objects within the datashare database.

2. The following shows how to grant permissions to a Redshift database user or role. You must be connected to a local database to run these statements. You cannot run these statements if you execute a USE command on the datashare database before running the grant statements.

```
GRANT USAGE ON DATABASE my_ds_db TO ROLE data_eng;
GRANT CREATE, USAGE ON SCHEMA my_ds_db.my_shared_schema TO ROLE data_eng;
GRANT ALL ON ALL TABLES IN SCHEMA my_ds_db.my_shared_schema TO ROLE data_eng;

GRANT USAGE ON DATABASE my_ds_db TO bi_user;
GRANT USAGE ON SCHEMA my_ds_db.my_shared_schema TO bi_user;
GRANT SELECT ON my_ds_db.my_shared_schema.table1 TO bi_user;
```

Removing association of a datashare from data consumers in a different AWS account in Amazon Redshift

With Amazon Redshift, you can remove association from datashares shared by other AWS accounts. Datashares are shareable database objects that encapsulate data from one or more Redshift databases. The following sections demonstrate the process of disassociating datashares within your Redshift environment.

Console

As a consumer administrator, you can remove association of datashares from data consumers on the console.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Datashares**. The datashare list page appears.
3. Choose **From other accounts**.
4. In the **Datashares from other accounts** section, choose the datashare to remove association from data consumers.
5. In the **Data consumers** section, choose one or more data consumers to remove association from. Then choose **Remove association**.
6. When the Remove association page appears, choose **Remove association**.

After association is removed, data consumers will lose access to the datashare. You can change the data consumer association at any time.

SQL

> **Note**
>
> The steps in this section are performed after the producer administrator grants specific actions on the shared database objects and, if the datashare is being shared with another account, the producer security administrator authorizes access.

The consumer security administrator can disassociate the datashare with the following command:

```
disassociate-data-share-consumer
--data-share-arn <value>
```

For more information about the command, see disassociate-data-share-consumer.

Declining a datashare from a different AWS account in Amazon Redshift

With Amazon Redshift, you can decline datashares shared by other AWS accounts, enabling seamless and secure data sharing across organizational boundaries. Datashares are shareable database objects that encapsulate data from one or more Amazon Redshift databases.

As a consumer administrator, you can reject any datashare whose state is available or active. After you reject a datashare, consumer cluster users lose access to the datashare. Amazon Redshift doesn't return the rejected datashare if you call the `DescribeDataSharesForConsumer` API operation. If the producer administrator runs the `DescribeDataSharesForProducer` API operation, they will see that the datashare was rejected. Once a datashare is rejected, the producer administrator can authorize the datashare to a consumer cluster again, and the consumer administrator can choose to associate their AWS account with the datashare or reject it.

If your AWS account has an association to a datashare and a pending association to a datashare that's managed by Lake Formation, rejecting the datashare association that's managed by Lake Formation also rejects the original datashare. To reject a specific association, the producer administrator can remove authorization from a specified datashare. This action doesn't affect other datashares.

To reject a datashare, use the AWS console, the API operation `RejectDataShare`, or `reject-datashare` in the AWS CLI.

Console

To reject a datashare using the AWS console, perform the following steps.

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. In the navigation menu, choose **Datashares**.
3. Choose **From other accounts**.
4. In the **Datashares from other accounts** section, choose the datashare you want to decline. When the **Decline datashare** page appears, choose **Decline**.

After you decline the datashares, you can't revert the change. Amazon Redshift removes the datashares from the list. To see the datashare again, the producer administrator must authorize it again.

CLI

To reject a datashare, the administrator uses the following command:

```
reject-data-share
--data-share-arn <value>
```

For more information about the command, see reject-data-share.

Getting started with data sharing with AWS CloudFormation in Amazon Redshift

You can automate data sharing setup by using an AWS CloudFormation stack, which provisions AWS resources. The CloudFormation stack sets up data sharing between two Amazon Redshift clusters in the same AWS account. Thus, you can start data sharing without running SQL statements to provision your resources.

The stack creates a datashare on the cluster that you designate. The datashare includes a table and sample read-only data. This data can be read by your other Amazon Redshift cluster.

If you want to start sharing data in an AWS account by running SQL statements to set up a datashare and grant permissions, without using CloudFormation, see Sharing read access to data within an AWS account.

Before running the data sharing CloudFormation stack, you must be logged in with a user that has permission to create an IAM role and a Lambda function. You also need two Amazon Redshift clusters in the same account. You use one, the *producer*, to share the sample data, and the other, the *consumer*, to read it. The primary requirement for these clusters is that each use RA3 nodes. For additional requirements, see Considerations for data sharing in Amazon Redshift.

For more information about getting started setting up an Amazon Redshift cluster, see Get started with Amazon Redshift provisioned data warehouses. For more information about automating setup with CloudFormation, see What is AWS CloudFormation?

> **Important**
>
> Before launching your CloudFormation stack, make sure you have two Amazon Redshift clusters in the same account and that the clusters use RA3 nodes. Make sure each cluster has a database and a superuser. For more information, see CREATE DATABASE and superuser.

To launch your CloudFormation stack for Amazon Redshift data sharing:

1. Click **Launch CFN stack**, which takes you to the CloudFormation service in the AWS Management Console.

   If you are prompted, sign in.

   The stack creation process starts, referencing a CloudFormation template file, which is stored in Amazon S3. A CloudFormation *template* is a text file in JSON format that declares AWS resources that make up a stack. For more information about CloudFormation templates, see Learn template basics.
2. Choose **Next** to enter the stack details.
3. Under **Parameters**, for each cluster, enter the following:

   - Your Amazon Redshift cluster name, for example **`ra3-consumer-cluster`**
   - Your database name, for example **`dev`**

- The name of your database user, for example **`consumeruser`**

   We recommend using test clusters, because the stack creates several database objects.

   Choose **Next**.

4. The stack options appear.

   Choose **Next** to accept the default settings.

5. Under **Capabilities**, choose **I acknowledge that AWS CloudFormation might create IAM resources.**
6. Choose **Create stack**.

CloudFormation takes about 10 minutes to build the Amazon Redshift stack using the template, creating a datashare called `myproducer_share`. The stack creates the datashare in the database specified in the stack details. Only objects from that database can be shared.

If an error occurs while the stack is created, do the following:

- Make sure that you entered the correct cluster name, database name, and database user name for each Redshift cluster.
- Make sure that your cluster has RA3 nodes.
- Make sure you are logged in with a user that has permission to create an IAM role and a Lambda function. For more information about creating IAM roles, see Creating IAM roles. For more information about policies for Λ function creation, see Function development.

Querying the datashare that you created

To use the following procedure, make sure that you have the required permissions for running queries on each cluster described.

To query your datashare:

1. Connect to the producer cluster on the database entered when your CloudFormation stack was created, using a client tool such as the Amazon Redshift query editor v2.
2. Query for datashares.

```
SHOW DATASHARES;
```

```
+------------------+-------------+----------------+------------------
+------------+------------+--------------------+-----------+------------------
+-------------------------------------+
|    share_name    | share_owner | source_database | consumer_database | share_type
 | createdate | is_publicaccessible | share_acl | producer_account |
 producer_namespace          |
+------------------+-------------+----------------+------------------
+------------+------------+--------------------+-----------+------------------
+-------------------------------------+
| myproducer_share | 100         | sample_data_dev | myconsumer_db     | INBOUND
  | NULL       | true                | NULL      | producer-acct    |        your-
producer-namespace        |
+------------------+-------------+----------------+------------------
+------------+------------+--------------------+-----------+------------------
+-------------------------------------+
```

The preceding command returns the name of the datashare created by the stack, called `myproducer_share`. It also returns the name of the database associated with the datashare, `myconsumer_db`.

Copy the producer namespace identifier to use in a later step.

3. Describe objects in the datashare.

```
DESC DATASHARE myproducer_share;

+------------------+-------------------------------------+------------
+------------------+-------------+-----------------------------------
+-------------+
| producer_account |          producer_namespace          | share_type |
 share_name     | object_type |              object_name              | include_new |
+------------------+-------------------------------------+------------
+------------------+-------------+-----------------------------------
+-------------+
|   producer-acct  |        your-producer-namespace       | OUTBOUND   |
 myproducer_share | schema      | myproducer_schema                   | true
 |
|   producer-acct  |        your-producer-namespace       | OUTBOUND   |
 myproducer_share | table       | myproducer_schema.tickit_sales      | NULL
 |
```

```
|    producer-acct   |         your-producer-namespace         | OUTBOUND    |
 myproducer_share | view        | myproducer_schema.ticket_sales_view | NULL
 |
+------------------+---------------------------------------+------------
+------------------+-------------+------------------------------------
+-------------+
```

When you describe the datashare, it returns properties for tables and views. The stack adds tables and views with sample data to the producer database, for example `tickit_sales` and `tickit_sales_view`. For more information about the TICKIT sample database, see [Sample database](#).

You don't have to delegate permissions on the datashare to run queries. The stack grants the necessary permissions.

4. Connect to the consumer cluster using your client tool. Describe the datashare, specifying the producer's namespace.

```
DESC DATASHARE myproducer_share OF NAMESPACE '<namespace id>'; --specify the unique
 identifier for the producer namespace

+------------------+---------------------------------------+------------
+------------------+-------------+------------------------------------
+-------------+
| producer_account |          producer_namespace           | share_type |
 share_name     | object_type |           object_name             | include_new |
+------------------+---------------------------------------+------------
+------------------+-------------+------------------------------------
+-------------+
|    producer-acct   |         your-producer-namespace         | INBOUND     |
 myproducer_share | schema      | myproducer_schema                   | NULL
 |
|    producer-acct   |         your-producer-namespace         | INBOUND     |
 myproducer_share | table       | myproducer_schema.tickit_sales      | NULL
 |
|    producer-acct   |         your-producer-namespace         | INBOUND     |
 myproducer_share | view        | myproducer_schema.ticket_sales_view | NULL
 |
+------------------+---------------------------------------+------------
+------------------+-------------+------------------------------------
+-------------+
```

5. You can query tables in the datashare by specifying the datashare's database and schema. For more information, see Cross-database query examples. The following queries return sales and seller data from the SALES table in the TICKIT sample database. For more information, see Sample database.

```
SELECT * FROM myconsumer_db.myproducer_schema.tickit_sales_view;

+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+--------------------+
| salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime       |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+--------------------+
|       1 |      1 |    36861 |   21191 |    7872 |   1875 |       4 |       728 |
     109.2 | 2008-02-18 02:36:48 |
|       2 |      4 |     8117 |   11498 |    4337 |   1983 |       2 |        76 |
      11.4 | 2008-06-06 05:00:16 |
|       3 |      5 |     1616 |   17433 |    8647 |   1983 |       2 |       350 |
      52.5 | 2008-06-06 08:26:17 |
|       4 |      5 |     1616 |   19715 |    8647 |   1986 |       1 |       175 |
     26.25 | 2008-06-09 08:38:52 |
|       5 |      6 |    47402 |   14115 |    8240 |   2069 |       2 |       154 |
      23.1 | 2008-08-31 09:17:02 |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+--------------------+
```

> **Note**
>
> The query runs against the view in the shared schema. You can't connect directly to databases created from datashares. They are read-only.

6. To run a query that includes aggregations, use the following example.

```
SELECT * FROM myconsumer_db.myproducer_schema.tickit_sales ORDER BY 1,2 LIMIT 5;

+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+--------------------+
| salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime       |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+--------------------+
```

```
|        1 |        1 |     36861 |    21191 |     7872 |    1875 |         4 |         728 |
      109.2 | 2008-02-18 02:36:48 |
|        2 |        4 |      8117 |    11498 |     4337 |    1983 |         2 |          76 |
       11.4 | 2008-06-06 05:00:16 |
|        3 |        5 |      1616 |    17433 |     8647 |    1983 |         2 |         350 |
       52.5 | 2008-06-06 08:26:17 |
|        4 |        5 |      1616 |    19715 |     8647 |    1986 |         1 |         175 |
      26.25 | 2008-06-09 08:38:52 |
|        5 |        6 |     47402 |    14115 |     8240 |    2069 |         2 |         154 |
       23.1 | 2008-08-31 09:17:02 |
+---------+--------+---------+---------+---------+--------+---------+-----------
+------------+--------------------+
```

The query returns sales and seller data from the sample TICKIT data.

For more examples of datashare queries, see Sharing read access to data within an AWS account.

Types of datashares in Amazon Redshift

A *datashare* is the unit of sharing data in Amazon Redshift. Use datashares to share data in the same AWS account or different AWS accounts. Also, share data for read purposes across different Amazon Redshift clusters.

Each datashare is associated with a specific database in your Amazon Redshift cluster.

A producer administrator can create datashares and add datashare objects to share data with other clusters, referred to as *outbound* shares. A consumer administrator can receive datashares from other clusters, referred to as *inbound* shares. For details on producers and consumers, see Datashare producers and consumers.

Datashare objects are objects from specific databases on a cluster that producer administrators can add to datashares to be shared with data consumers. Datashare objects are read-only for data consumers. Examples of datashare objects are tables, views, and user-defined functions. You can add datashare objects to datashares while creating datashares or editing a datashare at any time.

Data sharing continues to work when clusters are resized or when the producer cluster is paused.

There are different types of datashares: standard datashares, AWS Data Exchange datashares, and AWS Lake Formation-managed datashares. The following pages provide an overview of each of these.

Standard datashares

With standard datashares, you can share data across provisioned clusters, serverless workgroups, Availability Zones, AWS accounts, and AWS Regions. You can share between cluster types as well as between provisioned clusters and Amazon Redshift Serverless.

To share data, note the following provisioned cluster, serverless namespace, and AWS account identifiers:

- Provisioned namespaces are identifiers that identify Amazon Redshift provisioned clusters. A namespace globally unique identifier (GUID) is automatically created during provisioned cluster creation and attached to the cluster. A namespace Amazon Resource Name (ARN) is in the arn:{partition}:redshift:{region}:{account-id}:namespace:{namespace-guid} format. You can see the namespace of a provisioned cluster on the cluster details page on the Amazon Redshift console.

  In the data sharing workflow, the namespace GUID value and the namespace ARN are used to share data with clusters in the AWS account. You can also find the namespace for the current cluster by using the `current_namespace` function.
- Serverless namespaces are identifiers that identify Amazon Redshift Serverless. A namespace globally unique identifier (GUID) is automatically created during Amazon Redshift Serverless creation and attached to the instance. A serverless namespace ARN is in the arn:{partition}:redshift-serverless:{region}:{account-id}:namespace/{namespace-guid} format.
- AWS accounts can be consumers for datashares and are each represented by a 12-digit AWS account ID.

For *standard datashares*, consider the following:

- When a producer cluster is deleted, Amazon Redshift deletes the datashares created by the producer cluster. When a producer cluster is backed up and restored, the created datashares still persist on the restored cluster. However, datashare permissions granted to other clusters are no longer valid on the restored cluster. Re-grant usage permissions of datashares to desired consumer clusters. The consumer database on the consumer cluster points to the datashare from the original cluster where the snapshot is taken. To query the shared data from the restored cluster, the consumer administrator creates a different database. Or the administrator can drop and recreate an existing consumer database to use the datashare from the newly restored cluster.

- When a consumer cluster is deleted and restored from a snapshot, the previous access shared to this cluster would no longer be valid and visible. If access to datashares is still required on the restored consumer cluster, the producer administrator must grant usage of datashares to the restored consumer cluster again. The consumer administrator must drop any stale consumer databases created from the inactive datashares. Then the administrator must recreate the consumer database from the datashare, after the producer re-granted the permissions. As the namespace GUID is different on a restored cluster from the original cluster, re-grant datashare permissions when the consumer or producer cluster is restored from backup.

AWS Data Exchange datashares

You can use AWS Data Exchange datashares to manage billing for Amazon Redshift data sharing.

An AWS Data Exchange datashare is a unit of licensing for sharing your data through AWS Data Exchange. AWS manages all billing and payments associated with subscriptions to AWS Data Exchange and use of Amazon Redshift data sharing. Approved data providers can add AWS Data Exchange datashares to AWS Data Exchange products. When customers subscribe to a product with AWS Data Exchange datashares, they get access to the datashares in the product.

AWS Data Exchange for Amazon Redshift makes it convenient to license access to your Amazon Redshift data through AWS Data Exchange. When a customer subscribes to a product with AWS Data Exchange datashares, AWS Data Exchange automatically adds the customer as a data consumer on all AWS Data Exchange datashares included with the product. Invoices are automatically generated, and payments are centrally collected and automatically disbursed through AWS Marketplace Entitlement Service.

Providers can license data in Amazon Redshift at a granular level, such as schemas, tables, views, and user-defined functions. You can use the same AWS Data Exchange datashare across multiple AWS Data Exchange products. Any objects added to the AWS Data Exchange datashare is available to consumers. Producers can view all AWS Data Exchange datashares managed by AWS Data Exchange on their behalf using Amazon Redshift API operations, SQL commands, and the Amazon Redshift console. Customers who subscribe to a product AWS Data Exchange datashares have read-only access to the objects in the datashares.

Customers who want to consume third-party producer data can browse the AWS Data Exchange catalog to discover and subscribe to datasets in Amazon Redshift. After their AWS Data Exchange subscription is active, they can create a database from the datashare in their cluster and query the data in Amazon Redshift.

How AWS Data Exchange datashares work

Managing AWS Data Exchange datashares as a producer administrator

If you are a data producer (also known as a provider on AWS Data Exchange), you can create AWS Data Exchange datashares that connect to your Amazon Redshift databases. To add AWS Data Exchange datashares to products on AWS Data Exchange, you must be a registered AWS Data Exchange provider.

For more information on how to get started with AWS Data Exchange datashares, see Sharing licensed Amazon Redshift data on AWS Data Exchange.

Using AWS Data Exchange datashares as a consumer with an active AWS Data Exchange subscription

If you are a consumer with an active AWS Data Exchange subscription (also known as a subscriber on AWS Data Exchange), you can browse the AWS Data Exchange catalog on the AWS Data Exchange console to discover products containing AWS Data Exchange datashares.

After you subscribe to a product that contains AWS Data Exchange datashares, create a database from the datashare within your cluster. You can then query the data in Amazon Redshift directly without extracting, transforming, and loading the data.

For more information on how to get started with AWS Data Exchange datashares, see Sharing licensed Amazon Redshift data on AWS Data Exchange.

For *AWS Data Exchange datashares*, consider the following:

- When a producer cluster is deleted, Amazon Redshift deletes the datashares created by the producer cluster. When a producer cluster is backed up and restored, the created datashares still persist on the restored cluster. For data subscribers to be able to continue accessing the data, create the AWS Data Exchange datashares again and publish them to the product's data sets. The consumer database on the consumer cluster points to the datashare from the original cluster where the snapshot is taken. To query the shared data from the restored cluster, the consumer administrator creates a different database, or drops and recreates an existing consumer database to use the newly created AWS Data Exchange datashare from the newly restored cluster.
- When a consumer cluster is deleted and restored from a snapshot, the previous access shared to this cluster remains valid and visible. consumer administrator must drop any stale consumer databases created from the inactive datashares and recreate the consumer database from the

datashare after the producer re-grants the permissions. As the namespace GUID is different on a restored cluster from the original cluster, re-grant datashare permissions when the producer cluster is restored from backup.

- We recommend that you don't delete your cluster if you have any AWS Data Exchange datashares. Performing this type of alteration can breach data product terms in AWS Data Exchange.

Datashare producers and consumers

Data producers (also known as data sharing producers or datashare producers) are clusters that you want to share data from. producer administrators and database owners can create datashares using the CREATE DATASHARE command. You can add objects such as schemas, tables, views, and SQL user-defined functions (UDFs) from a database that you want the producer cluster to share with consumer clusters.

Data producers (also known as providers on AWS Data Exchange) for AWS Data Exchange datashares can license data through AWS Data Exchange. Approved providers can add AWS Data Exchange datashares to AWS Data Exchange products.

When a customer subscribes to a product with AWS Data Exchange datashares, AWS Data Exchange automatically adds the customer as a data consumer on all AWS Data Exchange datashares included with the product. AWS Data Exchange also removes all customers from AWS Data Exchange datashares when their subscription ends. AWS Data Exchange also automatically manages billing, invoicing, payment collection, and payment distribution for paid products with AWS Data Exchange datashares. For more information, see AWS Data Exchange datashares. To register as an AWS Data Exchange data provider, see Getting started as a provider.

Data consumers (also known as data sharing consumers or datashare consumers) are clusters that receive datashares from producer clusters.

Amazon Redshift clusters that share data can be in the same or different AWS accounts or different AWS Regions, so you can share data across organizations and collaborate with other parties. consumer administrators receive the datashares that they are granted usage for and review the contents of each datashare. To consume shared data, the consumer administrator creates an Amazon Redshift database from the datashare. The administrator then assigns permissions for the database to users and roles in the consumer cluster. After permissions are granted, users and roles can list the shared objects as part of the standard metadata queries, along with the local data on the consumer cluster. They can start querying immediately.

If you are a *consumer with an active AWS Data Exchange subscription* (also known as subscribers on AWS Data Exchange), you can find, subscribe to, and query granular, up-to-date data in Amazon Redshift without the need to extract, transform, and load the data. For more information, see AWS Data Exchange datashares.

AWS Lake Formation-managed datashares

With Amazon Redshift, you can access and share live data across AWS accounts and Amazon Redshift clusters through AWS Lake Formation-managed datashares. AWS Lake Formation datashares enable data providers to securely share live data from their Amazon S3 data lake with any consumer, including other AWS accounts and Amazon Redshift clusters.

Using AWS Lake Formation, you can centrally define and enforce database, table, column, and row-level access permissions of Amazon Redshift datashares and restrict user access to objects within a datashare. By sharing data through Lake Formation, you can define permissions in Lake Formation and apply those permissions to any datashare and its objects. For example, if you have a table containing employee information, you can use Lake Formation's column-level filters to prevent employees who don't work in the HR department from seeing personally identifiable information (PII), such as a social security number. For more information about data filters, see Data filtering and cell-level security in Lake Formation in the *AWS Lake Formation Developer Guide*.

You can also use tags in Lake Formation to configure permissions on Lake Formation resources. For more information, see Lake Formation Tag-based access control.

Amazon Redshift currently supports data sharing via Lake Formation when sharing within the same account or across accounts. Cross-Region sharing is currently not supported.

The following is a high-level overview of how to use Lake Formation to control datashare permissions:

1. In Amazon Redshift, the producer cluster or workgroup administrator creates a datashare on the producer cluster or workgroup and grants usage to a Lake Formation account.
2. The producer cluster or workgroup administrator authorizes the Lake Formation account to access the datashare.
3. The Lake Formation administrator discovers and registers the datashares. They must also discover the AWS Glue ARNs they have access to and associate the datashares with an AWS Glue Data Catalog ARN. If you're using the AWS CLI you can discover and accept datashares with the Redshift CLI operations `describe-data-shares` and `associate-data-share-`

consumer. To register a datashare, use the Lake Formation CLI operation register-resource.

4. The Lake Formation administrator creates a federated database in the AWS Glue Data Catalog, and configures Lake Formation permissions to control user access to objects within the datashare. For more information about federated databases in AWS Glue, see Managing permissions for data in an Amazon Redshift datashare.
5. The Lake Formation administrator discovers the AWS Glue databases they have access to and associates the datashare with an AWS Glue Data Catalog ARN.
6. The Redshift administrator discovers the AWS Glue database ARNs they have access to, creates an external database in the Amazon Redshift consumer cluster using a AWS Glue database ARN, and grants usage to database users authenticated with IAM credentials to start querying the Amazon Redshift database.
7. Database users can use the views SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS to find all of the tables or columns within the AWS Glue database that they have access to, and then they can query the AWS Glue database's tables.
8. When the producer cluster or workgroup administrator decides to no longer share the data with the consumer cluster, the producer administrator can revoke usage, deauthorize, or delete the datashare from Redshift. The associated permissions and objects in Lake Formation are not automatically deleted.

For more information about sharing a datashare with AWS Lake Formation as a producer cluster or workgroup administrator, see Working with Lake Formation-managed datashares as a producer. To consume the shared data from the producer cluster or workgroup, see Working with Lake Formation-managed datashares as a consumer.

Datashare status values in Amazon Redshift

With Amazon Redshift, you can securely share live data across Amazon Redshift clusters without having to copy or transfer data. Datashares for Amazon Redshift enables you to share live query results, including updates to the source data, with any Amazon Redshift cluster in the same or different AWS accounts and AWS Regions. This topic describes the possible statuses that datashares can have in Amazon Redshift.

With cross-account datashares, there are different statuses of datashares that require your actions. Your datashare can have a status of active, action required, or inactive.

Following describes each datashare status and its required action:

- When a producer administrator creates a datashare, the datashare status on the producer cluster is **Pending authorization**. The producer administrator can authorize data consumers to access the datashare. There isn't any action for the consumer administrator.
- When a producer administrator authorizes the datashare, the datashare status becomes **Authorized** on the producer cluster. There isn't any action for the producer administrator. When there is at least one association with a data consumer for the datashare, the datashare status changes from **Authorized** to **Active**.

  The datashare share status then becomes **Available (Action required on the Amazon Redshift console)** on the consumer cluster. The consumer administrator can associate the datashare with data consumers or reject the datashare. The consumer administrator can also use the AWS CLI command `describeDatashareforConsumer` to view the status of datashares. Or the administrator can use the CLI command `describeDatashare` and provide the datashare Amazon Resource Name (ARN) to view the status of the datashare.
- When the consumer administrator associates a datashare with data consumers, the datashare status becomes **Active** on the producer cluster. When there is at least one association with a data consumer for the datashare, the datashare status changes from **Authorized** to **Active**. There isn't any action required for the producer administrator.

  The datashare status becomes **Active** on the consumer cluster. There isn't any action required for the consumer administrator.
- When the consumer administrator removes a consumer association from a datashare, the datashare status becomes either **Active** or **Authorized**. It becomes **Active** when there is at least one association exists for the datashare with another data consumer. It becomes **Authorized** when there isn't any consumer association with the datashare on the producer cluster. There isn't any action for the producer administrator.

  The datashare status becomes **Action required** on the consumer cluster if all associations are removed. The consumer administrator can reassociate a datashare with data consumers when the datashare is available to the consumers.
- When a consumer administrator declines a datashare, the datashare status on the producer cluster becomes **Action required** and **Declined** on the consumer cluster. The producer administrator can reauthorize the datashare. There isn't any action for the consumer administrator.

- When the producer administrator removes authorization from a datashare, the datashare's status becomes **Action required** on the producer cluster. The producer administrator can choose to reauthorize the datashare, if necessary. There isn't any action required for the consumer administrator.

Managing access to data sharing API operations with IAM policies

To control the access to the data sharing API operations, use IAM action-based policies. For information about how to manage IAM policies, see Managing IAM policies in the *IAM User Guide*.

For information on the permissions required to use the data sharing API operations, see Permissions required to use the data sharing API operations in the *Amazon Redshift Management Guide*.

To make cross-account data sharing more secure, you can use a conditional key `ConsumerIdentifier` for the `AuthorizeDataShare` and `DeauthorizeDataShare` API operations. By doing this, you can explicitly control which AWS accounts can make calls to the two API operations.

You can deny authorizing or deauthorizing data sharing for any consumer that isn't your own account. To do so, specify the AWS account number in the IAM policy.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Deny",
            "Action": [
                "redshift:AuthorizeDataShare",
                "redshift:DeauthorizeDataShare"
            ],
            "Resource": "*",
            "Condition": {
                "StringNotEquals": {
                    "redshift:ConsumerIdentifier": "555555555555"
```

```
                }
            }
        }
    ]
}
```

You can allow a producer with a DataShareArn **testshare2** to explicitly share with a consumer with an AWS account of 111122223333 in the IAM policy.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "redshift:AuthorizeDataShare",
                "redshift:DeauthorizeDataShare"
            ],
            "Resource": "arn:aws:redshift:us-
east-1:666666666666:datashare:af06285e-8a45-4ee9-b598-648c218c8ff1/testshare2",
            "Condition": {
                "StringEquals": {
                    "redshift:ConsumerIdentifier": "111122223333"
                }
            }
        }
    ]
}
```

Connecting to consumer databases in Amazon Redshift

With a direct connection to a datashare database, you can directly connect to a database created from a datashare in the same way as you can connect to any other type of Amazon Redshift database. For example, you can connect to a database created from a datashare using JDBC or ODBC drivers, the Amazon Redshift query editor v2, or any other tool that can connect to an

Amazon Redshift database. For more information, see [Connecting to an Amazon Redshift data warehouse using SQL client tools](#).

Accessing shared data

When you connect to a database created from a datashare, you can query the shared objects using two-part notation (*schema_name*.*table_name*). If the table can be found in the consumer database search path, you can also use one-part notation (*table_name*).

If you want to perform cross-database queries, you can use three-part notation (*consumer_database_name*.*schema_name*.*table_name*). These queries can reference shared objects from other consumer database on the cluster, or local objects from local databases. They can also reference both local databases and data shared from other clusters within the same query.

> **Note**
>
> A database that is created from a datashare doesn't have a local catalog. Therefore, any queries that access local catalog tables, such as `pg_class`, return an empty result.

Accessing metadata for shared objects

To help cluster administrators discover shared objects in the consumer database, Amazon Redshift provides a set of metadata views and SHOW commands that list the metadata for these objects. When you connect to a consumer database, these metadata views and commands don't support cross-database metadata discovery. They only return metadata for the shared objects in the datashare that are associated with the connected database.

Use SHOW SCHEMAS to view a list of the shared schemas in the datashare associated with the connected database. For more information, see SHOW SCHEMAS.

Use SHOW TABLES to view a list of the tables in a shared schema from the datashare associated with the connected database. For more information, see SHOW TABLES.

Use SHOW COLUMNS to view a list of the columns from a shared table in the datashare associated with the connected database. For more information, see SHOW COLUMNS.

Use SVV_ALL_SCHEMAS to view a list of the shared schemas in the datashare associated with the connected database. For more information, see SVV_ALL_SCHEMAS.

Use SVV_ALL_TABLES to view a list of the shared tables in the datashare associated with the connected database. For more information, see SVV_ALL_TABLES.

Use SVV_ALL_COLUMNS to view a list of the shared columns in the datashare associated with the connected database. For more information, see SVV_ALL_COLUMNS.

Integrating Amazon Redshift data sharing with business intelligence tools

To integrate data sharing with business intelligence (BI) tools, we recommend that you use the Amazon Redshift JDBC or ODBC drivers. Amazon Redshift JDBC and ODBC drivers support the `GetCatalogs` API operation in the drivers. This operation returns a list of all databases, including those created from datashares.

The drivers also support downstream operations, such as `GetSchemas` and GetTables, that return data from all the databases that `GetCatalogs` returns. The drivers provide this support even when you don't explicitly specify the catalog in the call. For more information on JDBC or ODBC drivers, see Configuring connections in the *Amazon Redshift Management Guide*.

The Amazon Redshift query editor v2 includes consumer databases in its connection switching interface. However, most tools exclude these databases and only include local cluster databases as connectable databases.

> **Note**
>
> A new system database named `sys:internal` was added for internal maintenance. Some tools include this system database as a connectable database. However, you can't connect to it or run queries against its objects.

Monitoring and auditing data sharing in Amazon Redshift

With Amazon Redshift, you can monitor and audit data sharing activities to ensure compliance and security.

By auditing data sharing, producers can track the datashare evolution. For example, auditing helps track when datashares are created, objects are added or removed, and permissions are granted or revoked to Amazon Redshift clusters, AWS accounts, or AWS Regions.

In addition to auditing, producers and consumers track datashare usage at various granularities, such as account, cluster, and object levels. For more information about tracking usage and auditing views, see SVL_DATASHARE_CHANGE_LOG and SVL_DATASHARE_USAGE_PRODUCER.

You can monitor datashares by querying system views.

1. The producer administrator who wants to share data creates an Amazon Redshift datashare. The producer administrator then adds the needed database objects. These might be schemas, tables, and views to the datashare and specifies a list of consumers that the objects to be shared with.

   Use the following system views to see consolidated views for tracking changes to and usage of datashares on producer and/or consumer clusters:

   - SYS_DATASHARE_CHANGE_LOG
   - SYS_DATASHARE_USAGE_CONSUMER
   - SYS_DATASHARE_USAGE_PRODUCER

   Use the following system views to see datashare objects and data consumer information for outbound datashares:

   - SVV_DATASHARES
   - SVV_DATASHARE_CONSUMERS
   - SVV_DATASHARE_OBJECTS

2. The consumer administrators look at the datashares for which they're granted use and review the contents of each datashare by viewing inbound datashares using SVV_DATASHARES.

   To consume shared data, each consumer administrator creates an Amazon Redshift database from the datashare. The administrator then assigns permissions to appropriate users and roles in the consumer cluster. Users and roles can list the shared objects as part of the standard metadata queries by viewing the following metadata system views and can start querying data immediately.

   - SVV_REDSHIFT_COLUMNS
   - SVV_REDSHIFT_DATABASES
   - SVV_REDSHIFT_FUNCTIONS
   - SVV_REDSHIFT_SCHEMAS
   - SVV_REDSHIFT_TABLES

To view objects of both Amazon Redshift local and shared schemas and external schemas, use the following metadata system views to query them.

- SVV_ALL_COLUMNS
- SVV_ALL_SCHEMAS
- SVV_ALL_TABLES

When you connect to a consumer database, cross -database discovery is disabled. The metadata system views only return metadata for the shared objects in the datashare associated with the connected database.

Integrating Amazon Redshift data sharing with AWS CloudTrail

Data sharing is integrated with AWS CloudTrail. CloudTrail is a service that provides a record of actions taken by a user, a role, or an AWS service in Amazon Redshift. CloudTrail captures all API calls for data sharing as events. The calls captured include calls from the AWS CloudTrail console and code calls to the data sharing operations. For more information about Amazon Redshift integration with AWS CloudTrail, see Logging with CloudTrail.

For more information about CloudTrail, see How CloudTrail works.

Semi-structured data in Amazon Redshift

By using *semi-structured data support* in Amazon Redshift, you can ingest and store semi-structured data in your Amazon Redshift data warehouses. Using the SUPER data type and PartiQL language, Amazon Redshift expands data warehouse capability to integrate with both SQL and NoSQL data sources. This way, Amazon Redshift enables efficient analytics on relational and semi-structured stored data such as JSON. For information on Amazon Redshift integration with PartiQL, see PartiQL – an SQL-compatible query language for Amazon Redshift.

Amazon Redshift offers two forms of semi-structured data support: the SUPER data type and Amazon Redshift Spectrum.

You can query semi-structured data by ingesting it into Amazon Redshift and storing it in the SUPER data type or use Amazon Redshift Spectrum to query the data stored in Amazon S3.

Best practices for working with semi-structured data

Consider the following best practices when working with semi-structured data.

- We recommend that you set the `enable_case_sensitive_super_attribute` and `enable_case_sensitive_identifier`configuration options to true when working with SUPER data. For more information, see enable_case_sensitive_super_attribute and enable_case_sensitive_identifier.
- Use the COPY command to load data from Amazon S3 buckets into Amazon Redshift SUPER columns.
- Use PartiQL dynamic typing and lax semantics to run ad hoc queries on SUPER data values without having to impose a schema before querying. For information on dynamic typing, see Dynamic typing. For information on lax semantics, see Lax semantics.
- Shred schemaless and semi-structured data into materialized views using PartiQL if you plan to query the data frequently. When you perform analytics on the shredded data, the columnar organization of Amazon Redshift materialized views provides better performance. Furthermore, users and business intelligence (BI) tools that require a conventional schema for ingested data can use views (either materialized or virtual) as the conventional schema presentation of the data.

  After your PartiQL materialized views have extracted the data found in JSON or SUPER into conventional columnar materialized views, you can query the materialized views. For information on materialized views, see Materialized views in Amazon Redshift. For more information on how the SUPER data type works with materialized views, see SUPER data type and materialized views.

Concepts for SUPER data type use

Following, you can find some Amazon Redshift SUPER data type concepts.

Understand what the SUPER data type is in Amazon Redshift – The *SUPER* data type is an Amazon Redshift data type that enables the storage of schemaless arrays and structures that contain Amazon Redshift scalars and possibly nested arrays and structures. The SUPER data type can natively store different formats of semi-structured data, such as JSON or data originating from document-oriented sources. You can add a new SUPER column to store semi-structured data and write queries that access the SUPER column, along with the usual scalar columns. For more information about the SUPER data type, see SUPER type.

Ingest schemaless JSON into SUPER – With the flexible semi-structured SUPER data type, Amazon Redshift can receive and ingest schemaless JSON into columns with the SUPER data type. For example, you can ingest the JSON value `[10.5, “first”]` into a SUPER data type column by using the COPY command. The column would hold a SUPER value of `[10.5, ‘first’]`. You can also ingest JSON using JSON_PARSE function. Both COPY and `json_parse` ingest JSON using strict parsing semantics by default. You can also construct SUPER values including arrays and structures, using the database data themselves.

The SUPER column requires no schema modifications while ingesting the flexible structures of schemaless JSON. For example, while analyzing a click-stream, you initially store in the SUPER column “click” structures with attributes “IP” and “time”. You can add an attribute “customer id” without changing your schema in order to ingest such changes.

The native format used for the SUPER data type is a binary format that requires less space than the JSON value in its textual form. This enables faster ingestion and runtime processing of SUPER values at query.

Query SUPER data with PartiQL – PartiQL is a backward compatible extension of SQL-92 that many AWS services currently use. With the use of PartiQL, familiar SQL constructs seamlessly combine access to both the classic, tabular SQL data and the semi-structured data of SUPER. You can perform object and array navigation and unnest arrays. PartiQL extends the standard SQL language to declaratively express and process nested and multivalued data.

PartiQL is an extension of SQL where the nested and schemaless data of SUPER columns are first-class citizens. PartiQL doesn't require all query expressions to be type-checked during query compilation time. This approach enables query expressions that contain the SUPER data type to be dynamically typed during query execution when the actual types of the data inside the SUPER columns are accessed. Also, PartiQL operates in a lax mode where type inconsistencies don't cause failures but return null. The combination of schemaless and lax query processing makes PartiQL ideal for extract, load, transform (ELT) applications where your SQL query evaluates the JSON data that are ingested in the SUPER columns.

For more information on PartiQL for Amazon Redshift, see PartiQL – an SQL-compatible query language for Amazon Redshift. For information on dynamic typing, see Dynamic typing. For information on lax query processing, see Lax semantics.

Integrate with Redshift Spectrum – Amazon Redshift supports multiple aspects of PartiQL when running Redshift Spectrum queries over JSON, Parquet, and other formats that have nested data. Redshift Spectrum only supports nested data that has schemas. For example, with Redshift Spectrum you can declare that your JSON data has the attribute `nested_schemaful_example` in the schema `ARRAY<STRUCT<a:INTEGER, b:DECIMAL(5,2)>>`. The schema of this attribute determines that the data always contains an array, which contains a structure with integer *a* and decimal *b*. If the data changes to include more attributes, the type also changes. In contrast, the SUPER data type requires no schema. You can store arrays with structure elements that have different attributes or types. Also, values can be stored outside arrays.

Considerations for using SUPER type data

When working with SUPER data, consider the following:

- Use JDBC driver version 2.x, ODBC driver version 2.x, or Amazon Redshift Python driver version 2.0.872 or later. The ODBC driver version 1.x isn't supported.

  For information about JDBC drivers, see Configuring a connection for JDBC driver version 2.x for Amazon Redshift in the *Amazon Redshift Management Guide*.

  For information about ODBC drivers, see Configuring a connection for ODBC driver version 2.x for Amazon Redshift in the *Amazon Redshift Management Guide*..

  For information about Python drivers, see Amazon Redshift Python connector in the *Amazon Redshift Management Guide*..

For more information about SUPER configurations, see SUPER configurations.

PartiQL – an SQL-compatible query language for Amazon Redshift

Amazon Redshift supports PartiQL, an SQL-compatible query language, to select, insert, update, and delete data in Amazon Redshift. Using PartiQL, you can easily interact with Amazon Redshift tables and run ad hoc queries using the AWS Management Console, SQL Workbench/J, the AWS Command Line Interface, and Amazon Redshift Data APIs for PartiQL.

PartiQL operations provide the same availability, latency, and performance as the other Redshift data plane operations.

The following sections describe the Amazon Redshift implementation of PartiQL.

What is PartiQL?

PartiQL provides SQL-compatible query access across multiple data stores containing structured, semi-structured, and nested data. It is widely used within Amazon and is now available as part of many AWS services, including Amazon Redshift.

For the PartiQL specification and a tutorial on the core query language, see the PartiQL overview.

For examples of using PartiQL queries in Amazon Redshift with semi-structured data, see Examples of using semi-structured data in Amazon Redshift.

> **Note**
>
> - Amazon Redshift supports a subset of the PartiQL query language.
> - Amazon Redshift doesn't support the Amazon Ion data format or Amazon Ion literals.

PartiQL in Amazon Redshift

To run PartiQL queries in Amazon Redshift, you can use the following methods:

- The AWS Management Console
- SQL Workbench/J
- The AWS CLI

- Amazon Redshift Data APIs for PartiQL

Loading semi-structured data into Amazon Redshift

Use the SUPER data type to parse and query hierarchical and generic data in Amazon Redshift. Amazon Redshift introduces the JSON_PARSE function to parse data in JSON format and convert it into the SUPER representation. Amazon Redshift also supports loading SUPER columns using the COPY command. The supported file formats are JSON, Avro, text, comma-separated value (CSV) format, Parquet, and ORC.

You can use JSON_PARSE to insert and update JSON data into SUPER columns, or use COPY to load JSON data into Amazon Redshift from outside sources such as from Amazon S3 buckets.

Topics

Using JSON_PARSE to insert data into SUPER columns

You can insert or update JSON data into a SUPER column using the JSON_PARSE function. The function parses data in JSON format and converts it into the SUPER data type, which you can use in INSERT or UPDATE statements.

The following example inserts JSON data into a SUPER column. If the JSON_PARSE function is missing in the query, Amazon Redshift treats the value as a single string instead of a JSON-formatted string that must be parsed.

```
--Drop the table if it exists.
DROP TABLE IF EXISTS test_json;

--Create the table.
CREATE TABLE test_json (all_data SUPER);

--Populate the table.
INSERT INTO test_json VALUES (JSON_PARSE('
{
    "name": {
        "first_name": "Jake",
```

```
        "last_name": "Smith"
    },
    "age": 30,
    "hobby": "Biking"
}'
) );

SELECT * FROM test_json;

 all_data
---------
{"name":{"first_name":"Jake","last_name":"Smith"},"age":30,"hobby":"Biking"}
```

Using COPY to load data into SUPER columns

In the following sections, you can learn about different ways to use the COPY command to load JSON data into Amazon Redshift. For information about the data format parameters that Amazon Redshift uses to parse JSON in COPY commands, read the JSON format for COPY parameter description in Data format parameters.

Topics

Copying data from JSON and Avro

Amazon Redshift provides the following methods to ingest a JSON document using COPY, even with a JSON structure that is fully or partially unknown:

- Store the data deriving from a JSON document into a single SUPER data column using the `noshred` option. This method is useful when the schema isn't known or is expected to change. Thus, this method makes it easier to store the entire tuple in a single SUPER column.
- Shred the JSON document into multiple Amazon Redshift columns using the `auto` or `jsonpaths` option. Attributes can be Amazon Redshift scalars or SUPER values.

You can use these options with the JSON or Avro formats. For more information on JSON options such as `noshred`, `auto`, and `jsonpaths`, see JSON format for COPY.

The maximum size for a JSON object in Amazon Redshift is 4 MB, which applies before any shredding or parsing.

Method 1: Copying a JSON document into a single SUPER data column using noshred

You can copy entire JSON documents into single SUPER data columns using the `noshred` option in the COPY command. Consider the following example:

1. Create a table with a single SUPER data column.

```
CREATE TABLE region_nations_noshred (rdata SUPER);
```

2. Copy the data from Amazon S3 into the single SUPER data column. To ingest the JSON source data into a single SUPER data column, specify the `noshred` option in the FORMAT JSON clause.

```
COPY region_nations_noshred FROM 's3://redshift-downloads/semistructured/tpch-
nested/data/json/region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT JSON 'noshred';
```

   After COPY has successfully ingested the JSON, your table has a `rdata` SUPER data column that contains the data of the entire JSON object. The ingested data maintains all the properties of the JSON hierarchy. However, the leaves are converted to Amazon Redshift scalar types for efficient query processing.

3. Use the following query to retrieve the original JSON string.

```
SELECT rdata FROM region_nations_noshred;
```

   When Amazon Redshift generates a SUPER data column, it becomes accessible using JDBC as a string through JSON serialization. For more information, see Serializing complex nested JSON.

Method 2: Copying a JSON document into multiple SUPER data columns

You can shred a JSON document into multiple columns that can be either SUPER data columns or Amazon Redshift scalar types. Amazon Redshift spreads different portions of the JSON object to different columns. Consider the following example:

1. Create a table with multiple columns to hold the shredded JSON.

```
CREATE TABLE region_nations
(
 r_regionkey smallint
 ,r_name varchar
 ,r_comment varchar
 ,r_nations super
 );
```

2. To copy JSON into the `region_nations` table, specify the AUTO option in the FORMAT JSON clause to split the JSON value across multiple columns. COPY matches the top-level JSON attributes with column names and allows nested values to be ingested as SUPER values, such as JSON arrays and objects.

```
COPY region_nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/
json/region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT JSON 'auto';
```

When the JSON attribute names are in mixed upper and lower cases, specify the `auto ignorecase` option in the FORMAT JSON clause. For more information about the COPY command, see Load from JSON data using the 'auto ignorecase' option.

In some cases, there is a mismatch between column names and JSON attributes or the attribute to load is nested more than a level deep. If so, use a `jsonpaths` file to manually map JSON attributes to Amazon Redshift columns. Consider the following example:

1. Create a table with multiple columns to hold the shredded JSON.

```
CREATE TABLE region_nations
(
 r_regionkey smallint
 ,r_name varchar
 ,r_comment varchar
 ,r_nations super
 );
```

2. In this case, the column names don't match the JSON attributes. You can create a `jsonpaths` file that maps the paths of attributes to the table columns by their position in the `jsonpaths` array, like the following:

```
{"jsonpaths": [
       "$.r_regionkey",
       "$.r_name",
       "$.r_comment",
       "$.r_nations
    ]
}
```

3. Use the location of the `jsonpaths` file as the argument to the FORMAT JSON option in COPY.

```
COPY nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/json/
region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT JSON 's3://redshift-downloads/semistructured/tpch-nested/data/jsonpaths/
nations_jsonpaths.json';
```

4. Use the following query to access the table that shows data spread to multiple columns. The SUPER data columns are printed using the JSON format.

```
SELECT r_regionkey,r_name,r_comment,r_nations[0].n_nationkey FROM region_nations
 ORDER BY 1,2,3 LIMIT 1;
```

`jsonpaths` files map fields in the JSON document to table columns. You can extract additional columns, such as distribution and sort keys, while still loading the complete document as a SUPER column. The following query loads the complete document to the `nations` column. The `name` column is the sort key and the `regionkey` column is the distribution key. Consider the following example:

1. Create a table with multiple columns to hold the shredded JSON.

```
CREATE TABLE nations_sorted (
    regionkey smallint,
    name varchar,
    nations super
) DISTKEY(regionkey) SORTKEY(name);
```

2. Map the root jsonpath "$" to the root of the document as follows:

```
{"jsonpaths": [
```

```
        "$.r_regionkey",
        "$.r_name",
        "$"
    ]
}
```

3. Use the location of the `jsonpaths` file as the argument to the FORMAT JSON option in COPY.

```
COPY nations_sorted FROM 's3://redshift-downloads/semistructured/tpch-nested/data/
json/region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT JSON 's3://redshift-downloads/semistructured/tpch-nested/data/jsonpaths/
nations_sorted_jsonpaths.json';
```

For more information on using `jsonpaths`, see COPY from JSON format.

Copying data from text and CSV

Amazon Redshift represents SUPER columns in text and CSV formats as serialized JSON. Valid JSON formatting is required for SUPER columns to load with the correct type information. Unquote objects, arrays, numbers, booleans, and null values. Wrap string values in double quotes. SUPER columns use standard escaping rules for text and CSV formats.

When copying from CSV, delimiters are escaped according to the CSV standard. Consider the following example:

```
CREATE TABLE region_nations
(
 r_regionkey smallint
 ,r_name varchar
 ,r_comment varchar
 ,r_nations super
 );

 COPY region_nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/csv/
region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT CSV;
```

When copying from text, if the chosen delimiter might also appear in a SUPER field, use the ESCAPE option during COPY and UNLOAD. Consider the following example:

```
CREATE TABLE region_nations
(
 r_regionkey smallint
 ,r_name varchar
 ,r_comment varchar
 ,r_nations super
 );

COPY region_nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/text/
region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
DELIMITER ','
ESCAPE;
```

Copying data from columnar-format Parquet and ORC

If your semi-structured or nested data is already available in either Apache Parquet or Apache ORC format, you can use the COPY command to ingest data into Amazon Redshift.

The Amazon Redshift table structure should match the number of columns and the column data types of the Parquet or ORC files. By specifying SERIALIZETOJSON in the COPY command, you can load any column type in the file that aligns with a SUPER column in the table as SUPER. This includes structure and array types.

The following example uses a Parquet format:

```
COPY region_nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/
parquet/region_nation'
REGION 'us-east-1' IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT PARQUET SERIALIZETOJSON;
```

The following example uses an ORC format.

```
COPY region_nations FROM 's3://redshift-downloads/semistructured/tpch-nested/data/orc/
region_nation'
IAM_ROLE 'arn:aws:iam::xxxxxxxxxxxx:role/Redshift-S3'
FORMAT ORC SERIALIZETOJSON;
```

When the attributes of the date or time data types are in ORC, Amazon Redshift converts them to varchar upon encoding them in SUPER.

Unloading semi-structured data

With Amazon Redshift, you can export semi-structured data from your Amazon Redshift cluster to Amazon S3 in a variety of formats, including text, Apache Parquet, Apache ORC, and Avro. The following sections will guide you through the process of configuring and executing unload operations for your semi-structured data in Amazon Redshift.

CSV or text formats

You can unload tables with SUPER data columns to Amazon S3 in a comma-separated value (CSV) or text format. Using a combination of navigation and unnest clauses, Amazon Redshift unloads hierarchical data in SUPER data format to Amazon S3 in CSV or text formats. Subsequently, you can create external tables against unloaded data and query them using Redshift Spectrum. For information on using UNLOAD and the required IAM permissions, see UNLOAD.

The following example unloads all of the data from an Amazon Redshift table into an Amazon S3 bucket.

```
UNLOAD ('SELECT * FROM <redshift_table>')
TO '<S3_bucket>'
IAM_ROLE '<iam_role>'
DELIMITER AS '|'
GZIP
ALLOWOVERWRITE;
```

Unlike other data types where a user-defined string represents a null value, Amazon Redshift exports the SUPER data columns using the JSON format and represents it as *null* as determined by the JSON format. As a result, SUPER data columns ignore the NULL [AS] option used in UNLOAD commands.

Parquet format

You can unload tables with SUPER data columns to Amazon S3 in the Parquet format. Amazon Redshift represents SUPER columns in Parquet as the JSON data type. This enables semi-structured data to be represented in Parquet. You can query these columns using Redshift Spectrum or ingest them back to Amazon Redshift using the COPY command. For information on using UNLOAD and the required IAM permissions, see UNLOAD.

The following example unloads all of the data from an Amazon Redshift table into an Amazon S3 bucket in the Parquet format.

```
UNLOAD ('SELECT * FROM <Amazon Redshift_table>')
TO '<S3_bucket>'
IAM_ROLE '<iam_role>'
FORMAT PARQUET;
```

Querying semi-structured data

With Amazon Redshift, you can query and analyze semi-structured data, such as JSON, Avro, or Ion, alongside your structured data. Semi-structured data refers to data that has a flexible schema, allowing for hierarchical or nested structures. The following sections demonstrate querying semi-structured data using Amazon Redshift's support for open data formats, allowing you to unlock valuable information from complex data structures.

Amazon Redshift uses the PartiQL language to offer SQL-compatible access to relational, semi-structured, and nested data.

PartiQL operates with dynamic types. This approach enables intuitive filtering, joining, and aggregation on the combination of structured, semi-structured, and nested datasets. The PartiQL syntax uses dotted notation and array subscript for path navigation when accessing nested data. It also enables the FROM clause items to iterate over arrays and use for unnest operations. Following, you can find descriptions of the different query patterns that combine the use of the SUPER data type with path and array navigation, unnesting, unpivoting, and joins. For more information on PartiQL, see PartiQL – an SQL-compatible query language for Amazon Redshift.

Navigation

Amazon Redshift uses PartiQL to enable navigation into arrays and structures using the [...] bracket and dot notation respectively. Furthermore, you can mix navigation into structures using the dot notation and arrays using the bracket notation. For example, the following statement selects only the third element in an array nested one level deep in a SUPER object:

```
SELECT super_object.array[2];

 array
---------------
 third_element
```

You can use the dot and bracket notation when doing data operations such as filtering, joining, and aggregating. You can use these notations anywhere in a query where there are normally column references. For example, the following statement selects the number of events with the type UPDATED.

```
SELECT COUNT(*)
FROM test_json
WHERE all_data.data.pnr.events[0]."eventType" = 'UPDATED';

 eventType | count
-----------+-------
 "UPDATED" | 1
```

For more in-depth examples of using PartiQL navigation, see Examples of using semi-structured data in Amazon Redshift.

Unnesting queries

To unnest queries, Amazon Redshift provides two ways to iterate over SUPER arrays: PartiQL syntax and the UNNEST operation in the FROM clause. Both unnesting methods result in the same output. For information on the UNNEST operation, see FROM clause. For examples of using the UNNEST operation, see UNNEST examples.

Amazon Redshift can navigate SUPER arrays using PartiQL syntax in the FROM clause of a query. Using the previous example, the following example iterates over the attribute values for `c_orders`.

```
SELECT orders.*, o FROM customer_orders orders, orders.c_orders o;
```

The PartiQL syntax of unnesting using the FROM clause item `x (AS) y` means that `y` iterates over each (SUPER) value in (SUPER) array expression x. In this case, `x` is a SUPER expression and `y` is an alias for `x`.

The left operand can also use the dot and bracket notation for regular navigation. In the following example, `customer_orders_lineitem c` is the iteration over the `customer_order_lineitem` base table and `c.c_orders o` is the iteration over the `c.c_orders` array. To iterate over the `o_lineitems` attribute, which is an array within an array, you can add multiple clauses, like so:

```
SELECT c.*, o, l FROM customer_orders_lineitem c, c.c_orders o, o.o_lineitems l;
```

Amazon Redshift also supports an array index when iterating over the array using the AT keyword. The clause `x AS y AT z` iterates over array `x` and generates the field `z`, which is the array index. The following example shows how an array index works.

```
SELECT c_name,
       orders.o_orderkey AS orderkey,
       index AS orderkey_index
FROM customer_orders_lineitem c, c.c_orders AS orders AT index
ORDER BY orderkey_index;

c_name             | orderkey | orderkey_index
-------------------+----------+----------------
Customer#000008251 | 3020007  |        0
Customer#000009452 | 4043971  |        0
  (2 rows)
```

The following is an example of iterating over a scalar array.

```
CREATE TABLE bar AS SELECT json_parse('{"scalar_array": [1, 2.3, 45000000]}') AS data;

SELECT element, index FROM bar AS b, b.data.scalar_array AS element AT index;

 index | element
-------+----------
     0 | 1
     1 | 2.3
     2 | 45000000
(3 rows)
```

The following example iterates over an array of multiple levels. The example uses multiple unnest clauses to iterate into the innermost arrays. The `f.multi_level_array` AS array iterates over `multi_level_array`. The array AS element is the iteration over the arrays within `multi_level_array`.

```
CREATE TABLE foo AS SELECT json_parse('[[1.1, 1.2], [2.1, 2.2], [3.1, 3.2]]') AS
 multi_level_array;

SELECT array, element FROM foo AS f, f.multi_level_array AS array, array AS element;

 element | array
---------+---------
 1.1     | [1.1,1.2]
```

```
 1.2     | [1.1,1.2]
 2.1     | [2.1,2.2]
 2.2     | [2.1,2.2]
 3.1     | [3.1,3.2]
 3.2     | [3.1,3.2]
(6 rows)
```

For more information about the FROM clause, see FROM clause. For more examples of unnesting SUPER queries, see Examples of using semi-structured data in Amazon Redshift.

Object unpivoting

To perform object unpivoting, Amazon Redshift uses the PartiQL syntax to iterate over SUPER objects. It does this using the FROM clause of a query along with the UNPIVOT keyword. In the following example, the expression is the `c.c_orders[0]` object. The example query iterates over each attribute returned by the object.

```
SELECT attr as attribute_name, json_typeof(val) as value_type
FROM customer_orders_lineitem c, UNPIVOT c.c_orders[0] AS val AT attr
WHERE c_custkey = 9451;

 attribute_name  | value_type
-----------------+------------
 o_orderstatus   | string
 o_clerk         | string
 o_lineitems     | array
 o_orderdate     | string
 o_shippriority  | number
 o_totalprice    | number
 o_orderkey      | number
 o_comment       | string
 o_orderpriority | string
(9 rows)
```

As with unnesting, the unpivoting syntax is also an extension of the FROM clause. The difference is that the unpivoting syntax uses the UNPIVOT keyword to indicate that it's iterating over an object instead of an array. It uses the AS `value_alias` for iteration over all the values inside an object, and uses the AT `attribute_alias` for iterating over all the attributes. Consider the following syntax:

```
UNPIVOT expression AS value_alias [ AT attribute_alias ]
```

Amazon Redshift supports using object unpivoting and array unnesting in a single FROM clause as follows:

```
SELECT attr as attribute_name, val as object_value
FROM customer_orders_lineitem c, c.c_orders AS o, UNPIVOT o AS val AT attr
WHERE c_custkey = 9451;
```

When you use object unpivoting, Amazon Redshift doesn't support correlated unpivoting. Specifically, suppose that you have a case where there are multiple examples of unpivoting in different query levels and the inner unpivoting references the outer one. Amazon Redshift doesn't support this type of multiple unpivoting.

For more information about the FROM clause, see FROM clause. For examples of using pivoting with the SUPER type, see Examples of using semi-structured data in Amazon Redshift.

Dynamic typing

Dynamic typing doesn't require explicit casting of data that is extracted from the dot and bracket paths. Amazon Redshift uses dynamic typing to process schemaless SUPER data without the need to declare the data types before you use them in your query. Dynamic typing uses the results of navigating into SUPER data columns without having to explicitly cast them into Amazon Redshift types. Dynamic typing is most useful in joins and GROUP BY clauses. The following example uses a SELECT statement that requires no explicit casting of the dot and bracket expressions to the usual Amazon Redshift types. For information about type compatibility and conversion, see Type compatibility and conversion.

Consider the following example, which looks for rows where the status of an order is `shipped`:

```
SELECT c_orders[0].o_orderkey
FROM customer_orders_lineitem
WHERE c_orders[0].o_orderstatus = 'shipped';
```

The equality sign in this sample query evaluates to `true` when the value of c_orders[0].o_orderstatus is the string ‘shipped’. In all other cases, the equality sign evaluates to `false`, including the cases where the arguments of the equality are different types. For example, if the order status is an integer, its row won't be selected.

Dynamic and static typing

Without using dynamic typing, you can't determine whether c_orders[0].o_orderstatus is a string, an integer, or a structure. You can only determine that c_orders[0].o_orderstatus is a SUPER data type, which can be an Amazon Redshift scalar, an array, or a structure. The static type of c_orders[0].o_orderstatus is a SUPER data type. Conventionally, a type is implicitly a static type in SQL.

Amazon Redshift uses dynamic typing to the processing of schemaless data. When the query evaluates the data, c_orders[0].o_orderstatus turns out to be a specific type. For example, evaluating c_orders[0].o_orderstatus on the first record of customer_orders_lineitem may result into an integer. Evaluating on the second record may result into a string. These are the dynamic types of the expression.

When using an SQL operator or function with dot and bracket expressions that have dynamic types, Amazon Redshift produces results similar to using standard SQL operator or function with the respective static types. In this example, when the dynamic type of the path expression is a string, the comparison with the string ‘P’ is meaningful. Whenever the dynamic type of c_orders[0].o_orderstatus is any other data type except being a string, the equality returns false. Other functions return null when mistyped arguments are used.

The following example writes the previous query with static typing:

```
SELECT c_custkey
FROM customer_orders_lineitem
WHERE CASE WHEN JSON_TYPEOF(c_orders[0].o_orderstatus) = 'string'
           THEN c_orders[0].o_orderstatus::VARCHAR = 'P'
           ELSE FALSE END;
```

Note the following distinction between equality predicates and comparison predicates. In the previous example, if you replace the equality predicate with a less-than-or-equal predicate, the semantics produce null instead of false.

```
SELECT c_orders[0]. o_orderkey
FROM customer_orders_lineitem
WHERE c_orders[0].o_orderstatus <= 'P';
```

In this example, if c_orders[0].o_orderstatus is a string, Amazon Redshift returns true if it is alphabetically equal to or smaller than ‘P’. Amazon Redshift returns false if it is alphabetically larger than 'P'. However, if c_orders[0].o_orderstatus is not a string, Amazon Redshift returns null since Amazon Redshift can't compare values of different types, as shown in the following query:

```
SELECT c_custkey
FROM customer_orders_lineitem
WHERE CASE WHEN JSON_TYPEOF(c_orders[0].o_orderstatus) = 'string'
           THEN c_orders[0].o_orderstatus::VARCHAR <= 'P'
           ELSE NULL END;
```

Dynamic typing doesn't exclude from comparisons of types that are minimally comparable. For example, you can convert both CHAR and VARCHAR Amazon Redshift scalar types to SUPER. They are comparable as strings, including ignoring trailing white-space characters similar to Amazon Redshift CHAR and VARCHAR types. Similarly, integers, decimals, and floating-point values are comparable as SUPER values. Specifically for decimal columns, each value can also have a different scale. Amazon Redshift still considers them as dynamic types.

Amazon Redshift also supports equality on objects and arrays that are evaluated as deep equal, such as evaluating deep into objects or arrays and comparing all attributes. Use deep equal with caution, because the process of performing deep equal can be time-consuming.

Using dynamic typing for joins

For joins, dynamic typing automatically matches values with different dynamic types without performing a long CASE WHEN analysis to find out what data types may appear. For example, assume that your organization changed the format that it was using for part keys over time.

The initial integer part keys issued are replaced by string part keys, such as ‘A55’, and later replaced again by array part keys, such as [‘X’, 10] combining a string and a number. Amazon Redshift doesn't have to perform a lengthy case analysis about part keys and can use joins, as shown in the following example.

```
SELECT c.c_name
    ,l.l_extendedprice
    ,l.l_discount
FROM customer_orders_lineitem c
    ,c.c_orders o
    ,o.o_lineitems l
    ,supplier_partsupp s
    ,s.s_partsupps ps
WHERE l.l_partkey = ps.ps_partkey
```

```
AND c.c_nationkey = s.s_nationkey
ORDER BY c.c_name;
```

The following example shows how complex and inefficient the same query can be without using dynamic typing:

```
SELECT c.c_name
    ,l.l_extendedprice
    ,l.l_discount
FROM customer_orders_lineitem c
    ,c.c_orders o
    ,o.o_lineitems l
    ,supplier_partsupp s
    ,s.s_partsupps ps
WHERE CASE WHEN IS_INTEGER(l.l_partkey) AND IS_INTEGER(ps.ps_partkey)
           THEN l.l_partkey::integer = ps.ps_partkey::integer
           WHEN IS_VARCHAR(l.l_partkey) AND IS_VARCHAR(ps.ps_partkey)
           THEN l.l_partkey::varchar = ps.ps_partkey::varchar
           WHEN IS_ARRAY(l.l_partkey) AND IS_ARRAY(ps.ps_partkey)
                AND IS_VARCHAR(l.l_partkey[0]) AND IS_VARCHAR(ps.ps_partkey[0])
                AND IS_INTEGER(l.l_partkey[1]) AND IS_INTEGER(ps.ps_partkey[1])
           THEN l.l_partkey[0]::varchar = ps.ps_partkey[0]::varchar
                AND l.l_partkey[1]::integer = ps.ps_partkey[1]::integer
           ELSE FALSE END
AND c.c_nationkey = s.s_nationkey
ORDER BY c.c_name;
```

Lax semantics

By default, navigation operations on SUPER values return null instead of returning an error out when the navigation is invalid. Object navigation is invalid if the SUPER value is not an object or if the SUPER value is an object but doesn't contain the attribute name used in the query. For example, the following query accesses an invalid attribute name in the SUPER data column cdata:

```
SELECT c.c_orders.something FROM customer_orders_lineitem c;
```

Array navigation returns null if the SUPER value is not an array or the array index is out of bounds. The following query returns null because c_orders[1][1] is out of bounds.

```
SELECT c.c_orders[1][1] FROM customer_orders_lineitem c;
```

Lax semantics is especially useful when using dynamic typing to cast a SUPER value. Casting a SUPER value to the wrong type returns null instead of an error if the cast is invalid. For example, the following query returns null because it can't cast the string value 'Good' of the object attribute o_orderstatus to INTEGER. Amazon Redshift returns an error for a VARCHAR to INTEGER cast but not for a SUPER cast.

```
SELECT c.c_orders.o_orderstatus::integer FROM customer_orders_lineitem c;
```

Order by

Amazon Redshift doesn't define SUPER comparisons among values with different dynamic types. A SUPER value that is a string is neither smaller nor larger than a SUPER value that is a number. To use ORDER BY clauses with SUPER columns, Amazon Redshift defines a total ordering among different types to be observed when Amazon Redshift ranks SUPER values using ORDER BY clauses. The order among dynamic types is boolean, number, string, array, object.

For an example of using GROUP BY and ORDER BY in a SUPER query, see Filtering semi-structured data.

Operators and functions

With Amazon Redshift, you can perform advanced analytics on large datasets using SUPER data using operators and functions. Operators and functions for SUPER data are SQL constructs that enable complex analysis and manipulation of semi-structured data stored in Amazon Redshift tables.

The following sections will cover the syntax, examples, and best practices for using operators and functions for SUPER data in Amazon Redshift to unlock the full potential of your semi-structured data.

Arithmetic operators

SUPER values support all basic arithmetic operators +, -, *, /, % using dynamic typing. The resultant type of the operation remains as SUPER. For all operators, except for the binary operator +, the input operands must be numbers. Otherwise, Amazon Redshift returns null. The distinction between decimals and floating-point values is retained when Amazon Redshift runs these operators and the dynamic type doesn't change. However, decimal scale changes when you use multiplications and divisions. Arithmetic overflows still cause query errors, they aren't changed to null. Binary operator + performs addition if the inputs are numbers or concatenation if the inputs are string. If one operand is a string and the other operand is a number, the result is null. Unary prefix operators + and - returns null if the SUPER value is not a number as shown in the following example:

```
SELECT (c_orders[0]. o_orderkey + 0.5) * c_orders[0]. o_orderkey / 10 AS math FROM
 customer_orders_lineitem;
            math
----------------------------
 1757958232200.1500
(1 row)
```

Dynamic typing allows decimal values in SUPER to have different scales. Amazon Redshift treats decimal values as if they are different static types and allows all mathematical operations. Amazon Redshift computes the resulting scale dynamically based on the scales of the operands. If one of the operands is a floating-point number, then Amazon Redshift promotes the other operand to a floating-point number and generates the result as a floating-point number.

Arithmetic functions

Amazon Redshift supports the following arithmetic functions for SUPER columns. They return null if the input isn't a number:

- FLOOR. For more information, see FLOOR function.
- CEIL and CEILING. For more information, see CEILING (or CEIL) function.
- ROUND. For more information, see ROUND function.
- TRUNC. For more information, see TRUNC function.
- ABS. For more information, see ABS function.

The following example uses arithmetic functions to query data:

```
SELECT x, FLOOR(x), CEIL(x), ROUND(x)
FROM (
    SELECT (c_orders[0]. o_orderkey + 0.5) * c_orders[0].o_orderkey / 10 AS x
    FROM customer_orders_lineitem
    );
```

```
         x          |     floor      |     ceil       |     round
--------------------+----------------+----------------+---------------
 1389636795898.0500  | 1389636795898  | 1389636795899  | 1389636795898
```

The ABS function retains the scale of the input decimal while FLOOR, CEIL. The ROUND eliminates the scale of the input decimal.

Array functions

Amazon Redshift supports the following array composition and utility functions:

- ARRAY. For more information, see array function.
- ARRAY_CONCAT. For more information, see array_concat function.
- ARRAY_FLATTEN. For more information, see array_flatten function.
- GET_ARRAY_LENGTH. For more information, see get_array_length function.
- SPLIT_TO_ARRAY. For more information, see split_to_array function.
- SUBARRAY. For more information, see subarray function.

You can construct SUPER arrays from values in Amazon Redshift data types using the ARRAY function, including other SUPER values. The following example uses the variadic function ARRAY:

```
SELECT ARRAY(1, c.c_custkey, NULL, c.c_name, 'abc') FROM customer_orders_lineitem c;
                                array
 -------------------------------------------------------
[1,8401,null,""Customer#000008401"",""abc""]
[1,9452,null,""Customer#000009452"",""abc""]
[1,9451,null,""Customer#000009451"",""abc""]
[1,8251,null,""Customer#000008251"",""abc""]
[1,5851,null,""Customer#000005851"",""abc""]
(5 rows)
```

The following example uses array concatenation with the ARRAY_CONCAT function:

```
SELECT ARRAY_CONCAT(JSON_PARSE('[10001,10002]'),JSON_PARSE('[10003,10004]'));

             array_concat
------------------------------------
 [10001,10002,10003,10004]
```

```
(1 row)
```

The following example uses array manipulation with the SUBARRAY function which returns a subset of the input array.

```
SELECT SUBARRAY(ARRAY('a', 'b', 'c', 'd', 'e', 'f'), 2, 3);

   subarray
---------------
 ["c","d","e"]
(1 row))
```

The following example merges multiple levels of arrays into a single array using ARRAY_FLATTEN:

```
SELECT x, ARRAY_FLATTEN(x) FROM (SELECT ARRAY(1, ARRAY(2, ARRAY(3, ARRAY()))) AS x);

     x           | array_flatten
 ----------------+---------------
 [1,[2,[3,[]]]]  | [1,2,3]
(1 row)
```

Array functions ARRAY_CONCAT and ARRAY_FLATTEN use dynamic typing rules. They return a null instead of an error if the input isn't an array. The GET_ARRAY_LENGTH function returns the length of a SUPER array given an object or array path.

```
SELECT c_name
FROM customer_orders_lineitem
WHERE GET_ARRAY_LENGTH(c_orders) = (
    SELECT MAX(GET_ARRAY_LENGTH(c_orders))
    FROM customer_orders_lineitem
    );
```

The following example splits a string to an array of strings using SPLIT_TO_ARRAY. The function uses a delimiter as an optional parameter. If no delimiter is absent, then the default is a comma.

```
SELECT SPLIT_TO_ARRAY('12|345|6789', '|');

   split_to_array
---------------------
 ["12","345","6789"]
```

```
(1 row)
```

Information functions

SUPER data columns support inspection functions that return the dynamic type and other type information about the SUPER value. The most common example is the JSON_TYPEOF scalar function that returns a VARCHAR with values boolean, number, string, object, array, or null, depending on the dynamic type of the SUPER value. Amazon Redshift supports the following boolean functions for SUPER data columns:

- IS_ARRAY function
- IS_BIGINT function
- IS_CHAR function
- IS_DECIMAL function
- IS_FLOAT function
- IS_INTEGER function
- IS_OBJECT function
- IS_SCALAR function
- IS_SMALLINT function
- IS_VARCHAR function

For more information on SUPER type information functions, see SUPER type information functions.

SUPER configurations

You can configure your SUPER data for specific scenarios. The following sections provide details on choosing and applying the appropriate SUPER configurations based on your data format requirements.

Topics

- Lax and strict modes for SUPER
- Accessing JSON fields with uppercase and mixed-case field names or attributes
- Parsing options for SUPER

Lax and strict modes for SUPER

When you query SUPER data, the path expression may not match the actual SUPER data structure. If you try to access a non-existent member of an object or element of an array, Amazon Redshift returns a NULL value if your query is run in the default lax mode. If you run your query in the strict mode, Amazon Redshift returns an error. The following session parameters can be set to set the lax mode on or off.

The following example uses session parameters to enable lax mode.

```
SET navigate_super_null_on_error=ON;  --default lax mode for navigation

SET cast_super_null_on_error=ON;  --default lax mode for casting

SET parse_super_null_on_error=OFF;  --default strict mode for ingestion
```

Accessing JSON fields with uppercase and mixed-case field names or attributes

When your JSON attribute names are in uppercase or mixed-case, you must be able to navigate SUPER type structures in a case sensitive way. To do that, you can configure `enable_case_sensitive_identifier` to TRUE and wrap the uppercase and mixed-case attribute names with double quotation marks.

The following example illustrates how to set `enable_case_sensitive_identifier` to query data.

```
SET enable_case_sensitive_identifier to TRUE;

-- Accessing JSON attribute names with uppercase and mixed-case names
SELECT json_table.data."ITEMS"."Name",
       json_table.data."price"
FROM
  (SELECT json_parse('{"ITEMS":{"Name":"TV"}, "price": 345}') AS data) AS json_table;

 Name | price
------+-------
 "TV" | 345
(1 row)
```

```
RESET enable_case_sensitive_identifier;

-- After resetting the above configuration, the following query accessing JSON
 attribute names with uppercase and mixed-case names should return null (if in lax
 mode).
SELECT json_table.data."ITEMS"."Name",
       json_table.data."price"
FROM
  (SELECT json_parse('{"ITEMS":{"Name":"TV"}, "price": 345}') AS data) AS json_table;

 name | price
------+-------
      | 345
(1 row)
```

Parsing options for SUPER

When you use the JSON_PARSE function to parse JSON strings into SUPER values, certain restrictions apply:

- The same attribute name cannot appear in the same object, but can appear in a nested object. The `json_parse_dedup_attributes` configuration option allows JSON_PARSE to keep only the last occurrence of duplicate attributes instead of returning an error.
- String values cannot exceed the system max varchar size of 65535 bytes. The `json_parse_truncate_strings` configuration option allows JSON_PARSE() to automatically truncate strings that are longer than this limit without returning an error. This behavior affects string values only and not attribute names.

For more information about the JSON_PARSE function, see JSON_PARSE function.

The following example shows how to set the `json_parse_dedup_attributes` configuration option to the default behavior of returning an error for duplicate attributes.

```
SET json_parse_dedup_attributes=OFF;  --default behavior of returning error instead of
 de-duplicating attributes
```

The following example shows how to set the `json_parse_truncate_strings` configuration option for the default behavior of returning an error for strings that are longer than this limit.

```
SET json_parse_truncate_strings=OFF;  --default behavior of returning error instead of
 truncating strings
```

Limitations

With Amazon Redshift, you can work with the SUPER data type to store and query semi-structured data like JSON, Avro, or Ion. The SUPER data type limitations refer to the constraints and boundaries when using this data type in Amazon Redshift. The following sections provide details on the specific limitations of the SUPER data type, such as maximum size, nesting levels, and data types supported within semi-structured data.

- You can't define SUPER columns as either a distribution or sort key.
- An individual SUPER object can hold up to 16 MB of data.
- The maximum nesting depth for arrays and structures of the SUPER data type is 1,000.
- An individual value within a SUPER object is limited to the maximum length of the corresponding Amazon Redshift type. For example, a single string value loaded to SUPER is limited to the maximum VARCHAR length of 65535 bytes.
- You can't perform partial update or transform operations on SUPER columns.
- You can't use the SUPER data type and its alias in right joins or full outer joins.
- The SUPER data type doesn't support XML as inbound or outbound serialization format.
- In the FROM clause of a subquery (that is correlated or not) that references a table variable for unnesting, the query can only refer to its parent table and not other tables.
- You can’t perform unnesting or object unpivoting on SUPER columns produced by a recursive common table expression (`WITH RECURSIVE`). For more information on recursive CTEs, see Recursive common table expressions.
- Casting limitations

  SUPER values can be cast to and from other data types, with the following exceptions:

  - Amazon Redshift doesn't differentiate integers and decimals of scale 0.
  - If the scale isn't zero, SUPER data type has the same behavior as other Amazon Redshift data types, except that Amazon Redshift converts SUPER-related errors to null, as shown in the following example.

    ```
    SELECT 5::bool;
     bool
    ```

```
-------
 True
(1 row)

SELECT 5::decimal::bool;
ERROR:  cannot cast type numeric to boolean

SELECT 5::super::bool;
 bool
-------
 True
(1 row)

SELECT 5.0::bool;
ERROR:  cannot cast type numeric to boolean

SELECT 5.0::super::bool;
 bool
-------
(1 row)
```

- Amazon Redshift doesn't cast the date and time types to SUPER data type. Amazon Redshift can only cast the date and time data types from SUPER data type, as shown in the following example.

```
SELECT o.o_orderdate FROM customer_orders_lineitem c,c.c_orders o;
  order_date
------------------
 "2001-09-08"
(1 row)


SELECT JSON_TYPEOF(o.o_orderdate) FROM customer_orders_lineitem c,c.c_orders o;
 json_typeof
-----------------
 string
(1 row)


SELECT o.o_orderdate::date FROM customer_orders_lineitem c,c.c_orders o;
 order_date
----------------
 2001-09-08
```

```
(1 row)


--date/time cannot be cast to super
SELECT '2019-09-09'::date::super;
ERROR:  cannot cast type date to super
```

  - Cast from non-scalar values (object and array) to string returns NULL. To properly serialize these non-scalar values, don't cast them. Instead, use `json_serialize` to cast non-scalar values. The `json_serialize` function returns a varchar. Typically, you don't need to cast non-scalar values to varchar since Amazon Redshift implicitly serializes as shown in the following first example.

```
SELECT r_nations FROM region_nations WHERE r_regionkey=300;
   r_nations
----------------
 [1,"abc",null]
(1 row)

SELECT r_nations::varchar FROM region_nations WHERE r_regionkey=300;
 r_nations
-------------
(1 row)

SELECT JSON_SERIALIZE(r_nations) FROM region_nations WHERE r_regionkey=300;
 json_serialize
-----------------
 [1,"abc",null]
(1 row)
```

  - For case-insensitive databases, Amazon Redshift doesn't support the SUPER data type. For case-insensitive columns, Amazon Redshift doesn't cast them to the SUPER type. Thus, Amazon Redshift doesn't support SUPER columns interacting with case-insensitive columns that trigger casting.

- Amazon Redshift doesn't support volatile functions, such as RANDOM ( ) or TIMEOFDAY ( ), in subqueries that unnest an outer table or a left-hand side (LHS) of IN functions with such subqueries.

SUPER data type and materialized views

With Amazon Redshift, you can use materialized views to enhance the performance and flexibility of queries run against the SUPER data type. The SUPER data type lets you store a superset of columns from the base tables in a materialized view, letting you query the materialized view directly without joining the base tables. The following sections show you how to create and use materialized views with the SUPER data type in Amazon Redshift.

Amazon Redshift supports materialized views that incorporate SUPER data type columns and PartiQL queries. Materialized views can incrementally refresh, whereas Amazon Redshift only updates data that has changed in the base tables since the last refresh operation. This selective update approach makes the refresh process more efficient than full recalculations. For more information about materialized views, see Materialized views in Amazon Redshift.

Accelerating PartiQL queries

You can use materialized views to accelerate PartiQL queries that navigate and/or unnest hierarchical data in SUPER columns. By creating one or more materialized views to shred the SUPER values into multiple columns and utilize the columnar organization of Amazon Redshift analytical queries, you can essentially extract and normalize nested data. The level of normalization depends on how much effort you put into turning the SUPER data into conventional columnar data.

The following topics showcase examples of breaking down, or shredding, complex data into smaller columns, as well as creating scalar columns out of shredded data to improve performance.

Topics

Shredding semi-structured data into SUPER columns with materialized views

With Amazon Redshift, you can improve query performance by shredding data into SUPER columns using materialized views. Shredding refers to the process of breaking down complex data types like semi-structured JSON or XML into smaller, flatter columns. SUPER columns are a specialized form of columnar storage optimized for rapidly scanning shredded data.

The following sections describe the steps and considerations for shredding data into SUPER columns using materialized views in Amazon Redshift.

The following example shows a materialized view that shreds the nested data with the resulting columns still being the SUPER data type.

```
SELECT c.c_name, o.o_orderstatus
FROM customer_orders_lineitem c, c.c_orders o;
```

The following example shows a materialized view that creates conventional Amazon Redshift scalar columns from the shredded data.

```
SELECT c.c_name, c.c_orders[0].o_totalprice
FROM customer_orders_lineitem c;
```

You can create a single materialized view super_mv to accelerate both queries.

To answer the first query, you must materialize the attribute o_orderstatus. You can omit the attribute c_name because it doesn't involve nested navigation nor unnesting. You must also include in the materialized view the attribute c_custkey of customer_orders_lineitem to be able to join the base table with the materialized view.

To answer the second query, you must also materialize the attribute o_totalprice and the array index o_idx of c_orders. Hence, you can access the index 0 of c_orders.

```
CREATE MATERIALIZED VIEW super_mv distkey(c_custkey) sortkey(c_custkey) AS (
  SELECT c_custkey, o.o_orderstatus, o.o_totalprice, o_idx
  FROM customer_orders_lineitem c, c.c_orders o AT o_idx
);
```

The attributes o_orderstatus and o_totalprice of the materialized view super_mv are SUPER.

The materialized view super_mv will be refreshed incrementally upon changes to the base table customer_orders_lineitem.

```
REFRESH MATERIALIZED VIEW super_mv;
INFO: Materialized view super_mv was incrementally updated successfully.
```

To rewrite the first PartiQL query as a regular SQL query, join customer_orders_lineitem with super_mv as follows.

```
SELECT c.c_name, v.o_orderstatus
FROM customer_orders_lineitem c
JOIN super_mv v ON c.c_custkey = v.c_custkey;
```

Similarly, you can rewrite the second PartiQL query. The following example uses a filter on o_idx = 0.

```
SELECT c.c_name, v.o_totalprice
FROM customer_orders_lineitem c
JOIN super_mv v ON c.c_custkey = v.c_custkey
WHERE v.o_idx = 0;
```

In the CREATE MATERIALIZED VIEW command, specify c_custkey as distribution key and sort key for super_mv. Amazon Redshift performs an efficient merge join, assuming that c_custkey is also the distribution key and sort key of customer_orders_lineitem. If that isn't the case, you can specify c_custkey as the sort key and distribution key of customer_orders_lineitem as follows.

```
ALTER TABLE customer_orders_lineitem
ALTER DISTKEY c_custkey, ALTER SORTKEY (c_custkey);
```

Use the EXPLAIN statement to verify that Amazon Redshift performs a merge join on the rewritten queries.

```
EXPLAIN
      SELECT c.c_name, v.o_orderstatus
      FROM customer_orders_lineitem c JOIN super_mv v ON c.c_custkey = v.c_custkey;

      QUERY PLAN

 ---------------------------------------------------------------------------------------------------
      XN Merge Join DS_DIST_NONE  (cost=0.00..34701.82 rows=1470776 width=27)
      Merge Cond: ("outer".c_custkey = "inner".c_custkey)
      ->  XN Seq Scan on mv_tbl__super_mv__0 derived_table2  (cost=0.00..14999.86
 rows=1499986 width=13)
      ->  XN Seq Scan on customer_orders_lineitem c  (cost=0.00..999.96 rows=99996
 width=30)
      (4 rows)
```

Creating Amazon Redshift scalar columns out of shredded data

Schemaless data stored in SUPER can affect the performance of Amazon Redshift. For instance, filter predicates or join conditions as range-restricted scans can't effectively use zone maps. Users and BI tools can use materialized views as the conventional presentation of the data and increase performance of analytical queries.

The following query scans the materialized view `super_mv` and filters on `o_orderstatus`.

```
SELECT c.c_name, v.o_totalprice
FROM customer_orders_lineitem c
JOIN super_mv v ON c.c_custkey = v.c_custkey
WHERE v.o_orderstatus = 'F';
```

Inspect `stl_scan` to verify that Amazon Redshift can't effectively use zone maps on the range-restricted scan over `o_orderstatus`.

```
SELECT slice, is_rrscan FROM stl_scan
WHERE query = pg_last_query_id() AND perm_table_name LIKE '%super_mv%';

 slice | is_rrscan
-------+-----------
     0 | f
     1 | f
     5 | f
     4 | f
     2 | f
     3 | f
(6 rows)
```

The following example adapts the materialized view `super_mv` to create scalar columns out of the shredded data. In this case, Amazon Redshift casts `o_orderstatus` from SUPER to VARCHAR. In addition, specify `o_orderstatus` as the sort key for `super_mv`.

```
CREATE MATERIALIZED VIEW super_mv distkey(c_custkey) sortkey(c_custkey, o_orderstatus)
 AS (
  SELECT c_custkey, o.o_orderstatus::VARCHAR AS o_orderstatus, o.o_totalprice, o_idx
  FROM customer_orders_lineitem c, c.c_orders o AT o_idx
);
```

After re-running the query, verify that Amazon Redshift can now use zone maps.

```
SELECT v.o_totalprice
FROM super_mv v
WHERE v.o_orderstatus = 'F';
```

You can verify that the range-restricted scan now uses zone maps as follows.

```
SELECT slice, is_rrscan FROM stl_scan
WHERE query = pg_last_query_id() AND perm_table_name LIKE '%super_mv%';

 slice | is_rrscan
-------+-----------
     0 | t
     1 | t
     2 | t
     3 | t
     4 | t
     5 | t
(6 rows)
```

Examples of using semi-structured data in Amazon Redshift

The following examples demonstrate how to work with semi-structured data in Amazon Redshift using PartiQL syntax. You will create a sample table to load a sample set of semi-structured data, then query semi-structured data objects in a variety of use cases.

> **Note**
>
> We recommend that you set the `enable_case_sensitive_identifier` and `enable_case_sensitive_super_attribute` configuration options before working with the SUPER data type. For more information, see enable_case_sensitive_identifier and enable_case_sensitive_super_attribute.

Loading semi-structured data

The following statements create a sample table and load a sample JSON object into the `all_data` SUPER column.

```
DROP TABLE IF EXISTS test_json;
```

```
SET enable_case_sensitive_super_attribute TO true;
SET enable_case_sensitive_identifier TO true;

CREATE TABLE test_json (all_data SUPER);

INSERT INTO test_json VALUES (JSON_PARSE('
{
   "data":{
      "pnr":{
         "type":"pnr",
         "pnrid":"123PQRS-2024-09-20",
         "bookingIdentifier":"123PQRS",
         "version":"5",
         "triggerType":"",
         "events":[
            {
               "eventType":"UPDATED",
               "type":"PART",
               "id":"123PQRS-2024-09-20-HO-1"
            },
            {
               "eventType":"CREATED",
               "type":"ABC",
               "id":"123PQRS-2024-09-20-OT-38"
            }
         ],
         "create":{
            "pnrCreateDate":"2024-09-20T16:56:00Z",
            "officeID":"OFFCID1234",
            "officeIDCategory":"Email"
         },
         "lastModification":{
            "dateTime":"2024-09-20T17:09:00Z"
         },
         "PARTDetails":[
            {
               "path":"1",
               "TrainPARTs":[
                  {
                     "PARTID":"123PQRS-2024-09-20-HO-1",
                     "departure":{
                        "departureStation":"XYZ",
                        "departureTimeLocal":"2024-10-03T06:30:00",
```

```
                        "departureTimeGMT":"2024-10-03T10:30:00Z"
                     },
                     "arrival":{
                        "arrivalStation":"ABC",
                        "arrivalTimeLocal":"2024-10-03T08:20:00",
                        "arrivalTimeGMT":"2024-10-03T15:20:00Z"
                     },
                     "marketing":{
                        "carrierCode":"XX",
                        "TrainNumber":"100"
                     },
                     "operating":{
                        "carrierCode":"YY",
                        "TrainNumber":"100-A"
                     },
                     "status":"ON",
                     "aircraft":{
                        "code":"222"
                     },
                     "class":"WC",
                     "first":"Y",
                     "seating":[

                     ]
                  }
               ]
            }
         ],
         "commuterInformation":[
            {
               "commuterID":"2",
               "commuterPNR":"123PQRS-2024-09-20-RO-2",
               "commuterTypeCode":"DOM",
               "firstName":"JOHN",
               "lastName":"MILLER"
            }
         ],
         "contactDetail":[
            {
               "emailContacts":[
                  {
                     "id":"123PQRS-2024-09-20-OT-4",
                     "contact":"JOHNMILLER@EXAMPLE.COM",
                     "purpose":[
```

```
                        "BUSINESS"
                     ],
                     "commuter":[
                        "123PQRS-2024-09-20-RO-2"
                     ],
                     "language":"EN"
                  },
                  {
                     "id":"123PQRS-2024-09-20-OT-5",
                     "contact":"HARVEYCORMIER@EXAMPLE.COM",
                     "purpose":[
                        "NOTIFICATION"
                     ],
                     "commuter":[
                        "123PQRS-2024-09-20-RO-2"
                     ],
                     "language":"EN"
                  }
               ]
            },
            {
               "phoneContacts":[
                  {
                     "id":"123PQRS-2024-09-20-OT-3",
                     "contact":"1234567890",
                     "purpose":[
                        "NOTIFICATION"
                     ],
                     "commuter":[
                        "123PQRS-2024-09-20-RO-2"
                     ],
                     "language":""
                  }
               ]
            },
            {
               "addressInfo":[
                  {
                     "id":"123PQRS-2024-09-20-OT-6",
                     "addressline":[
                        "112 PORT STREET"
                     ],
                     "provinceState":"CA",
                     "cityName":"SAN JOSE",
```

```
                "postalCode":"12345",
                "countryCode":"USA",
                "purpose":[
                   "MAILING"
                ],
                "commuter":[
                   "123PQRS-2024-09-20-RO-2"
                ]
             }
          ]
       }
    ],
    "PendingService":[
       {
          "id":"123PQRS-2024-09-20-OT-26",
          "code":"MONO",
          "status":"",
          "text":"Broken Seat at Coach-No XYZ123 Seat-No 567",
          "trainCode":"WC-1",
          "TrainsArray":[
             "123PQRS-2024-09-20-HO-1"
          ],
          "commuter":[
             "123PQRS-2024-09-20-RO-2"
          ]
       },
       {
          "id":"123PQRS-2024-09-20-OT-27",
          "code":"OTHS",
          "status":"",
          "text":"Broken Seat at Coach-No XYZ567 Seat-No 111",
          "trainCode":"WC-1",
          "TrainsArray":[
             "123PQRS-2024-09-20-HO-1"
          ],
          "commuter":[
             "123PQRS-2024-09-20-RO-2"
          ]
       },
       {
          "id":"123PQRS-2024-09-20-OT-28",
          "code":"OTHS",
          "status":"",
          "text":"Broken Seat at Coach-No XYZ890 Seat-No 123",
```

```
            "trainCode":"WC-1",
            "TrainsArray":[
               "123PQRS-2024-09-20-HO-1"
            ],
            "commuter":[
               "123PQRS-2024-09-20-RO-2"
            ]
         },
         {
            "id":"123PQRS-2024-09-20-OT-29",
            "code":"OTHS",
            "status":"",
            "text":"Broken Seat at Coach-No XYZ111 Seat-No 333",
            "trainCode":"WC-1",
            "TrainsArray":[
               "123PQRS-2024-09-20-HO-1"
            ],
            "commuter":[
               "123PQRS-2024-09-20-RO-2"
            ]
         }
      ],
      "parts": [
         {
            "partname": "prop",
            "manufacturer": "local parts co",
            "quality": 2,
            "price": 10.00
         },
         {
            "partname": "prop",
            "manufacturer": "big parts co",
            "quality": null,
            "price": 9.00
         },
         {
            "partname": "prop",
            "manufacturer": "small parts co",
            "quality": 1,
            "price": 12.00
         },
         {
            "partname": "rudder",
            "manufacturer": "local parts co",
```

```
                "quality": 1,
                "price": 2.50
             },
             {
                "partname": "rudder",
                "manufacturer": "big parts co",
                "quality": 2,
                "price": 3.75
             },
             {
                "partname": "rudder",
                "manufacturer": "small parts co",
                "quality": null,
                "price": 1.90
             },
             {
                "partname": "wing",
                "manufacturer": "local parts co",
                "quality": null,
                "price": 7.50
             },
             {
                "partname": "wing",
                "manufacturer": "big parts co",
                "quality": 1,
                "price": 15.20
             },
             {
                "partname": "wing",
                "manufacturer": "small parts co",
                "quality": null,
                "price": 11.80
             }
          ],
          "count_by_color": [
             {
                "quality": "high",
                "red": 15,
                "green": 20,
                "blue": 7
             },
             {
                "quality": "normal",
                "red": 35,
```

```
                "green": null,
                "blue": 40
             },
             {
                "quality": "low",
                "red": 10,
                "green": 23,
                "blue": null
             }
          ]
       }
    },
    "id":"abcdefgh-ijklmnop-qrstuvwxyz123",
    "mainIds":[
       {
          "ID":"pqrstuvwxyz-aabbcc123",
          "Source":"NYC"
       }
    ]
}
'));
```

Querying nested semi-structured data

The following statement uses PartiQL's dot notation to extract the `pnrid` field, which is nested three levels deep inside the top-level `all_data` object.

```
select all_data.data.pnr.pnrid::varchar from test_json;

 pnrid
--------------------
 123PQRS-2024-09-20
```

The following statement uses PartiQL's bracket notation to specify and extract only the first element from the `events` array nested inside the top-level object.

```
SELECT
    all_data.data.pnr.events[0]
FROM test_json;

 events
---------------------------------
```

```
{
   "eventType":"UPDATED",
   "type":"PART",
   "id":"123PQRS-2024-09-20-HO-1"
}
```

The following statement extracts the `eventType` property of only the specified element from the `events` array.

```
SELECT
    all_data.data.pnr.events[0].eventType
FROM test_json;

 eventtype
-----------
 "UPDATED"
```

The following statements

Using enable_case_sensitive_identifier and enable_case_sensitive_super_attribute with semi-structured data

The following examples show how the configuration options enable_case_sensitive_identifier and enable_case_sensitive_super_attribute differ when used for querying semi-structured data. For more information on these configuration options, see Accessing JSON fields with uppercase and mixed-case field names or attributes.

In the following statement, resetting both configuration options to their default of false makes the query return NULL.

```
RESET enable_case_sensitive_identifier;
RESET enable_case_sensitive_super_attribute;

SELECT
    all_data.data.pnr.events[0].eventType
FROM test_json;

 eventtype
-----------
```

```
NULL
```

In following example, the sample query returns the desired result after you wrap the case sensitive attributes in double quotation marks and set `enable_case_sensitive_identifier` to true.

```
RESET enable_case_sensitive_identifier;
RESET enable_case_sensitive_super_attribute;

SELECT
    all_data.data.pnr.events[0]."eventType"
FROM test_json;

 eventtype
-----------
NULL

SET enable_case_sensitive_identifier TO true;

SELECT
    all_data.data.pnr.events[0]."eventType"
FROM test_json;

 eventtype
-----------
 "UPDATED"
```

In the following example, the sample query returns the desired result after you set `enable_case_sensitive_super_attribute` to true without wrapping the case sensitive attributes in double quotation marks.

```
RESET enable_case_sensitive_identifier;
RESET enable_case_sensitive_super_attribute;

SELECT
    all_data.data.pnr.events[0].eventType
FROM test_json;

 eventtype
-----------
NULL

SET enable_case_sensitive_super_attribute TO true;
```

```
SELECT
    all_data.data.pnr.events[0].eventType
FROM test_json;

 eventtype
-----------
 "UPDATED"
```

Filtering semi-structured data

The following statement uses PartiQL syntax in the WHERE clause of a statement that counts events of the type UPDATED to retrieve data of a certain attribute from inside an array. You can use this syntax in any portion of the query where you would normally reference columns.

```
SELECT COUNT(*)
FROM test_json
WHERE all_data.data.pnr.events[0].eventType = 'UPDATED';

 count
------
 1
```

The following example uses PartiQL's bracket and dot syntax in both GROUP BY and ORDER BY clauses.

```
SELECT all_data.data.pnr.events[0].eventType::varchar,
       COUNT(*)
FROM test_json
WHERE all_data.data.pnr.events[0].eventType IS NOT NULL
GROUP BY all_data.data.pnr.events[0].eventType
ORDER BY all_data.data.pnr.events[0].eventType;

 eventtype | count
-----------+-------
 "UPDATED" | 1
```

Unnesting semi-structured data

The following statement uses PartiQL joins to unnest the `events` array. Note that this join works even when the number of indexes for the array aren't static.

For examples of unnesting semi-structured data using UNNEST in the FROM clause, see UNNEST examples.

```
SELECT
a.all_data.data.pnr.type::varchar type_info,
a.all_data.data.pnr.pnrid::varchar pnr_id ,
a.all_data.data.pnr.bookingIdentifier::varchar booking_id,
a.all_data.data.pnr.version::varchar version_info,
b.eventType::varchar event_type,
b.id::varchar event_id
FROM test_json a,
  a.all_data.data.pnr.events b;

 type_info | pnr_id              | booking_id | version_info | event_type | event_id
-----------+---------------------+------------+--------------+------------
+-------------------------
 pnr       | 123PQRS-2024-09-20  | 123PQRS    | 5            | UPDATED    |
 123PQRS-2024-09-20-HO-1
 pnr       | 123PQRS-2024-09-20  | 123PQRS    | 5            | CREATED    |
 123PQRS-2024-09-20-OT-38
```

Unnesting nested arrays

The following statement uses PartiQL joins to unnest an array that's nested inside another array.

For examples of unnesting semi-structured data using UNNEST in the FROM clause, see UNNEST examples.

```
SELECT
a.all_data.data.pnr.type::varchar type_info,
a.all_data.data.pnr.pnrid::varchar pnr_id ,
a.all_data.data.pnr.bookingIdentifier::varchar booking_id,
a.all_data.data.pnr.version::varchar version_info,
d.id::varchar email_record_id,
d.contact::varchar email_contact,
e::varchar email_purpose,
f::varchar email_commuter
FROM test_json a,
  a.all_data.data.pnr.contactDetail c,
  c."emailContacts" d,
  d.purpose e,
  d.commuter f;
```

```
 type_info | pnr_id               | booking_id | version_info | email_record_id
 | email_contact              | email_purpose | email_commuter
-----------+---------------------+------------+--------------+-------------------------
+---------------------------+---------------+-------------------------
 pnr       | 123PQRS-2024-09-20  | 123PQRS    | 5            | 123PQRS-2024-09-20-OT-4
 | JOHNMILLER@EXAMPLE.COM    | BUSINESS      | 123PQRS-2024-09-20-RO-2
 pnr       | 123PQRS-2024-09-20  | 123PQRS    | 5            | 123PQRS-2024-09-20-OT-5
 | HARVEYCORMIER@EXAMPLE.COM | NOTIFICATION  | 123PQRS-2024-09-20-RO-2
```

Using semi-structured data in subqueries

The following statement uses a subquery in the WHERE clause to return only a subsection of the results from the previous example.

```
SELECT
a.all_data.data.pnr.type::varchar type_info,
a.all_data.data.pnr.pnrid::varchar pnr_id ,
a.all_data.data.pnr.bookingIdentifier::varchar booking_id,
a.all_data.data.pnr.version::varchar version_info,
d.id::varchar email_record_id,
d.contact::varchar email_contact
FROM test_json a,
a.all_data.data.pnr.contactDetail c,
c."emailContacts" d
WHERE (SELECT COUNT(*) FROM d.purpose e WHERE e = 'BUSINESS') > 0;

 type_info | pnr_id               | booking_id | version_info | email_record_id
 | email_contact              | email_purpose | email_commuter
-----------+---------------------+------------+--------------+-------------------------
+---------------------------+---------------+-------------------------
 pnr       | 123PQRS-2024-09-20  | 123PQRS    | 5            | 123PQRS-2024-09-20-OT-4
 | JOHNMILLER@EXAMPLE.COM    | BUSINESS      | 123PQRS-2024-09-20-RO-2
```

Aggregating queries using semi-structured data

The following statement uses the COUNT function to aggregate the number of elements in the `PendingService` array.

```
SELECT
a.all_data.data.pnr.type::varchar type_info,
a.all_data.data.pnr.pnrid::varchar pnr_id ,
```

```
a.all_data.data.pnr.bookingIdentifier::varchar booking_id,
a.all_data.data.pnr.version::varchar version_info,
COUNT(*) AS total_pending_service
FROM test_json a,
  a.all_data.data.pnr.PendingService c
GROUP BY 1,2,3,4;

 type_info | pnr_id             | booking_id | version_info | total_pending_service
-----------+--------------------+------------+--------------+----------------------
 pnr       | 123PQRS-2024-09-20 | 123PQRS    | 5            | 4
```

Using semi-structured data in materialized views

The following statement uses the statement from the previous example to create a materialized view. The materialized view automatically refresh the number of pending services when the base table gets new data.

```
CREATE MATERIALIZED VIEW mv_total_pending_service
AUTO REFRESH YES
AS
SELECT
a.all_data.data.pnr.type::varchar type_info,
a.all_data.data.pnr.pnrid::varchar pnr_id ,
a.all_data.data.pnr.bookingIdentifier::varchar booking_id,
a.all_data.data.pnr.version::varchar version_info,
COUNT(*) AS total_pending_service
FROM test_json a,
  a.all_data.data.pnr.PendingService c
GROUP BY 1,2,3,4;
```

Using PIVOT and UNPIVOT with semi-structured data

The following statement uses PIVOT on the `partname` column to return the average price of each part.

```
SELECT *
FROM
(
SELECT
c.partname::varchar, c.price
FROM test_json a,
```

```
  a.all_data.data.pnr.parts c)
PIVOT (AVG(price) for partname IN ('prop', 'rudder', 'wing'));


 prop       | rudder              |  wing
------------+---------------------+--------
 10.33      | 2.71                |  11.50
```

In the previous example, the results are transformed into columns. The following example shows a GROUP BY query that returns the average prices in rows, rather than in columns.

```
SELECT partname, avg(price)
FROM (
SELECT
c.partname::varchar, c.price
FROM test_json a,
  a.all_data.data.pnr.parts c)
WHERE partname IN ('prop', 'rudder', 'wing')
GROUP BY partname;

 partname |  avg
----------+-------
 prop     | 10.33
 rudder   |  2.71
 wing     | 11.50
```

Following is a PIVOT example with `manufacturer` as an implicit column.

```
SELECT *
FROM (
SELECT
c.quality, c.manufacturer::varchar
FROM test_json a,
  a.all_data.data.pnr.parts c) PIVOT (
count(*) FOR quality IN (1, 2, NULL)
);

 manufacturer      | 1  | 2  | null
-------------------+----+----+------
 local parts co    | 1  | 1  |  1
 big parts co      | 1  | 1  |  1
 small parts co    | 1  | 0  |  2
```

Following is an UNPIVOT example on the `quality` column.

```
SELECT *
FROM
(
SELECT
c.quality as quality
FROM test_json a,
  a.all_data.data.pnr.parts c)
UNPIVOT (cnt FOR column_header IN (quality));

 column_header   | cnt
-----------------+----
 quality         | 2
 quality         | 1
 quality         | 1
 quality         | 2
 quality         | 1
```

Machine learning

Amazon Redshift machine learning (Amazon Redshift ML) is a robust, cloud-based service that makes it easier for analysts and data scientists of all skill levels to use machine learning technology. Amazon Redshift ML uses a model to generate results. You can use models in the following ways:

- You can provide the data that you want to train a model, and metadata associated with data inputs to Amazon Redshift. Then Amazon Redshift ML creates models in Amazon SageMaker AI that capture patterns in the input data. By using your own data for the model, you can use Amazon Redshift ML to identify trends in the data, such as churn prediction, customer lifetime value, or revenue prediction. You can use these models to generate predictions for new input data without incurring additional costs.
- You can use one of the Foundation Models (FM) provided by Amazon Bedrock, such as Claude or Amazon Titan. Using Amazon Bedrock, you can combine the power of large language models (LLMs) with your analytics data in Amazon Redshift in a few steps. By using an external Large Language Model (LLM), you can use Amazon Redshift to perform Natural Language Processing (NLP) on your data. You can use NLP for such applications as text generation, sentiment analysis, or translation. For information about using Amazon Bedrock with Amazon Redshift see Amazon Redshift ML integration with Amazon Bedrock.

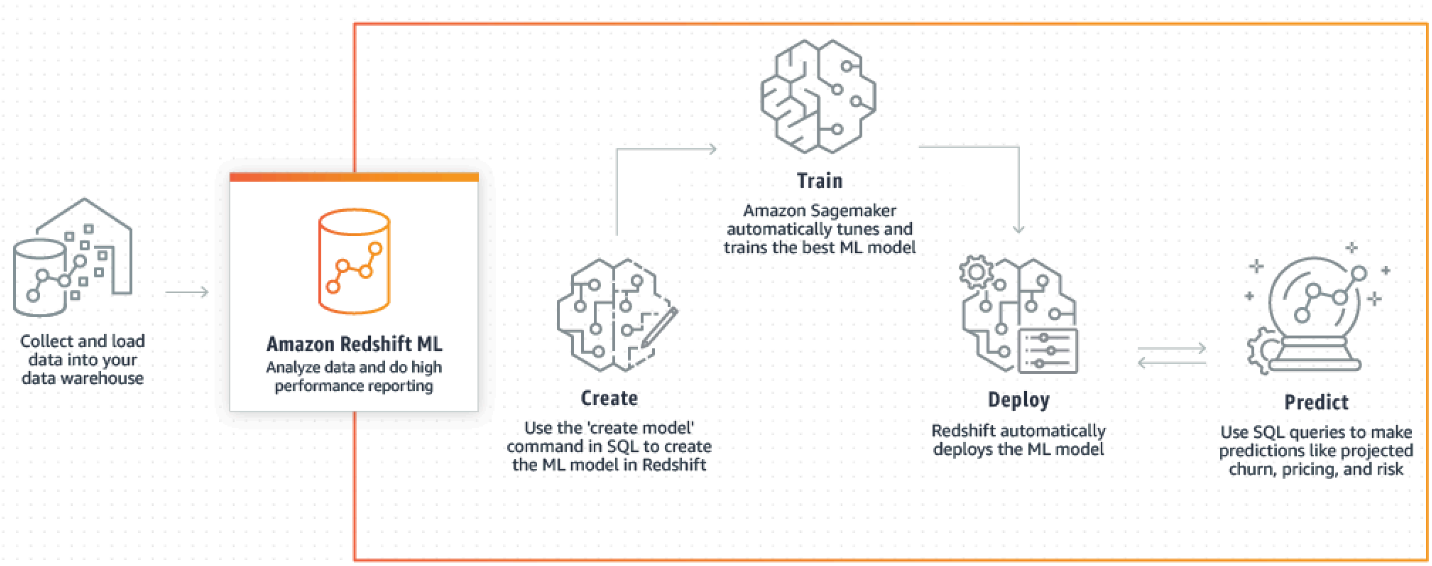
> **Note**
>
> **Opting out of using your data for service improvement**
> If you are using Amazon Bedrock models, we encourage you to read the AWS policies about how the Amazon Bedrock service handles your data. You should determine if you need to use an opt-out policy to prevent the service from using your data for model or service improvements, should Amazon Bedrock implement such functionality in the future. To ensure that the service doesn't use your data for such purposes, use the general AWS opt-out policy.
> For more information, see the following:
>
> - AI services opt-out policies
> - Amazon Bedrock FAQs

> **Note**
>
> LLMs can generate inaccurate or incomplete information. We recommend verifying the information that LLMs produce to ensure that it is accurate and complete.

How Amazon Redshift ML works with Amazon SageMaker AI

Amazon Redshift works with Amazon SageMaker AI Autopilot to automatically obtain the best model and make the prediction function available in Amazon Redshift.

The following diagram illustrates how Amazon Redshift ML works.



The general workflow is as follows:

1. Amazon Redshift exports the training data into Amazon S3.
2. Amazon SageMaker AI Autopilot preprocesses the training data. *Preprocessing* performs important functions, such as imputing missing values. It recognizes that certain columns are categorical (such as the postal code), properly formats them for training, and performs numerous other tasks. Choosing the best preprocessors to apply on the training dataset is a problem in itself, and Amazon SageMaker AI Autopilot automates its solution.
3. Amazon SageMaker AI Autopilot finds the algorithm and algorithm hyperparameters that deliver the model with the most accurate predictions.
4. Amazon Redshift registers the prediction function as a SQL function in your Amazon Redshift cluster.

5. When you run CREATE MODEL statements, Amazon Redshift uses Amazon SageMaker AI for training. Therefore, there is an associated cost for training your model. This is a separate line item for Amazon SageMaker AI in your AWS bill. You also pay for the storage used in Amazon S3 for storing your training data. Inference using models created with CREATE MODEL that you can compile and run on your Redshift cluster aren't charged. There are no additional Amazon Redshift charges for using Amazon Redshift ML.

Topics

Machine learning overview

With Amazon Redshift, you can leverage machine learning capabilities to gain valuable insights from your data. This Machine Learning (ML) overview shows you how to explore, visualize, and prepare your data for ML model training and deployment. The following sections will guide you through the process of utilizing Amazon Redshift ML to unlock the potential of your data through machine learning.

By using Amazon Redshift ML, you can train machine learning models using SQL statements and invoke them in SQL queries for prediction.

To help you learn how to use Amazon Redshift ML, you can watch the following video: Amazon Redshift ML.

For information about the prerequisites for setting up your Redshift cluster or Serverless workgroup, permissions, and ownership for using Amazon Redshift ML, read the following sections. These sections also describe how simple training and predictions work in Amazon Redshift ML.

How machine learning can solve a problem

A machine learning model generates predictions by finding patterns in your training data and then applying these patterns to new data. In machine learning, you train these models by learning the patterns that best explain your data. Then you use the models to make predictions (also called inferences) on new data. Machine learning is typically an iterative process where you can continue to improve the accuracy of the predictions by changing parameters and improving your training data. If data changes, retraining new models with the new dataset happens.

To address various business goals, there are different fundamental machine learning approaches.

Supervised learning in Amazon Redshift ML

Amazon Redshift supports supervised learning, which is the most common approach to advanced enterprise analytics. Supervised learning is the preferred machine learning approach when you have an established set of data and an understanding of how specific input data predicts various business outcomes. These outcomes are sometimes called labels. In particular, your dataset is a table with attributes that comprise features (inputs) and targets (outputs). For example, suppose that you have a table that provides the age and postal code for past and present customers. Suppose that you also have a field “active” that is true for present customers and false for customers who have suspended their membership. The goal of supervised machine learning is to spot the patterns of age and postal code leading to customer churn, as represented by customers whose targets are “False.” You can use this model to predict customers who are likely to churn, such as suspending their membership, and potentially offer retention incentives.

Amazon Redshift supports supervised learning that includes regression, binary classification, and multiclass classification. Regression refers to the problem of predicting continuous values, such as the total spending of customers. Binary classification refers to the problem of predicting one of two outcomes, such as predicting whether a customer churns or not. Multiclass classification refers to the problem of predicting one of many outcomes, such as predicting the item a customer might be interested. Data analysts and data scientists can use it to perform supervised learning to tackle problems ranging from forecasting, personalization, or customer churn prediction. You can also use supervised learning in problems such as prediction of which sales will close, revenue prediction, fraud detection, and customer life-time value prediction.

Unsupervised learning in Amazon Redshift ML

Unsupervised learning uses machine learning algorithms to analyze and group unlabeled training data. The algorithms discover hidden patterns or groupings. The goal is to model the underlying structure or distribution in the data to learn more about the data.

Amazon Redshift supports the K-Means clustering algorithm to solve an unsupervised learning problem. This algorithm solves clustering problems where you want to discover groupings in the data. The K-Means algorithm attempts to find discrete groupings within the data. Unclassified data is grouped and partitioned based on its similarities and differences. By grouping, the K-Means algorithm iteratively determines the best centroids and assigns each member to the closest centroid. Members nearest the same centroid belong to the same group. Members of a group are as similar as possible to other members in the same group, and as different as possible from members of other groups. For example, the K-Means clustering algorithm can be used to classify cities impacted by a pandemic or classify cities based on the popularity of consumer products.

When using the K-Means algorithm, you specify an input k that specifies the number of clusters to find in the data. The output of this algorithm is a set of k centroids. Each data point belongs to one of the k clusters that is closest to it. Each cluster is described by its centroid. The centroid can be thought of as the multi-dimensional average of the cluster. The K-Means algorithm compares the distances to see how different the clusters are from each other. A larger distance generally indicates a greater difference between the clusters.

Preprocessing the data is important for K-Means, as it ensures that the features of the model stay on the same scale and produce reliable results. Amazon Redshift supports some K-Means preprocessors for the CREATE MODEL statement, such as StandardScaler, MinMax, and NumericPassthrough. If you don't want to apply any preprocessing for K-means, choose NumericPassthrough explicitly as a transformer. For more information about K-Means parameters, see CREATE MODEL with K-MEANS parameters.

To help you learn how to perform unsupervised training with K-Means clustering, you can watch the following video: Unsupervised training with K-Means clustering.

Terms and concepts for Amazon Redshift ML

The following terms are used to describe some Amazon Redshift ML concepts:

- *Machine learning* in Amazon Redshift trains a model with one SQL command. Amazon Redshift ML and Amazon SageMaker AI manage all the data conversions, permissions, resource usage, and discovery of the proper model.
- *Training* is the phase when Amazon Redshift creates a machine learning model by running a specified subset of data into the model. Amazon Redshift automatically launches a training job in Amazon SageMaker AI and generates a model.
- *Prediction* (also called *inference*) is the use of the model in Amazon Redshift SQL queries to predict outcomes. At inference time, Amazon Redshift uses a model-based prediction function

as part of a larger query to produce predictions. The predictions are computed locally, at the Redshift cluster, thus providing high throughput, low latency, and zero additional cost.

- With *bring your own model (BYOM)*, you can use a model trained outside of Amazon Redshift with Amazon SageMaker AI for in-database inference locally in Amazon Redshift. Amazon Redshift ML supports using BYOM in local inference.
- *Local inference* is used when models are pretrained in Amazon SageMaker AI, compiled by Amazon SageMaker AI Neo, and localized in Amazon Redshift ML. To import models that are supported for local inference to Amazon Redshift, use the CREATE MODEL command. Amazon Redshift imports the pretrained SageMaker AI models by calling Amazon SageMaker AI Neo. You compile the model there and import the compiled model into Amazon Redshift. Use local inference for faster speed and lower costs.
- *Remote inference* is used when Amazon Redshift invokes a model endpoint deployed in SageMaker AI. Remote inference provides the flexibility to invoke all types of custom models and deep learning models, such as TensorFlow models that you built and deployed in Amazon SageMaker AI.

Also important are the following:

- *Amazon SageMaker AI* is a fully managed machine learning service. With Amazon SageMaker AI, data scientists and developers can easily build, train, and directly deploy models into a production-ready hosted environment. For information about Amazon SageMaker AI, see What is Amazon SageMaker AI in the *Amazon SageMaker AI Developer Guide*.
- *Amazon SageMaker AI Autopilot* is a feature set that automatically trains and tunes the best machine learning models for classification or regression, based on your data. You maintain full control and visibility. Amazon SageMaker AI Autopilot supports input data in tabular format. Amazon SageMaker AI Autopilot provides automatic data cleaning and preprocessing, automatic algorithm selection for linear regression, binary classification, and multiclass classification. It also supports automatic hyperparameter optimization (HPO), distributed training, automatic instance, and cluster size selection. For information about Amazon SageMaker AI Autopilot, see Automate model development with Amazon SageMaker AI Autopilot in the *Amazon SageMaker AI Developer Guide*.
- *Amazon Bedrock* is a fully managed service that offers a choice of high-performing foundation models (FMs) from leading AI companies like AI21 Labs, Anthropic, Cohere, Meta, Mistral AI, Stability AI, and Amazon via a single API, along with a broad set of capabilities needed to build generative AI applications.

Machine learning for novices and experts

With Amazon Redshift, you can leverage Machine Learning (ML) capabilities to gain insights from your data, whether you are a novice or an expert in ML. Machine Learning is an Amazon Redshift feature that enables you to create, train, and deploy ML models using SQL commands, without the need for extensive ML expertise or complex data engineering.

The following sections guide you through the process of utilizing Machine Learning, empowering you to unlock the full potential of your data with Amazon Redshift.

Amazon Redshift ML enables you to train models with one single SQL CREATE MODEL command. The CREATE MODEL command creates a model that Amazon Redshift uses to generate model-based predictions with familiar SQL constructs.

Amazon Redshift ML is especially useful when you don't have expertise in machine learning, tools, languages, algorithms, and APIs. With Amazon Redshift ML, you don't have to perform the undifferentiated heavy lifting required for integrating with an external machine learning service. Amazon Redshift saves you the time to format and move data, manage permission controls, or build custom integrations, workflows, and scripts. You can easily use popular machine learning algorithms and simplify training needs that require frequent iteration from training to prediction. Amazon Redshift automatically discovers the best algorithm and tunes the best model for your problem. You can make predictions from within the Amazon Redshift cluster without the need to move data out of Amazon Redshift nor to interface with and pay for another service.

Amazon Redshift ML supports data analysts and data scientists in using machine learning. It also makes it possible for machine learning experts to use their knowledge to guide the CREATE MODEL statement to use only the aspects that they specify. By doing so, you can speed up the time that CREATE MODEL needs to find the best candidate, improve the accuracy of the model, or both.

The CREATE MODEL statement offers flexibility in how you can specify the parameters to training job. Using this flexibility, both machine learning novices or experts can choose their preferred preprocessors, algorithms, problem types, and hyperparameters. For example, a user interested in customer churn might specify for the CREATE MODEL statement that the problem type is a binary classification, which works well for customer churn. Then the CREATE MODEL statement narrows down its search for the best model into binary classification models. Even with the user choice of the problem type, there are still many options that the CREATE MODEL statement can work with. For example, the CREATE MODEL discovers and applies the best preprocessing transformations and discovers the best hyperparameter settings.

Amazon Redshift ML makes training easier by automatically finding the best model using Amazon SageMaker AI Autopilot. Behind the scenes, Amazon SageMaker AI Autopilot automatically trains and tunes the best machine learning model based on your supplied data. Amazon SageMaker AI Neo then compiles the training model and makes it available for prediction in your Redshift cluster. When you run a machine learning inference query using a trained model, the query can use the massively parallel processing capabilities of Amazon Redshift. At the same time, the query can use machine learning–based prediction.

- As a *machine learning beginner*, with general knowledge of different aspects of machine learning such as preprocessors, algorithms, and hyperparameters, use the CREATE MODEL statement for only the aspects that you specify. Then you can shorten the time that CREATE MODEL needs to find the best candidate or improve the accuracy of the model. Also, you can increase the business value of the predictions by introducing additional domain knowledge such as the problem type or the objective. For example, in a customer churn scenario, if the outcome “customer is not active” is rare, then the F1 objective is often preferred to the Accuracy objective. Because high Accuracy models might predict “customer is active” all the time, this results in high accuracy but little business value. For information about F1 objectives, see AutoMLJobObjective in the *Amazon SageMaker AI API Reference*.

  For more information about the basic options for the CREATE MODEL statement, see Simple CREATE MODEL.
- As a *machine learning advanced practitioner*, you can specify the problem type and preprocessors for certain (but not all) features. Then CREATE MODEL follows your suggestions on the specified aspects. At the same time, CREATE MODEL still discovers the best preprocessors for the remaining features and the best hyperparameters. For more information about how you can constrain one or more aspects of the training pipeline, see CREATE MODEL with user guidance.
- As a *machine learning expert*, you can take full control of training and hyperparameter tuning. Then the CREATE MODEL statement doesn't attempt to discover the optimal preprocessors, algorithms, and hyperparameters because you make all the choices. For more information about how to use CREATE MODEL with AUTO OFF, see CREATE XGBoost models with AUTO OFF.
- As a *data engineer*, you can bring a pretrained XGBoost model in Amazon SageMaker AI and import it into Amazon Redshift for local inference. With bring your own model (BYOM), you can use a model trained outside of Amazon Redshift with Amazon SageMaker AI for in-database inference locally in Amazon Redshift. Amazon Redshift ML supports using BYOM in either local or remote inference.

For more information about how to use the CREATE MODEL statement for local or remote inference, see Bring your own model (BYOM) - local inference.

As an Amazon Redshift ML user, you can choose any of the following options to train and deploy your model:

- Problem types, see CREATE MODEL with user guidance.
- Objectives, see CREATE MODEL with user guidance or CREATE XGBoost models with AUTO OFF.
- Model types, see CREATE XGBoost models with AUTO OFF.
- Preprocessors, see CREATE MODEL with user guidance.
- Hyperparameters, see CREATE XGBoost models with AUTO OFF.
- Bring your own model (BYOM), see Bring your own model (BYOM) - local inference.

Costs for using Amazon Redshift ML

With Amazon Redshift, you can leverage machine learning capabilities to gain insights from your data without the need for extensive data engineering or machine learning expertise. The following sections describe the costs associated with using Amazon Redshift ML, helping you plan and optimize your expenses while leveraging this powerful machine learning integration.

Costs for using Amazon Redshift ML with SageMaker AI

Amazon Redshift ML for SageMaker AI uses your existing cluster resources for prediction so you can avoid additional Amazon Redshift charges. There is no additional Amazon Redshift charge for creating or using a model. Prediction happens locally in your Redshift cluster, so you don't have to pay extra unless you need to resize your cluster. Amazon Redshift ML uses Amazon SageMaker AI for training your model, which does have an additional associated cost.

There is no additional charge for prediction functions that run within your Amazon Redshift cluster. The CREATE MODEL statement uses Amazon SageMaker AI and incurs an additional cost. The cost increases with the number of cells in your training data. The number of cells is the product of the number of records (in the training query or table times) times the number of columns. For example, when a SELECT query of the CREATE MODEL statement creates 10,000 records and 5 columns, then the number of cells it creates is 50,000.

In some cases, the training data produced by the SELECT query of the CREATE MODEL exceeds the MAX_CELLS limit that you provided (or the default 1 million if you didn't provide a limit). In these cases, CREATE MODEL randomly chooses approximately MAX_CELLS (that is the “number of columns” records from the training dataset). CREATE MODEL then performs training using these randomly chosen tuples. The random sampling ensures that the reduced training dataset doesn't have any bias. Thus, by setting the MAX_CELLS, you can control your training costs.

When using the CREATE MODEL statement, you can use the MAX_CELLS and MAX_RUNTIME options to control the costs, time, and potential model accuracy.

MAX_RUNTIME specifies the maximum amount of time the training can take in SageMaker AI when the AUTO ON or OFF option is used. Training jobs often complete sooner than MAX_RUNTIME, depending on the size of the dataset. After a model is trained, Amazon Redshift does additional work in the background to compile and install your models in your cluster. Thus, CREATE MODEL can take longer than MAX_RUNTIME to complete. However, MAX_RUNTIME limits the amount of computation and time used in SageMaker AI to train your model. You can check the status of your model at any time using SHOW MODEL.

When you run CREATE MODEL with AUTO ON, Amazon Redshift ML uses SageMaker AI Autopilot to automatically and intelligently explore different models (or candidates) to find the best one. MAX_RUNTIME limits the amount of time and computation spent. If MAX_RUNTIME is set too low, there might not be enough time to explore even one candidate. If you see the error "Autopilot candidate has no models," rerun the CREATE MODEL with a larger MAX_RUNTIME value. For more information about this parameter, see MaxAutoMLJobRuntimeInSeconds in the *Amazon SageMaker AI API Reference*.

When you run CREATE MODEL with AUTO OFF, MAX_RUNTIME corresponds to a limit on how long the training job is run in SageMaker AI. Training jobs often complete sooner, depending on the size of the dataset and other parameters used, such as num_rounds in MODEL_TYPE XGBOOST.

You can also control costs or reduce training time by specifying a smaller MAX_CELLS value when you run CREATE MODEL. A *cell* is an entry in the database. Each row corresponds to as many cells as there are columns, which can be of fixed or varying width. MAX_CELLS limits the number of cells, and thus the number of training examples used to train your model. By default, MAX_CELLS is set to 1 million cells. Reducing MAX_CELLS reduces the number of rows from the result of the SELECT query in CREATE MODEL that Amazon Redshift exports and sends to SageMaker AI to train a model. Reducing MAX_CELLS thus reduces the size of the dataset used to train models both with AUTO ON and AUTO OFF. This approach helps reduce the costs and time to train models. To see information about training and billing times of a specific training job, choose **Training jobs** in Amazon SageMaker AI.

Increasing MAX_RUNTIME and MAX_CELLS often improves model quality by allowing SageMaker AI to explore more candidates. This way, SageMaker AI can take more time to train each candidate and use more data to train better models. If you want faster iteration or exploration of your dataset, use lower MAX_RUNTIME and MAX_CELLS. If you want improved accuracy of models, use higher MAX_RUNTIME and MAX_CELLS.

For more information about costs associated with various cell numbers and free trial details, see [Amazon Redshift pricing](#).

Costs for using Amazon Redshift ML with Amazon Bedrock

Using Amazon Redshift ML with Amazon Bedrock incurs additional costs. For more information, see [Amazon Bedrock Pricing](#).

Getting started with Amazon Redshift ML

Amazon Redshift ML makes it easy for SQL users to create, train, and deploy machine learning models using familiar SQL commands. With Amazon Redshift ML, you can use your data in your Redshift cluster to train models with Amazon SageMaker AI. Later, the models are localized and predictions can be made within an Amazon Redshift database. Amazon Redshift ML currently supports the machine learning algorithms: XGBoost (AUTO ON and OFF) and multilayer perceptron (AUTO ON), K-Means (AUTO OFF), and Linear Learner.

Topics

Cluster and configure setup for Amazon Redshift ML administration

Before you work with Amazon Redshift ML, complete the cluster setup and configure permissions for using Amazon Redshift ML.

Cluster setup for using Amazon Redshift ML

Before you work with Amazon Redshift ML, complete the following prerequisites.

As an Amazon Redshift administrator, do the following one-time setup for using Amazon Redshift provisioned clusters. For using Amazon Redshift ML with Amazon Redshift Serverless, see Getting started with Amazon Redshift Serverless.

To perform one-time cluster setup for Amazon Redshift ML

1. Create a Redshift cluster using the AWS Management Console or the AWS Command Line Interface (AWS CLI). Make sure to attach the AWS Identity and Access Management (IAM) policy while creating the cluster. For more information about permissions required to use Amazon Redshift ML with Amazon SageMaker AI, see Permissions required to use Amazon Redshift machine learning (ML)
2. Create the IAM role required for using Amazon Redshift ML in one of the following ways:

   - To use SageMaker AI with Amazon Redshift ML, create an IAM role with `AmazonS3FullAccess` and `AmazonSageMakerFullAccess` policies. If you plan to also create Forecast models, attach the `AmazonForecastFullAccess` policy to your role as well.
   - To use Amazon Bedrock with Amazon Redshift ML, create an IAM role with `AmazonS3FullAccess` and `AmazonBedrockFullAccess` policies.
   - We recommend that you create an IAM role through the Amazon Redshift console that has the `AmazonRedshiftAllCommandsFullAccess` policy with permissions to run SQL commands, such as CREATE MODEL. Amazon Redshift uses a seamless API-based mechanism to programmatically create IAM roles in your AWS account on your behalf. Amazon Redshift automatically attaches existing AWS managed policies to the IAM role. This approach means that you can stay within the Amazon Redshift console and don't have to switch to the IAM console for role creation. For more information, see Creating an IAM role as default for Amazon Redshift.

     When an IAM role is created as the default for your cluster, include `redshift` as part of the resource name or use a Redshift-specific tag to tag those resources.

     To use Amazon Bedrock foundation models, add the following section:

     ```
     // Required section if you use Bedrock models.
     {
     ```

```
    "Effect": "Allow",
    "Action": "bedrock:InvokeModel",
    "Resource": [
        "arn:aws:bedrock:<region>::foundation-model/*"
    ]
}
```

- If you want to create an IAM role with a more restrictive policy, you can use the policy following. You can also modify this policy to meet your needs.

  The Amazon S3 bucket `redshift-downloads/redshift-ml/` is the location where the sample data used for other steps and examples is stored. You can remove it if you don't need to load data from Amazon S3. Or, replace it with other Amazon S3 buckets that you use to load data into Amazon Redshift.

  The *`your-account-id`*, *`your-role`*, and `amzn-s3-demo-bucket` values are the ones that you specify as part of your CREATE MODEL command.

  (Optional) Use the AWS KMS keys section of the sample policy if you specify an AWS KMS key while using Amazon Redshift ML. The *`your-kms-key`* value is the key that you use as part of your CREATE MODEL command.

3. To allow Amazon Redshift and SageMaker AI to assume the role to interact with other services, add the following trust policy to the IAM role.

   JSON

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Service": [
          "redshift.amazonaws.com",
          "sagemaker.amazonaws.com",
          "forecast.amazonaws.com"
        ]
      },
      "Action": "sts:AssumeRole"
```

```
        }
    ]
}
```

4. (Optional) Create an Amazon S3 bucket and an AWS KMS key. These are for Amazon Redshift to use to store the training data sent to Amazon SageMaker AI and receive the trained model from Amazon SageMaker AI.

5. (Optional) Create different combinations of IAM roles and Amazon S3 buckets for controlling access to different user groups.

6. When you turn on enhanced VPC routing, traffic between Redshift ML and your S3 bucket goes through your private VPC. For more information about VPC routing, see Enhanced VPC routing in Amazon Redshift.

   For more information about permissions required to specify a private VPC for your hyperparameter tuning job, see Permissions required to use Amazon Redshift ML with Amazon SageMaker AI.

   > **Note**
   >
   > Inference calls made to remote SageMaker AI models do not go through your VPC.

For information on how to use the CREATE MODEL statement to start creating models for different use cases, see CREATE MODEL.

Managing permissions and ownership

Just as with other database objects, such as tables or functions, Amazon Redshift binds creating and using ML models to access control mechanisms. There are separate permissions for creating a model that runs prediction functions.

The following examples use two user groups, `retention_analyst_grp` (model creator) and `marketing_analyst_grp` (model user) to illustrate how Amazon Redshift manages access control. The retention analyst creates machine learning models that the other set of users can use through acquired permissions.

A superuser can GRANT USER or GROUP permission to create machine learning models using the following statement.

```
GRANT CREATE MODEL TO GROUP retention_analyst_grp;
```

Users or groups with this permission can create a model in any schema in the cluster if a user has the usual CREATE permission on the SCHEMA. The machine learning model is part of the schema hierarchy in a similar way to tables, views, procedures, and user-defined functions.

Assuming a schema `demo_ml` already exists, grant the two user groups the permission on the schema as follows.

```
GRANT CREATE, USAGE ON SCHEMA demo_ml TO GROUP retention_analyst_grp;
```

```
GRANT USAGE ON SCHEMA demo_ml TO GROUP marketing_analyst_grp;
```

To let other users use your machine learning inference function, grant the EXECUTE permission. The following example uses the EXECUTE permission to grant the marketing_analyst_grp GROUP the permission to use the model.

```
GRANT EXECUTE ON MODEL demo_ml.customer_churn_auto_model TO GROUP
 marketing_analyst_grp;
```

Use the REVOKE statement with CREATE MODEL and EXECUTE to revoke those permissions from users or groups. For more information on permission control commands, see GRANT and REVOKE.

Using model explainability with Amazon Redshift ML

With model explainability in Amazon Redshift ML, you use feature importance values to help understand how each attribute in your training data contributes to the predicted result.

Model explainability helps improve your machine learning (ML) models by explaining the predictions that your models make. Model explainability helps explain how these models make predictions using a feature attribution approach.

Amazon Redshift ML incorporates model explainability to provide model explanation functionality to Amazon Redshift ML users. For more information about model explainability, see What Is Fairness and Model Explainability for Machine Learning Predictions? in the *Amazon SageMaker AI Developer Guide*.

Model explainability also monitors the inferences that models make in production for feature attribution drift. It also provides tools to help you generate model governance reports that you can use to inform risk and compliance teams, and external regulators.

When you specify the AUTO ON or AUTO OFF option when using the CREATE MODEL statement, after the model training job finishes, SageMaker AI creates the explanation output. You can use the EXPLAIN_MODEL function to query the explainability report in a JSON format. For more information, see Machine learning functions.

Amazon Redshift ML probability metrics

In supervised learning problems, class labels are outcomes of predictions that use the input data. For example, if you're using a model to predict whether a customer would resubscribe to a streaming service, possible labels are likely and unlikely. Redshift ML provides the capability of probability metrics, which assign a probability to each label to indicate its likelihood. This helps you make more informed decisions based on the predicted outcomes. In Amazon Redshift ML, probability metrics are available when creating AUTO ON models with a problem type of either binary classification or multiclass classification. If you omit the AUTO ON parameter, Redshift ML assumes that the model should have AUTO ON.

Create the model

When creating a model, Amazon Redshift automatically detects the model type and problem type. If it is a classification problem, Redshift automatically creates a second inference function that you can use to output probabilities relative to each label. This second inference function's name is your specified inference function name followed by the string `_probabilities`. For example, if you name your inference function as `customer_churn_predict`, then the second inference function's name is `customer_churn_predict_probabilities`. You can then query this function to get the probabilities of each label.

```
CREATE MODEL customer_churn_model
FROM customer_activity
    PROBLEM_TYPE BINARY_CLASSIFICATION
TARGET churn
FUNCTION customer_churn_predict
IAM_ROLE {default}
AUTO ON
SETTINGS ( S3_BUCKET 'amzn-s3-demo-bucket'
```

Get probabilities

Once the probability function is ready, running the command returns a SUPER type that contains arrays of the returned probabilities and their associated labels. For example, the result `"probabilities" : [0.7, 0.3], "labels" : ["False.", "True."]` means that the False label has a probability of 0.7, and the True label has a probability of 0.3.

```
SELECT customer_churn_predict_probabilities(Account_length, Area_code,
            VMail_message, Day_mins, Day_calls, Day_charge,Eve_mins, Eve_calls,
            Eve_charge, Night_mins, Night_calls, Night_charge,Intl_mins, Intl_calls,
            Intl_charge, Cust_serv_calls)
FROM customer_activity;

customer_churn_predict_probabilities
 --------------------
 {"probabilities" : [0.7, 0.3], "labels" : ["False.", "True."]}
 {"probabilities" : [0.8, 0.2], "labels" : ["False.", "True."]}
 {"probabilities" : [0.75, 0.25], "labels" : ["True.", "False"]}
```

The probabilities and labels arrays are always sorted by their probabilities in descending order. You can write a query to return just the predicted label with the highest probability by unnesting the SUPER returned results of the probability function.

```
SELECT prediction.labels[0], prediction.probabilities[0]
            FROM (SELECT customer_churn_predict_probabilities(Account_length,
 Area_code,
            VMail_message, Day_mins, Day_calls, Day_charge,Eve_mins, Eve_calls,
            Eve_charge, Night_mins, Night_calls, Night_charge,Intl_mins, Intl_calls,
            Intl_charge, Cust_serv_calls) AS prediction
FROM customer_activity);

  labels   | probabilities
-----------+--------------
 "False."  | 0.7
 "False."  | 0.8
 "True."   | 0.75
```

To make the queries simpler, you can store the results of the prediction function in a table.

```
CREATE TABLE churn_auto_predict_probabilities AS
             (SELECT customer_churn_predict_probabilities(Account_length, Area_code,
```

```
             VMail_message, Day_mins, Day_calls, Day_charge,Eve_mins, Eve_calls,
             Eve_charge, Night_mins, Night_calls, Night_charge,Intl_mins,
             Intl_calls, Intl_charge, Cust_serv_calls) AS prediction
FROM customer_activity);
```

You can query the table with the results to return only predictions that have a probability higher than 0.7.

```
SELECT prediction.labels[0], prediction.probabilities[0]
FROM churn_auto_predict_probabilities
WHERE prediction.probabilities[0] > 0.7;

  labels   | probabilities
-----------+--------------
 "False."  | 0.8
 "True."   | 0.75
```

Using index notation, you can get the probability of a specific label. The following example returns probabilities of all the `True.` labels.

```
SELECT label, index, p.prediction.probabilities[index]
FROM churn_auto_predict_probabilities p, p.prediction.labels AS label AT index
WHERE label='True.';

  label  | index | probabilities
---------+-------+---------------
 "True." |     0 | 0.3
 "True." |     0 | 0.2
 "True." |     0 | 0.75
```

The following example returns all rows that have a `True`. label with a probability greater than 0.7, indicating that the customer is likely to churn.

```
SELECT prediction.labels[0], prediction.probabilities[0]
FROM churn_auto_predict_probabilities
WHERE prediction.probabilities[0] > 0.7 AND prediction.labels[0] = "True.";

labels     | probabilities
-----------+--------------
 "True."   | 0.75
```

Tutorials for Amazon Redshift ML

You can use Amazon Redshift ML to train machine learning models using SQL statements, and then invoke the models in SQL queries for prediction. Machine learning in Amazon Redshift trains a model with one SQL command. Amazon Redshift automatically launches a training job in Amazon SageMaker AI and generates a model. Once a model is created, you can perform predictions in Amazon Redshift using the model's prediction function.

Follow the steps in these tutorials to learn about Amazon Redshift ML features:

- Tutorial: Building customer churn models – In this tutorial, you use Amazon Redshift ML to create a customer churn model with the CREATE MODEL command, and run prediction queries for user scenarios. Then, you implement queries using the SQL function that the CREATE MODEL command generates.
- Tutorial: Building K-means clustering models – In this tutorial, you use Amazon Redshift ML to create, train, and deploy a machine learning model based on the K-means algorithm.
- Tutorial: Building multi-class classification models – In this tutorial, you use Amazon Redshift ML to create a machine learning model that solves multi-class classification problems. The multi-class classification algorithm classifies data points into one of three or more classes. Then, you implement queries using the SQL function that the CREATE MODEL command generates.
- Tutorial: Building XGBoost models – In this tutorial, you create a model with data from Amazon S3 and run prediction queries with the model using Amazon Redshift ML. The XGBoost algorithm is an optimized implementation of the gradient boosted trees algorithm.
- Tutorial: Building regression models – In this tutorial, you use Amazon Redshift ML to create a machine learning regression model and run prediction queries on the model. Regression models allow you to predict numerical outcomes, such as the price of a house, or how many people will use a city's bike rental service.
- Tutorial: Building regression models with linear learner – In this tutorial, you create a linear learner model with data from Amazon S3 and run prediction queries with the model using Amazon Redshift ML. The SageMaker AI linear learner algorithm solves either regression or multi-class classification problems.
- Tutorial: Building multi-class classification models with linear learner – In this tutorial, you create a linear learner model with data from Amazon S3, and then run prediction queries with the model using Amazon Redshift ML. The SageMaker AI linear learner algorithm solves either regression or classification problems.

Tutorial: Building customer churn models

In this tutorial, you use Amazon Redshift ML to create a customer churn model with the CREATE MODEL command, and run prediction queries for user scenarios. Then, you implement queries using the SQL function that the CREATE MODEL command generates.

You can use a simple CREATE MODEL command to export training data, train a model, import the model, and prepare an Amazon Redshift prediction function. Use the CREATE MODEL statement to specify training data either as a table or SELECT statement.

This example uses historical information to construct a machine learning model of a mobile operator's customer churn. First, SageMaker AI trains your machine learning model and then tests your model using the profile information of an arbitrary customer. After the model is validated, Amazon SageMaker AI deploys the model and the prediction function to Amazon Redshift. You can use the prediction function to predict whether a customer is going to churn or not.

Use case examples

You can solve other binary classification problems using Amazon Redshift ML, such as predicting if a sales lead will close or not. You could also predict whether a financial transaction is fraudulent or not.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Perform predictions with the model

Prerequisites

To complete this tutorial, you must have the following prerequisites:

- You must set up an Amazon Redshift cluster for Amazon Redshift ML. To do so, use the documentation for [Cluster and configure setup for Amazon Redshift ML administration.]
- The Amazon Redshift cluster that you use to create the model, and the Amazon S3 bucket that you use to stage the training data and store the model artifacts must be in the same AWS Region.

- To download the SQL commands and the sample dataset used in this documentation, do one of the following:
  - Download the SQL commands, Customer activity file, and Abalone file.
  - Using the AWS CLI for Amazon S3, run the following command. You can use your own target path.

```
aws s3 cp s3://redshift-downloads/redshift-ml/tutorial-scripts/redshift-ml-tutorial.sql </target/path>
aws s3 cp s3://redshift-downloads/redshift-ml/customer_activity/customer_activity.csv </target/path>
aws s3 cp s3://redshift-downloads/redshift-ml/abalone_xgb/abalone_xgb.csv </target/path>
```

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to edit and run queries and visualize results.

Running the following queries creates a table named `customer_activity` and ingests the sample dataset from Amazon S3.

```
DROP TABLE IF EXISTS customer_activity;

CREATE TABLE customer_activity (
state varchar(2),
account_length int,
area_code int,
phone varchar(8),
intl_plan varchar(3),
vMail_plan varchar(3),
vMail_message int,
day_mins float,
day_calls int,
day_charge float,
total_charge float,
eve_mins float,
eve_calls int,
eve_charge float,
night_mins float,
night_calls int,
night_charge float,
intl_mins float,
```

```
intl_calls int,
intl_charge float,
cust_serv_calls int,
churn varchar(6),
record_date date
);

COPY customer_activity
FROM 's3://redshift-downloads/redshift-ml/customer_activity/'
REGION 'us-east-1' IAM_ROLE default
FORMAT AS CSV IGNOREHEADER 1;
```

Step 2: Create the machine learning model

Churn is our target input in this model. All other inputs for the model are attributes that help to create a function to predict churn.

The following example uses the CREATE MODEL operation to deliver a model that predicts whether a customer will be active, using inputs such as the customer’s age, postal code, spending, and cases. In the following example, replace amzn-s3-demo-bucket with your own Amazon S3 bucket.

```
CREATE MODEL customer_churn_auto_model
FROM
    (
      SELECT state,
             account_length,
             area_code,
             total_charge/account_length AS average_daily_spend,
             cust_serv_calls/account_length AS average_daily_cases,
             churn
      FROM customer_activity
      WHERE  record_date < '2020-01-01'
     )
TARGET churn FUNCTION ml_fn_customer_churn_auto
IAM_ROLE default SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket'
);
```

The SELECT query in the preceding example creates the training data. The TARGET clause specifies which column is the machine learning label that the CREATE MODEL operation uses to learn how to predict. The target column “churn” indicates whether the customer still has an active membership or has suspended the membership. The S3_BUCKET field is the name of the Amazon

S3 bucket that you previously created. The Amazon S3 bucket is used to share training data and artifacts between Amazon Redshift and Amazon SageMaker AI. The remaining columns are the features that are used for the prediction.

For a summary of the syntax and features of a basic use case of the CREATE MODEL command, see Simple CREATE MODEL.

Add permissions for server-side encryption (optional)

Amazon Redshift by default uses Amazon SageMaker AI Autopilot for training. In particular, Amazon Redshift securely exports the training data to the customer-specified Amazon S3 bucket. If you don't specify a `KMS_KEY_ID`, then the data is encrypted using server-side encryption SSE-S3 by default.

When you encrypt your input using server-side encryption with a AWS KMS managed key (SSE-MMS), then add the following permissions:

```
{
    "Effect": "Allow",
    "Action": [
    "kms:Encrypt"
    "kms:Decrypt"
    ]
}
```

For more information about Amazon SageMaker AI roles, see Amazon SageMaker AI roles in the *Amazon SageMaker AI Developer Guide*.

Check the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

Use the following operation to check the status of the model.

```
SHOW MODEL customer_churn_auto_model;
```

The following is an example of the output of the previous operation.

```
+--------------------------
+-------------------------------------------------------------------------------------------------
+
```

```
|           Key            |
                  Value
             |
+--------------------------
+---------------------------------------------------------------------------------------------------
+
|        Model Name        |
        customer_churn_auto_model
             |
|       Schema Name        |
                 public
             |
|          Owner           |
                 awsuser
             |
|      Creation Time       |
        Tue, 14.06.2022 17:15:52
             |
|       Model State        |
                TRAINING
             |
|                          |

             |
|      TRAINING DATA:      |

             |
|          Query           | SELECT STATE, ACCOUNT_LENGTH, AREA_CODE, TOTAL_CHARGE /
 ACCOUNT_LENGTH AS AVERAGE_DAILY_SPEND, CUST_SERV_CALLS / ACCOUNT_LENGTH AS
 AVERAGE_DAILY_CASES, CHURN |
|                          |
         FROM CUSTOMER_ACTIVITY
             |
|                          |
    WHERE RECORD_DATE < '2020-01-01'
             |
|      Target Column       |
                  CHURN
             |
|                          |

             |
```

```
|       PARAMETERS:        |
             |
|        Model Type        |
                  auto
             |
|       Problem Type       |

             |
|        Objective         |

             |
|     AutoML Job Name      |
     redshiftml-20220614171552640901
             |
|      Function Name       |
        ml_fn_customer_churn_auto
             |
|   Function Parameters    |                                            state
 account_length area_code average_daily_spend average_daily_cases
                       |
| Function Parameter Types |
      varchar int4 int4 float8 int4
             |
|         IAM Role         |
          default-aws-iam-role
             |
|        S3 Bucket         |
             amzn-s3-demo-bucket
              |
|       Max Runtime        |
                  5400
             |
+--------------------------
+------------------------------------------------------------------------------------------
+
```

When the model training is complete, the `model_state` variable becomes `Model is Ready`, and the prediction function becomes available.

Step 3: Perform predictions with the model

You can use SQL statements to view the predictions made by the prediction model. In this example, the prediction function created by the CREATE MODEL operation is named `ml_fn_customer_churn_auto`. The input arguments for the prediction function correspond to the types of the features, such as varchar for the `state` and integer for `account_length`. The output of the prediction function is the same type as the TARGET column of the CREATE MODEL statement.

1. You trained the model on data from before 2020-01-01, so now you use the prediction function on the testing set. The following query displays the predictions of whether customers who signed up after 2020-01-01 will go through churn or not.

```
SELECT
    phone,
    ml_fn_customer_churn_auto(
        state,
        account_length,
        area_code,
        total_charge / account_length,
        cust_serv_calls / account_length
    ) AS active
FROM
    customer_activity
WHERE
    record_date > '2020-01-01';
```

2. The following example uses the same prediction function for a different use case. In this case, Amazon Redshift predicts the proportion of churners and non-churners among customers from different states where the record date is greater than 2020-01-01.

```
WITH predicted AS (
    SELECT
        state,
        ml_fn_customer_churn_auto(
            state,
            account_length,
            area_code,
            total_charge / account_length,
            cust_serv_calls / account_length
        ) :: varchar(6) AS active
```

```
    FROM
        customer_activity
    WHERE
        record_date > '2020-01-01'
)
SELECT
    state,
    SUM(
        CASE
            WHEN active = 'True.' THEN 1
            ELSE 0
        END
    ) AS churners,
    SUM(
        CASE
            WHEN active = 'False.' THEN 1
            ELSE 0
        END
    ) AS nonchurners,
    COUNT(*) AS total_per_state
FROM
    predicted
GROUP BY
    state
ORDER BY
    state;
```

3. The following example uses the prediction function for the use case of predicting the percentage of customers who churn in a state. In this case, Amazon Redshift predicts the churn percentage where the record date is greater than 2020-01-01.

```
WITH predicted AS (
    SELECT
        state,
        ml_fn_customer_churn_auto(
            state,
            account_length,
            area_code,
            total_charge / account_length,
            cust_serv_calls / account_length
        ) :: varchar(6) AS active
    FROM
        customer_activity
```

```
    WHERE
        record_date > '2020-01-01'
)
SELECT
    state,
    CAST((CAST((SUM(
        CASE
            WHEN active = 'True.' THEN 1
            ELSE 0
        END
    )) AS FLOAT) / CAST(COUNT(*) AS FLOAT)) AS DECIMAL (3, 2)) AS pct_churn,
    COUNT(*) AS total_customers_per_state
FROM
    predicted
GROUP BY
    state
ORDER BY
    3 DESC;
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon RedshiftML
- CREATE MODEL command
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building K-means clustering models

In this tutorial, you use Amazon Redshift ML to create, train, and deploy a machine learning model based on the K-means algorithm. This algorithm solves clustering problems where you want to discover groupings in the data. K-means helps in grouping data that has not been labeled yet. To learn more about K-means clustering, see [How K-means Clustering Works](#)in the Amazon SageMaker AI Developer Guide.

You will use a CREATE MODEL operation to create a K-means model from a Amazon Redshift cluster. You can use a CREATE MODEL command to export training data, train a model, import the model, and prepare an Amazon Redshift prediction function. Use the CREATE MODEL operation to specify training data either as a table or a SELECT statement.

In this tutorial, you use K-means on the [Global Database of Events, Language, and Tone (GDELT)](#) dataset, which monitors world news across the world, and the data is stored for every second of every day. K-means will group events that have similar tone, actors, or locations. The data is stored as multiple files on Amazon Simple Storage Service, in two different folders. The folders are historical, which cover the years 1979–2013, and daily updates, which cover the years 2013 and later. For this example, we use the historical format and bring in 1979 data.

Use case examples

You can solve other clustering problems with Amazon Redshift ML, such as grouping customers who have similar viewing habits on a streaming service. You could also use Redshift ML to predict the optimal number of shipping centers for a delivery service.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Perform predictions with the model

Prerequisites

To complete this tutorial, you must complete the [Administrative setup](#) for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

1. Use the [Amazon Redshift query editor v2](#) to run the following query. The query drops the `gdelt_data` table in the public schema if it exists and creates a table of the same name in the public schema.

```
DROP TABLE IF EXISTS gdelt_data CASCADE;
```

```
CREATE TABLE gdelt_data (
    GlobalEventId bigint,
    SqlDate bigint,
    MonthYear bigint,
    Year bigint,
    FractionDate double precision,
    Actor1Code varchar(256),
    Actor1Name varchar(256),
    Actor1CountryCode varchar(256),
    Actor1KnownGroupCode varchar(256),
    Actor1EthnicCode varchar(256),
    Actor1Religion1Code varchar(256),
    Actor1Religion2Code varchar(256),
    Actor1Type1Code varchar(256),
    Actor1Type2Code varchar(256),
    Actor1Type3Code varchar(256),
    Actor2Code varchar(256),
    Actor2Name varchar(256),
    Actor2CountryCode varchar(256),
    Actor2KnownGroupCode varchar(256),
    Actor2EthnicCode varchar(256),
    Actor2Religion1Code varchar(256),
    Actor2Religion2Code varchar(256),
    Actor2Type1Code varchar(256),
    Actor2Type2Code varchar(256),
    Actor2Type3Code varchar(256),
    IsRootEvent bigint,
    EventCode bigint,
    EventBaseCode bigint,
    EventRootCode bigint,
    QuadClass bigint,
    GoldsteinScale double precision,
    NumMentions bigint,
    NumSources bigint,
    NumArticles bigint,
    AvgTone double precision,
    Actor1Geo_Type bigint,
    Actor1Geo_FullName varchar(256),
    Actor1Geo_CountryCode varchar(256),
    Actor1Geo_ADM1Code varchar(256),
    Actor1Geo_Lat double precision,
    Actor1Geo_Long double precision,
    Actor1Geo_FeatureID bigint,
```

```
    Actor2Geo_Type bigint,
    Actor2Geo_FullName varchar(256),
    Actor2Geo_CountryCode varchar(256),
    Actor2Geo_ADM1Code varchar(256),
    Actor2Geo_Lat double precision,
    Actor2Geo_Long double precision,
    Actor2Geo_FeatureID bigint,
    ActionGeo_Type bigint,
    ActionGeo_FullName varchar(256),
    ActionGeo_CountryCode varchar(256),
    ActionGeo_ADM1Code varchar(256),
    ActionGeo_Lat double precision,
    ActionGeo_Long double precision,
    ActionGeo_FeatureID bigint,
    DATEADDED bigint
);
```

2. The following query loads the sample data into the `gdelt_data` table.

```
COPY gdelt_data
FROM 's3://gdelt-open-data/events/1979.csv'
REGION 'us-east-1'
IAM_ROLE default
CSV
DELIMITER '\t';
```

Examine the training data (optional)

To see what data your model will be trained on, use the following query.

```
SELECT
    AvgTone,
    EventCode,
    NumArticles,
    Actor1Geo_Lat,
    Actor1Geo_Long,
    Actor2Geo_Lat,
    Actor2Geo_Long
FROM
    gdelt_data LIMIT 100;
```

Step 2: Create the machine learning model

The following example uses the CREATE MODEL command to create a model that groups the data into seven clusters. The K value is the number of clusters that your data points are divided into. The model classifies your data points into clusters where data points are more similar to each other. By clustering the data points into groups, the K-Means algorithm iteratively determines the best cluster center. The algorithm then assigns each data point to the closest cluster center. Members nearest the same cluster center belong to the same group. Members of a group are as similar as possible to other members in the same group, and as different as possible from members of other groups. The K value is subjective and depends on methods that measure the similarities among data points. You can change the K value to smooth out cluster sizes if the clusters are unevenly distributed.

In the following example, replace amzn-s3-demo-bucket with your own Amazon S3 bucket.

```
CREATE MODEL news_data_clusters
FROM
    (
        SELECT
            AvgTone,
            EventCode,
            NumArticles,
            Actor1Geo_Lat,
            Actor1Geo_Long,
            Actor2Geo_Lat,
            Actor2Geo_Long
        FROM
            gdelt_data
    ) FUNCTION news_monitoring_cluster
    IAM_ROLE default
    AUTO OFF
    MODEL_TYPE KMEANS
    PREPROCESSORS 'none'
    HYPERPARAMETERS DEFAULT
    EXCEPT
    (K '7')
    SETTINGS (S3_BUCKET 'amzn-s3-demo-bucket');
```

Check the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

To check the model status, use the following SHOW MODEL operation and find if the `Model State` is `Ready`.

```
SHOW MODEL NEWS_DATA_CLUSTERS;
```

When the model is ready, the output of the previous operation should show that the `Model State` is `Ready`. The following is an example of the output of the SHOW MODEL operation.

```
+--------------------------
+------------------------------------------------------------------------------------------------------
+
|        Model Name        |
 news_data_clusters                                                    |
+--------------------------
+------------------------------------------------------------------------------------------------------
+
|       Schema Name        |                                                          public
                                             |
|          Owner           |                                                         awsuser
                                             |
|      Creation Time       |                                                Fri, 17.06.2022
 16:32:19                                         |
|       Model State        |                                                          READY
                                             |
|        train:msd         |                                                      2973.822754
                                             |
|      train:progress      |                                                       100.000000
                                             |
|     train:throughput     |                                                    237114.875000
                                             |
|      Estimated Cost      |                                                         0.004983
                                             |
|                          |
                                             |
|      TRAINING DATA:      |
                                             |
|          Query           | SELECT AVGTONE, EVENTCODE, NUMARTICLES, ACTOR1GEO_LAT,
 ACTOR1GEO_LONG, ACTOR2GEO_LAT, ACTOR2GEO_LONG |
|                          |                                                  FROM GDELT_DATA
                                             |
|                          |
                                             |
```

```
|       PARAMETERS:        |
                                            |
|        Model Type        |                                                kmeans
                                            |
|    Training Job Name     |
 redshiftml-20220617163219978978-kmeans                           |
|      Function Name       |
 news_monitoring_cluster                                    |
|   Function Parameters    |       avgtone eventcode numarticles actor1geo_lat
 actor1geo_long actor2geo_lat actor2geo_long        |
| Function Parameter Types |                             float8 int8 int8 float8 float8
 float8 float8                              |
|         IAM Role         |                                         default-aws-iam-
role                                          |
|        S3 Bucket         |                                            amzn-s3-demo-
bucket                                        |
|       Max Runtime        |                                                 5400
                                            |
|                          |
                                            |
|     HYPERPARAMETERS:     |
                                            |
|       feature_dim        |                                                  7
                                            |
|            k             |                                                  7
                                            |
+--------------------------
+------------------------------------------------------------------------------------------------------
+
```

Step 3: Perform predictions with the model

Identify the clusters

You can find discrete groupings identified in the data by your model, otherwise known as clusters. A cluster is the set of data points that is closer to its cluster center than any other cluster center. Since the K value represents the number of clusters in the model, it also represents the number of cluster centers. The following query identifies the clusters by showing the cluster associated with each `globaleventid`.

```
SELECT
    globaleventid,
```

```
    news_monitoring_cluster (
        AvgTone,
        EventCode,
        NumArticles,
        Actor1Geo_Lat,
        Actor1Geo_Long,
        Actor2Geo_Lat,
        Actor2Geo_Long
    ) AS cluster
FROM
    gdelt_data;
```

Check the distribution of data

You can check the distribution of data across clusters to see if the K value that you chose caused the data to be somewhat evenly distributed. Use the following query to determine if the data is evenly distributed across your clusters.

```
SELECT
    events_cluster,
    COUNT(*) AS nbr_events
FROM
    (
        SELECT
            globaleventid,
            news_monitoring_cluster(
                AvgTone,
                EventCode,
                NumArticles,
                Actor1Geo_Lat,
                Actor1Geo_Long,
                Actor2Geo_Lat,
                Actor2Geo_Long
            ) AS events_cluster
        FROM
            gdelt_data
    )
GROUP BY
    1;
```

Note that you can change the K value to smooth out cluster sizes if the clusters are unevenly distributed.

Determine the cluster centers

A data point is closer to its cluster center than it is to any other cluster center. Thus, finding the cluster centers helps you define the clusters.

Run the following query to determine the centers of the clusters based on the number of articles by event code.

```
SELECT
    news_monitoring_cluster (
        AvgTone,
        EventCode,
        NumArticles,
        Actor1Geo_Lat,
        Actor1Geo_Long,
        Actor2Geo_Lat,
        Actor2Geo_Long
    ) AS events_cluster,
    eventcode,
    SUM(numArticles) AS numArticles
FROM
    gdelt_data
GROUP BY
    1,
    2;
```

Show information about data points in a cluster

Use the following query to return the data for the points assigned to the fifth cluster. The selected articles must have two actors.

```
SELECT
    news_monitoring_cluster (
        AvgTone,
        EventCode,
        NumArticles,
        Actor1Geo_Lat,
        Actor1Geo_Long,
        Actor2Geo_Lat,
        Actor2Geo_Long
    ) AS events_cluster,
    eventcode,
    actor1name,
```

```
    actor2name,
    SUM(numarticles) AS totalarticles
FROM
    gdelt_data
WHERE
    events_cluster = 5
    AND actor1name <> ' '
    AND actor2name <> ' '
GROUP BY
    1,
    2,
    3,
    4
ORDER BY
    5 desc;
```

Show data about events with actors of the same ethnic code

The following query counts the number of articles written about events with a positive tone. The query also requires that the two actors have the same ethnic code and it returns which cluster each event is assigned to.

```
SELECT
    news_monitoring_cluster (
        AvgTone,
        EventCode,
        NumArticles,
        Actor1Geo_Lat,
        Actor1Geo_Long,
        Actor2Geo_Lat,
        Actor2Geo_Long
    ) AS events_cluster,
    SUM(numarticles) AS total_articles,
    eventcode AS event_code,
    Actor1EthnicCode AS ethnic_code
FROM
    gdelt_data
WHERE
    Actor1EthnicCode = Actor2EthnicCode
    AND Actor1EthnicCode <> ' '
    AND Actor2EthnicCode <> ' '
    AND AvgTone > 0
GROUP BY
```

```
    1,
    3,
    4
HAVING
    (total_articles) > 4
ORDER BY
    1,
    2 ASC;
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building multi-class classification models

In this tutorial, you use Amazon Redshift ML to create a machine learning model that solves multi-class classification problems. The multi-class classification algorithm classifies data points into one of three or more classes. Then, you implement queries using the SQL function that the CREATE MODEL command generates.

You can use a CREATE MODEL command to export training data, train a model, import the model, and prepare an Amazon Redshift prediction function. Use the CREATE MODEL operation to specify training data either as a table or a SELECT statement.

To follow along with the tutorial, you use the public dataset E-Commerce Sales Forecast, which includes sales data of an online UK retailer. The model you generate will target the most active customers for a special customer loyalty program. With multi-class classification, you can use the model to predict how many months a customer will be active over a 13-month period. The prediction function designates customers who are predicted to be active for 7 or more months for admission to the program.

Use case examples

You can solve other multi-class classification problems with Amazon Redshift ML, such as predicting the best-selling product from a product line. You could also predict which fruit an image contains, such as selecting apples or pears or oranges.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Perform predictions with the model

Prerequisites

To complete this tutorial, you must complete the Administrative setup for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to run the following queries. These queries load the sample data into Amazon Redshift.

1. The following query creates a table named `ecommerce_sales`.

```
CREATE TABLE IF NOT EXISTS ecommerce_sales (
    invoiceno VARCHAR(30),
    stockcode VARCHAR(30),
    description VARCHAR(60),
    quantity DOUBLE PRECISION,
    invoicedate VARCHAR(30),
    unitprice DOUBLE PRECISION,
    customerid BIGINT,
    country VARCHAR(25)
);
```

2. The following query copies the sample data from the E-Commerce Sales Forecast dataset into the `ecommerce_sales`table.

```
COPY ecommerce_sales
FROM
    's3://redshift-ml-multiclass/ecommerce_data.txt'
IAM_ROLE default
DELIMITER '\t'
IGNOREHEADER 1
REGION 'us-east-1'
MAXERROR 100;
```

Split the data

When you create a model in Amazon Redshift ML, SageMaker AI automatically splits your data into training and test sets, so that SageMaker AI can determine the model accuracy. By manually splitting the data at this step, you will be able to verify the accuracy of the model by allocating an additional prediction set.

Use the following SQL statement to split the data into three sets for training, validation, and prediction.

```
--creates table with all data
CREATE TABLE ecommerce_sales_data AS (
    SELECT
        t1.stockcode,
        t1.description,
        t1.invoicedate,
        t1.customerid,
        t1.country,
        t1.sales_amt,
        CAST(RANDOM() * 100 AS INT) AS data_group_id
    FROM
        (
            SELECT
                stockcode,
                description,
                invoicedate,
                customerid,
                country,
                SUM(quantity * unitprice) AS sales_amt
            FROM
                ecommerce_sales
            GROUP BY
```

```
                1,
                2,
                3,
                4,
                5
        ) t1
);

--creates training set
CREATE TABLE ecommerce_sales_training AS (
    SELECT
        a.customerid,
        a.country,
        a.stockcode,
        a.description,
        a.invoicedate,
        a.sales_amt,
        (b.nbr_months_active) AS nbr_months_active
    FROM
        ecommerce_sales_data a
        INNER JOIN (
            SELECT
                customerid,
                COUNT(
                    DISTINCT(
                        DATE_PART(y, CAST(invoicedate AS DATE)) || '-' || LPAD(
                            DATE_PART(mon, CAST(invoicedate AS DATE)),
                            2,
                            '00'
                        )
                    )
                ) AS nbr_months_active
            FROM
                ecommerce_sales_data
            GROUP BY
                1
        ) b ON a.customerid = b.customerid
    WHERE
        a.data_group_id < 80
);

--creates validation set
CREATE TABLE ecommerce_sales_validation AS (
    SELECT
```

```
        a.customerid,
        a.country,
        a.stockcode,
        a.description,
        a.invoicedate,
        a.sales_amt,
        (b.nbr_months_active) AS nbr_months_active
    FROM
        ecommerce_sales_data a
        INNER JOIN (
            SELECT
                customerid,
                COUNT(
                    DISTINCT(
                        DATE_PART(y, CAST(invoicedate AS DATE)) || '-' || LPAD(
                            DATE_PART(mon, CAST(invoicedate AS DATE)),
                            2,
                            '00'
                        )
                    )
                ) AS nbr_months_active
            FROM
                ecommerce_sales_data
            GROUP BY
                1
        ) b ON a.customerid = b.customerid
    WHERE
        a.data_group_id BETWEEN 80
        AND 90
);

--creates prediction set
CREATE TABLE ecommerce_sales_prediction AS (
    SELECT
        customerid,
        country,
        stockcode,
        description,
        invoicedate,
        sales_amt
    FROM
        ecommerce_sales_data
    WHERE
```

```
        data_group_id > 90);
```

Step 2: Create the machine learning model

In this step, you use the CREATE MODEL statement to create your machine learning model using multi-class classification.

The following query creates the multi-class classification model with the training set using the CREATE MODEL operation. Replace amzn-s3-demo-bucket with your own Amazon S3 bucket.

```
CREATE MODEL ecommerce_customer_activity
FROM
    (
        SELECT
            customerid,
            country,
            stockcode,
            description,
            invoicedate,
            sales_amt,
            nbr_months_active
        FROM
            ecommerce_sales_training
    ) TARGET nbr_months_active FUNCTION predict_customer_activity IAM_ROLE default
 PROBLEM_TYPE MULTICLASS_CLASSIFICATION SETTINGS (
        S3_BUCKET 'amzn-s3-demo-bucket',
        S3_GARBAGE_COLLECT OFF
    );
```

In this query, you specify the problem type as `Multiclass_Classification`. The target that you predict for the model is `nbr_months_active`. When SageMaker AI finishes training the model, it creates the function `predict_customer_activity`, which you will use to make predictions in Amazon Redshift.

Show the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

Use the following query to return various metrics of the model, including model state and accuracy.

```
SHOW MODEL ecommerce_customer_activity;
```

When the model is ready, the output of the previous operation should show that the `Model State` is `Ready`. The following is an example of the output of the SHOW MODEL operation.

```
+--------------------------
+------------------------------------------------------------------------------------------
+
|        Model Name        |
 ecommerce_customer_activity                                  |
+--------------------------
+------------------------------------------------------------------------------------------
+
|       Schema Name        |                                                    public
                                   |
|          Owner           |                                                    awsuser
                                   |
|      Creation Time       |                                           Fri, 17.06.2022 19:02:15
                                   |
|       Model State        |                                                     READY
                                   |
|   Training Job Status    |
 MaxAutoMLJobRuntimeReached                                   |
|   validation:accuracy    |                                                   0.991280
                                   |
|      Estimated Cost      |                                                   7.897689
                                   |
|                          |
                                   |
|      TRAINING DATA:      |
                                   |
|          Query           | SELECT CUSTOMERID, COUNTRY, STOCKCODE, DESCRIPTION,
 INVOICEDATE, SALES_AMT, NBR_MONTHS_ACTIVE |
|                          |                                 FROM
 ECOMMERCE_SALES_TRAINING                                 |
|      Target Column       |                                               NBR_MONTHS_ACTIVE
                                   |
|                          |
                                   |
|       PARAMETERS:        |
                                   |
|        Model Type        |                                                    xgboost
                                   |
|       Problem Type       |                                           MulticlassClassification
                                   |
```

```
|        Objective        |                                            Accuracy
                                     |
|     AutoML Job Name     |
 redshiftml-20220617190215268770                            |
|      Function Name      |
 predict_customer_activity                                 |
|   Function Parameters   |                customerid country stockcode description
 invoicedate sales_amt                       |
| Function Parameter Types |                          int8 varchar varchar varchar
 varchar float8                                |
|         IAM Role        |                                    default-aws-iam-role
                                     |
|        S3 Bucket        |                                        amzn-s3-demo-
bucket                                         |
|       Max Runtime       |                                            5400
                                     |
+--------------------------
+----------------------------------------------------------------------------------------------------
+
```

Step 3: Perform predictions with the model

The following query shows which customers qualify for your customer loyalty program. If the model predicts that the customer will be active for at least seven months, then the model selects the customer for the loyalty program.

```
SELECT
    customerid,
    predict_customer_activity(
        customerid,
        country,
        stockcode,
        description,
        invoicedate,
        sales_amt
    ) AS predicted_months_active
FROM
    ecommerce_sales_prediction
WHERE
    predicted_months_active >= 7
GROUP BY
    1,
    2
```

```
LIMIT
    10;
```

Run prediction queries against the validation data (optional)

Run the following prediction queries against the validation data to see the model's level of accuracy.

```
SELECT
    CAST(SUM(t1.match) AS decimal(7, 2)) AS predicted_matches,
    CAST(SUM(t1.nonmatch) AS decimal(7, 2)) AS predicted_non_matches,
    CAST(SUM(t1.match + t1.nonmatch) AS decimal(7, 2)) AS total_predictions,
    predicted_matches / total_predictions AS pct_accuracy
FROM
    (
        SELECT
            customerid,
            country,
            stockcode,
            description,
            invoicedate,
            sales_amt,
            nbr_months_active,
            predict_customer_activity(
                customerid,
                country,
                stockcode,
                description,
                invoicedate,
                sales_amt
            ) AS predicted_months_active,
            CASE
                WHEN nbr_months_active = predicted_months_active THEN 1
                ELSE 0
            END AS match,
            CASE
                WHEN nbr_months_active <> predicted_months_active THEN 1
                ELSE 0
            END AS nonmatch
        FROM
            ecommerce_sales_validation
    )t1;
```

Predict how many customers miss entry (optional)

The following query compares the number of customers that are predicted to be active for only 5 or 6 months. The model predicts that these customers will miss out on the loyalty program. The query then compares the amount that barely miss the program to the number that are predicted to be eligible for the loyalty program. This query could be used to inform a decision on whether to lower the threshold for the loyalty program. You can also determine if there is a significant amount of customers that are predicted to barely miss out on the program. You could then encourage those customers to increase their activity to get a loyalty program membership.

```
SELECT
    predict_customer_activity(
        customerid,
        country,
        stockcode,
        description,
        invoicedate,
        sales_amt
    ) AS predicted_months_active,
    COUNT(customerid)
FROM
    ecommerce_sales_prediction
WHERE
    predicted_months_active BETWEEN 5 AND 6
GROUP BY
    1
ORDER BY
    1 ASC
LIMIT
    10)
UNION
(SELECT
      NULL AS predicted_months_active,
    COUNT (customerid)
FROM
    ecommerce_sales_prediction
WHERE
    predict_customer_activity(
        customerid,
        country,
        stockcode,
        description,
        invoicedate,
```

```
        sales_amt
    ) >=7);
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building XGBoost models

In this tutorial, you create a model with data from Amazon S3 and run prediction queries with the model using Amazon Redshift ML. The XGBoost algorithm is an optimized implementation of the gradient boosted trees algorithm. XGBoost handles more data types, relationships, and distributions than other gradient boosted trees algorithms. You can use XGBoost for regression, binary classification, multi-class classification, and ranking problems. For more information about the XGBoost algorithm, see XGBoost algorithm in the Amazon SageMaker AI Developer Guide.

The Amazon Redshift ML `CREATE MODEL` operation with the `AUTO OFF` option currently supports XGBoost as the `MODEL_TYPE`. You can provide relevant information such as the objective and hyperparameters as part of the `CREATE MODEL` command, based on your use case.

In this tutorial, you use the banknote authentication dataset, which is a binary classification problem to predict whether a given banknote is genuine or forged.

Use case examples

You can solve other binary classification problems using Amazon Redshift ML, such as predicting whether a patient is healthy or has a disease. You could also predict whether an email is spam or not spam.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Perform predictions with the model

Prerequisites

To complete this tutorial, you must complete the Administrative setup for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to run the following queries.

The following query creates two tables, loads the data from Amazon S3, and splits the data into a training set and a testing set. You will use the training set to train your model and create the prediction function. Then, you will test the prediction function on the testing set.

```
--create training set table
CREATE TABLE banknoteauthentication_train(
    variance FLOAT,
    skewness FLOAT,
    curtosis FLOAT,
    entropy FLOAT,
    class INT
);

--Load into training table
COPY banknoteauthentication_train
FROM
    's3://redshiftbucket-ml-sagemaker/banknote_authentication/train_data/' IAM_ROLE
 default REGION 'us-west-2' IGNOREHEADER 1 CSV;

--create testing set table
CREATE TABLE banknoteauthentication_test(
    variance FLOAT,
    skewness FLOAT,
    curtosis FLOAT,
    entropy FLOAT,
    class INT
```

```
);

--Load data into testing table
COPY banknoteauthentication_test
FROM
    's3://redshiftbucket-ml-sagemaker/banknote_authentication/test_data/'
    IAM_ROLE default
    REGION 'us-west-2'
    IGNOREHEADER 1
    CSV;
```

Step 2: Create the machine learning model

The following query creates the XGBoost model in Amazon Redshift ML from the training set you created in the previous step. Replace `amzn-s3-demo-bucket` with your own S3_BUCKET, which will store your input datasets and other Redshift ML artifacts.

```
CREATE MODEL model_banknoteauthentication_xgboost_binary
FROM
    banknoteauthentication_train
    TARGET class
    FUNCTION func_model_banknoteauthentication_xgboost_binary
    IAM_ROLE default
    AUTO OFF
    MODEL_TYPE xgboost
    OBJECTIVE 'binary:logistic'
    PREPROCESSORS 'none'
    HYPERPARAMETERS DEFAULT
EXCEPT(NUM_ROUND '100')
SETTINGS(S3_BUCKET 'amzn-s3-demo-bucket');
```

Show the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

Use the following query to monitor the progress of the model training.

```
SHOW MODEL model_banknoteauthentication_xgboost_binary;
```

If the model is READY, the SHOW MODEL operation also provides the `train:error` metric, as shown in the following example of the output. The `train:error` metric is a measure of accuracy of your model that measures to six decimal places. A value of 0 is most accurate and a value of 1 is least accurate.

```
+--------------------------+--------------------------------------------------+
|        Model Name        |   model_banknoteauthentication_xgboost_binary    |
+--------------------------+--------------------------------------------------+
| Schema Name              | public                                           |
| Owner                    | awsuser                                          |
| Creation Time            | Tue, 21.06.2022 19:07:35                         |
| Model State              | READY                                            |
| train:error              |                                         0.000000 |
| Estimated Cost           |                                         0.006197 |
|                          |                                                  |
| TRAINING DATA:           |                                                  |
| Query                    | SELECT *                                         |
|                          | FROM "BANKNOTEAUTHENTICATION_TRAIN"              |
| Target Column            | CLASS                                            |
|                          |                                                  |
| PARAMETERS:              |                                                  |
| Model Type               | xgboost                                          |
| Training Job Name        | redshiftml-20220621190735686935-xgboost          |
| Function Name            | func_model_banknoteauthentication_xgboost_binary |
| Function Parameters      | variance skewness curtosis entropy               |
| Function Parameter Types | float8 float8 float8 float8                      |
| IAM Role                 | default-aws-iam-role                             |
| S3 Bucket                | amzn-s3-demo-bucket                              |
| Max Runtime              |                                             5400 |
|                          |                                                  |
| HYPERPARAMETERS:         |                                                  |
| num_round                |                                              100 |
| objective                | binary:logistic                                  |
+--------------------------+--------------------------------------------------+
```

Step 3: Perform predictions with the model

Check the accuracy of the model

The following prediction query uses the prediction function created in the previous step to check the accuracy of your model. Run this query on the testing set to make sure the model does not correspond too closely to the training set. This close correspondence is also known as overfitting, and overfitting could cause the model to make unreliable predictions.

```
WITH predict_data AS (
    SELECT
        class AS label,
        func_model_banknoteauthentication_xgboost_binary (variance, skewness, curtosis,
 entropy) AS predicted,
        CASE
            WHEN label IS NULL THEN 0
            ELSE label
        END AS actual,
        CASE
            WHEN actual = predicted THEN 1 :: INT
            ELSE 0 :: INT
        END AS correct
    FROM
        banknoteauthentication_test
),
aggr_data AS (
    SELECT
        SUM(correct) AS num_correct,
        COUNT(*) AS total
    FROM
        predict_data
)
SELECT
    (num_correct :: FLOAT / total :: FLOAT) AS accuracy
FROM
    aggr_data;
```

Predict the amount of original and counterfeit banknotes

The following prediction query returns the predicted amount of original and counterfeit banknotes in the testing set.

```
WITH predict_data AS (
    SELECT
        func_model_banknoteauthentication_xgboost_binary(variance, skewness, curtosis,
 entropy) AS predicted
    FROM
        banknoteauthentication_test
)
SELECT
    CASE
        WHEN predicted = '0' THEN 'Original banknote'
```

```
        WHEN predicted = '1' THEN 'Counterfeit banknote'
        ELSE 'NA'
    END AS banknote_authentication,
    COUNT(1) AS count
FROM
    predict_data
GROUP BY
    1;
```

Find the average observation for an original and a counterfeit banknote

The following prediction query returns the average value of each feature for banknotes that are predicted to be original and counterfeit in the testing set.

```
WITH predict_data AS (
    SELECT
        func_model_banknoteauthentication_xgboost_binary(variance, skewness, curtosis,
 entropy) AS predicted,
          variance,
          skewness,
          curtosis,
          entropy
    FROM
        banknoteauthentication_test
)
SELECT
    CASE
        WHEN predicted = '0' THEN 'Original banknote'
        WHEN predicted = '1' THEN 'Counterfeit banknote'
        ELSE 'NA'
    END AS banknote_authentication,
    TRUNC(AVG(variance), 2) AS avg_variance,
    TRUNC(AVG(skewness), 2) AS avg_skewness,
    TRUNC(AVG(curtosis), 2) AS avg_curtosis,
    TRUNC(AVG(entropy), 2) AS avg_entropy
FROM
    predict_data
GROUP BY
    1
ORDER BY
    2;
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building regression models

In this tutorial, you use Amazon Redshift ML to create a machine learning regression model and run prediction queries on the model. Regression models allow you to predict numerical outcomes, such as the price of a house, or how many people will use a city's bike rental service. You use the CREATE MODEL command in Amazon Redshift with your training data. Then, Amazon Redshift ML compiles the model, imports the trained model to Redshift, and prepares a SQL prediction function. You can use the prediction function in SQL queries in Amazon Redshift.

In this tutorial, you will use Amazon Redshift ML to build a regression model that predicts the number of people that use the city of Toronto's bike sharing service at any given hour of a day. The inputs for the model include holidays and weather conditions. You will use a regression model, because you want a numerical outcome for this problem.

You can use the CREATE MODEL command to export training data, train a model, and make the model available in Amazon Redshift as a SQL function. Use the CREATE MODEL operation to specify training data either as a table or a SELECT statement.

Use case examples

You can solve other regression problems with Amazon Redshift ML, such as predicting a customer's lifetime value. You could also use Redshift ML to predict the most profitable price and the resulting revenue of a product.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Validate the model

Prerequisites

To complete this tutorial, you must complete the Administrative setup for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to run the following queries.

1. You must create three tables to load the three public datasets into Amazon Redshift. The datasets are Toronto Bike Ridership Data, historical weather data, and historical holidays data. Run the following query in the Amazon Redshift query editor to create tables named `ridership`, `weather`, and `holiday`.

```
CREATE TABLE IF NOT EXISTS ridership (
    trip_id INT,
    trip_duration_seconds INT,
    trip_start_time timestamp,
    trip_stop_time timestamp,
    from_station_name VARCHAR(50),
    to_station_name VARCHAR(50),
    from_station_id SMALLINT,
    to_station_id SMALLINT,
    user_type VARCHAR(20)
);

CREATE TABLE IF NOT EXISTS weather (
    longitude_x DECIMAL(5, 2),
    latitude_y DECIMAL(5, 2),
    station_name VARCHAR(20),
    climate_id BIGINT,
    datetime_utc TIMESTAMP,
    weather_year SMALLINT,
    weather_month SMALLINT,
    weather_day SMALLINT,
```

```
    time_utc VARCHAR(5),
    temp_c DECIMAL(5, 2),
    temp_flag VARCHAR(1),
    dew_point_temp_c DECIMAL(5, 2),
    dew_point_temp_flag VARCHAR(1),
    rel_hum SMALLINT,
    rel_hum_flag VARCHAR(1),
    precip_amount_mm DECIMAL(5, 2),
    precip_amount_flag VARCHAR(1),
    wind_dir_10s_deg VARCHAR(10),
    wind_dir_flag VARCHAR(1),
    wind_spd_kmh VARCHAR(10),
    wind_spd_flag VARCHAR(1),
    visibility_km VARCHAR(10),
    visibility_flag VARCHAR(1),
    stn_press_kpa DECIMAL(5, 2),
    stn_press_flag VARCHAR(1),
    hmdx SMALLINT,
    hmdx_flag VARCHAR(1),
    wind_chill VARCHAR(10),
    wind_chill_flag VARCHAR(1),
    weather VARCHAR(10)
);

CREATE TABLE IF NOT EXISTS holiday (holiday_date DATE, description VARCHAR(100));
```

2. The following query loads the sample data into the tables that you created in the previous step.

```
COPY ridership
FROM
    's3://redshift-ml-bikesharing-data/bike-sharing-data/ridership/'
    IAM_ROLE default
    FORMAT CSV
    IGNOREHEADER 1
    DATEFORMAT 'auto'
    TIMEFORMAT 'auto'
    REGION 'us-west-2'
    gzip;

COPY weather
FROM
    's3://redshift-ml-bikesharing-data/bike-sharing-data/weather/'
    IAM_ROLE default
    FORMAT csv
```

```
    IGNOREHEADER 1
    DATEFORMAT 'auto'
    TIMEFORMAT 'auto'
    REGION 'us-west-2'
    gzip;

COPY holiday
FROM
    's3://redshift-ml-bikesharing-data/bike-sharing-data/holiday/'
    IAM_ROLE default
    FORMAT csv
    IGNOREHEADER 1
    DATEFORMAT 'auto'
    TIMEFORMAT 'auto'
    REGION 'us-west-2'
    gzip;
```

3. The following query performs transformations on the `ridership` and `weather` datasets to remove bias or anomalies. Removing bias and anomalies results in improved model accuracy. The query simplifies the tables by creating two new views called `ridership_view` and `weather_view`.

```
CREATE
OR REPLACE VIEW ridership_view AS
SELECT
    trip_time,
    trip_count,
    TO_CHAR(trip_time, 'hh24') :: INT trip_hour,
    TO_CHAR(trip_time, 'dd') :: INT trip_day,
    TO_CHAR(trip_time, 'mm') :: INT trip_month,
    TO_CHAR(trip_time, 'yy') :: INT trip_year,
    TO_CHAR(trip_time, 'q') :: INT trip_quarter,
    TO_CHAR(trip_time, 'w') :: INT trip_month_week,
    TO_CHAR(trip_time, 'd') :: INT trip_week_day
FROM
    (
        SELECT
            CASE
                WHEN TRUNC(r.trip_start_time) < '2017-07-01' :: DATE THEN
 CONVERT_TIMEZONE(
                    'US/Eastern',
                    DATE_TRUNC('hour', r.trip_start_time)
                )
```

```
                ELSE DATE_TRUNC('hour', r.trip_start_time)
            END trip_time,
            COUNT(1) trip_count
        FROM
            ridership r
        WHERE
            r.trip_duration_seconds BETWEEN 60
            AND 60 * 60 * 24
        GROUP BY
            1
    );

CREATE
OR REPLACE VIEW weather_view AS
SELECT
    CONVERT_TIMEZONE(
        'US/Eastern',
        DATE_TRUNC('hour', datetime_utc)
    ) daytime,
    ROUND(AVG(temp_c)) temp_c,
    ROUND(AVG(precip_amount_mm)) precip_amount_mm
FROM
    weather
GROUP BY
    1;
```

4. The following query creates a table that combines all the relevant input attributes from `ridership_view` and `weather_view` into the `trip_data` table.

```
CREATE TABLE trip_data AS
SELECT
    r.trip_time,
    r.trip_count,
    r.trip_hour,
    r.trip_day,
    r.trip_month,
    r.trip_year,
    r.trip_quarter,
    r.trip_month_week,
    r.trip_week_day,
    w.temp_c,
    w.precip_amount_mm,CASE
        WHEN h.holiday_date IS NOT NULL THEN 1
```

```
        WHEN TO_CHAR(r.trip_time, 'D') :: INT IN (1, 7) THEN 1
        ELSE 0
    END is_holiday,
    ROW_NUMBER() OVER (
        ORDER BY
            RANDOM()
    ) serial_number
FROM
    ridership_view r
    JOIN weather_view w ON (r.trip_time = w.daytime)
    LEFT OUTER JOIN holiday h ON (TRUNC(r.trip_time) = h.holiday_date);
```

View the sample data (optional)

The following query shows entries from the table. You can run this operation to make sure the table was made correctly.

```
SELECT *
FROM trip_data
LIMIT 5;
```

The following is an example of the output of the previous operation.

```
+---------------------+------------+-----------+-----------+------------+-----------
+--------------+-----------------+---------------+--------+------------------
+------------+---------------+
|      trip_time      | trip_count | trip_hour | trip_day | trip_month | trip_year
 | trip_quarter | trip_month_week | trip_week_day | temp_c | precip_amount_mm |
 is_holiday | serial_number |
+---------------------+------------+-----------+-----------+------------+-----------
+--------------+-----------------+---------------+--------+------------------
+------------+---------------+
| 2017-03-21 22:00:00 |         47 |        22 |        21 |          3 |        17 |
        1 |              3 |             3 |      1 |                0 |          0 |
            1 |
| 2018-05-04 01:00:00 |         19 |         1 |         4 |          5 |        18 |
        2 |              1 |             6 |     12 |                0 |          0 |
            3 |
| 2018-01-11 10:00:00 |         93 |        10 |        11 |          1 |        18 |
        1 |              2 |             5 |      9 |                0 |          0 |
            5 |
```

```
| 2017-10-28 04:00:00 |          20 |          4 |        28 |          10 |          17 |
        4 |                4 |              7 |     11 |                 0 |           1 |
             7 |
| 2017-12-31 21:00:00 |          11 |         21 |        31 |          12 |          17 |
        4 |                5 |              1 |    -15 |                 0 |           1 |
             9 |
+---------------------+------------+----------+---------+------------+-----------
+-------------+----------------+-------------+--------+-----------------
+------------+---------------+
```

Show the correlation between attributes (optional)

Determining correlation helps you measure the strength of association between attributes. The level of association can help you determine what affects your target output. In this tutorial, the target output is `trip_count`.

The following query creates or replaces the `sp_correlation` procedure. You use the stored procedure called `sp_correlation` to show the correlation between an attribute and other attributes in a table in Amazon Redshift.

```
CREATE OR REPLACE PROCEDURE sp_correlation(source_schema_name in varchar(255),
 source_table_name in varchar(255), target_column_name in varchar(255),
 output_temp_table_name inout varchar(255)) AS $$
DECLARE
  v_sql varchar(max);
  v_generated_sql varchar(max);
  v_source_schema_name varchar(255)=lower(source_schema_name);
  v_source_table_name varchar(255)=lower(source_table_name);
  v_target_column_name varchar(255)=lower(target_column_name);
BEGIN
  EXECUTE 'DROP TABLE IF EXISTS ' || output_temp_table_name;
  v_sql = '
SELECT
  ''CREATE temp table '|| output_temp_table_name||' AS SELECT ''|| outer_calculation||
  '' FROM (SELECT COUNT(1) number_of_items, SUM('||v_target_column_name||')
 sum_target, SUM(POW('||v_target_column_name||',2)) sum_square_target, POW(SUM('||
v_target_column_name||'),2) square_sum_target,''||
  inner_calculation||
  '' FROM (SELECT ''||
  column_name||
  '' FROM '||v_source_table_name||'))''
FROM
  (
```

```
  SELECT
    DISTINCT
    LISTAGG(outer_calculation,'','') OVER () outer_calculation
    ,LISTAGG(inner_calculation,'','') OVER () inner_calculation
    ,LISTAGG(column_name,'','') OVER () column_name
  FROM
    (
    SELECT
      CASE WHEN atttypid=16 THEN ''DECODE(''||column_name||'',true,1,0)'' ELSE
 column_name END column_name
      ,atttypid
      ,''CAST(DECODE(number_of_items * sum_square_''||rn||'' - square_sum_''||
rn||'',0,null,(number_of_items*sum_target_''||rn||'' - sum_target * sum_''||rn||
        '')/SQRT((number_of_items * sum_square_target - square_sum_target) *
 (number_of_items * sum_square_''||rn||
        '' - square_sum_''||rn||''))) AS numeric(5,2)) ''||column_name
 outer_calculation
      ,''sum(''||column_name||'') sum_''||rn||'',''||
            ''SUM(trip_count*''||column_name||'') sum_target_''||rn||'',''||
            ''SUM(POW(''||column_name||'',2)) sum_square_''||rn||'',''||
            ''POW(SUM(''||column_name||''),2) square_sum_''||rn inner_calculation
    FROM
      (
      SELECT
        row_number() OVER (order by a.attnum) rn
        ,a.attname::VARCHAR column_name
        ,a.atttypid
      FROM pg_namespace AS n
        INNER JOIN pg_class AS c ON n.oid = c.relnamespace
        INNER JOIN pg_attribute AS a ON c.oid = a.attrelid
      WHERE a.attnum > 0
        AND n.nspname = '''||v_source_schema_name||'''
        AND c.relname = '''||v_source_table_name||'''
        AND a.atttypid IN (16,20,21,23,700,701,1700)
      )
    )
)';
  EXECUTE v_sql INTO v_generated_sql;
  EXECUTE  v_generated_sql;
END;
$$ LANGUAGE plpgsql;
```

The following query shows the correlation between the target column, `trip_count`, and other numeric attributes in our dataset.

```
call sp_correlation(
    'public',
    'trip_data',
    'trip_count',
    'tmp_corr_table'
);

SELECT
    *
FROM
    tmp_corr_table;
```

The following example shows the output of the previous `sp_correlation` operation.

```
+------------+-----------+----------+------------+-----------+-------------
+-----------------+---------------+--------+-----------------+------------
+---------------+
| trip_count | trip_hour | trip_day | trip_month | trip_year | trip_quarter
 | trip_month_week | trip_week_day | temp_c | precip_amount_mm | is_holiday |
 serial_number |
+------------+-----------+----------+------------+-----------+-------------
+-----------------+---------------+--------+-----------------+------------
+---------------+
|          1 |      0.32 |     0.01 |       0.18 |      0.12 |         0.18 |
     0 |           0.02 |   0.53 |            -0.07 |      -0.13 |             0 |
+------------+-----------+----------+------------+-----------+-------------
+-----------------+---------------+--------+-----------------+------------
+---------------+
```

Step 2: Create the machine learning model

1. The following query splits your data into a training set and a validation set by designating 80% of the dataset for training and 20% for validation. The training set is the input for the ML model to identify the best possible algorithm for the model. After the model is created, you use the validation set to validate the model accuracy.

```
CREATE TABLE training_data AS
SELECT
```

```
    trip_count,
    trip_hour,
    trip_day,
    trip_month,
    trip_year,
    trip_quarter,
    trip_month_week,
    trip_week_day,
    temp_c,
    precip_amount_mm,
    is_holiday
FROM
    trip_data
WHERE
    serial_number > (
        SELECT
            COUNT(1) * 0.2
        FROM
            trip_data
    );

CREATE TABLE validation_data AS
SELECT
    trip_count,
    trip_hour,
    trip_day,
    trip_month,
    trip_year,
    trip_quarter,
    trip_month_week,
    trip_week_day,
    temp_c,
    precip_amount_mm,
    is_holiday,
    trip_time
FROM
    trip_data
WHERE
    serial_number <= (
        SELECT
            COUNT(1) * 0.2
        FROM
            trip_data
```

```
    );
```

2. The following query creates a regression model to predict the `trip_count` value for any input date and time. In the following example, replace amzn-s3-demo-bucket with your own S3 bucket.

```
CREATE MODEL predict_rental_count
FROM
    training_data TARGET trip_count FUNCTION predict_rental_count
    IAM_ROLE default
    PROBLEM_TYPE regression
    OBJECTIVE 'mse'
    SETTINGS (
        s3_bucket 'amzn-s3-demo-bucket',
        s3_garbage_collect off,
        max_runtime 5000
    );
```

Step 3: Validate the model

1. Use the following query to output aspects of the model, and find the mean square error metric in the output. Mean square error is a typical accuracy metric for regression problems.

```
show model predict_rental_count;
```

2. Run the following prediction queries against the validation data to compare the predicted trip count to the actual trip count.

```
SELECT
    trip_time,
    actual_count,
    predicted_count,
    (actual_count - predicted_count) difference
FROM
    (
        SELECT
            trip_time,
            trip_count AS actual_count,
            PREDICT_RENTAL_COUNT (
                trip_hour,
                trip_day,
```

```
                trip_month,
                trip_year,
                trip_quarter,
                trip_month_week,
                trip_week_day,
                temp_c,
                precip_amount_mm,
                is_holiday
            ) predicted_count
        FROM
            validation_data
    )
LIMIT
    5;
```

3. The following query calculates the mean square error and root mean square error based on your validation data. You use mean square error and root mean square error to measure the distance between the predicted numeric target and the actual numeric answer. A good model has a low score in both metrics. The following query returns the value of both metrics.

```
SELECT
    ROUND(
        AVG(POWER((actual_count - predicted_count), 2)),
        2
    ) mse,
    ROUND(
        SQRT(AVG(POWER((actual_count - predicted_count), 2))),
        2
    ) rmse
FROM
    (
        SELECT
            trip_time,
            trip_count AS actual_count,
            PREDICT_RENTAL_COUNT (
                trip_hour,
                trip_day,
                trip_month,
                trip_year,
                trip_quarter,
                trip_month_week,
                trip_week_day,
                temp_c,
```

```
                precip_amount_mm,
                is_holiday
            ) predicted_count
        FROM
            validation_data
    );
```

4. The following query calculates the percent error in trip count for each trip time on 2017-01-01. The query orders the trip times from the time with the lowest percent error to the time with the highest percent error.

```
SELECT
    trip_time,
    CAST(ABS(((actual_count - predicted_count) / actual_count)) * 100 AS DECIMAL
 (7,2)) AS pct_error
FROM
    (
        SELECT
            trip_time,
            trip_count AS actual_count,
            PREDICT_RENTAL_COUNT (
                trip_hour,
                trip_day,
                trip_month,
                trip_year,
                trip_quarter,
                trip_month_week,
                trip_week_day,
                temp_c,
                precip_amount_mm,
                is_holiday
            ) predicted_count
        FROM
            validation_data
    )
WHERE
   trip_time LIKE '2017-01-01 %%:%%:%%'
ORDER BY
   2 ASC;
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building regression models with linear learner

In this tutorial, you create a linear learner model with data from Amazon S3 and run prediction queries with the model using Amazon Redshift ML. The SageMaker AI linear learner algorithm solves either regression or multi-class classification problems. To learn more about regression and multi-class classification problems, see Problem types for the machine learning paradigms in the Amazon SageMaker AI Developer Guide. In this tutorial, you solve a regression problem. The linear learner algorithm trains many models in parallel, and automatically determines the most optimized model. You use the CREATE MODEL operation in Amazon Redshift, which creates your linear learner model using SageMaker AI and sends a prediction function to Amazon Redshift. For more information about the linear learner algorithm, see Linear Learner Algorithm in the Amazon SageMaker AI Developer Guide.

You can use a CREATE MODEL command to export training data, train a model, import the model, and prepare an Amazon Redshift prediction function. Use the CREATE MODEL operation to specify training data either as a table or a SELECT statement.

Linear learner models optimize either continuous objectives or discrete objectives. Continuous objectives are used for regression, while discrete variables are used for classification. Some methods provide a solution for only continuous objectives, such as the regression method. The linear learner algorithm provides an increase in speed over naive hyperparameter optimization techniques, such as the Naive Bayes technique. A naive optimization technique assumes that each input variable is independent. To use the linear learner algorithm, you must provide columns representing the dimensions of the inputs, and rows representing the observations. For more information about the linear learner algorithm, see the Linear Learner Algorithm in the Amazon SageMaker AI Developer Guide.

In this tutorial, you build a linear learner model that predicts the age of abalone. You use the CREATE MODEL command on the Abalone dataset to determine the relationship between the physical measurements of abalone. Then, you use the model to determine the age of abalone.

Use case examples

You can solve other regression problems with linear learner and Amazon Redshift ML, such as predicting the price of a house. You could also use Redshift ML to predict the number of people who will use a city's bike rental service.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Validate the model

Prerequisites

To complete this tutorial, you must complete the Administrative setup for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to run the following queries. These queries load the sample data into Redshift and divide the data into a training set and a validation set.

1. The following query creates the `abalone_dataset` table.

```
CREATE TABLE abalone_dataset (
    id INT IDENTITY(1, 1),
    Sex CHAR(1),
    Length float,
    Diameter float,
    Height float,
    Whole float,
```

```
    Shucked float,
    Viscera float,
    Shell float,
    Rings integer
);
```

2. The following query copies the sample data from the Abalone dataset in Amazon S3 to the `abalone_dataset` table you created previously in Amazon Redshift.

```
COPY abalone_dataset
FROM
    's3://redshift-ml-multiclass/abalone.csv' REGION 'us-east-1' IAM_ROLE default CSV
 IGNOREHEADER 1 NULL AS 'NULL';
```

3. By manually splitting the data, you will be able to verify the accuracy of the model by allocating an additional prediction set. The following query splits the data into two sets. The `abalone_training` table is for training and the `abalone_validation` table is for validation.

```
CREATE TABLE abalone_training as
SELECT
    *
FROM
    abalone_dataset
WHERE
    mod(id, 10) < 8;

CREATE TABLE abalone_validation as
SELECT
    *
FROM
    abalone_dataset
WHERE
    mod(id, 10) >= 8;
```

Step 2: Create the machine learning model

In this step, you use the CREATE MODEL statement to create your machine learning model with the linear learner algorithm.

The following query creates the linear learner model with the CREATE MODEL operation using your S3 bucket. Replace amzn-s3-demo-bucket with your own S3 bucket.

```
CREATE MODEL model_abalone_ring_prediction
FROM
    (
        SELECT
            Sex,
            Length,
            Diameter,
            Height,
            Whole,
            Shucked,
            Viscera,
            Shell,
            Rings AS target_label
        FROM
            abalone_training
    ) TARGET target_label FUNCTION f_abalone_ring_prediction IAM_ROLE default
 MODEL_TYPE LINEAR_LEARNER PROBLEM_TYPE REGRESSION OBJECTIVE 'MSE' SETTINGS (
        S3_BUCKET 'amzn-s3-demo-bucket',
        MAX_RUNTIME 15000
    );
```

Show the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

Use the following query to monitor the progress of the model training.

```
SHOW MODEL model_abalone_ring_prediction;
```

When the model is ready, the output of the previous operation should look similar to the following example. Note that the output provides the `validation:mse` metric, which is the mean square error. You will use the mean square error to validate the accuracy of the model in the next step.

```
+--------------------------
+-------------------------------------------------------------------------------------------------------
+
|         Model Name        |
 model_abalone_ring_prediction                                    |
+--------------------------
+-------------------------------------------------------------------------------------------------------
+
```

```
| Schema Name              | public
                                         |
| Owner                    | awsuser
                                         |
| Creation Time            | Thu, 30.06.2022 18:00:10
                                         |
| Model State              | READY
                                         |
| validation:mse           |
                               4.168633 |
| Estimated Cost           |
                               4.291608 |
|                          |
                                         |
| TRAINING DATA:           |
                                         |
| Query                    | SELECT SEX , LENGTH , DIAMETER , HEIGHT , WHOLE ,
 SHUCKED , VISCERA , SHELL, RINGS AS TARGET_LABEL |
|                          | FROM ABALONE_TRAINING
                                         |
| Target Column            | TARGET_LABEL
                                         |
|                          |
                                         |
| PARAMETERS:              |
                                         |
| Model Type               | linear_learner
                                         |
| Problem Type             | Regression
                                         |
| Objective                | MSE
                                         |
| AutoML Job Name          | redshiftml-20220630180010947843
                                         |
| Function Name            | f_abalone_ring_prediction
                                         |
| Function Parameters      | sex length diameter height whole shucked viscera shell
                                         |
| Function Parameter Types | bpchar float8 float8 float8 float8 float8 float8 float8
                                         |
| IAM Role                 | default-aws-iam-role
                                         |
| S3 Bucket                | amzn-s3-demo-bucket
                                         |
```

```
| Max Runtime               |
                                   15000 |
+--------------------------
+-----------------------------------------------------------------------------------------------------
+
```

Step 3: Validate the model

1. The following prediction query validates the accuracy of the model on the `abalone_validation` dataset by calculating mean square error and root mean square error.

```
SELECT
    ROUND(AVG(POWER((tgt_label - predicted), 2)), 2) mse,
    ROUND(SQRT(AVG(POWER((tgt_label - predicted), 2))), 2) rmse
FROM
    (
        SELECT
            Sex,
            Length,
            Diameter,
            Height,
            Whole,
            Shucked,
            Viscera,
            Shell,
            Rings AS tgt_label,
            f_abalone_ring_prediction(
                Sex,
                Length,
                Diameter,
                Height,
                Whole,
                Shucked,
                Viscera,
                Shell
            ) AS predicted,
            CASE
                WHEN tgt_label = predicted then 1
                ELSE 0
            END AS match,
            CASE
                WHEN tgt_label <> predicted then 1
                ELSE 0
```

```
            END AS nonmatch
        FROM
            abalone_validation
    ) t1;
```

The output of the previous query should look like the following example. The value of the mean square error metric should be similar to the `validation:mse` metric shown by the SHOW MODEL operation's output.

```
+-----+--------------------+
| mse |        rmse        |
+-----+--------------------+
| 5.1 | 2.2600000000000002 |
+-----+--------------------+
```

2. Use the following query to run the EXPLAIN_MODEL operation on your prediction function. The operation will return a model explainability report. For more information about the EXPLAIN_MODEL operation, see the [EXPLAIN_MODEL function](#) in the Amazon Redshift Database Developer Guide.

```
SELECT
    EXPLAIN_MODEL ('model_abalone_ring_prediction');
```

The following information is an example of the model explainability report produced by the previous EXPLAIN_MODEL operation. The values for each of the inputs are Shapley values. The Shapley values represent the effect each input has on the prediction of your model, with higher-valued inputs having more impact on the prediction. In this example, the higher-valued inputs have more impact on predicting the age of abalone.

```
{
    "explanations": {
        "kernel_shap": {
            "label0": {
                "expected_value" :10.290688514709473,
                "global_shap_values": {
                    "diameter" :0.6856910187882492,
                    "height" :0.4415323937124035,
                    "length" :0.21507476107609084,
                    "sex" :0.448611774505744,
                    "shell" :1.70426496893776,
```

```
                    "shucked" :2.1181392924386994,
                    "viscera" :0.342220754059912,
                    "whole" :0.6711906974084011
                }
            }
        }
    },
    "version" :"1.0"
};
```

3. Use the following query to calculate the percentage of correct predictions that the model makes about abalone that are not yet mature. Abalone that are immature have 10 rings or less, and a correct prediction is accurate to within one ring of the actual number of rings.

```
SELECT
    TRUNC(
        SUM(
            CASE
                WHEN ROUND(
                    f_abalone_ring_prediction(
                        Sex,
                        Length,
                        Diameter,
                        Height,
                        Whole,
                        Shucked,
                        Viscera,
                        Shell
                    ),
                    0
                ) BETWEEN Rings - 1
                AND Rings + 1 THEN 1
                ELSE 0
            END
        ) / CAST(COUNT(SHELL) AS FLOAT),
        4
    ) AS prediction_pct
FROM
    abalone_validation
WHERE
    Rings <= 10;
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Tutorial: Building multi-class classification models with linear learner

In this tutorial, you create a linear learner model with data from Amazon S3, and then run prediction queries with the model using Amazon Redshift ML. The SageMaker AI linear learner algorithm solves either regression or classification problems. To learn more about regression and multi-class classification problems, see Problem types for the machine learning paradigms in the Amazon SageMaker AI Developer Guide. In this tutorial, you solve a multi-class classification problem. The linear learner algorithm trains many models in parallel, and automatically determines the most optimized model. You use the CREATE MODEL operation in Amazon Redshift, which creates your linear learner model using SageMaker AI and sends the prediction function to Amazon Redshift. For more information about the linear learner algorithm, see the Linear Learner Algorithm in the Amazon SageMaker AI Developer Guide.

You can use a CREATE MODEL command to export training data, train a model, import the model, and prepare an Amazon Redshift prediction function. Use the CREATE MODEL operation to specify training data either as a table or a SELECT statement.

Linear learner models optimize either continuous objectives or discrete objectives. Continuous objectives are used for regression, while discrete variables are used for classification. Some methods provide a solution for only continuous objectives, such as a regression method. The linear learner algorithm provides an increase in speed over naive hyperparameter optimization techniques, such as the Naive Bayes technique. A naive optimization technique assumes that each input variable is independent. The linear learner algorithm trains many models in parallel and selects the most optimized model. A similar algorithm is XGBoost, which combines estimates from a set of simpler and weaker models to make predictions. To learn more about XGBoost, see XGBoost algorithm in the Amazon SageMaker AI Developer Guide.

To use the linear learner algorithm, you must provide columns representing the dimensions of the inputs, and rows representing the observations. For more information about the linear learner algorithm, see the Linear Learner Algorithm in the Amazon SageMaker AI Developer Guide.

In this tutorial, you build a linear learner model that predicts the types of cover for a given area. You use the CREATE MODEL command on the Covertype dataset from the UCI Machine Learning Repository. Then, you use the prediction function created by the command to determine the types of cover in a wilderness area. A forest cover type is usually a type of tree. The inputs that Redshift ML will use to create the model include soil type, distance to roadways, and wilderness area designation. For more information about the dataset, see the Covertype Dataset from the UCI Machine Learning Repository.

Use case examples

You can solve other multi-class classification problems with linear learner with Amazon Redshift ML, such as predicting the species of a plant from an image. You could also predict the quantity of a product that a customer will purchase.

Tasks

- Prerequisites
- Step 1: Load the data from Amazon S3 to Amazon Redshift
- Step 2: Create the machine learning model
- Step 3: Validate the model

Prerequisites

To complete this tutorial, you must complete the Administrative setup for Amazon Redshift ML.

Step 1: Load the data from Amazon S3 to Amazon Redshift

Use the Amazon Redshift query editor v2 to run the following queries. These queries load the sample data into Redshift and divide the data into a training set and a validation set.

1. The following query creates the `covertype_data` table.

```
CREATE TABLE public.covertype_data (
    elevation bigint ENCODE az64,
    aspect bigint ENCODE az64,
    slope bigint ENCODE az64,
    horizontal_distance_to_hydrology bigint ENCODE az64,
    vertical_distance_to_hydrology bigint ENCODE az64,
    horizontal_distance_to_roadways bigint ENCODE az64,
    hillshade_9am bigint ENCODE az64,
    hillshade_noon bigint ENCODE az64,
    hillshade_3pm bigint ENCODE az64,
    horizontal_distance_to_fire_points bigint ENCODE az64,
    wilderness_area1 bigint ENCODE az64,
    wilderness_area2 bigint ENCODE az64,
    wilderness_area3 bigint ENCODE az64,
    wilderness_area4 bigint ENCODE az64,
    soil_type1 bigint ENCODE az64,
    soil_type2 bigint ENCODE az64,
    soil_type3 bigint ENCODE az64,
    soil_type4 bigint ENCODE az64,
    soil_type5 bigint ENCODE az64,
    soil_type6 bigint ENCODE az64,
    soil_type7 bigint ENCODE az64,
    soil_type8 bigint ENCODE az64,
    soil_type9 bigint ENCODE az64,
    soil_type10 bigint ENCODE az64,
    soil_type11 bigint ENCODE az64,
    soil_type12 bigint ENCODE az64,
    soil_type13 bigint ENCODE az64,
    soil_type14 bigint ENCODE az64,
    soil_type15 bigint ENCODE az64,
    soil_type16 bigint ENCODE az64,
    soil_type17 bigint ENCODE az64,
    soil_type18 bigint ENCODE az64,
    soil_type19 bigint ENCODE az64,
    soil_type20 bigint ENCODE az64,
    soil_type21 bigint ENCODE az64,
    soil_type22 bigint ENCODE az64,
    soil_type23 bigint ENCODE az64,
    soil_type24 bigint ENCODE az64,
    soil_type25 bigint ENCODE az64,
    soil_type26 bigint ENCODE az64,
    soil_type27 bigint ENCODE az64,
    soil_type28 bigint ENCODE az64,
```

```
    soil_type29 bigint ENCODE az64,
    soil_type30 bigint ENCODE az64,
    soil_type31 bigint ENCODE az64,
    soil_type32 bigint ENCODE az64,
    soil_type33 bigint ENCODE az64,
    soil_type34 bigint ENCODE az64,
    soil_type35 bigint ENCODE az64,
    soil_type36 bigint ENCODE az64,
    soil_type37 bigint ENCODE az64,
    soil_type38 bigint ENCODE az64,
    soil_type39 bigint ENCODE az64,
    soil_type40 bigint ENCODE az64,
    cover_type bigint ENCODE az64
) DISTSTYLE AUTO;
```

2. The following query copies the sample data from the [Covertype dataset](#) in Amazon S3 to the `covertype_data` table you created previously in Amazon Redshift.

```
COPY public.covertype_data
FROM
    's3://redshift-ml-multiclass/covtype.data.gz' IAM_ROLE DEFAULT gzip DELIMITER ','
 REGION 'us-east-1';
```

3. By manually splitting the data, you will be able to verify the accuracy of the model by allocating an additional testing set. The following query splits the data into three sets. The `covertype_training` table is for training, the `covertype_validation` table is for validation, and the `covertype_test` table is for testing your model. You will use the training set to train your model and the validation set to validate the model's development. Then, you use the testing set to test the performance of the model and see if the model is overfitting or underfitting the dataset.

```
CREATE TABLE public.covertype_data_prep AS
SELECT
    a.*,
    CAST (random() * 100 AS int) AS data_group_id
FROM
    public.covertype_data a;

--training dataset
 CREATE TABLE public.covertype_training as
SELECT
    *
```

```
FROM
    public.covertype_data_prep
WHERE
    data_group_id < 80;

--validation dataset
 CREATE TABLE public.covertype_validation AS
SELECT
    *
FROM
    public.covertype_data_prep
WHERE
    data_group_id BETWEEN 80
    AND 89;

--test dataset
 CREATE TABLE public.covertype_test AS
SELECT
    *
FROM
    public.covertype_data_prep
WHERE
    data_group_id > 89;
```

Step 2: Create the machine learning model

In this step, you use the CREATE MODEL statement to create your machine learning model with the linear learner algorithm.

The following query creates the linear learner model with the CREATE MODEL operation using your S3 bucket. Replace amzn-s3-demo-bucket with your own S3 bucket.

```
CREATE MODEL forest_cover_type_model
FROM
    (
        SELECT
            Elevation,
            Aspect,
            Slope,
            Horizontal_distance_to_hydrology,
            Vertical_distance_to_hydrology,
            Horizontal_distance_to_roadways,
```

```
            HIllshade_9am,
            Hillshade_noon,
            Hillshade_3pm,
            Horizontal_Distance_To_Fire_Points,
            Wilderness_Area1,
            Wilderness_Area2,
            Wilderness_Area3,
            Wilderness_Area4,
            soil_type1,
            Soil_Type2,
            Soil_Type3,
            Soil_Type4,
            Soil_Type5,
            Soil_Type6,
            Soil_Type7,
            Soil_Type8,
            Soil_Type9,
            Soil_Type10,
            Soil_Type11,
            Soil_Type12,
            Soil_Type13,
            Soil_Type14,
            Soil_Type15,
            Soil_Type16,
            Soil_Type17,
            Soil_Type18,
            Soil_Type19,
            Soil_Type20,
            Soil_Type21,
            Soil_Type22,
            Soil_Type23,
            Soil_Type24,
            Soil_Type25,
            Soil_Type26,
            Soil_Type27,
            Soil_Type28,
            Soil_Type29,
            Soil_Type30,
            Soil_Type31,
            Soil_Type32,
            Soil_Type33,
            Soil_Type34,
            Soil_Type36,
            Soil_Type37,
```

```
            Soil_Type38,
            Soil_Type39,
            Soil_Type40,
            Cover_type
        from
            public.covertype_training
    ) TARGET cover_type FUNCTION predict_cover_type IAM_ROLE default MODEL_TYPE
 LINEAR_LEARNER PROBLEM_TYPE MULTICLASS_CLASSIFICATION OBJECTIVE 'Accuracy' SETTINGS (
        S3_BUCKET 'amzn-s3-demo-bucket',
        S3_GARBAGE_COLLECT OFF,
        MAX_RUNTIME 15000
    );
```

Show the status of model training (optional)

You can use the SHOW MODEL command to know when your model is ready.

Use the following query to monitor the progress of the model training.

```
SHOW MODEL forest_cover_type_model;
```

When the model is ready, the output of the previous operation should look similar to the following example. Note that the output provides the `validation:multiclass_accuracy` metric, which you can view on the righthand side of the following example. Multi-class accuracy measures the percentage of data points that are classified correctly by the model. You will use multi-class accuracy to validate the accuracy of the model in the next step.

```
+--------------------------------
+-----------------------------------------------------------------------------------------------------
+
|              Key               |



 Value




                                                          |
```

```
+--------------------------------
+------------------------------------------------------------------------------------------------------
+
| Model Name                      | forest_cover_type_model
                                                  |
| Schema Name                     | public
                                                  |
| Owner                           | awsuser
                                                  |
| Creation Time                   | Tue, 12.07.2022 20:24:32
                                                  |
```

```
| Model State                  | READY
                                                                  |
| validation:multiclass_accuracy |
                                                       0.724952 |
| Estimated Cost               |
                                                       5.341750 |
|                              |
                                                                  |
| TRAINING DATA:               |
```

```
                                                          |
| Query                            | SELECT ELEVATION, ASPECT, SLOPE,
 HORIZONTAL_DISTANCE_TO_HYDROLOGY, VERTICAL_DISTANCE_TO_HYDROLOGY,
 HORIZONTAL_DISTANCE_TO_ROADWAYS, HILLSHADE_9AM, HILLSHADE_NOON, HILLSHADE_3PM ,
 HORIZONTAL_DISTANCE_TO_FIRE_POINTS, WILDERNESS_AREA1, WILDERNESS_AREA2,
 WILDERNESS_AREA3, WILDERNESS_AREA4, SOIL_TYPE1, SOIL_TYPE2, SOIL_TYPE3, SOIL_TYPE4,
 SOIL_TYPE5, SOIL_TYPE6, SOIL_TYPE7, SOIL_TYPE8, SOIL_TYPE9, SOIL_TYPE10 , SOIL_TYPE11,
 SOIL_TYPE12 , SOIL_TYPE13 , SOIL_TYPE14, SOIL_TYPE15, SOIL_TYPE16, SOIL_TYPE17,
 SOIL_TYPE18, SOIL_TYPE19, SOIL_TYPE20, SOIL_TYPE21, SOIL_TYPE22, SOIL_TYPE23,
 SOIL_TYPE24, SOIL_TYPE25, SOIL_TYPE26, SOIL_TYPE27, SOIL_TYPE28, SOIL_TYPE29,
 SOIL_TYPE30, SOIL_TYPE31, SOIL_TYPE32, SOIL_TYPE33, SOIL_TYPE34, SOIL_TYPE36,
 SOIL_TYPE37, SOIL_TYPE38, SOIL_TYPE39, SOIL_TYPE40, COVER_TYPE |
|                                  | FROM PUBLIC.COVERTYPE_TRAINING

                                                          |
| Target Column                    | COVER_TYPE

                                                          |
|                                  |
```

```
                                          |
| PARAMETERS:                     |

                                          |
| Model Type                      | linear_learner

                                          |
| Problem Type                    | MulticlassClassification

                                          |
| Objective                       | Accuracy

                                          |
```

```
| AutoML Job Name              | redshiftml-20220712202432187659

                                                                |
| Function Name                | predict_cover_type

                                                                |
| Function Parameters          | elevation aspect slope
horizontal_distance_to_hydrology vertical_distance_to_hydrology
horizontal_distance_to_roadways hillshade_9am hillshade_noon hillshade_3pm
horizontal_distance_to_fire_points wilderness_area1 wilderness_area2 wilderness_area3
wilderness_area4 soil_type1 soil_type2 soil_type3 soil_type4 soil_type5 soil_type6
soil_type7 soil_type8 soil_type9 soil_type10 soil_type11 soil_type12 soil_type13
soil_type14 soil_type15 soil_type16 soil_type17 soil_type18 soil_type19 soil_type20
soil_type21 soil_type22 soil_type23 soil_type24 soil_type25 soil_type26 soil_type27
soil_type28 soil_type29 soil_type30 soil_type31 soil_type32 soil_type33 soil_type34
soil_type36 soil_type37 soil_type38 soil_type39 soil_type40
                                                              |
| Function Parameter Types     | int8 int8 int8 int8 int8 int8 int8 int8 int8 int8
int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8
int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8 int8
int8 int8 int8 int8 int8 int8 int8 int8 int8

                                                                       |
| IAM Role                     | default-aws-iam-role
```

```
                                                      |
| S3 Bucket                       | amzn-s3-demo-bucket

                                                      |
| Max Runtime                     |

                                                15000 |
+--------------------------------
+----------------------------------------------------------------------------------------------
+
```

Step 3: Validate the model

1. The following prediction query validates the accuracy of the model on the `covertype_validation` dataset by calculating multi-class accuracy. Multi-class accuracy is the percentage of the model's predictions that are correct.

```
SELECT
    CAST(sum(t1.match) AS decimal(7, 2)) AS predicted_matches,
    CAST(sum(t1.nonmatch) AS decimal(7, 2)) AS predicted_non_matches,
    CAST(sum(t1.match + t1.nonmatch) AS decimal(7, 2)) AS total_predictions,
    predicted_matches / total_predictions AS pct_accuracy
FROM
```

```
    (
        SELECT
            Elevation,
            Aspect,
            Slope,
            Horizontal_distance_to_hydrology,
            Vertical_distance_to_hydrology,
            Horizontal_distance_to_roadways,
            HIllshade_9am,
            Hillshade_noon,
            Hillshade_3pm,
            Horizontal_Distance_To_Fire_Points,
            Wilderness_Area1,
            Wilderness_Area2,
            Wilderness_Area3,
            Wilderness_Area4,
            soil_type1,
            Soil_Type2,
            Soil_Type3,
            Soil_Type4,
            Soil_Type5,
            Soil_Type6,
            Soil_Type7,
            Soil_Type8,
            Soil_Type9,
            Soil_Type10,
            Soil_Type11,
            Soil_Type12,
            Soil_Type13,
            Soil_Type14,
            Soil_Type15,
            Soil_Type16,
            Soil_Type17,
            Soil_Type18,
            Soil_Type19,
            Soil_Type20,
            Soil_Type21,
            Soil_Type22,
            Soil_Type23,
            Soil_Type24,
            Soil_Type25,
            Soil_Type26,
            Soil_Type27,
            Soil_Type28,
```

```
            Soil_Type29,
            Soil_Type30,
            Soil_Type31,
            Soil_Type32,
            Soil_Type33,
            Soil_Type34,
            Soil_Type36,
            Soil_Type37,
            Soil_Type38,
            Soil_Type39,
            Soil_Type40,
            Cover_type AS actual_cover_type,
            predict_cover_type(
                Elevation,
                Aspect,
                Slope,
                Horizontal_distance_to_hydrology,
                Vertical_distance_to_hydrology,
                Horizontal_distance_to_roadways,
                HIllshade_9am,
                Hillshade_noon,
                Hillshade_3pm,
                Horizontal_Distance_To_Fire_Points,
                Wilderness_Area1,
                Wilderness_Area2,
                Wilderness_Area3,
                Wilderness_Area4,
                soil_type1,
                Soil_Type2,
                Soil_Type3,
                Soil_Type4,
                Soil_Type5,
                Soil_Type6,
                Soil_Type7,
                Soil_Type8,
                Soil_Type9,
                Soil_Type10,
                Soil_Type11,
                Soil_Type12,
                Soil_Type13,
                Soil_Type14,
                Soil_Type15,
                Soil_Type16,
                Soil_Type17,
```

```
                Soil_Type18,
                Soil_Type19,
                Soil_Type20,
                Soil_Type21,
                Soil_Type22,
                Soil_Type23,
                Soil_Type24,
                Soil_Type25,
                Soil_Type26,
                Soil_Type27,
                Soil_Type28,
                Soil_Type29,
                Soil_Type30,
                Soil_Type31,
                Soil_Type32,
                Soil_Type33,
                Soil_Type34,
                Soil_Type36,
                Soil_Type37,
                Soil_Type38,
                Soil_Type39,
                Soil_Type40
            ) AS predicted_cover_type,
            CASE
                WHEN actual_cover_type = predicted_cover_type THEN 1
                ELSE 0
            END AS match,
            CASE
                WHEN actual_cover_type <> predicted_cover_type THEN 1
                ELSE 0
            END AS nonmatch
        FROM
            public.covertype_validation
    ) t1;
```

The output of the previous query should look like the following example. The value of the multi-class accuracy metric should be similar to the `validation:multiclass_accuracy` metric shown by the SHOW MODEL operation's output.

```
+-------------------+-----------------------+-------------------+--------------+
| predicted_matches | predicted_non_matches | total_predictions | pct_accuracy |
+-------------------+-----------------------+-------------------+--------------+
|             41211 |                 16324 |             57535 |   0.71627704 |
```

```
+------------------+----------------------+------------------+-------------+
```

2. The following query predicts the most common cover type for `wilderness_area2`. This dataset includes four wilderness areas and seven cover types. A wilderness area can have multiple cover types.

```
SELECT t1. predicted_cover_type, COUNT(*)
FROM
(
SELECT
   Elevation,
   Aspect,
   Slope,
   Horizontal_distance_to_hydrology,
   Vertical_distance_to_hydrology,
   Horizontal_distance_to_roadways,
   HIllshade_9am,
   Hillshade_noon,
   Hillshade_3pm ,
   Horizontal_Distance_To_Fire_Points,
   Wilderness_Area1,
   Wilderness_Area2,
   Wilderness_Area3,
   Wilderness_Area4,
   soil_type1,
   Soil_Type2,
   Soil_Type3,
   Soil_Type4,
   Soil_Type5,
   Soil_Type6,
   Soil_Type7,
   Soil_Type8,
   Soil_Type9,
   Soil_Type10 ,
   Soil_Type11,
   Soil_Type12 ,
   Soil_Type13 ,
   Soil_Type14,
   Soil_Type15,
   Soil_Type16,
   Soil_Type17,
   Soil_Type18,
   Soil_Type19,
```

```
    Soil_Type20,
    Soil_Type21,
    Soil_Type22,
    Soil_Type23,
    Soil_Type24,
    Soil_Type25,
    Soil_Type26,
    Soil_Type27,
    Soil_Type28,
    Soil_Type29,
    Soil_Type30,
    Soil_Type31,
    Soil_Type32,
    Soil_Type33,
    Soil_Type34,
    Soil_Type36,
    Soil_Type37,
    Soil_Type38,
    Soil_Type39,
    Soil_Type40,
    predict_cover_type( Elevation,
    Aspect,
    Slope,
    Horizontal_distance_to_hydrology,
    Vertical_distance_to_hydrology,
    Horizontal_distance_to_roadways,
    HIllshade_9am,
    Hillshade_noon,
    Hillshade_3pm ,
    Horizontal_Distance_To_Fire_Points,
    Wilderness_Area1,
    Wilderness_Area2,
    Wilderness_Area3,
    Wilderness_Area4,
    soil_type1,
    Soil_Type2,
    Soil_Type3,
    Soil_Type4,
    Soil_Type5,
    Soil_Type6,
    Soil_Type7,
    Soil_Type8,
    Soil_Type9,
    Soil_Type10,
```

```
    Soil_Type11,
    Soil_Type12,
    Soil_Type13,
    Soil_Type14,
    Soil_Type15,
    Soil_Type16,
    Soil_Type17,
    Soil_Type18,
    Soil_Type19,
    Soil_Type20,
    Soil_Type21,
    Soil_Type22,
    Soil_Type23,
    Soil_Type24,
    Soil_Type25,
    Soil_Type26,
    Soil_Type27,
    Soil_Type28,
    Soil_Type29,
    Soil_Type30,
    Soil_Type31,
    Soil_Type32,
    Soil_Type33,
    Soil_Type34,
    Soil_Type36,
    Soil_Type37,
    Soil_Type38,
    Soil_Type39,
    Soil_Type40) AS predicted_cover_type

FROM public.covertype_test
WHERE wilderness_area2 = 1)
t1
GROUP BY 1;
```

The output of the previous operation should look similar to the following example. This output means that the model predicted that the majority of cover is cover type 1, and there is some cover of cover types 2 and 7.

```
+----------------------+-------+
| predicted_cover_type | count |
+----------------------+-------+
|                    2 |   564 |
```

```
|                    7 |    97 |
|                    1 |  2309 |
+----------------------+-------+
```

3. The following query shows the most common cover type in a single wilderness area. The query displays the amount of that cover type and the cover type's wilderness area.

```
SELECT t1. predicted_cover_type, COUNT(*), wilderness_area
FROM
(
SELECT
   Elevation,
   Aspect,
   Slope,
   Horizontal_distance_to_hydrology,
   Vertical_distance_to_hydrology,
   Horizontal_distance_to_roadways,
   HIllshade_9am,
   Hillshade_noon,
   Hillshade_3pm ,
   Horizontal_Distance_To_Fire_Points,
   Wilderness_Area1,
   Wilderness_Area2,
   Wilderness_Area3,
   Wilderness_Area4,
   soil_type1,
   Soil_Type2,
   Soil_Type3,
   Soil_Type4,
   Soil_Type5,
   Soil_Type6,
   Soil_Type7,
   Soil_Type8,
   Soil_Type9,
   Soil_Type10 ,
   Soil_Type11,
   Soil_Type12 ,
   Soil_Type13 ,
   Soil_Type14,
   Soil_Type15,
   Soil_Type16,
   Soil_Type17,
   Soil_Type18,
```

```
    Soil_Type19,
    Soil_Type20,
    Soil_Type21,
    Soil_Type22,
    Soil_Type23,
    Soil_Type24,
    Soil_Type25,
    Soil_Type26,
    Soil_Type27,
    Soil_Type28,
    Soil_Type29,
    Soil_Type30,
    Soil_Type31,
    Soil_Type32,
    Soil_Type33,
    Soil_Type34,
    Soil_Type36,
    Soil_Type37,
    Soil_Type38,
    Soil_Type39,
    Soil_Type40,
    predict_cover_type( Elevation,
    Aspect,
    Slope,
    Horizontal_distance_to_hydrology,
    Vertical_distance_to_hydrology,
    Horizontal_distance_to_roadways,
    HIllshade_9am,
    Hillshade_noon,
    Hillshade_3pm ,
    Horizontal_Distance_To_Fire_Points,
    Wilderness_Area1,
    Wilderness_Area2,
    Wilderness_Area3,
    Wilderness_Area4,
    soil_type1,
    Soil_Type2,
    Soil_Type3,
    Soil_Type4,
    Soil_Type5,
    Soil_Type6,
    Soil_Type7,
    Soil_Type8,
    Soil_Type9,
```

```
    Soil_Type10,
    Soil_Type11,
    Soil_Type12,
    Soil_Type13,
    Soil_Type14,
    Soil_Type15,
    Soil_Type16,
    Soil_Type17,
    Soil_Type18,
    Soil_Type19,
    Soil_Type20,
    Soil_Type21,
    Soil_Type22,
    Soil_Type23,
    Soil_Type24,
    Soil_Type25,
    Soil_Type26,
    Soil_Type27,
    Soil_Type28,
    Soil_Type29,
    Soil_Type30,
    Soil_Type31,
    Soil_Type32,
    Soil_Type33,
    Soil_Type34,
    Soil_Type36,
    Soil_Type37,
    Soil_Type38,
    Soil_Type39,
    Soil_Type40) AS predicted_cover_type,
    CASE WHEN Wilderness_Area1 = 1 THEN 1
         WHEN Wilderness_Area2 = 1 THEN 2
         WHEN Wilderness_Area3 = 1 THEN 3
         WHEN Wilderness_Area4 = 1 THEN 4
         ELSE 0
    END AS wilderness_area

FROM public.covertype_test)
t1
GROUP BY 1, 3
ORDER BY 2 DESC
LIMIT 1;
```

The output of the previous operation should look similar to the following example.

```
+---------------------+-------+-----------------+
| predicted_cover_type | count | wilderness_area |
+---------------------+-------+-----------------+
|                    2 | 15738 |               1 |
+---------------------+-------+-----------------+
```

Related topics

For more information about Amazon Redshift ML, see the following documentation:

- Costs for using Amazon Redshift ML
- CREATE MODEL operation
- EXPLAIN_MODEL function

For more information about machine learning, see the following documentation:

- Machine learning overview
- Machine learning for novices and experts
- What Is Fairness and Model Explainability for Machine Learning Predictions?

Amazon Redshift ML integration with Amazon Bedrock

This section describes how to use Amazon Redshift ML integration with Amazon Bedrock. With this feature, you can invoke an Amazon Bedrock model using SQL, and you can use your data from a Amazon Redshift data warehouse to build generative AI applications such as text generation, sentiment analysis, or translation.

Topics

Creating or updating an IAM role for Amazon Redshift ML integration with Amazon Bedrock

This section demonstrates how to create an IAM role to use with Amazon Redshift ML integration with Amazon Bedrock.

Add the following policy to the IAM role you use with Amazon Redshift ML integration with Amazon Bedrock:

- `AmazonBedrockFullAccess`

To allow Amazon Redshift to assume a role to interact with other services, add the following trust policy to the IAM role:

JSON

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Principal": {
            "Service": [
               "redshift.amazonaws.com"
            ]
         },
         "Action": "sts:AssumeRole"
      }
   ]
}
```

If the cluster or namespace is in a VPC, follow the instructions in Cluster and configure setup for Amazon Redshift ML administration.

If you need a more restrictive policy, you can create one that includes only the Amazon Bedrock permissions specified in the following pages:

- Cluster and configure setup for Amazon Redshift ML administration
- Permissions required to use Amazon Redshift machine learning (ML)

For information about creating an IAM role, see IAM Role Creation in the *AWS Identity and Access Management User Guide*.

Creating an external model for Amazon Redshift ML integration with Amazon Bedrock

This section shows how to create an external model to use as an interface for Amazon Bedrock within your Amazon Redshift data warehouse.

To invoke an Amazon Bedrock model from Amazon Redshift, you must first run the `CREATE EXTERNAL MODEL` command. This command creates an external model object in the database, and an associated user function that you use to generate text content with Amazon Bedrock.

The following code example shows a basic `CREATE EXTERNAL MODEL` command:

```
CREATE EXTERNAL MODEL llm_claude
FUNCTION llm_claude_func
IAM_ROLE '<IAM role arn>'
MODEL_TYPE BEDROCK
SETTINGS (
   MODEL_ID 'anthropic.claude-v2:1',
   PROMPT 'Summarize the following text:');
```

The `CREATE EXTERNAL MODEL` command has a unified and consistent interface with Amazon Bedrock for all Foundation Models (FM) that support messages. This is the default option when using the `CREATE EXTERNAL MODEL` command or when explicitly specifying the request type to be `UNIFIED`. For more information, see the Converse API documentation in the *Amazon Bedrock API documentation*.

If an FM doesn't support messages, then you must set the `request_type` setting to `RAW`. When you set `request_type` to `RAW`, you must construct the request sent to Amazon Bedrock when using the inference function based on the selected FM.

The `PROMPT` parameter for the `CREATE EXTERNAL MODEL` command is a static prompt. If you need a dynamic prompt for your application, you must specify it when using the inference function. For more details, see Prompt engineering for Amazon Redshift ML integration with Amazon Bedrock following.

For more information about the `CREATE EXTERNAL MODEL` statement and its parameters and settings, see CREATE EXTERNAL MODEL.

Using an external model for Amazon Redshift ML integration with Amazon Bedrock

This section shows how to invoke an external model to generate text in response to provided prompts. To invoke an external model, use the inference function that you create with `CREATE EXTERNAL MODEL`.

Topics

Inference with `UNIFIED` request type models

The inference function for models with request type `UNIFIED` has the following three parameters that are passed to the function in order:

- **Input text** (required): This parameter specifies the input text that Amazon Redshift passes to Amazon Bedrock.
- **Inference configuration** and **Additional model request fields** (optional): Amazon Redshift passes these parameters to the corresponding parameters for the Converse model API.

The following code example shows how to use a `UNIFIED` type inference function:

```
SELECT llm_claude_func(input_text, object('temperature', 0.7, 'maxtokens', 500))
   FROM some_data;
```

Inference with `RAW` request type models

The inference function for models with request type `RAW` has only one parameter of data type `SUPER`. The syntax of this parameter depends on the Amazon Bedrock model used.

The following code example shows how to use a `RAW` type inference function:

```
SELECT llm_titan_func(
    object(
```

```
        "inputText", "Summarize the following text: " | input_text,
        "textGenerationConfig", object("temperature", 0.5, "maxTokenCount", 500)
    )
)
FROM some_data;
```

Inference functions as leader-only functions

Inference functions for Amazon Bedrock models can run as leader node-only functions when the query that uses them doesn't reference any tables. This can be helpful if you want to quickly ask an LLM a question.

The following code example shows how to use a leader-only inference function:

```
SELECT general_titan_llm_func('Summarize the benefits of LLM on data analytics in 100
 words');
```

Inference function usage notes

Note the following when using inference functions with Amazon Redshift ML integration with Amazon Bedrock:

- The names of the parameters for all Amazon Bedrock models are case sensitive. If your parameters do not match the ones required by the model, Amazon Bedrock might quietly ignore them.
- The throughput of inference queries is limited by the runtime quotas of the different models offered by Amazon Bedrock in different regions. For more information, see Quotas for Amazon Bedrock in the *Amazon Bedrock User Guide*.
- If you need guaranteed and consistent throughput, consider getting provisioned throughput for the model you need from Amazon Bedrock. For more information, see Increase model invocation capacity with Provisioned Throughput in Amazon Bedrock in the *Amazon Bedrock User Guide*.
- Inference queries with large amounts of data might get throttling exceptions. This is because of the limited runtime quotas for Amazon Bedrock. Amazon Redshift retries requests multiple times, but queries can still get throttled because throughput for non-provisioned models might be variable.
- If you encounter throttling exceptions coming from Amazon Bedrock such as `Too many requests, please wait before trying again.` even with small amounts of data, check the quotas under **Service Quotas** in your Amazon Bedrock account. Check that the applied

account-level quota is at least the same as the AWS default quota value for the **InvokeModel** requests for the model you are using.

Prompt engineering for Amazon Redshift ML integration with Amazon Bedrock

This section shows how to use static prompts with an external model.

To use static prefix and suffix prompts for your external model, provide them using the `PROMPT` and `SUFFIX` parameters of the `CREATE EXTERNAL MODEL` statement. These prompts are added to every query using the external model.

The following example shows how to add prefix and suffix prompts to an external model:

```
CREATE EXTERNAL MODEL llm_claude
FUNCTION llm_claude_func
IAM_ROLE '<IAM role arn>'
MODEL_TYPE BEDROCK
SETTINGS (
   MODEL_ID 'anthropic.claude-v2:1',
   PROMPT 'Summarize the following text:',
   SUFFIX 'Respond in an analytic tone');
```

To use dynamic prompts, you can provide them when using the inference function by concatenating them in the function input. The following example shows how to use dynamic prompts with an inference function:

```
SELECT llm_claude_func('Summarize the following review:' | input_text | 'The review
 should have formal tone.')
FROM some_data
```

Query performance tuning

Amazon Redshift uses queries based on structured query language (SQL) to interact with data and objects in the system. Data manipulation language (DML) is the subset of SQL that you use to view, add, change, and delete data. Data definition language (DDL) is the subset of SQL that you use to add, change, and delete database objects such as tables and views.

Once your system is set up, you typically work with DML the most, especially the SELECT command for retrieving and viewing data. To write effective data retrieval queries in Amazon Redshift, become familiar with SELECT and apply the tips outlined in Amazon Redshift best practices for designing tables to maximize query efficiency.

To understand how Amazon Redshift processes queries, use the Query processing and Query analysis and improvement sections. Then you can apply this information in combination with diagnostic tools to identify and remove issues in query performance.

To identify and address some of the most common and most serious issues you are likely to encounter with Amazon Redshift queries, use the Query troubleshooting section.

Topics

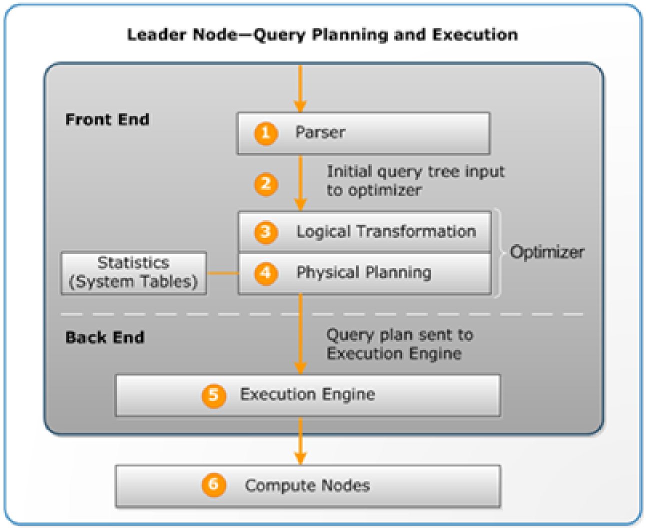
Query processing

Amazon Redshift routes a submitted SQL query through the parser and optimizer to develop a query plan. The execution engine then translates the query plan into code and sends that code to the compute nodes for execution.

Topics

Query planning and execution workflow

The following illustration provides a high-level view of the query planning and execution workflow.



The query planning and execution workflow follow these steps:

1. The leader node receives the query and parses the SQL.
2. The parser produces an initial query tree that is a logical representation of the original query. Amazon Redshift then inputs this query tree into the query optimizer.
3. The optimizer evaluates and if necessary rewrites the query to maximize its efficiency. This process sometimes results in creating multiple related queries to replace a single one.
4. The optimizer generates a query plan (or several, if the previous step resulted in multiple queries) for the execution with the best performance. The query plan specifies execution options such as join types, join order, aggregation options, and data distribution requirements.

   You can use the EXPLAIN command to view the query plan. The query plan is a fundamental tool for analyzing and tuning complex queries. For more information, see Creating and interpreting a query plan.
5. The execution engine translates the query plan into *steps*, *segments*, and *streams*:

   Step

   Each step is an individual operation needed during query execution. Steps can be combined to allow compute nodes to perform a query, join, or other database operation.

Segment

A combination of several steps that can be done by a single process, also the smallest compilation unit executable by a compute node slice. A *slice* is the unit of parallel processing in Amazon Redshift. The segments in a stream run in parallel.

Stream

A collection of segments to be parceled out over the available compute node slices.

The execution engine generates compiled code based on steps, segments, and streams. Compiled code runs faster than interpreted code and uses less compute capacity. This compiled code is then broadcast to the compute nodes.

> **Note**
>
> When benchmarking your queries, you should always compare the times for the second execution of a query, because the first execution time includes the overhead of compiling the code. For more information, see [Factors affecting query performance](#).

6. The compute node slices run the query segments in parallel. As part of this process, Amazon Redshift takes advantage of optimized network communication, memory, and disk management to pass intermediate results from one query plan step to the next. This also helps to speed query execution.

Steps 5 and 6 happen once for each stream. The engine creates the executable segments for one stream and sends them to the compute nodes. When the segments of that stream are complete, the engine generates the segments for the next stream. In this way, the engine can analyze what happened in the prior stream (for example, whether operations were disk-based) to influence the generation of segments in the next stream.

When the compute nodes are done, they return the query results to the leader node for final processing. The leader node merges the data into a single result set and addresses any needed sorting or aggregation. The leader node then returns the results to the client.

Note

The compute nodes might return some data to the leader node during query execution if necessary. For example, if you have a subquery with a LIMIT clause, the limit is applied on the leader node before data is redistributed across the cluster for further processing.

Creating and interpreting a query plan

You can use the query plan to get information on the individual operations required to run a query. Before you work with a query plan, we recommend that you first understand how Amazon Redshift handles processing queries and creating query plans. For more information, see Query planning and execution workflow.

To create a query plan, run the EXPLAIN command followed by the actual query text. The query plan gives you the following information:

- What operations the execution engine performs, reading the results from bottom to top.
- What type of step each operation performs.
- Which tables and columns are used in each operation.
- How much data is processed in each operation, in terms of number of rows and data width in bytes.
- The relative cost of the operation. *Cost* is a measure that compares the relative execution times of the steps within a plan. Cost does not provide any precise information about actual execution times or memory consumption, nor does it provide a meaningful comparison between execution plans. It does give you an indication of which operations in a query are consuming the most resources.

The EXPLAIN command doesn't actually run the query. It only shows the plan that Amazon Redshift runs if the query is run under current operating conditions. If you change the schema or data for a table and run ANALYZE again to update the statistical metadata, the query plan might be different.

The query plan output by EXPLAIN is a simplified, high-level view of query execution. It doesn't illustrate the details of parallel query processing. To see detailed information, run the query itself, and then get query summary information from the SVL_QUERY_SUMMARY or

SVL_QUERY_REPORT view. For more information about using these views, see Analyzing the query summary.

The following example shows the EXPLAIN output for a simple GROUP BY query on the EVENT table:

```
explain select eventname, count(*) from event group by eventname;

                            QUERY PLAN
-------------------------------------------------------------------
XN HashAggregate  (cost=131.97..133.41 rows=576 width=17)
  ->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=17)
```

EXPLAIN returns the following metrics for each operation:

Cost

A relative value that is useful for comparing operations within a plan. Cost consists of two decimal values separated by two periods, for example `cost=131.97..133.41`. The first value, in this case 131.97, provides the relative cost of returning the first row for this operation. The second value, in this case 133.41, provides the relative cost of completing the operation. The costs in the query plan are cumulative as you read up the plan, so the HashAggregate cost in this example (131.97..133.41) includes the cost of the Seq Scan below it (0.00..87.98).

Rows

The estimated number of rows to return. In this example, the scan is expected to return 8798 rows. The HashAggregate operator on its own is expected to return 576 rows (after duplicate event names are discarded from the result set).

> **Note**
>
> The rows estimate is based on the available statistics generated by the ANALYZE command. If ANALYZE has not been run recently, the estimate is less reliable.

Width

The estimated width of the average row, in bytes. In this example, the average row is expected to be 17 bytes wide.

EXPLAIN operators

This section briefly describes the operators that you see most often in the EXPLAIN output. For a complete list of operators, see EXPLAIN in the SQL Commands section.

Sequential scan operator

The sequential scan operator (Seq Scan) indicates a table scan. Seq Scan scans each column in the table sequentially from beginning to end and evaluates query constraints (in the WHERE clause) for every row.

Join operators

Amazon Redshift selects join operators based on the physical design of the tables being joined, the location of the data required for the join, and the specific requirements of the query itself.

- **Nested Loop**

  The least optimal join, a nested loop is used mainly for cross-joins (Cartesian products) and some inequality joins.
- **Hash Join and Hash**

  Typically faster than a nested loop join, a hash join and hash are used for inner joins and left and right outer joins. These operators are used when joining tables where the join columns are not both distribution keys *and* sort keys. The hash operator creates the hash table for the inner table in the join; the hash join operator reads the outer table, hashes the joining column, and finds matches in the inner hash table.
- **Merge Join**

  Typically the fastest join, a merge join is used for inner joins and outer joins. The merge join is not used for full joins. This operator is used when joining tables where the join columns are both distribution keys *and* sort keys, and when less than 20 percent of the joining tables are unsorted. It reads two sorted tables in order and finds the matching rows. To view the percent of unsorted rows, query the SVV_TABLE_INFO system table.
- **Spatial Join**

  Typically a fast join based on proximity of spatial data, used for `GEOMETRY` and `GEOGRAPHY` data types.

Aggregate operators

The query plan uses the following operators in queries that involve aggregate functions and GROUP BY operations.

- **Aggregate**

  Operator for scalar aggregate functions such as AVG and SUM.
- **HashAggregate**

  Operator for unsorted grouped aggregate functions.
- **GroupAggregate**

  Operator for sorted grouped aggregate functions.

Sort operators

The query plan uses the following operators when queries have to sort or merge result sets.

- **Sort**

  Evaluates the ORDER BY clause and other sort operations, such as sorts required by UNION queries and joins, SELECT DISTINCT queries, and window functions.
- **Merge**

  Produces final sorted results according to intermediate sorted results that derive from parallel operations.

UNION, INTERSECT, and EXCEPT operators

The query plan uses the following operators for queries that involve set operations with UNION, INTERSECT, and EXCEPT.

- **Subquery**

  Used to run UNION queries.
- **Hash Intersect Distinct**

  Used to run INTERSECT queries.
- **SetOp Except**

Used to run EXCEPT (or MINUS) queries.

Other operators

The following operators also appear frequently in EXPLAIN output for routine queries.

- **Unique**

  Removes duplicates for SELECT DISTINCT queries and UNION queries.
- **Limit**

  Processes the LIMIT clause.
- **Window**

  Runs window functions.
- **Result**

  Runs scalar functions that do not involve any table access.
- **Subplan**

  Used for certain subqueries.
- **Network**

  Sends intermediate results to the leader node for further processing.
- **Materialize**

  Saves rows for input to nested loop joins and some merge joins.

Joins in EXPLAIN

The query optimizer uses different join types to retrieve table data, depending on the structure of the query and the underlying tables. The EXPLAIN output references the join type, the tables used, and the way the table data is distributed across the cluster to describe how the query is processed.

Join type examples

The following examples show the different join types that the query optimizer can use. The join type used in the query plan depends on the physical design of the tables involved.

Example: Hash join two tables

The following query joins EVENT and CATEGORY on the CATID column. CATID is the distribution and sort key for CATEGORY but not for EVENT. A hash join is performed with EVENT as the outer table and CATEGORY as the inner table. Because CATEGORY is the smaller table, the planner broadcasts a copy of it to the compute nodes during query processing by using DS_BCAST_INNER. The join cost in this example accounts for most of the cumulative cost of the plan.

```
explain select * from category, event where category.catid=event.catid;

                               QUERY PLAN
-------------------------------------------------------------------------
 XN Hash Join DS_BCAST_INNER  (cost=0.14..6600286.07 rows=8798 width=84)
   Hash Cond: ("outer".catid = "inner".catid)
   ->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=35)
   ->  XN Hash  (cost=0.11..0.11 rows=11 width=49)
         ->  XN Seq Scan on category  (cost=0.00..0.11 rows=11 width=49)
```

Note

Aligned indents for operators in the EXPLAIN output sometimes indicate that those operations do not depend on each other and can start in parallel. In the preceding example, although the scan on the EVENT table and the hash operation are aligned, the EVENT scan must wait until the hash operation has fully completed.

Example: Merge join two tables

The following query also uses SELECT *, but it joins SALES and LISTING on the LISTID column, where LISTID has been set as both the distribution and sort key for both tables. A merge join is chosen, and no redistribution of data is required for the join (DS_DIST_NONE).

```
explain select * from sales, listing where sales.listid = listing.listid;
QUERY PLAN
-----------------------------------------------------------------------------
XN Merge Join DS_DIST_NONE  (cost=0.00..6285.93 rows=172456 width=97)
  Merge Cond: ("outer".listid = "inner".listid)
  ->  XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497 width=44)
  ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=53)
```

The following example demonstrates the different types of joins within the same query. As in the previous example, SALES and LISTING are merge joined, but the third table, EVENT, must be hash joined with the results of the merge join. Again, the hash join incurs a broadcast cost.

```
explain select * from sales, listing, event
where sales.listid = listing.listid and sales.eventid = event.eventid;
                                  QUERY PLAN
----------------------------------------------------------------------------
XN Hash Join DS_BCAST_INNER  (cost=109.98..3871130276.17 rows=172456 width=132)
  Hash Cond: ("outer".eventid = "inner".eventid)
  ->  XN Merge Join DS_DIST_NONE  (cost=0.00..6285.93 rows=172456 width=97)
        Merge Cond: ("outer".listid = "inner".listid)
        ->  XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497 width=44)
        ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=53)
  ->  XN Hash  (cost=87.98..87.98 rows=8798 width=35)
        ->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=35)
```

Example: Join, aggregate, and sort

The following query runs a hash join of the SALES and EVENT tables, followed by aggregation and sort operations to account for the grouped SUM function and the ORDER BY clause. The initial sort operator runs in parallel on the compute nodes. Then the Network operator sends the results to the leader node, where the Merge operator produces the final sorted results.

```
explain select eventname, sum(pricepaid) from sales, event
where sales.eventid=event.eventid group by eventname
order by 2 desc;
                                           QUERY PLAN
---------------------------------------------------------------------------------
 XN Merge  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
  Merge Key: sum(sales.pricepaid)
  ->  XN Network  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
        Send to leader
        ->  XN Sort  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
              Sort Key: sum(sales.pricepaid)
              ->  XN HashAggregate  (cost=2815366577.07..2815366578.51 rows=576
 width=27)
                    ->  XN Hash Join DS_BCAST_INNER  (cost=109.98..2815365714.80
 rows=172456 width=27)
                          Hash Cond: ("outer".eventid = "inner".eventid)
                          ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456
 width=14)
```

```
                           ->  XN Hash  (cost=87.98..87.98 rows=8798 width=21)
                                 ->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 
width=21)
```

Data redistribution

The EXPLAIN output for joins also specifies a method for how data is moved around a cluster to facilitate the join. This data movement can be either a broadcast or a redistribution. In a broadcast, the data values from one side of a join are copied from each compute node to every other compute node, so that every compute node ends up with a complete copy of the data. In a redistribution, participating data values are sent from their current slice to a new slice (possibly on a different node). Data is typically redistributed to match the distribution key of the other table participating in the join if that distribution key is one of the joining columns. If neither of the tables has distribution keys on one of the joining columns, either both tables are distributed or the inner table is broadcast to every node.

The EXPLAIN output also references inner and outer tables. The inner table is scanned first, and appears nearer the bottom of the query plan. The inner table is the table that is probed for matches. It is usually held in memory, is usually the source table for hashing, and if possible, is the smaller table of the two being joined. The outer table is the source of rows to match against the inner table. It is usually read from disk. The query optimizer chooses the inner and outer table based on database statistics from the latest run of the ANALYZE command. The order of tables in the FROM clause of a query doesn't determine which table is inner and which is outer.

Use the following attributes in query plans to identify how data is moved to facilitate a query:

- **DS_BCAST_INNER**

  A copy of the entire inner table is broadcast to all compute nodes.
- **DS_DIST_ALL_NONE**

  No redistribution is required, because the inner table has already been distributed to every node using DISTSTYLE ALL.
- **DS_DIST_NONE**

  No tables are redistributed. Collocated joins are possible because corresponding slices are joined without moving data between nodes.
- **DS_DIST_INNER**

The inner table is redistributed.

- **DS_DIST_OUTER**

  The outer table is redistributed.

- **DS_DIST_ALL_INNER**

  The entire inner table is redistributed to a single slice because the outer table uses DISTSTYLE ALL.

- **DS_DIST_BOTH**

  Both tables are redistributed.

Reviewing query plan steps

You can see the steps in a query plan by running the EXPLAIN command. The following example shows an SQL query and explains the output. Reading the query plan from the bottom up, you can see each of the logical operations used to perform the query. For more information, see [Creating and interpreting a query plan](#).

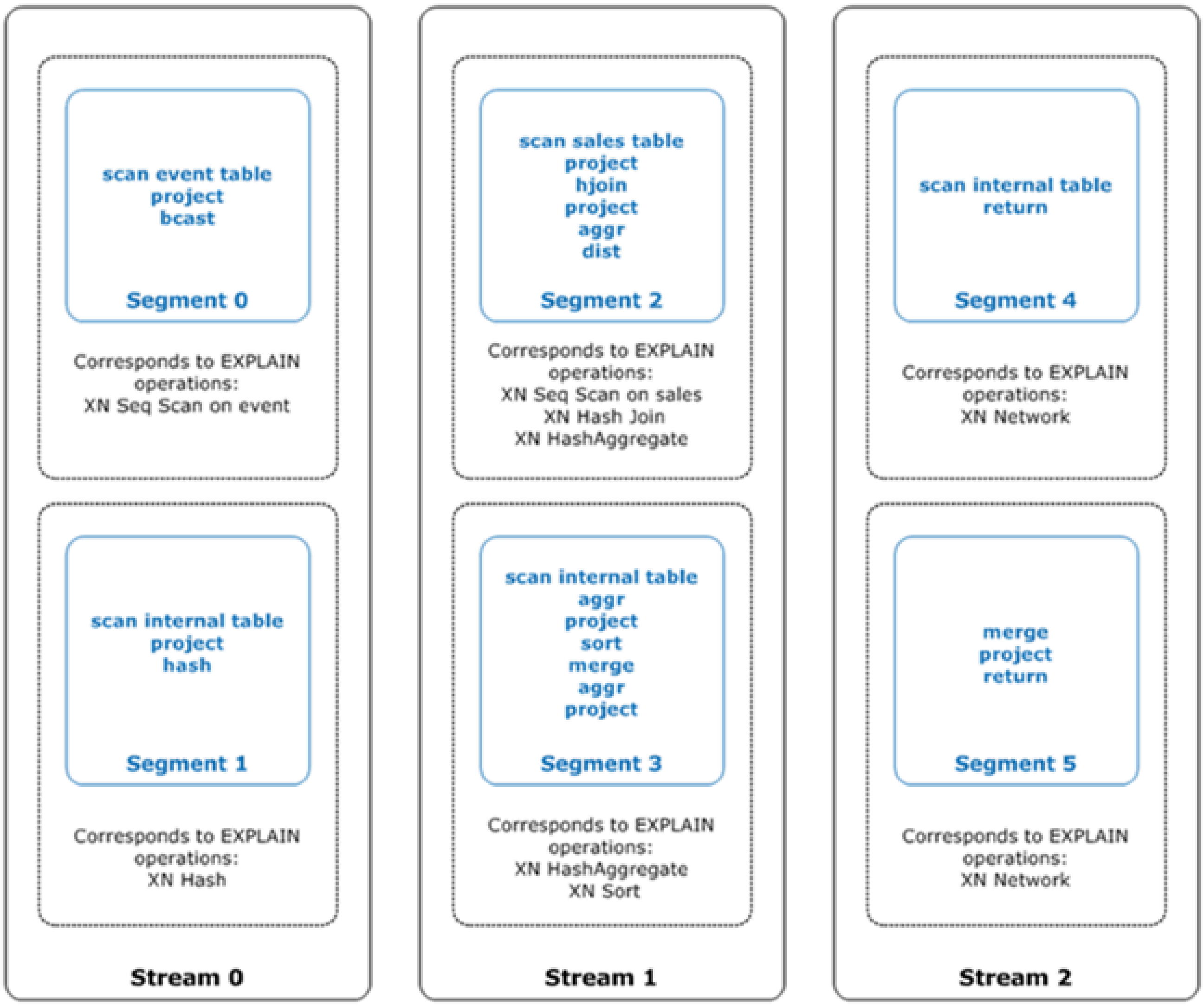
```
explain
select eventname, sum(pricepaid) from sales, event
where sales.eventid = event.eventid
group by eventname
order by 2 desc;
```

```
XN Merge  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
  Merge Key: sum(sales.pricepaid)
  ->  XN Network  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
        Send to leader
        ->  XN Sort  (cost=1002815366604.92..1002815366606.36 rows=576 width=27)
              Sort Key: sum(sales.pricepaid)
              ->  XN HashAggregate  (cost=2815366577.07..2815366578.51 rows=576
 width=27)
                    ->  XN Hash Join DS_BCAST_INNER  (cost=109.98..2815365714.80
 rows=172456 width=27)
                          Hash Cond: ("outer".eventid = "inner".eventid)
                          ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456
 width=14)
                          ->  XN Hash  (cost=87.98..87.98 rows=8798 width=21)
```

```
                                       ->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 
width=21)
```

As part of generating a query plan, the query optimizer breaks down the plan into streams, segments, and steps. The query optimizer breaks the plan down to prepare for distributing the data and query workload to the compute nodes. For more information about streams, segments, and steps, see Query planning and execution workflow.

The following illustration shows the preceding query and associated query plan. It displays how the query operations involved map to steps that Amazon Redshift uses to generate compiled code for the compute node slices. Each query plan operation maps to multiple steps within the segments, and sometimes to multiple segments within the streams.



In this illustration, the query optimizer runs the query plan as follows:

1. In `Stream 0`, the query runs `Segment 0` with a sequential scan operation to scan the `events` table. The query continues to `Segment 1` with a hash operation to create the hash table for the inner table in the join.
2. In `Stream 1`, the query runs `Segment 2` with a sequential scan operation to scan the `sales` table. It continues with `Segment 2` with a hash join to join tables where the join columns are not both distribution keys and sort keys. It again continues with `Segment 2` with a hash aggregate to aggregate results. Then the query runs `Segment 3` with a hash aggregate operation to perform unsorted grouped aggregate functions, and a sort operation to evaluate the ORDER BY clause and other sort operations.
3. In `Stream 2`, the query runs a network operation in `Segment 4` and `Segment 5` to send intermediate results to the leader node for further processing.

The last segment of a query returns the data. If the return set is aggregated or sorted, the compute nodes each send their piece of the intermediate result to the leader node. The leader node then merges the data so the final result can be sent back to the requesting client.

For more information about EXPLAIN operators, see EXPLAIN.

Factors affecting query performance

A number of factors can affect query performance. The following aspects of your data, cluster, and database operations all play a part in how quickly your queries process.

- **Number of nodes, processors, or slices –** A compute node is partitioned into slices. More nodes means more processors and more slices, which enables your queries to process faster by running portions of the query concurrently across the slices. However, more nodes also means greater expense, so you need to find the balance of cost and performance that is appropriate for your system. For more information on Amazon Redshift cluster architecture, see Data warehouse system architecture.
- **Node types –** An Amazon Redshift cluster can use one of several node types. Each node type offers different sizes and limits to help you scale your cluster appropriately. The node size determines the storage capacity, memory, CPU, and price of each node in the cluster. For more information about node types, see Overview of Amazon Redshift clusters in the *Amazon Redshift Management Guide*.
- **Data distribution –** Amazon Redshift stores table data on the compute nodes according to a table's distribution style. When you run a query, the query optimizer redistributes the data to the

compute nodes as needed to perform any joins and aggregations. Choosing the right distribution style for a table helps minimize the impact of the redistribution step by locating the data where it needs to be before the joins are performed. For more information, see Data distribution for query optimization.

- **Data sort order** – Amazon Redshift stores table data on disk in sorted order according to a table's sort keys. The query optimizer and the query processor use the information about where the data is located to reduce the number of blocks that need to be scanned and thereby improve query speed. For more information, see Sort keys.
- **Dataset size** – A higher volume of data in the cluster can slow query performance for queries, because more rows need to be scanned and redistributed. You can mitigate this effect by regular vacuuming and archiving of data, and by using a predicate to restrict the query dataset.
- **Concurrent operations** – Running multiple operations at once can affect query performance. Each operation takes one or more slots in an available query queue and uses the memory associated with those slots. If other operations are running, enough query queue slots might not be available. In this case, the query has to wait for slots to open before it can begin processing. For more information about creating and configuring query queues, see Workload management.
- **Query structure** – How your query is written affects its performance. As much as possible, write queries to process and return as little data as meets your needs. For more information, see Amazon Redshift best practices for designing queries.
- **Code compilation** – Amazon Redshift generates and compiles code for each query execution plan.

  The compiled code runs faster because it removes the overhead of using an interpreter. You generally have some overhead cost the first time code is generated and compiled. As a result, the performance of a query the first time you run it can be misleading. The overhead cost might be especially noticeable when you run one-off queries. Run the query a second time to determine its typical performance. Amazon Redshift uses a serverless compilation service to scale query compilations beyond the compute resources of an Amazon Redshift cluster. The compiled code segments are cached locally on the cluster and in a virtually unlimited cache. This cache persists after cluster reboots. Subsequent executions of the same query run faster because they can skip the compilation phase.

  The cache is not compatible across Amazon Redshift versions, so the compilation cache is flushed and the code is recompiled when queries run after a version upgrade. If your queries have strict SLAs, we recommend you pre-run query segments that scan data from cluster tables. This lets Amazon Redshift cache the base table data, reducing the planning time for queries after a version upgrade. By using a scalable compilation service, Amazon Redshift can compile code in parallel to provide consistently fast performance. The magnitude of workload speed-up depends on the complexity and concurrency of queries.

Query analysis and improvement

Retrieving information from an Amazon Redshift data warehouse involves running complex queries on extremely large amounts of data, which can take a long time to process. To make sure that queries process as quickly as possible, there are a number of tools you can use to identify potential performance issues.

Topics

Query analysis workflow

If a query is taking longer than expected, use the following steps to identify and correct issues that might be negatively affecting the query's performance. If you aren't sure what queries in your system might benefit from performance tuning, start by running the diagnostic query in Identifying queries that are top candidates for tuning.

1. Make sure that your tables are designed according to best practices. For more information, see Amazon Redshift best practices for designing tables.
2. See if you can delete or archive any unneeded data in your tables. For example, suppose your queries always target the last 6 months' worth of data but you have the last 18 months' worth in your tables. In this case, you can delete or archive the older data to reduce the number of records that must be scanned and distributed.
3. Run the VACUUM command on the tables in the query to reclaim space and re-sort rows. Running VACUUM helps if the unsorted region is large and the query uses the sort key in a join or in the predicate.

4. Run the ANALYZE command on the tables in the query to make sure that statistics are up to date. Running ANALYZE helps if any of the tables in the query have recently changed a lot in size. If running a full ANALYZE command will take too long, run ANALYZE on a single column to reduce processing time. This approach still updates the table size statistics; table size is a significant factor in query planning.
5. Make sure that your query has been run once for each type of client (based on what type of connection protocol the client uses) so that the query is compiled and cached. This approach speeds up subsequent runs of the query. For more information, see Factors affecting query performance.
6. Check the STL_ALERT_EVENT_LOG table to identify and correct possible issues with your query. For more information, see Reviewing query alerts.
7. Run the EXPLAIN command to get the query plan and use it to optimize the query. For more information, see Analyzing the query plan.
8. Use the SVL_QUERY_SUMMARY and SVL_QUERY_REPORT views to get summary information and use it to optimize the query. For more information, see Analyzing the query summary.

Sometimes a query that should run quickly is forced to wait until another, longer-running query finishes. In that case, you might have nothing to improve in the query itself, but you can improve overall system performance by creating and using query queues for different types of queries. To get an idea of queue wait time for your queries, see Reviewing queue wait times for queries. For more information about configuring query queues, see Workload management.

Reviewing query alerts

To use the STL_ALERT_EVENT_LOG system table to identify and correct potential performance issues with your query, follow these steps:

1. Run the following to determine your query ID:

```
select query, elapsed, substring
from svl_qlog
order by query
desc limit 5;
```

   Examine the truncated query text in the `substring` field to determine which `query` value to select. If you have run the query more than once, use the `query` value from the row with the lower `elapsed` value. That is the row for the compiled version. If you have been running many queries, you can raise the value used by the LIMIT clause used to make sure that your query is included.

2. Select rows from STL_ALERT_EVENT_LOG for your query:

```
Select * from stl_alert_event_log where query = MyQueryID;
```

userid	query	slice	segment	step	pid	xid	event	solution	event_time
100	32359	4	0	0	8780	71195	Very selective query filter:ratio=rows(2)/r	Review the choice of sort key to enable...	2015-02-10 17:40:50
100	32359	5	0	0	8781	71195	Very selective query filter:ratio=rows(2)/r	Review the choice of sort key to enable...	2015-02-10 17:40:50
100	109142	4	0	0	8780	302411	Very selective query filter:ratio=rows(2)/r	Review the choice of sort key to enable...	2015-02-24 20:32:28
100	109142	5	0	0	8781	302411	Very selective query filter:ratio=rows(2)/r	Review the choice of sort key to enable...	2015-02-24 20:32:28
100	109828	4	1	0	8746	304543	Very selective query filter:ratio=rows(3)/r	Review the choice of sort key to enable...	2015-02-24 23:27:52
100	109828	5	1	0	8747	304543	Very selective query filter:ratio=rows(3)/r	Review the choice of sort key to enable...	2015-02-24 23:27:52
100	109829	4	1	0	8760	304543	Very selective query filter:ratio=rows(3)/r	Review the choice of sort key to enable...	2015-02-24 23:28:01
100	109829	5	1	0	8761	304543	Very selective query filter:ratio=rows(3)/r	Review the choice of sort key to enable...	2015-02-24 23:28:01
100	113910	4	1	0	8774	316848	Very selective query filter:ratio=rows(3)/r	Review the choice of sort key to enable...	2015-02-25 17:14:58

3. Evaluate the results for your query. Use the following table to locate potential solutions for any issues that you have identified.

> **Note**
>
> Not all queries have rows in STL_ALERT_EVENT_LOG, only those with identified issues.

Issue	Event value	Solution value	Recommended solution
Statistics for the tables in the query are missing or out of date.	Missing query planner statistics	Run the ANALYZE command	See Table statistics missing or out of date.
There is a nested loop join (the least optimal join) in the query plan.	Nested Loop Join in the query plan	Review the join predicates to avoid Cartesian products	See Nested loop.
The scan skipped a relatively large number of rows that are marked as deleted but not vacuumed, or	Scanned a large number of deleted rows	Run the VACUUM command to	See Ghost rows or uncommitted rows.

Issue	Event value	Solution value	Recommended solution
rows that have been inserted but not committed.		reclaim deleted space	
More than 1,000,000 rows were redistributed for a hash join or aggregation.	Distributed a large number of rows across the network:RowCount rows were distributed in order to process the aggregation	Review the choice of distribution key to collocate the join or aggregation	See Suboptimal data distribution.
More than 1,000,000 rows were broadcast for a hash join.	Broadcasted a large number of rows across the network	Review the choice of distribution key to collocate the join and consider using distributed tables	See Suboptimal data distribution.
A DS_DIST_ALL_INNER redistribution style was indicated in the query plan, which forces serial execution because the entire inner table was redistributed to a single node.	DS_DIST_ALL_INNER for Hash Join in the query plan	Review the choice of distribution strategy to distribute the inner, rather than outer, table	See Suboptimal data distribution.

Analyzing the query plan

Run the EXPLAIN command to get a query plan.

Before analyzing the query plan, you should be familiar with how to read it. If you are unfamiliar with reading a query plan, we recommend that you read Creating and interpreting a query plan before proceeding.

To analyze the data provided by the query plan, follow these steps:

1. Identify the steps with the highest cost. Concentrate on optimizing those when proceeding through the remaining steps.
2. Look at the join types:
   - **Nested Loop**: Such joins usually occur because a join condition was omitted. For recommended solutions, see Nested loop.
   - **Hash and Hash Join**: Hash joins are used when joining tables where the join columns are not distribution keys and also not sort keys. For recommended solutions, see Hash join.
   - **Merge Join**: No change is needed.
3. Notice which table is used for the inner join, and which for the outer join. The query engine generally chooses the smaller table for the inner join, and the larger table for the outer join. If such a choice doesn't occur, your statistics are likely out of date. For recommended solutions, see Table statistics missing or out of date.
4. See if there are any high-cost sort operations. If there are, see Unsorted or missorted rows for recommended solutions.
5. Look for the following broadcast operators where there are high-cost operations:
   - **DS_BCAST_INNER**: Indicates that the table is broadcast to all the compute nodes. This is fine for a small table, but not ideal for a larger table.
   - **DS_DIST_ALL_INNER**: Indicates that all of the workload is on a single slice.
   - **DS_DIST_BOTH**: Indicates heavy redistribution.

   For recommended solutions for these situations, see Suboptimal data distribution.

Analyzing the query summary

To get execution steps and statistics in more detail than in the query plan that EXPLAIN produces, use the SVL_QUERY_SUMMARY and SVL_QUERY_REPORT system views.

SVL_QUERY_SUMMARY provides query statistics by stream. You can use the information it provides to identify issues with expensive steps, long-running steps, and steps that write to disk.

The SVL_QUERY_REPORT system view enables you to see information similar to that for SVL_QUERY_SUMMARY, only by compute node slice rather than by stream. You can use the slice-level information for detecting uneven data distribution across the cluster (also known as data distribution skew), which forces some nodes to do more work than others and impairs query performance.

Topics

Using the SVL_QUERY_SUMMARY view

To analyze query summary information by stream using SVL_QUERY_SUMMARY, do the following:

1. Run the following query to determine your query ID:

```
select query, elapsed, substring
from svl_qlog
order by query
desc limit 5;
```

   Examine the truncated query text in the `substring` field to determine which `query` value represents your query. If you have run the query more than once, use the `query` value from the row with the lower `elapsed` value. That is the row for the compiled version. If you have been running many queries, you can raise the value used by the LIMIT clause used to make sure that your query is included.

2. Select rows from SVL_QUERY_SUMMARY for your query. Order the results by stream, segment, and step:

```
select * from svl_query_summary where query = MyQueryID order by stm, seg, step;
```

   The following is an example result.

Result 1 | Messages

userid	query	stm	seg	step	maxtime	avgtime	rows	bytes	rate_row	rate_byte	label	is_diskbased	workmem	is_rrscan	is_delayed_scan	rows_pre_filter
1	249059	0	0	0	58	27	4	192			scan tbl=246 name=Internal Worktable	f	0	f	f	0
1	249059	0	0	1	58	27	4	0			project	f	0	f	f	0
1	249059	0	0	2	58	27	4	64			save tbl=249	f	481296384	f	f	0
1	249059	1	1	0	20	20	1	48			scan tbl=250 name=Internal Worktable	f	0	f	f	0
1	249059	1	1	1	20	20	1	0			dist	f	0	f	f	0
1	249059	1	2	0	2275	1350	1	48			scan tbl=19221 name=Internal Worktable	f	0	f	f	0
1	249059	1	2	1	2275	1350	1	0			project	f	0	f	f	0
1	249059	1	2	2	2275	1350	1	16			save tbl=249	f	475004928	f	f	0
1	249059	2	3	0	1640	792	5	80			scan tbl=249 name=Internal Worktable	f	0	f	f	0
1	249059	2	3	1	1640	792	5	80			sort tbl=248	f	468713472	f	f	0
1	249059	3	4	0	26	9	5	80			scan tbl=248 name=Internal Worktable	f	0	f	f	0
1	249059	3	4	1	26	9	5	0			return	f	0	f	f	0
1	249059	3	5	0	49	49	0	0			merge	f	0	f	f	0
1	249059	3	5	1	49	49	5	0			project	f	0	f	f	0
1	249059	3	5	2	49	49	0	0			return	f	0	f	f	0

3. Map the steps to the operations in the query plan using the information in Mapping the query plan to the query summary. They should have approximately the same values for rows and bytes (rows * width from the query plan). If they don't, see Table statistics missing or out of date for recommended solutions.

4. See if the `is_diskbased` field has a value of `t` (true) for any step. Hashes, aggregates, and sorts are the operators that are likely to write data to disk if the system doesn't have enough memory allocated for query processing.

   If `is_diskbased` is true, see Insufficient memory allocated to the query for recommended solutions.

5. Review the `label` field values and see if there is an AGG-DIST-AGG sequence anywhere in the steps. Its presence indicates two-step aggregation, which is expensive. To fix this, change the GROUP BY clause to use the distribution key (the first key, if there are multiple ones).

6. Review the `maxtime` value for each segment (it is the same across all steps in the segment). Identify the segment with the highest `maxtime` value and review the steps in this segment for the following operators.

> **Note**
>
> A high `maxtime` value doesn't necessarily indicate a problem with the segment. Despite a high value, the segment might not have taken a long time to process. All segments in a stream start getting timed in unison. However, some downstream segments might not be able to run until they get data from upstream ones. This effect might make them seem to have taken a long time because their `maxtime` value includes both their waiting time and their processing time.

- **BCAST or DIST**: In these cases, the high `maxtime` value might be the result of redistributing a large number of rows. For recommended solutions, see Suboptimal data distribution.

- **HJOIN (hash join)**: If the step in question has a very high value in the `rows` field compared to the `rows` value in the final RETURN step in the query, see Hash join for recommended solutions.
- **SCAN/SORT**: Look for a SCAN, SORT, SCAN, MERGE sequence of steps just before a join step. This pattern indicates that unsorted data is being scanned, sorted, and then merged with the sorted area of the table.

  See if the rows value for the SCAN step has a very high value compared to the rows value in the final RETURN step in the query. This pattern indicates that the execution engine is scanning rows that are later discarded, which is inefficient. For recommended solutions, see Insufficiently restrictive predicate.

  If the `maxtime` value for the SCAN step is high, see Suboptimal WHERE clause for recommended solutions.

  If the `rows` value for the SORT step is not zero, see Unsorted or missorted rows for recommended solutions.

7. Review the `rows` and `bytes` values for the 5–10 steps that precede the final RETURN step to get an idea of the amount of data that is returned to the client. This process can be a bit of an art.

   For example, in the following sample query summary, the third PROJECT step provides a `rows` value, but not a `bytes` value. By looking through the preceding steps for one with the same `rows` value, you find the SCAN step that provides both rows and bytes information.

   The following is a sample result.

userid	query	stm	seg	step	maxtime	avgtime	rows	bytes	rate_row	rate_byte	label	is_diskbased	workmem
1	187435	2	5	2	14307	12797	0	0			hash tbl=256	f	46871347
1	187435	3	6	0	531	308	387	229104			scan tbl=242 name=Internal Worktable	f	
1	187435	3	6	1	531	308	387	0			project	f	
1	187435	3	6	2	531	308	387	222912			save tbl=245	f	38063308
1	187435	4	7	0	390	390	0	0			scan tbl=238 name=Internal Worktable	f	
1	187435	4	7	1	390	390	0	0			dist	f	
1	187435	4	8	0	1218	1066	0	0			scan tbl=134954 name=Internal Worktable	f	
1	187435	4	8	1	1218	1066	0	0			project	f	
1	187435	4	8	2	1218	1066	0	0			save tbl=245	f	37434163
1	187435	5	9	0	171	83	387	222912			scan tbl=245 name=Internal Worktable	f	
1	187435	5	9	1	171	83	387	60120			dist	f	
1	187435	5	10	0	3579	3383	387	222912			scan tbl=134955 name=Internal Worktable	f	
1	187435	5	10	1	3579	3383	387	0			project	f	
1	187435	5	10	2	3579	3383	0	0			hjoin tbl=256	f	
1	187435	5	10	3	3579	3383	0	0			project	f	
1	187435	5	10	4	3579	3383	0	0			sort tbl=259	f	36805017
1	187435	6	11	0	10	7	0	0			scan tbl=259 name=Internal Worktable	f	
1	187435	6	11	1	10	7	0	0			return	f	
1	187435	6	12	0	9	9	0	0			merge	f	
1	187435	6	12	1	9	9	0	0			project	f	
1	187435	6	12	2	9	9	0	0			return	f	

If you are returning an unusually large volume of data, see Very large result set for recommended solutions.

8. See if the `bytes` value is high relative to the `rows` value for any step, in comparison to other steps. This pattern can indicate that you are selecting a lot of columns. For recommended solutions, see Large SELECT list.

Using the SVL_QUERY_REPORT view

To analyze query summary information by slice using SVL_QUERY_REPORT, do the following:

1. Run the following to determine your query ID:

```
select query, elapsed, substring
from svl_qlog
order by query
desc limit 5;
```

   Examine the truncated query text in the `substring` field to determine which `query` value represents your query. If you have run the query more than once, use the `query` value from the row with the lower `elapsed` value. That is the row for the compiled version. If you have been running many queries, you can raise the value used by the LIMIT clause used to make sure that your query is included.

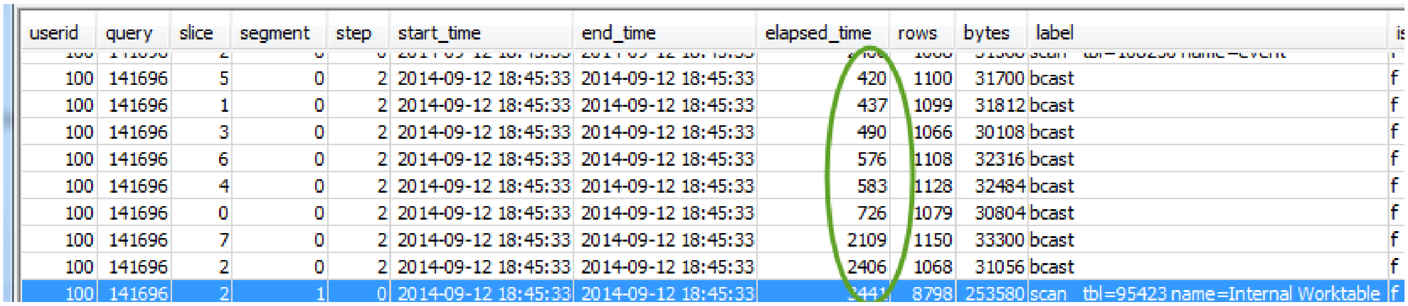
2. Select rows from SVL_QUERY_REPORT for your query. Order the results by segment, step, elapsed_time, and rows:

```
select * from svl_query_report where query = MyQueryID order by segment, step,
 elapsed_time, rows;
```

3. For each step, check to see that all slices are processing approximately the same number of rows:

userid	query	slice	segment	step	start_time	end_time	elapsed_time	rows	bytes	label	is
100	141696	5	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	420	1100	31700	bcast	f
100	141696	1	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	437	1099	31812	bcast	f
100	141696	3	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	490	1066	30108	bcast	f
100	141696	6	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	576	1108	32316	bcast	f
100	141696	4	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	583	1128	32484	bcast	f
100	141696	0	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	726	1079	30804	bcast	f
100	141696	7	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	2109	1150	33300	bcast	f
100	141696	2	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	2406	1068	31056	bcast	f
100	141696	2	1	0	2014-09-12 18:45:33	2014-09-12 18:45:33	3441	3798	253580	scan tbl=95423 name=Internal Worktable	f

Also check to see that all slices are taking approximately the same amount of time:



userid	query	slice	segment	step	start_time	end_time	elapsed_time	rows	bytes	label	is
100	141696	5	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	420	1100	31700	bcast	f
100	141696	1	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	437	1099	31812	bcast	f
100	141696	3	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	490	1066	30108	bcast	f
100	141696	6	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	576	1108	32316	bcast	f
100	141696	4	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	583	1128	32484	bcast	f
100	141696	0	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	726	1079	30804	bcast	f
100	141696	7	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	2109	1150	33300	bcast	f
100	141696	2	0	2	2014-09-12 18:45:33	2014-09-12 18:45:33	2406	1068	31056	bcast	f
100	141696	2	1	0	2014-09-12 18:45:33	2014-09-12 18:45:33	[illegible]	8798	253580	scan tbl=95423 name=Internal Worktable	f

Large discrepancies in these values can indicate data distribution skew due to a suboptimal distribution style for this particular query. For recommended solutions, see Suboptimal data distribution.

Mapping the query plan to the query summary

When analyzing the query summary, you can get further details by mapping the operations from the query plan to the steps (identified by the label field values) in the query summary. The following table maps query plan operations to query summary steps.

Query plan operation	Label field value	Description
Aggregate HashAggregate GroupAggregate	AGGR	Evaluates aggregate functions and GROUP BY conditions.
DS_BCAST_INNER	BCAST (broadcast)	Broadcasts an entire table or some set of rows (such as a filtered set of rows from a table) to all nodes.
Doesn’t appear in query plan	DELETE	Deletes rows from tables.
DS_DIST_NONE DS_DIST_ALL_NONE DS_DIST_INNER	DIST (distribute)	Distributes rows to nodes for parallel joining purposes or other parallel processing.

Query plan operation	Label field value	Description
DS_DIST_ALL_INNER DS_DIST_ALL_BOTH		
HASH	HASH	Builds hash table for use in hash joins.
Hash Join	HJOIN (hash join)	Performs a hash join of two tables or intermediate result sets.
Doesn’t appear in query plan	INSERT	Inserts rows into tables.
Limit	LIMIT	Applies a LIMIT clause to result sets.
Merge	MERGE	Merges rows derived from parallel sort or join operation s.
Merge Join	MJOIN (merge join)	Performs a merge join of two tables or intermediate result sets.
Nested Loop	NLOOP (nested loop)	Performs a nested loop join of two tables or intermediate result sets.
Doesn’t appear in query plan	PARSE	Parses strings into binary values for loading.
Project	PROJECT	Evaluates expressions.
Network	RETURN	Returns rows to the leader or the client.
Doesn’t appear in query plan	SAVE	Materializes rows for use in the next processing step.

Query plan operation	Label field value	Description
Seq Scan	SCAN	Scans tables or intermediate result sets.
Sort	SORT	Sorts rows or intermediate result sets as required by other subsequent operation s (such as joins or aggregati ons) or to satisfy an ORDER BY clause.
Unique	UNIQUE	Applies a SELECT DISTINCT clause or removes duplicate s as required by other operations.
Window	WINDOW	Computes aggregate and ranking window functions.

Query performance improvement

Following are some common issues that affect Amazon Redshift query performance, with instructions on ways to diagnose and resolve them.

Topics

- Very large result set
- Large SELECT list

Table statistics missing or out of date

If table statistics are missing or out of date, you might see the following:

- A warning message in EXPLAIN command results.
- A missing statistics alert event in STL_ALERT_EVENT_LOG. For more information, see Reviewing query alerts.

To fix this issue, run ANALYZE.

Nested loop

If a nested loop is present, you might see a nested loop alert event in STL_ALERT_EVENT_LOG. You can also identify this type of event by running the query at Identifying queries with nested loops. For more information, see Reviewing query alerts.

To fix this, review your query for cross-joins and remove them if possible. Cross-joins are joins without a join condition that result in the Cartesian product of two tables. They are typically run as nested loop joins, which are the slowest of the possible join types.

Hash join

If a hash join is present, you might see the following:

- Hash and hash join operations in the query plan. For more information, see Analyzing the query plan.
- An HJOIN step in the segment with the highest maxtime value in SVL_QUERY_SUMMARY. For more information, see Using the SVL_QUERY_SUMMARY view.

To fix this issue, you can take a couple of approaches:

- Rewrite the query to use a merge join if possible. You can do this by specifying join columns that are both distribution keys and sort keys.
- If the HJOIN step in SVL_QUERY_SUMMARY has a very high value in the rows field compared to the rows value in the final RETURN step in the query, check whether you can rewrite the query to

join on a unique column. When a query does not join on a unique column, such as a primary key, that increases the number of rows involved in the join.

Ghost rows or uncommitted rows

If ghost rows or uncommitted rows are present, you might see an alert event in STL_ALERT_EVENT_LOG that indicates excessive ghost rows. For more information, see Reviewing query alerts.

To fix this issue, you can take a couple of approaches:

- Check the **Loads** tab of your Amazon Redshift console for active load operations on any of the query tables. If you see active load operations, wait for those to complete before taking action.
- If there are no active load operations, run VACUUM on the query tables to remove deleted rows.

Unsorted or missorted rows

If unsorted or missorted rows are present, you might see a very selective filter alert event in STL_ALERT_EVENT_LOG. For more information, see Reviewing query alerts.

You can also check to see if any of the tables in your query have large unsorted areas by running the query in Identifying tables with data skew or unsorted rows.

To fix this issue, you can take a couple of approaches:

- Run VACUUM on the query tables to re-sort the rows.
- Review the sort keys on the query tables to see if any improvements can be made. Remember to weigh the performance of this query against the performance of other important queries and the system overall before making any changes. For more information, see Sort keys.

Suboptimal data distribution

If data distribution is suboptimal, you might see the following:

- A serial execution, large broadcast, or large distribution alert event appears in STL_ALERT_EVENT_LOG. For more information, see Reviewing query alerts.
- Slices are not processing approximately the same number of rows for a given step. For more information, see Using the SVL_QUERY_REPORT view.

- Slices are not taking approximately the same amount of time for a given step. For more information, see Using the SVL_QUERY_REPORT view.

If none of the preceding is true, you can also see if any of the tables in your query have data skew by running the query in Identifying tables with data skew or unsorted rows.

To fix this issue, review the distribution styles for the tables in the query and see if any improvements can be made. Remember to weigh the performance of this query against the performance of other important queries and the system overall before making any changes. For more information, see Data distribution for query optimization.

Insufficient memory allocated to the query

If insufficient memory is allocated to your query, you might see a step in SVL_QUERY_SUMMARY that has an `is_diskbased` value of true. For more information, see Using the SVL_QUERY_SUMMARY view.

To fix this issue, allocate more memory to the query by temporarily increasing the number of query slots it uses. Workload Management (WLM) reserves slots in a query queue equivalent to the concurrency level set for the queue. For example, a queue with a concurrency level of 5 has 5 slots. Memory assigned to the queue is allocated equally to each slot. Assigning several slots to one query gives that query access to the memory for all of those slots. For more information on how to temporarily increase the slots for a query, see wlm_query_slot_count.

Suboptimal WHERE clause

If your WHERE clause causes excessive table scans, you might see a SCAN step in the segment with the highest `maxtime` value in SVL_QUERY_SUMMARY. For more information, see Using the SVL_QUERY_SUMMARY view.

To fix this issue, add a WHERE clause to the query based on the primary sort column of the largest table. This approach helps minimize scanning time. For more information, see Amazon Redshift best practices for designing tables.

Insufficiently restrictive predicate

If your query has an insufficiently restrictive predicate, you might see a SCAN step in the segment with the highest `maxtime` value in SVL_QUERY_SUMMARY that has a very high `rows` value compared to the `rows` value in the final RETURN step in the query. For more information, see Using the SVL_QUERY_SUMMARY view.

To fix this issue, try adding a predicate to the query or making the existing predicate more restrictive to narrow the output.

Very large result set

If your query returns a very large result set, consider rewriting the query to use UNLOAD to write the results to Amazon S3. This approach improves the performance of the RETURN step by taking advantage of parallel processing. For more information on checking for a very large result set, see Using the SVL_QUERY_SUMMARY view.

Large SELECT list

If your query has an unusually large SELECT list, you might see a `bytes` value that is high relative to the `rows` value for any step (in comparison to other steps) in SVL_QUERY_SUMMARY. This high `bytes` value can be an indicator that you are selecting a lot of columns. For more information, see Using the SVL_QUERY_SUMMARY view.

To fix this issue, review the columns you are selecting and see if any can be removed.

Diagnostic queries for query tuning

Use the following queries to identify issues with queries or underlying tables that can affect query performance. We recommend using these queries with the query tuning processes discussed in Query analysis and improvement.

> **Note**
>
> These queries are for Amazon Redshift provisioned clusters. These queries are not for use with Redshift Serverless workgroups.

Topics

- Reviewing query alerts by table
- Identifying tables with missing statistics

Identifying queries that are top candidates for tuning

The following query identifies the top 50 most time-consuming statements that have been run in the last 7 days. You can use the results to identify queries that are taking unusually long. You can also identify queries that are run frequently (those that appear more than once in the result set). These queries are frequently good candidates for tuning to improve system performance.

This query also provides a count of the alert events associated with each query identified. These alerts provide details that you can use to improve the query's performance. For more information, see Reviewing query alerts.

```
select trim(database) as db, count(query) as n_qry,
max(substring (qrytext,1,80)) as qrytext,
min(run_minutes) as "min" ,
max(run_minutes) as "max",
avg(run_minutes) as "avg", sum(run_minutes) as total,
max(query) as max_query_id,
max(starttime)::date as last_run,
sum(alerts) as alerts, aborted
from (select userid, label, stl_query.query,
trim(database) as database,
trim(querytxt) as qrytext,
md5(trim(querytxt)) as qry_md5,
starttime, endtime,
(datediff(seconds, starttime,endtime)::numeric(12,2))/60 as run_minutes,
alrt.num_events as alerts, aborted
from stl_query
left outer join
(select query, 1 as num_events from stl_alert_event_log group by query ) as alrt
on alrt.query = stl_query.query
where userid <> 1 and starttime >=  dateadd(day, -7, current_date))
group by database, label, qry_md5, aborted
order by total desc limit 50;
```

Identifying tables with data skew or unsorted rows

The following query identifies tables that have uneven data distribution (data skew) or a high percentage of unsorted rows.

A low skew value indicates that table data is properly distributed. If a table has a skew value of 4.00 or higher, consider modifying its data distribution style. For more information, see Suboptimal data distribution.

If a table has a pct_unsorted value greater than 20 percent, consider running the VACUUM command. For more information, see Unsorted or missorted rows.

Also review the mbytes and pct_of_total values for each table. These columns identify the size of the table and what percentage of raw disk space the table consumes. The raw disk space includes space that is reserved by Amazon Redshift for internal use, so it is larger than the nominal disk capacity, which is the amount of disk space available to the user. Use this information to verify that you have free disk space equal to at least 2.5 times the size of your largest table. Having this space available enables the system to write intermediate results to disk when processing complex queries.

```
select trim(pgn.nspname) as schema,
trim(a.name) as table, id as tableid,
decode(pgc.reldiststyle,0, 'even',1,det.distkey ,8,'all') as distkey,
 dist_ratio.ratio::decimal(10,4) as skew,
det.head_sort as "sortkey",
det.n_sortkeys as "#sks", b.mbytes,
decode(b.mbytes,0,0,((b.mbytes/part.total::decimal)*100)::decimal(5,2)) as
 pct_of_total,
decode(det.max_enc,0,'n','y') as enc, a.rows,
decode( det.n_sortkeys, 0, null, a.unsorted_rows ) as unsorted_rows ,
decode( det.n_sortkeys, 0, null, decode( a.rows,0,0, (a.unsorted_rows::decimal(32)/
a.rows)*100) )::decimal(5,2) as pct_unsorted
from (select db_id, id, name, sum(rows) as rows,
sum(rows)-sum(sorted_rows) as unsorted_rows
from stv_tbl_perm a
group by db_id, id, name) as a
join pg_class as pgc on pgc.oid = a.id
join pg_namespace as pgn on pgn.oid = pgc.relnamespace
left outer join (select tbl, count(*) as mbytes
from stv_blocklist group by tbl) b on a.id=b.tbl
inner join (select attrelid,
min(case attisdistkey when 't' then attname else null end) as "distkey",
min(case attsortkeyord when 1 then attname  else null end ) as head_sort ,
max(attsortkeyord) as n_sortkeys,
max(attencodingtype) as max_enc
from pg_attribute group by 1) as det
on det.attrelid = a.id
```

```
inner join ( select tbl, max(mbytes)::decimal(32)/min(mbytes) as ratio
from (select tbl, trim(name) as name, slice, count(*) as mbytes
from svv_diskusage group by tbl, name, slice )
group by tbl, name ) as dist_ratio on a.id = dist_ratio.tbl
join ( select sum(capacity) as  total
from stv_partitions where part_begin=0 ) as part on 1=1
where mbytes is not null
order by  mbytes desc;
```

Identifying queries with nested loops

The following query identifies queries that have had alert events logged for nested loops. For information on how to fix the nested loop condition, see Nested loop.

```
select query, trim(querytxt) as SQL, starttime
from stl_query
where query in (
select distinct query
from stl_alert_event_log
where event like 'Nested Loop Join in the query plan%')
order by starttime desc;
```

Reviewing queue wait times for queries

The following query shows how long recent queries waited for an open slot in a query queue before running. If you see a trend of high wait times, you might want to modify your query queue configuration for better throughput. For more information, see Implementing manual WLM.

```
select trim(database) as DB , w.query,
substring(q.querytxt, 1, 100) as querytxt,  w.queue_start_time,
w.service_class as class, w.slot_count as slots,
w.total_queue_time/1000000 as queue_seconds,
w.total_exec_time/1000000 exec_seconds, (w.total_queue_time+w.total_Exec_time)/1000000
 as total_seconds
from stl_wlm_query w
left join stl_query q on q.query = w.query and q.userid = w.userid
where w.queue_start_Time >= dateadd(day, -7, current_Date)
and w.total_queue_Time > 0  and w.userid >1
and q.starttime >= dateadd(day, -7, current_Date)
order by w.total_queue_time desc, w.queue_start_time desc limit 35;
```

Reviewing query alerts by table

The following query identifies tables that have had alert events logged for them, and also identifies what type of alerts are most frequently raised.

If the `minutes` value for a row with an identified table is high, check that table to see if it needs routine maintenance, such as having ANALYZE or VACUUM run against it.

If the `count` value is high for a row but the `table` value is null, run a query against STL_ALERT_EVENT_LOG for the associated `event` value to investigate why that alert is getting raised so often.

```
select trim(s.perm_table_name) as table,
(sum(abs(datediff(seconds, s.starttime, s.endtime)))/60)::numeric(24,0) as minutes,
 trim(split_part(l.event,':',1)) as event,  trim(l.solution) as solution,
max(l.query) as sample_query, count(*)
from stl_alert_event_log as l
left join stl_scan as s on s.query = l.query and s.slice = l.slice
and s.segment = l.segment and s.step = l.step
where l.event_time >=  dateadd(day, -7, current_Date)
group by 1,3,4
order by 2 desc,6 desc;
```

Identifying tables with missing statistics

The following query provides a count of the queries that you are running against tables that are missing statistics. If this query returns any rows, look at the `plannode` value to determine the affected table, and then run ANALYZE on it.

```
select substring(trim(plannode),1,100) as plannode, count(*)
from stl_explain
where plannode like '%missing statistics%'
group by plannode
order by 2 desc;
```

Query troubleshooting

This section provides a quick reference for identifying and addressing some of the most common and most serious issues that you are likely to encounter with Amazon Redshift queries.

Topics

These suggestions give you a starting point for troubleshooting. You can also refer to the following resources for more detailed information.

For information about behavior changes in Amazon Redshift functionality that may affect your application, see Behavior Changes.

- Accessing Amazon Redshift clusters and databases
- Automatic table optimization
- Loading data in Amazon Redshift
- Tutorial: Loading data from Amazon S3

Connection fails

Your query connection can fail because for the following reasons. We suggest the following troubleshooting approaches.

Client cannot connect to server

If you are using SSL or server certificates, first remove this complexity while you troubleshoot the connection issue. Then add SSL or server certificates back when you have found a solution. For more information, go to Configure Security Options for Connections in the *Amazon Redshift Management Guide.*

Connection is refused

Generally, when you receive an error message indicating that there is a failure to establish a connection, it means that there is an issue with the permission to access the cluster. For more information, go to The connection is refused or fails in the *Amazon Redshift Management Guide.*

Query hangs

Your query can hang, or stop responding, for the following reasons. We suggest the following troubleshooting approaches.

Connection to the database is dropped

Reduce the size of maximum transmission unit (MTU). The MTU size determines the maximum size, in bytes, of a packet that can be transferred in one Ethernet frame over your network connection. For more information, go to The connection to the database is dropped in the *Amazon Redshift Management Guide.*

Connection to the database times out

Your client connection to the database appears to hang or time out when running long queries, such as a COPY command. In this case, you might observe that the Amazon Redshift console displays that the query has completed, but the client tool itself still appears to be running the query. The results of the query might be missing or incomplete depending on when the connection stopped. This effect happens when idle connections are terminated by an intermediate network component. For more information, go to Firewall Timeout Issue in the *Amazon Redshift Management Guide.*

Client-side out-of-memory error occurs with ODBC

If your client application uses an ODBC connection and your query creates a result set that is too large to fit in memory, you can stream the result set to your client application by using a cursor. For more information, see DECLARE and Performance considerations when using cursors.

Client-side out-of-memory error occurs with JDBC

When you attempt to retrieve large result sets over a JDBC connection, you might encounter client-side out-of-memory errors. For more information, see Setting the JDBC fetch size parameter.

There is a potential deadlock

If there is a potential deadlock, try the following:

- View the STV_LOCKS and STL_TR_CONFLICT system tables to find conflicts involving updates to more than one table.
- Use the PG_CANCEL_BACKEND function to cancel one or more conflicting queries.
- Use the PG_TERMINATE_BACKEND function to terminate a session, which forces any currently running transactions in the terminated session to release all locks and roll back the transaction.
- Schedule concurrent write operations carefully. For more information, see Managing concurrent write operations.

Query takes too long

Your query can take too long for the following reasons. We suggest the following troubleshooting approaches.

Tables are not optimized

Set the sort key, distribution style, and compression encoding of the tables to take full advantage of parallel processing. For more information, see Automatic table optimization

Query is writing to disk

Your queries might be writing to disk for at least part of the query execution. For more information, see Query performance improvement.

Query must wait for other queries to finish

You might be able to improve overall system performance by creating query queues and assigning different types of queries to the appropriate queues. For more information, see Workload management.

Queries are not optimized

Analyze the explain plan to find opportunities for rewriting queries or optimizing the database. For more information, see Creating and interpreting a query plan.

Query needs more memory to run

If a specific query needs more memory, you can increase the available memory by increasing the wlm_query_slot_count.

Database requires a VACUUM command to be run

Run the VACUUM command whenever you add, delete, or modify a large number of rows, unless you load your data in sort key order. The VACUUM command reorganizes your data to maintain the sort order and restore performance. For more information, see Vacuuming tables.

Additional resources for troubleshooting long-running queries

The following are system-view topics and other documentation sections that are helpful for query tuning:

- The STV_INFLIGHT system view shows which queries are running on the cluster. It can be helpful to use it together with STV_RECENTS to determine which queries are currently running or recently completed.
- SYS_QUERY_HISTORY is useful for troubleshooting. It shows DDL and DML queries with relevant properties like their current status, such as `running` or `failed`, the time it took each to run, and whether a query ran on a concurrency-scaling cluster.
- STL_QUERYTEXT captures the query text for SQL commands. Additionally, SVV_QUERY_INFLIGHT, which joins STL_QUERYTEXT to STV_INFLIGHT, shows more query metadata.
- A transaction-lock conflict can be a possible source of query-performance issues. For information about transactions that currently hold locks on tables, see SVV_TRANSACTIONS.
- Identifying queries that are top candidates for tuning provides a troubleshooting query that helps you determine which recently-run queries were the most time consuming. This can help you focus your efforts on queries that need improvement.
- If you want to explore query management further and understand how to manage query queues, Workload management shows how to do it. Workload management is an advanced feature and we recommend automated workload management in most cases.

Load fails

Your data load can fail for the following reasons. We suggest the following troubleshooting approaches.

Data Source is in a different AWS Region

By default, the Amazon S3 bucket or Amazon DynamoDB table specified in the COPY command must be in the same AWS Region as the cluster. If your data and your cluster are in different Regions, you receive an error similar to the following:

```
The bucket you are attempting to access must be addressed using the specified endpoint.
```

If at all possible, make sure your cluster and your data source are in the same Region. You can specify a different Region by using the [REGION](https://docs.aws.amazon.com/redshift/latest/dg/copy-parameters-data-source-s3.html#copy-region) option with the COPY command.

> **Note**
>
> If your cluster and your data source are in different AWS Regions, you incur data transfer costs. You also have higher latency.

COPY command fails

Query STL_LOAD_ERRORS to discover the errors that occurred during specific loads. For more information, see STL_LOAD_ERRORS.

Load takes too long

Your load operation can take too long for the following reasons. We suggest the following troubleshooting approaches.

COPY loads data from a single file

Split your load data into multiple files. When you load all the data from a single large file, Amazon Redshift is forced to perform a serialized load, which is much slower. The number of files should be a multiple of the number of slices in your cluster, and the files should be about equal size, between 1 MB and 1 GB after compression. For more information, see Amazon Redshift best practices for designing queries.

Load operation uses multiple COPY commands

If you use multiple concurrent COPY commands to load one table from multiple files, Amazon Redshift is forced to perform a serialized load, which is much slower. In this case, use a single COPY command.

Load data is incorrect

Your COPY operation can load incorrect data in the following ways. We suggest the following troubleshooting approaches.

Wrong files are loaded

Using an object prefix to specify data files can cause unwanted files to be read. Instead, use a manifest file to specify exactly which files to load. For more information, see the copy_from_s3_manifest_file option for the COPY command and Example: COPY from Amazon S3 using a manifest in the COPY examples.

Setting the JDBC fetch size parameter

By default, the JDBC driver collects all the results for a query at one time. As a result, when you attempt to retrieve a large result set over a JDBC connection, you might encounter a client-side out-of-memory error. To enable your client to retrieve result sets in batches instead of in a single all-or-nothing fetch, set the JDBC fetch size parameter in your client application.

> **Note**
>
> Fetch size is not supported for ODBC.

For the best performance, set the fetch size to the highest value that does not lead to out of memory errors. A lower fetch size value results in more server trips, which prolong execution times. The server reserves resources, including the WLM query slot and associated memory, until the client retrieves the entire result set or the query is canceled. When you tune the fetch size appropriately, those resources are released more quickly, making them available to other queries.

> **Note**
>
> If you need to extract large datasets, we recommend using an UNLOAD statement to transfer the data to Amazon S3. When you use UNLOAD, the compute nodes work in parallel to speed up the transfer of data.

For more information about setting the JDBC fetch size parameter, go to Getting results based on a cursor in the PostgreSQL documentation.

Workload management

You can configure Amazon Redshift WLM to run with either automatic WLM or manual WLM.

With Amazon Redshift, you can manage and prioritize concurrent queries and user workloads to optimize performance and resource utilization. Workload management (WLM) allows you to define queues, user groups, and other constructs to control the resources allocated to different types of queries or users.

The following sections outline the specific workload management features in Amazon Redshift, and guide you through their configuration and monitoring.

Automatic WLM

To maximize system throughput and use resources effectively, you can enable Amazon Redshift to manage how resources are divided to run concurrent queries with automatic WLM. *Automatic WLM* manages the resources required to run queries. Amazon Redshift determines how many queries run concurrently and how much memory is allocated to each dispatched query. Use Auto WLM when you want Amazon Redshift to manage how resources are divided to run concurrent queries. For more information, see Implementing automatic WLM.

Working with concurrency scaling and automatic WLM, you can support virtually unlimited concurrent users and concurrent queries, with consistently fast query performance. For more information, see Concurrency scaling.

> **Note**
>
> In most cases we recommend that you use automatic WLM. If you're using manual WLM and you want to migrate from to automatic WLM, see Migrating from manual WLM to automatic WLM.

With Auto WLM, it's possible to define query priorities for workloads in a queue. For more information about query priority, see Query priority.

Manual WLM

You might have multiple sessions or users running queries at the same time. Some queries might consume cluster resources for long periods and affect the performance of others. Manual WLM can help manage this for specialized use cases. Use Manual WLM when you want more control over concurrency.

You can manage system performance by modifying your WLM configuration to create separate queues for long-running queries and short-running queries. At runtime, you can route queries to these queues according to user groups or query groups.

You can set up rules to route queries to particular queues based on the user running the query or labels that you specify. You can also configure the amount of memory allocated to each queue, so that large queries run in queues with more memory than other queues. You can also configure a query monitoring rule (QMR) to limit long-running queries. For more information, see Implementing manual WLM.

> **Note**
>
> We recommend configuring your manual WLM query queues with a total of 15 or fewer query slots. For more information, see Concurrency level.

Note that in regards to a manual WLM configuration, the maximum slots you can allocate to a queue is 50. However, this doesn't mean that in an automatic WLM configuration, a Amazon Redshift cluster always runs 50 queries concurrently. This can change, based on the memory needs or other types of resource allocation on the cluster.

Topics

- Switching WLM mode
- Modifying the WLM configuration
- Implementing automatic WLM
- Implementing manual WLM
- Concurrency scaling
- Short query acceleration
- WLM queue assignment rules
- Assigning queries to queues
- WLM dynamic and static configuration properties
- WLM query monitoring rules
- WLM system tables and views

Switching WLM mode

You can enable automatic or manual WLM using the Amazon Redshift console:

1. Choose **Switch WLM mode**.
2. To set it to automatic WLM, choose **Auto WLM**. With this choice, up to eight queues are used to manage queries, and the **Memory** and **Concurrency on main** fields are both set to **Auto**. Additionally, the default priority of queries is set to **Normal**.
3. To enable manual configuration using the Amazon Redshift console, switching to **Manual WLM**. With this choice, you specify the queues used to manage queries, and the **Memory** and **Concurrency on main** field values. With a manual configuration, you can configure up to eight query queues and set the number of queries that can run in each of those queues concurrently.

Modifying the WLM configuration

The easiest way to modify the WLM configuration is by using the Amazon Redshift console. You can also use the AWS CLI or the Amazon Redshift API.

When you switch your cluster between automatic and manual WLM, your cluster is put into `pending reboot` state. The change doesn't take effect until the next cluster reboot.

For detailed information about modifying WLM configurations, see Configuring Workload Management in the *Amazon Redshift Management Guide.*

Migrating from manual WLM to automatic WLM

To maximize system throughput and use resources most effectively, we recommend that you set up automatic WLM for your queues. Consider taking the following approach to set up a smooth transition from manual WLM to automatic WLM.

To migrate from manual WLM to automatic WLM and use query priorities, we recommend that you create a new parameter group, and then attach that parameter group to your cluster. For more information, see Amazon Redshift Parameter Groups in the *Amazon Redshift Management Guide.*

Important

To change the parameter group or to switch from manual to automatic WLM requires a cluster reboot. For more information, see WLM dynamic and static configuration properties.

Let's take an example where there are three manual WLM queues. One each for an ETL workload, an analytics workload, and a data science workload. The ETL workload runs every 6 hours, the analytics workload runs throughout the day, and the data science workload can spike at any time. With manual WLM, you specify the memory and concurrency that each workload queue gets based on your understanding of the importance of each workload to the business. Specifying the memory and concurrency is not only hard to figure out, it also results in cluster resources being statically partitioned and thereby wasted when only a subset of the workloads is running.

You can use automatic WLM with query priorities to indicate the relative priorities of the workloads, avoiding the preceding issues. For this example, follow these steps:

- Create a new parameter group and switch to **Auto WLM** mode.
- Add queues for each of the three workloads: ETL workload, analytics workload, and data science workload. Use the same user groups for each workload that was used with **Manual WLM** mode.
- Set the priority for the ETL workload to `High`, the analytics workload to `Normal`, and the data science to `Low`. These priorities reflect your business priorities for the different workloads or user groups.
- Optionally, enable concurrency scaling for the analytics or data science queue so that queries in these queues get consistent performance even when the ETL workload is running every 6 hours.

With query priorities, when only the analytics workload is running on the cluster, it gets the entire system to itself. This yields high throughput with better system utilization. However, when the ETL workload starts, it gets the right of the way since it has a higher priority. Queries running as part of the ETL workload get priority during admission, in addition to preferential resource allocation after they are admitted. As a consequence, the ETL workload performs predictably regardless of what else might be running on the system. The predictable performance for a high priority workload comes at the cost of other, lower priority workloads that run longer either because their queries are waiting behind more important queries to complete. Or, because they are getting a smaller fraction of resources when they are running concurrently with higher priority queries. The scheduling algorithms used by Amazon Redshift facilitate that the lower priority queries do not suffer from starvation, but rather continue to make progress albeit at a slower pace.

Note

- The timeout field is not available in automatic WLM. Instead, use the QMR rule, `query_execution_time`. For more information, see WLM query monitoring rules.

- The QMR action, HOP, is not applicable to automatic WLM. Instead, use the `change priority` action. For more information, see WLM query monitoring rules.
- Clusters use automatic WLM and manual WLM queues differently, which can lead to confusion with your configurations. For example, you can configure the priority property in automatic WLM queues but not in manual WLM queues. As such, avoid mixing automatic WLM queues and manual WLM queues within a parameter group. Instead, create a new parameter group when migrating to automatic WLM.

Implementing automatic WLM

With automatic workload management (WLM), Amazon Redshift manages query concurrency and memory allocation. You can create up to eight queues with the service class identifiers 100–107. Each queue has a priority. For more information, see Query priority.

Automatic WLM determines the amount of resources that queries need and adjusts the concurrency based on the workload. When queries requiring large amounts of resources are in the system (for example, hash joins between large tables), the concurrency is lower. When lighter queries (such as inserts, deletes, scans, or simple aggregations) are submitted, concurrency is higher.

Automatic WLM is separate from short query acceleration (SQA) and it evaluates queries differently. Automatic WLM and SQA work together to allow short running and lightweight queries to complete even while long running, resource intensive queries are active. For more information about SQA, see Short query acceleration.

Amazon Redshift enables automatic WLM through parameter groups:

- If your clusters use the default parameter group, Amazon Redshift enables automatic WLM for them.
- If your clusters use custom parameter groups, you can configure the clusters to enable automatic WLM. We recommend that you create a separate parameter group for your automatic WLM configuration.

To configure WLM, edit the `wlm_json_configuration` parameter in a parameter group that can be associated with one or more clusters. For more information, see Modifying the WLM configuration.

You define query queues within the WLM configuration. You can add additional query queues to the default WLM configuration, up to a total of eight user queues. You can configure the following for each query queue:

- Priority
- Concurrency scaling mode
- User groups
- Query groups
- Query monitoring rules

Priority

You can define the relative importance of queries in a workload by setting a priority value. The priority is specified for a queue and inherited by all queries associated with the queue. For more information, see Query priority.

Concurrency scaling mode

When concurrency scaling is enabled, Amazon Redshift automatically adds additional cluster capacity when you need it to process an increase in concurrent read and write queries. Your users see the most current data, whether the queries run on the main cluster or on a concurrency scaling cluster.

You manage which queries are sent to the concurrency scaling cluster by configuring WLM queues. When you enable concurrency scaling for a queue, eligible queries are sent to the concurrency scaling cluster instead of waiting in a queue. For more information, see Concurrency scaling.

User groups

You can assign a set of user groups to a queue by specifying each user group name or by using wildcards. When a member of a listed user group runs a query, that query runs in the corresponding queue. There is no set limit on the number of user groups that can be assigned to a queue. For more information, see Assigning queries to queues based on user groups.

User roles

You can assign a set of user roles to a queue by specifying each user role name or by using wildcards. When a member of a listed user role runs a query, that query runs in the corresponding queue. There is no set limit on the number of user roles that can be assigned to a queue. For more information,see Assigning queries to queues based on user roles.

Query groups

You can assign a set of query groups to a queue by specifying each query group name or by using wildcards. A *query group* is simply a label. At runtime, you can assign the query group label to a series of queries. Any queries that are assigned to a listed query group run in the corresponding queue. There is no set limit to the number of query groups that can be assigned to a queue. For more information, see Assigning a query to a query group.

Wildcards

If wildcards are enabled in the WLM queue configuration, you can assign user groups and query groups to a queue either individually or by using Unix shell–style wildcards. The pattern matching is case-insensitive.

For example, the '*' wildcard character matches any number of characters. Thus, if you add `dba_*` to the list of user groups for a queue, any user-run query that belongs to a group with a name that begins with `dba_` is assigned to that queue. Examples are `dba_admin` or `DBA_primary`. The '?' wildcard character matches any single character. Thus, if the queue includes user-group `dba?1`, then user groups named `dba11` and `dba21` match, but `dba12` doesn't match.

By default, wildcards aren't enabled.

Query monitoring rules

Query monitoring rules define metrics-based performance boundaries for WLM queues and specify what action to take when a query goes beyond those boundaries. For example, for a queue dedicated to short running queries, you might create a rule that cancels queries that run for more than 60 seconds. To track poorly designed queries, you might have another rule that logs queries that contain nested loops. For more information, see WLM query monitoring rules.

Checking for automatic WLM

To check whether automatic WLM is enabled, run the following query. If the query returns at least one row, then automatic WLM is enabled.

```
select * from stv_wlm_service_class_config
where service_class >= 100;
```

The following query shows the number of queries that went through each query queue (service class). It also shows the average execution time, the number of queries with wait time at the 90th percentile, and the average wait time. Automatic WLM queries use service classes 100 through 107.

```
select final_state, service_class, count(*), avg(total_exec_time),
percentile_cont(0.9) within group (order by total_queue_time), avg(total_queue_time)
from stl_wlm_query where userid >= 100 group by 1,2 order by 2,1;
```

To find which queries were run by automatic WLM, and completed successfully, run the following query.

```
select a.queue_start_time, a.total_exec_time, label, trim(querytxt)
from stl_wlm_query a, stl_query b
where a.query = b.query and a.service_class >= 100 and a.final_state = 'Completed'
order by b.query desc limit 5;
```

Query priority

With Amazon Redshift, you can manage query prioritization and resource allocation across concurrent queries and workloads using Workload Management (WM). The following sections detail how to configure WM query queues, define queue properties like memory allocation and concurrency scaling, and implement priority rules tailored to your workload requirements.

Not all queries are of equal importance, and often performance of one workload or set of users might be more important. If you have enabled automatic WLM, you can define the relative importance of queries in a workload by setting a priority value. The priority is specified for a queue and inherited by all queries associated with the queue. You associate queries to a queue by mapping user groups and query groups to the queue. You can set the following priorities (listed from highest to lowest priority):

1. `HIGHEST`
2. `HIGH`
3. `NORMAL`
4. `LOW`
5. `LOWEST`

Administrators use these priorities to show the relative importance of their workloads when there are queries with different priorities contending for the same resources. Amazon Redshift uses the priority when letting queries into the system, and to determine the amount of resources allocated to a query. By default, queries run with their priority set to `NORMAL`.

An additional priority, `CRITICAL`, which is a higher priority than `HIGHEST`, is available to superusers. To set this priority, you can use the functions CHANGE_QUERY_PRIORITY, CHANGE_SESSION_PRIORITY. and CHANGE_USER_PRIORITY. To grant a database user permission to use these functions, you can create a stored procedure and grant permission to a user. For an example, see CHANGE_SESSION_PRIORITY.

> **Note**
>
> Only one `CRITICAL` query can run at a time.
> Rollbacks always run as CRITICAL priority.

Let's take an example where the priority of an extract, transform, load (ETL) workload is higher than the priority of the analytics workload. The ETL workload runs every six hours, and the analytics workload runs throughout the day. When only the analytics workload is running on the cluster, it gets the entire system to itself, yielding high throughput with optimal system utilization. However, when the ETL workload starts, it gets the right of the way because it has a higher priority. Queries running as part of the ETL workload get the right of the way during admission and also preferential resource allocation after they are admitted. As a consequence, the ETL workload performs predictably regardless of what else might be running on the system. Thus, it provides predictable performance and the ability for administrators to provide service level agreements (SLAs) for their business users.

Within a given cluster, the predictable performance for a high priority workload comes at the cost of other, lower priority workloads. Lower priority workloads might run longer either because their queries are waiting behind more important queries to complete. Or they might run longer because they're getting a smaller fraction of resources when they are running concurrently with higher priority queries. Lower priority queries don't suffer from starvation, but rather keep making progress at a slower pace.

In the preceding example, the administrator can enable concurrency scaling for the analytics workload. Doing this enables that workload to maintain its throughput, even though the ETL workload is running at high priority.

Configuring queue priority

If you have enabled automatic WLM, each queue has a priority value. Queries are routed to queues based on user groups and query groups. Start with a queue priority set to `NORMAL`. Set the priority higher or lower based on the workload associated with the queue's user groups and query groups.

You can change the priority of a queue on the Amazon Redshift console. On the Amazon Redshift console, the **Workload Management** page displays the queues and enables editing of queue properties such as **Priority**. To set the priority using the CLI or API operations, use the `wlm_json_configuration` parameter. For more information, see [Configuring Workload Management](#) in the *Amazon Redshift Management Guide*.

The following `wlm_json_configuration` example defines three user groups (`ingest`, `reporting`, and `analytics`). Queries submitted from users from one of these groups run with priority `highest`, `normal`, and `low`, respectively.

```
[
    {
        "user_group": [
            "ingest"
        ],
        "priority": "highest",
        "queue_type": "auto"
    },
    {
        "user_group": [
            "reporting"
        ],
        "priority": "normal",
        "queue_type": "auto"
    },
    {
        "user_group": [
            "analytics"
        ],
        "priority": "low",
        "queue_type": "auto",
        "auto_wlm": true
    }
]
```

Changing query priority with query monitoring rules

Query monitoring rules (QMR) enable you to change the priority of a query based on its behavior while it is running. You do this by specifying the priority attribute in a QMR predicate in addition to an action. For more information, see WLM query monitoring rules.

For example, you can define a rule to cancel any query classified as `high` priority that runs for more than 10 minutes.

```
"rules" :[
  {
    "rule_name":"rule_abort",
    "predicate":[
      {
        "metric_name":"query_cpu_time",
        "operator":">",
        "value":600
      },
      {
        "metric_name":"query_priority",
        "operator":"=",
        "value":"high"
      }
    ],
    "action":"abort"
  }
]
```

Another example is to define a rule to change the query priority to `lowest` for any query with current priority `normal` that spills more than 1 TB to disk.

```
"rules":[
  {
    "rule_name":"rule_change_priority",
    "predicate":[
      {
        "metric_name":"query_temp_blocks_to_disk",
        "operator":">",
        "value":1000000
      },
      {
        "metric_name":"query_priority",
```

```
        "operator":"=",
        "value":"normal"
      }
    ],
    "action":"change_query_priority",
    "value":"lowest"
  }
]
```

Monitoring query priority

To display priority for waiting and running queries, view the `query_priority` column in the stv_wlm_query_state system table.

```
query    | service_cl | wlm_start_time             | state            | queue_time |
 query_priority
---------+------------+----------------------------+------------------+------------
+----------------
2673299  | 102        | 2019-06-24 17:35:38.866356 | QueuedWaiting    | 265116     |
 Highest
2673236  | 101        | 2019-06-24 17:35:33.313854 | Running          | 0          |
 Highest
2673265  | 102        | 2019-06-24 17:35:33.523332 | Running          | 0          |
 High
2673284  | 102        | 2019-06-24 17:35:38.477366 | Running          | 0          |
 Highest
2673288  | 102        | 2019-06-24 17:35:38.621819 | Running          | 0          |
 Highest
2673310  | 103        | 2019-06-24 17:35:39.068513 | QueuedWaiting    | 62970      |
 High
2673303  | 102        | 2019-06-24 17:35:38.968921 | QueuedWaiting    | 162560     |
 Normal
2673306  | 104        | 2019-06-24 17:35:39.002733 | QueuedWaiting    | 128691     |
 Lowest
```

To list query priority for completed queries, see the `query_priority` column in the stl_wlm_query system table.

```
select query, service_class as svclass, service_class_start_time as starttime,
 query_priority
from stl_wlm_query order by 3 desc limit 10;
```

```
  query   | svclass |         starttime          |    query_priority
---------+---------+----------------------------+----------------------
 2723254 |     100 | 2019-06-24 18:14:50.780094 | Normal
 2723251 |     102 | 2019-06-24 18:14:50.749961 | Highest
 2723246 |     102 | 2019-06-24 18:14:50.725275 | Highest
 2723244 |     103 | 2019-06-24 18:14:50.719241 | High
 2723243 |     101 | 2019-06-24 18:14:50.699325 | Low
 2723242 |     102 | 2019-06-24 18:14:50.692573 | Highest
 2723239 |     101 | 2019-06-24 18:14:50.668535 | Low
 2723237 |     102 | 2019-06-24 18:14:50.661918 | Highest
 2723236 |     102 | 2019-06-24 18:14:50.643636 | Highest
```

To optimize the throughput of your workload, Amazon Redshift might modify the priority of user submitted queries. Amazon Redshift uses advanced machine learning algorithms to determine when this optimization benefits your workload and automatically applies it when all the following conditions are met.

- Automatic WLM is enabled.
- Only one WLM queue is defined.
- You have not defined query monitoring rules (QMRs) which set query priority. Such rules include the QMR metric `query_priority` or the QMR action `change_query_priority`. For more information, see WLM query monitoring rules.

Implementing manual WLM

With manual WLM, you can manage system performance and your users' experience by modifying the WLM configuration to create separate queues for the long-running queries and short-running queries.

When users run queries in Amazon Redshift, the queries are routed to query queues. Each query queue contains a number of query slots. Each queue is allocated a portion of the cluster's available memory. A queue's memory is divided among the queue's query slots. You can enable Amazon Redshift to manage query concurrency with automatic WLM. For more information, see Implementing automatic WLM.

Or you can configure WLM properties for each query queue. You do so to specify the way that memory is allocated among slots and how queries can be routed to specific queues at runtime. You can also configure WLM properties to cancel long-running queries.

By default, Amazon Redshift configures the following query queues:

- **One superuser queue**

  The superuser queue is reserved for superusers only and it can't be configured. Use this queue only when you need to run queries that affect the system or for troubleshooting purposes. For example, use this queue when you need to cancel a user's long-running query or to add users to the database. Don't use it to perform routine queries. The queue doesn't appear in the console, but it does appear in the system tables in the database as the fifth queue. To run a query in the superuser queue, a user must be logged in as a superuser, and must run the query using the predefined `superuser` query group.
- **One default user queue**

  The default queue is initially configured to run five queries concurrently. When you use manual WLM, you can change the concurrency, timeout, and memory allocation properties for the default queue, but you cannot specify user groups or query groups. The default queue must be the last queue in the WLM configuration. Any queries that are not routed to other queues run in the default queue.

Query queues are defined in the WLM configuration. The WLM configuration is an editable parameter (`wlm_json_configuration`) in a parameter group, which can be associated with one or more clusters. For more information, see Configuring Workload Management in the *Amazon Redshift Management Guide*.

You can add additional query queues to the default WLM configuration, up to a total of eight user queues. You can configure the following for each query queue:

- Concurrency scaling mode
- Concurrency level
- User groups
- Query groups
- WLM memory percent to use
- WLM timeout
- WLM query queue hopping
- Query monitoring rules

Concurrency scaling mode

When concurrency scaling is enabled, Amazon Redshift automatically adds additional cluster capacity when you need it to process an increase in concurrent read and write queries. Users see the most current data, whether the queries run on the main cluster or on a concurrency scaling cluster.

You manage which queries are sent to the concurrency scaling cluster by configuring WLM queues. When you enable concurrency scaling for a queue, eligible queries are sent to the concurrency scaling cluster instead of waiting in a queue. For more information, see Concurrency scaling.

Concurrency level

Queries in a queue run concurrently until they reach the WLM query slot count, or *concurrency level*, defined for that queue. Subsequent queries then wait in the queue.

> **Note**
>
> WLM concurrency level is different from the number of concurrent user connections that can be made to a cluster. For more information, see Connecting to a Cluster in the *Amazon Redshift Management Guide*.

In an automatic WLM configuration, which is recommended, the concurrency level is set to **Auto**. Amazon Redshift dynamically allocates memory to queries, which subsequently determines how many to run concurrently. This is based on the resources required for both running and queued queries. Auto WLM isn't configurable. For more information, see Implementing automatic WLM.

In a manual WLM configuration, Amazon Redshift statically allocates a fixed amount of memory to each queue. The queue's memory is split evenly among the query slots. To illustrate, if a queue is allocated 20% of a cluster's memory and has 10 slots, each query is allocated 2% of the cluster's memory. The memory allocation remains fixed regardless of the number of queries running concurrently. Because of this fixed memory allocation, queries that run entirely in memory when the slot count is 5 might write intermediate results to disk if the slot count is increased to 20. In this instance each query's share of the queue's memory is reduced from 1/5th to 1/20th. The additional disk I/O could degrade performance.

The maximum slot count across all user-defined queues is 50. This limits the total slots for all queues, including the default queue. The only queue that isn't subject to the limit is the reserved superuser queue.

By default, manual WLM queues have a concurrency level of 5. Your workload might benefit from a higher concurrency level in certain cases, such as the following:

- If many small queries are forced to wait for long-running queries, create a separate queue with a higher slot count and assign the smaller queries to that queue. A queue with a higher concurrency level has less memory allocated to each query slot, but the smaller queries require less memory.

> **Note**
>
> If you enable short-query acceleration (SQA), WLM automatically prioritizes short queries over longer-running queries, so you don't need a separate queue for short queries for most workflows. For more information, see Short query acceleration.

- If you have multiple queries that each access data on a single slice, set up a separate WLM queue to run those queries concurrently. Amazon Redshift assigns concurrent queries to separate slices, which allows multiple queries to run in parallel on multiple slices. For example, if a query is a simple aggregate with a predicate on the distribution key, the data for the query is located on a single slice.

A manual WLM example

This example is a simple, manual WLM scenario to show how slots and memory can be allocated. You implement manual WLM with three queues, which are the following:

- *data-ingestion queue* – This is set up for ingesting data. It's allocated 20% of the cluster's memory and it has 5 slots. Subsequently, 5 queries can run concurrently in the queue and each is allocated 4% of the memory.
- *data-scientist queue* – This is designed for memory-intensive queries. It's allocated 40% of the cluster's memory and it has 5 slots. Subsequently, 5 queries can run concurrently and each is allocated 8% of the memory.
- *default queue* – This is designed for the majority of the users in the organization. This includes sales and accounting groups that typically have short or medium running queries that aren't complicated. It's allocated 40% of the cluster's memory and it has 40 slots. 40 queries can run

concurrently in this queue, with each query allocated 1% of the memory. This is the maximum number of slots that can be allocated for this queue because between all queues the limit is 50.

If you're running automatic WLM and your workload requires more than 15 queries to run in parallel, we recommend turning on concurrency scaling. This is because increasing the query slot count above 15 might create contention for system resources and limit the overall throughput of a single cluster. With concurrency scaling, you can run hundreds of queries in parallel, up to a configured number of concurrency scaling clusters. The number of concurrency scaling clusters is controlled by max_concurrency_scaling_clusters. For more information about concurrency scaling, see Concurrency scaling.

For more information, see Query performance improvement.

User groups

You can assign a set of user groups to a queue by specifying each user group name or by using wildcards. When a member of a listed user group runs a query, that query runs in the corresponding queue. There is no set limit on the number of user groups that can be assigned to a queue. For more information, see Assigning queries to queues based on user groups.

User roles

You can assign a set of user roles to a queue by specifying each user role name or by using wildcards. When a member of a listed user role runs a query, that query runs in the corresponding queue. There is no set limit on the number of user roles that can be assigned to a queue. For more information, see Assigning queries to queues based on user roles.

Query groups

You can assign a set of query groups to a queue by specifying each query group name or by using wildcards. A query group is simply a label. At runtime, you can assign the query group label to a series of queries. Any queries that are assigned to a listed query group run in the corresponding queue. There is no set limit to the number of query groups that can be assigned to a queue. For more information, see Assigning a query to a query group.

Wildcards

If wildcards are enabled in the WLM queue configuration, you can assign user groups and query groups to a queue either individually or by using Unix shell-style wildcards. The pattern matching is case-insensitive.

For example, the '*' wildcard character matches any number of characters. Thus, if you add `dba_*` to the list of user groups for a queue, any user-run query that belongs to a group with a name that begins with `dba_` is assigned to that queue. Examples are `dba_admin` or `DBA_primary`, . The '?' wildcard character matches any single character. Thus, if the queue includes user-group `dba?1`, then user groups named `dba11` and `dba21` match, but `dba12` doesn't match.

Wildcards are turned off by default.

WLM memory percent to use

In an automatic WLM configuration, memory percent is set to **`auto`**. For more information, see Implementing automatic WLM.

In a manual WLM configuration, to specify the amount of available memory that is allocated to a query, you can set the `WLM Memory Percent to Use` parameter. By default, each user-defined queue is allocated an equal portion of the memory that is available for user-defined queries. For example, if you have four user-defined queues, each queue is allocated 25 percent of the available memory. The superuser queue has its own allocated memory and cannot be modified. To change the allocation, you assign an integer percentage of memory to each queue, up to a total of 100 percent. Any unallocated memory is managed by Amazon Redshift and can be temporarily given to a queue if the queue requests additional memory for processing.

For example, if you configure four queues, you can allocate memory as follows: 20 percent, 30 percent, 15 percent, 15 percent. The remaining 20 percent is unallocated and managed by the service.

WLM timeout

WLM timeout (`max_execution_time`) is deprecated. Instead, create a query monitoring rule (QMR) using `query_execution_time` to limit the elapsed execution time for a query. For more information, see WLM query monitoring rules.

To limit the amount of time that queries in a given WLM queue are permitted to use, you can set the WLM timeout value for each queue. The timeout parameter specifies the amount of time, in milliseconds, that Amazon Redshift waits for a query to run before either canceling or hopping the query. The timeout is based on query execution time and doesn't include time spent waiting in a queue.

WLM attempts to hop CREATE TABLE AS (CTAS) statements and read-only queries, such as SELECT statements. Queries that can't be hopped are canceled. For more information, see WLM query queue hopping.

WLM timeout doesn't apply to a query that has reached the returning state. To view the state of a query, see the STV_WLM_QUERY_STATE system table. COPY statements and maintenance operations, such as ALTER, ANALYZE and VACUUM, are not subject to WLM timeout.

The function of WLM timeout is similar to the statement_timeout configuration parameter. The difference is that, where the `statement_timeout` configuration parameter applies to the entire cluster, WLM timeout is specific to a single queue in the WLM configuration.

If statement_timeout is also specified, the lower of statement_timeout and WLM timeout (max_execution_time) is used.

Query monitoring rules

Query monitoring rules define metrics-based performance boundaries for WLM queues and specify what action to take when a query goes beyond those boundaries. For example, for a queue dedicated to short running queries, you might create a rule that cancels queries that run for more than 60 seconds. To track poorly designed queries, you might have another rule that logs queries that contain nested loops. For more information, see WLM query monitoring rules.

WLM query queue hopping

With Amazon Redshift, you can manage workload concurrency and resource allocation by enabling WLM (Workload Management) query queue hopping. This feature allows queries to temporarily "hop" from an assigned queue to a higher priority queue when resources are available, improving overall query performance and system utilization. The following sections provide detailed guidance on configuring and utilizing WLM query queue hopping in Amazon Redshift.

A query can be hopped due to a WLM timeout or a query monitoring rule (QMR) hop action. You can only hop queries in a manual WLM configuration.

When a query is hopped, WLM attempts to route the query to the next matching queue based on the WLM queue assignment rules. If the query doesn't match any other queue definition, the query is canceled. It's not assigned to the default queue.

WLM timeout actions

The following table summarizes the behavior of different types of queries with a WLM timeout.

Query type	Action
INSERT, UPDATE, and DELETE	Cancel
User-defined functions (UDFs)	Cancel
UNLOAD	Cancel
COPY	Continue execution
Maintenance operations	Continue execution
Read-only queries in a `returning` state	Continue execution
Read-only queries in a `running` state	Reassign or restart
CREATE TABLE AS (CTAS), SELECT INTO	Reassign or restart

WLM timeout queue hopping

WLM hops the following types of queries when they time out:

- Read-only queries, such as SELECT statements, that are in a WLM state of `running`. To find the WLM state of a query, view the STATE column on the STV_WLM_QUERY_STATE system table.
- CREATE TABLE AS (CTAS) statements. WLM queue hopping supports both user-defined and system-generated CTAS statements.
- SELECT INTO statements.

Queries that aren't subject to WLM timeout continue running in the original queue until completion. The following types of queries aren't subject to WLM timeout:

- COPY statements
- Maintenance operations, such as ALTER, ANALYZE and VACUUM
- Read-only queries, such as SELECT statements, that have reached a WLM state of `returning`. To find the WLM state of a query, view the STATE column on the STV_WLM_QUERY_STATE system table.

Queries that aren't eligible for hopping by WLM timeout are canceled when they time out. The following types of queries are not eligible for hopping by a WLM timeout:

- INSERT, UPDATE, and DELETE statements
- UNLOAD statements
- User-defined functions (UDFs)

WLM timeout reassigned and restarted queries

When a query is hopped and no matching queue is found, the query is canceled.

When a query is hopped and a matching queue is found, WLM attempts to reassign the query to the new queue. If a query can't be reassigned, it's restarted in the new queue, as described following.

A query is reassigned only if all of the following are true:

- A matching queue is found.
- The new queue has enough free slots to run the query. A query might require multiple slots if the wlm_query_slot_count parameter was set to a value greater than 1.
- The new queue has at least as much memory available as the query currently uses.

If the query is reassigned, the query continues executing in the new queue. Intermediate results are preserved, so there is minimal effect on total execution time.

If the query can't be reassigned, the query is canceled and restarted in the new queue. Intermediate results are deleted. The query waits in the queue, then begins running when enough slots are available.

QMR hop actions

The following table summarizes the behavior of different types of queries with a QMR hop action.

Query type	Action
COPY	Continue execution
Maintenance operations	Continue execution
User-defined functions (UDFs)	Continue execution
UNLOAD	Reassign or continue execution
INSERT, UPDATE, and DELETE	Reassign or continue execution
Read-only queries in a `returning` state	Reassign or continue execution
Read-only queries in a `running` state	Reassign or restart
CREATE TABLE AS (CTAS), SELECT INTO	Reassign or restart

To find whether a query that was hopped by QMR was reassigned, restarted, or canceled, query the STL_WLM_RULE_ACTION system log table.

QMR hop action reassigned and restarted queries

When a query is hopped and no matching queue is found, the query is canceled.

When a query is hopped and a matching queue is found, WLM attempts to reassign the query to the new queue. If a query can't be reassigned, it's restarted in the new queue or continues execution in the original queue, as described following.

A query is reassigned only if all of the following are true:

- A matching queue is found.
- The new queue has enough free slots to run the query. A query might require multiple slots if the wlm_query_slot_count parameter was set to a value greater than 1.
- The new queue has at least as much memory available as the query currently uses.

If the query is reassigned, the query continues executing in the new queue. Intermediate results are preserved, so there is minimal effect on total execution time.

If a query can't be reassigned, the query is either restarted or continues execution in the original queue. If the query is restarted, the query is canceled and restarted in the new queue. Intermediate results are deleted. The query waits in the queue, then begins execution when enough slots are available.

Tutorial: Configuring manual workload management (WLM) queues

With Amazon Redshift, you can configure manual workload management (WLM) queues to prioritize and allocate resources for different types of queries and users. Manual WLM queues allow you to control the memory and concurrency settings for specific queues, ensuring that critical workloads receive the necessary resources while preventing low-priority queries from monopolizing the system. The following sections guide you through the process of creating and configuring manual WLM queues in Amazon Redshift to meet your workload management requirements.

Overview

We recommend configuring automatic workload management (WLM) in Amazon Redshift. For more information about automatic WLM, see Workload management. However, if you need multiple WLM queues, this tutorial walks you through the process of configuring manual workload management (WLM) in Amazon Redshift. By configuring manual WLM, you can improve query performance and resource allocation in your cluster.

Amazon Redshift routes user queries to queues for processing. WLM defines how those queries are routed to the queues. By default, Amazon Redshift has two queues available for queries: one for superusers, and one for users. The superuser queue cannot be configured and can only process one query at a time. You should reserve this queue for troubleshooting purposes only. The user queue can process up to five queries at a time, but you can configure this by changing the concurrency level of the queue if needed.

When you have several users running queries against the database, you might find another configuration to be more efficient. For example, if some users run resource-intensive operations, such as VACUUM, these might have a negative impact on less-intensive queries, such as reports. You might consider adding additional queues and configuring them for different workloads.

Estimated time: 75 minutes

Estimated cost: 50 cents

Prerequisites

You need an Amazon Redshift cluster, the sample TICKIT database, and the Amazon Redshift RSQL client tool. If you do not already have these set up, go to Amazon Redshift Getting Started Guide and Amazon Redshift RSQL.

Sections

- Section 1: Understanding the default queue processing behavior
- Section 2: Modifying the WLM query queue configuration
- Section 3: Routing queries to queues based on user groups and query groups
- Section 4: Using wlm_query_slot_count to temporarily override the concurrency level in a queue
- Section 5: Cleaning up your resources

Section 1: Understanding the default queue processing behavior

Before you start to configure manual WLM, it's useful to understand the default behavior of queue processing in Amazon Redshift. In this section, you create two database views that return information from several system tables. Then you run some test queries to see how queries are routed by default. For more information about system tables, see System tables and views reference.

Step 1: Create the WLM_QUEUE_STATE_VW view

In this step, you create a view called WLM_QUEUE_STATE_VW. This view returns information from the following system tables.

- STV_WLM_CLASSIFICATION_CONFIG
- STV_WLM_SERVICE_CLASS_CONFIG
- STV_WLM_SERVICE_CLASS_STATE

You use this view throughout the tutorial to monitor what happens to queues after you change the WLM configuration. The following table describes the data that the WLM_QUEUE_STATE_VW view returns.

Column	Description
queue	The number associated with the row that represents a queue. Queue number determines the order of the queues in the database.
description	A value that describes whether the queue is available only to certain user groups, to certain query groups, or all types of queries.
slots	The number of slots allocated to the queue.
mem	The amount of memory, in MB per slot, allocated to the queue.
max_execution_time	The amount of time a query is allowed to run before it is terminated.
user_*	A value that indicates whether wildcard characters are allowed in the WLM configuration to match user groups.
query_*	A value that indicates whether wildcard characters are allowed in the WLM configuration to match query groups.
queued	The number of queries that are waiting in the queue to be processed.
executing	The number of queries that are currently running.
executed	The number of queries that have been run.

To create the WLM_QUEUE_STATE_VW view

1. Open Amazon Redshift RSQL and connect to your TICKIT sample database. If you do not have this database, see Prerequisites.
2. Run the following query to create the WLM_QUEUE_STATE_VW view.

```
create view WLM_QUEUE_STATE_VW as
select (config.service_class-5) as queue
, trim (class.condition) as description
, config.num_query_tasks as slots
, config.query_working_mem as mem
, config.max_execution_time as max_time
, config.user_group_wild_card as "user_*"
, config.query_group_wild_card as "query_*"
```

```
, state.num_queued_queries queued
, state.num_executing_queries executing
, state.num_executed_queries executed
from
STV_WLM_CLASSIFICATION_CONFIG class,
STV_WLM_SERVICE_CLASS_CONFIG config,
STV_WLM_SERVICE_CLASS_STATE state
where
class.action_service_class = config.service_class
and class.action_service_class = state.service_class
and config.service_class > 4
order by config.service_class;
```

3. Run the following query to see the information that the view contains.

```
select * from wlm_queue_state_vw;
```

The following is an example result.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+-----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |         0
    1 | (querytype:any)                           |     5 | 836 |        0 |  false |
 false   |      0 |         1 |       160
```

Step 2: Create the WLM_QUERY_STATE_VW view

In this step, you create a view called WLM_QUERY_STATE_VW. This view returns information from the STV_WLM_QUERY_STATE system table.

You use this view throughout the tutorial to monitor the queries that are running. The following table describes the data that the WLM_QUERY_STATE_VW view returns.

Column	Description
query	The query ID.

Column	Description
queue	The queue number.
slot_count	The number of slots allocated to the query.
start_time	The time that the query started.
state	The state of the query, such as executing.
queue_time	The number of microseconds that the query has spent in the queue.
exec_time	The number of microseconds that the query has been running.

To create the WLM_QUERY_STATE_VW view

1. In RSQL, run the following query to create the WLM_QUERY_STATE_VW view.

```
create view WLM_QUERY_STATE_VW as
select query, (service_class-5) as queue, slot_count, trim(wlm_start_time) as
 start_time, trim(state) as state, trim(queue_time) as queue_time, trim(exec_time) as
 exec_time
from stv_wlm_query_state;
```

2. Run the following query to see the information that the view contains.

```
select * from wlm_query_state_vw;
```

The following is an example result.

```
query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 1249 |     1 |          1 | 2014-09-24 22:19:16 | Executing | 0          | 516
```

Step 3: Run test queries

In this step, you run queries from multiple connections in RSQL and review the system tables to determine how the queries were routed for processing.

For this step, you need two RSQL windows open:

- In RSQL window 1, you run queries that monitor the state of the queues and queries using the views you already created in this tutorial.
- In RSQL window 2, you run long-running queries to change the results you find in RSQL window 1.

To run the test queries

1. Open two RSQL windows. If you already have one window open, you only need to open a second window. You can use the same user account for both of these connections.
2. In RSQL window 1, run the following query.

   ```
   select * from wlm_query_state_vw;
   ```

   The following is an example result.

   ```
   query | queue | slot_count | start_time          | state     | queue_time | exec_time
   ------+-------+------------+---------------------+-----------+------------
   +-----------
    1258 |     1 |          1 | 2014-09-24 22:21:03 | Executing | 0          | 549
   ```

   This query returns a self-referential result. The query that is currently running is the SELECT statement from this view. A query on this view always returns at least one result. Compare this result with the result that occurs after starting the long-running query in the next step.
3. In RSQL window 2, run a query from the TICKIT sample database. This query should run for approximately a minute so that you have time to explore the results of the WLM_QUEUE_STATE_VW view and the WLM_QUERY_STATE_VW view that you created earlier. In some cases, you might find that the query doesn't run long enough for you to query both views. In these cases, you can increase the value of the filter on `l.listid` to make it run longer.

   > **Note**
   >
   > To reduce query execution time and improve system performance, Amazon Redshift caches the results of certain types of queries in memory on the leader node. When result

caching is enabled, subsequent queries run much faster. To prevent the query from running to quickly, disable result caching for the current session.

To turn off result caching for the current session, set the enable_result_cache_for_session parameter to `off`, as shown following.

```
set enable_result_cache_for_session to off;
```

In RSQL window 2, run the following query.

```
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <
 100000;
```

4. In RSQL window 1, query WLM_QUEUE_STATE_VW and WLM_QUERY_STATE_VW and compare the results to your earlier results.

```
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+------------------------------------------+-------+-----+----------+--------
+---------+--------+-----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |        0
    1 | (querytype:any)                           |     5 | 836 |        0 |  false |
 false   |      0 |         2 |      163

query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 1267 |     1 |          1 | 2014-09-24 22:22:30 | Executing | 0          | 684
 1265 |     1 |          1 | 2014-09-24 22:22:36 | Executing | 0          | 4080859
```

Note the following differences between your previous queries and the results in this step:

- There are two rows now in WLM_QUERY_STATE_VW. One result is the self-referential query for running a SELECT operation on this view. The second result is the long-running query from the previous step.
- The executing column in WLM_QUEUE_STATE_VW has increased from 1 to 2. This column entry means that there are two queries running in the queue.
- The executed column is incremented each time you run a query in the queue.

The WLM_QUEUE_STATE_VW view is useful for getting an overall view of the queues and how many queries are being processed in each queue. The WLM_QUERY_STATE_VW view is useful for getting a more detailed view of the individual queries that are currently running.

Section 2: Modifying the WLM query queue configuration

Now that you understand how queues work by default, you can learn how to configure query queues using manual WLM. In this section, you create and configure a new parameter group for your cluster. You create two additional user queues and configure them to accept queries based on the queries' user group or query group labels. Any queries that don't get routed to one of these two queues are routed to the default queue at runtime.

To create a manual WLM configuration in a parameter group

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Configurations**, then choose **Workload management** to display the **Workload management** page.
3. Choose **Create** to display the **Create parameter group** window.
4. Enter **`WLMTutorial`** for both **Parameter group name** and **Description**, and then choose **Create** to create the parameter group.

   > **Note**
   >
   > The **Parameter group name** is converted to all lower case format when created.

5. On the **Workload management** page, choose the parameter group **`wlmtutorial`** to display the details page with tabs for **Parameters** and **Workload management**.
6. Confirm that you're on the **Workload management** tab, then choose **Switch WLM mode** to display the **Concurrency settings** window.

7. Choose **Manual WLM**, then choose **Save** to switch to manual WLM.
8. Choose **Edit workload queues**.
9. Choose **Add queue** twice to add two queues. Now there are three queues: **Queue 1**, **Queue 2**, and **Default queue**.
10. Enter information for each queue as follows:
    - For **Queue 1**, enter **`30`** for **Memory (%)**, **2** for **Concurrency on main**, and **`test`** for **Query groups**. Leave the other settings with their default values.
    - For **Queue 2**, enter **`40`** for **Memory (%)**, **3** for **Concurrency on main**, and **`admin`** for **User groups**. Leave the other settings with their default values.
    - Set the **Concurrency on main** value for the default queue to a value greater than or equal to 1. Don't make any other changes to the **Default queue**. WLM assigns unallocated memory to the default queue.
11. Choose **Save** to save your settings.

Next, associate the parameter group that has the manual WLM configuration with a cluster.

To associate a parameter group with a manual WLM configuration with a cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshiftv2/.
2. On the navigation menu, choose **Clusters**, then choose **Clusters** to display a list of your clusters.
3. Choose your cluster, such as `examplecluster` to display the details of the cluster. Then choose the **Properties** tab to display the properties of that cluster.
4. In the **Database configurations** section, choose **Edit**, **Edit parameter group** to display the parameter groups window.
5. For **Parameter groups** choose the **`wlmtutorial`** parameter group that you previously created.
6. Choose **Save changes** to associate the parameter group.

   The cluster is modified with the changed parameter group. However, you need to reboot the cluster for the changes to also be applied to the database.
7. Choose your cluster, and then choose **Reboot** for **Actions**.

After the cluster is rebooted, its status returns to **Available**.

Section 3: Routing queries to queues based on user groups and query groups

Now you have your cluster associated with a new parameter group and you've configured WLM. Next, run some queries to see how Amazon Redshift routes queries into queues for processing.

Step 1: View query queue configuration in the database

First, verify that the database has the WLM configuration that you expect.

To view the query queue configuration

1. Open RSQL and run the following query. The query uses the WLM_QUEUE_STATE_VW view you created in Step 1: Create the WLM_QUEUE_STATE_VW view. If you already had a session connected to the database prior to the cluster reboot, you need to reconnect.

   ```
   select * from wlm_queue_state_vw;
   ```

   The following is an example result.

   ```
   query | description                               | slots | mem | max_time | user_* |
    query_* | queued | executing | executed
   ------+-------------------------------------------+-------+-----+----------+--------
   +---------+--------+-----------+----------
       0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
    false   |      0 |         0 |        0
       1 | (query group: test)                       |     2 | 627 |        0 |  false |
    false   |      0 |         0 |        0
       2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
    false   |      0 |         0 |        0
       3 | (querytype:any)                           |     5 | 250 |        0 |  false |
    false   |      0 |         1 |        0
   ```

   Compare these results to the results you received in Step 1: Create the WLM_QUEUE_STATE_VW view. Notice that there are now two additional queues. Queue 1 is now the queue for the test query group, and queue 2 is the queue for the admin user group.

   Queue 3 is now the default queue. The last queue in the list is always the default queue. That's the queue to which queries are routed by default if no user group or query group is specified in a query.

2. Run the following query to confirm that your query now runs in queue 3.

```
select * from wlm_query_state_vw;
```

The following is an example result.

```
query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2144 |     3 |          1 | 2014-09-24 23:49:59 | Executing | 0          | 550430
```

Step 2: Run a query using the query group queue

To run a query using the query group queue

1. Run the following query to route it to the `test` query group.

```
set query_group to test;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

2. From the other RSQL window, run the following query.

```
select * from wlm_query_state_vw;
```

The following is an example result.

```
query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2168 |     1 |          1 | 2014-09-24 23:54:18 | Executing | 0          | 6343309
 2170 |     3 |          1 | 2014-09-24 23:54:24 | Executing | 0          | 847
```

The query was routed to the test query group, which is queue 1 now.

3. Select all from the queue state view.

```
select * from wlm_queue_state_vw;
```

You see a result similar to the following.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |        0
    1 | (query group: test)                       |     2 | 627 |        0 |  false |
 false   |      0 |         1 |        0
    2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
 false   |      0 |         0 |        0
    3 | (querytype:any)                           |     5 | 250 |        0 |  false |
 false   |      0 |         1 |        0
```

4. Now, reset the query group and run the long query again:

```
reset query_group;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

5. Run the queries against the views to see the results.

```
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |        0
    1 | (query group: test)                       |     2 | 627 |        0 |  false |
 false   |      0 |         0 |        1
    2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
 false   |      0 |         0 |        0
    3 | (querytype:any)                           |     5 | 250 |        0 |  false |
 false   |      0 |         2 |        5

query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
```

```
 2186 |     3 |           1 | 2014-09-24 23:57:52 | Executing | 0           | 649
 2184 |     3 |           1 | 2014-09-24 23:57:48 | Executing | 0           | 4137349
```

The result should be that the query is now running in queue 3 again.

Step 3: Create a database user and group

Before you can run any queries in this queue, you need to create the user group in the database and add a user to the group. Then you log in with RSQL using the new user's credentials and run queries. You need to run queries as a superuser, such as the admin user, to create database users.

To create a new database user and user group

1. In the database, create a new database user named `adminwlm` by running the following command in an RSQL window.

```
create user adminwlm createuser password '123Admin';
```

2. Then, run the following commands to create the new user group and add your new `adminwlm` user to it.

```
create group admin;
alter group admin add user adminwlm;
```

Step 4: Run a query using the user group queue

Next you run a query and route it to the user group queue. You do this when you want to route your query to a queue that is configured to handle the type of query you want to run.

To run a query using the user group queue

1. In RSQL window 2, run the following queries to switch to the `adminwlm` account and run a query as that user.

```
set session authorization 'adminwlm';
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

2. In RSQL window 1, run the following query to see the query queue that the queries are routed to.

```
select * from wlm_query_state_vw;
select * from wlm_queue_state_vw;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |        0 |        0
    1 | (query group: test)                       |     2 | 627 |        0 |  false |
 false   |      0 |        0 |        1
    2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
 false   |      0 |        1 |        0
    3 | (querytype:any)                           |     5 | 250 |        0 |  false |
 false   |      0 |        1 |        8

query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2202 |     2 |          1 | 2014-09-25 00:01:38 | Executing | 0          | 4885796
 2204 |     3 |          1 | 2014-09-25 00:01:43 | Executing | 0          | 650
```

The queue that this query ran in is queue 2, the `admin` user queue. Anytime you run queries logged in as this user, they run in queue 2 unless you specify a different query group to use. The chosen queue depends on the queue assignment rules. For more information, see WLM queue assignment rules.

3. Now run the following query from RSQL window 2.

```
set query_group to test;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

4. In RSQL window 1, run the following query to see the query queue that the queries are routed to.

```
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |        0 |        0
    1 | (query group: test)                       |     2 | 627 |        0 |  false |
 false   |      0 |        1 |        1
    2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
 false   |      0 |        0 |        1
    3 | (querytype:any)                           |     5 | 250 |        0 |  false |
 false   |      0 |        1 |       10

query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2218 |     1 |          1 | 2014-09-25 00:04:30 | Executing | 0          | 4819666
 2220 |     3 |          1 | 2014-09-25 00:04:35 | Executing | 0          | 685
```

5. When you're done, reset the query group.

```
reset query_group;
```

Section 4: Using wlm_query_slot_count to temporarily override the concurrency level in a queue

Sometimes, users might temporarily need more resources for a particular query. If so, they can use the wlm_query_slot_count configuration setting to temporarily override the way slots are allocated in a query queue. *Slots* are units of memory and CPU that are used to process queries. You might override the slot count when you have occasional queries that take a lot of resources in the cluster, such as when you perform a VACUUM operation in the database.

You might find that users often need to set wlm_query_slot_count for certain types of queries. If so, consider adjusting the WLM configuration and giving users a queue that better suits the needs of their queries. For more information about temporarily overriding the concurrency level by using slot count, see wlm_query_slot_count.

Step 1: Override the concurrency level using wlm_query_slot_count

For the purposes of this tutorial, we run the same long-running SELECT query. We run it as the `adminwlm` user using wlm_query_slot_count to increase the number of slots available for the query.

To override the concurrency level using wlm_query_slot_count

1. Increase the limit on the query to make sure that you have enough time to query the WLM_QUERY_STATE_VW view and see a result.

```
set wlm_query_slot_count to 3;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

2. Now, query WLM_QUERY_STATE_VW with the admin user to see how the query is running.

```
select * from wlm_query_state_vw;
```

   The following is an example result.

```
query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2240 |     2 |          1 | 2014-09-25 00:08:45 | Executing | 0          | 3731414
 2242 |     3 |          1 | 2014-09-25 00:08:49 | Executing | 0          | 596
```

   Notice that the slot count for the query is 3. This count means that the query is using all three slots to process the query, allocating all of the resources in the queue to that query.

3. Now, run the following query.

```
select * from WLM_QUEUE_STATE_VW;
```

   The following is an example result.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+-----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |        0
```

```
   1 | (query group: test)                        |     2 | 627 |         0 |  false |
 false   |      0 |         0 |        4
   2 | (suser group: admin)                       |     3 | 557 |         0 |  false |
 false   |      0 |         1 |        3
   3 | (querytype:any)                            |     5 | 250 |         0 |  false |
 false   |      0 |         1 |       25
```

The wlm_query_slot_count configuration setting is valid for the current session only. If that session expires, or another user runs a query, the WLM configuration is used.

4. Reset the slot count and rerun the test.

```
reset wlm_query_slot_count;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+-------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |         0 |  false |
 false   |      0 |         0 |        0
    1 | (query group: test)                       |     2 | 627 |         0 |  false |
 false   |      0 |         0 |        2
    2 | (suser group: admin)                      |     3 | 557 |         0 |  false |
 false   |      0 |         1 |        2
    3 | (querytype:any)                           |     5 | 250 |         0 |  false |
 false   |      0 |         1 |       14

query | queue | slot_count | start_time          | state     | queue_time | exec_time
------+-------+------------+---------------------+-----------+------------
+-----------
 2260 |     2 |          1 | 2014-09-25 00:12:11 | Executing | 0          | 4042618
 2262 |     3 |          1 | 2014-09-25 00:12:15 | Executing | 0          | 680
```

Step 2: Run queries from different sessions

Next, run queries from different sessions.

To run queries from different sessions

1. In RSQL window 1 and 2, run the following to use the test query group.

```
set query_group to test;
```

2. In RSQL window 1, run the following long-running query.

```
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

3. As the long-running query is still going in RSQL window 1, run the following. These commands increase the slot count to use all the slots for the queue and then start running the long-running query.

```
set wlm_query_slot_count to 2;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

4. Open a third RSQL window and query the views to see the results.

```
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

```
query | description                               | slots | mem | max_time | user_* |
 query_* | queued | executing | executed
------+------------------------------------------+-------+-----+----------+--------
+---------+--------+----------+----------
    0 | (super user) and (query group: superuser) |     1 | 357 |        0 |  false |
 false   |      0 |         0 |        0
    1 | (query group: test)                       |     2 | 627 |        0 |  false |
 false   |      1 |         1 |        2
    2 | (suser group: admin)                      |     3 | 557 |        0 |  false |
 false   |      0 |         0 |        3
    3 | (querytype:any)                           |     5 | 250 |        0 |  false |
 false   |      0 |         1 |       18

query | queue | slot_count | start_time          | state          | queue_time |
 exec_time
------+-------+------------+---------------------+---------------+------------
+-----------
 2286 |     1 |          2 | 2014-09-25 00:16:48 | QueuedWaiting | 3758950    | 0
```

```
2282 |     1 |          1 | 2014-09-25 00:16:33 | Executing     | 0          |
19335850
2288 |     3 |          1 | 2014-09-25 00:16:52 | Executing     | 0          | 666
```

Notice that the first query is using one of the slots allocated to queue 1 to run the query. In addition, notice that there is one query that is waiting in the queue (where `queued` is `1` and `state` is `QueuedWaiting`). After the first query completes, the second one begins running. This execution happens because both queries are routed to the `test` query group, and the second query must wait for enough slots to begin processing.

Section 5: Cleaning up your resources

Your cluster continues to accrue charges as long as it is running. When you have completed this tutorial, return your environment to the previous state by following the steps in Find Additional Resources and Reset Your Environment in *Amazon Redshift Getting Started Guide*.

For more information about WLM, see Workload management.

Concurrency scaling

With the Concurrency Scaling feature, you can support thousands of concurrent users and concurrent queries, with consistently fast query performance. When you turn on concurrency scaling, Amazon Redshift automatically adds additional cluster capacity to process an increase in both read and write queries. Users see the most current data, whether the queries run on the main cluster or a concurrency-scaling cluster.

You can manage which queries are sent to the concurrency-scaling cluster by configuring WLM queues. When you turn on concurrency scaling, eligible queries are sent to the concurrency-scaling cluster instead of waiting in a queue.

You're charged for concurrency-scaling clusters only for the time they're actively running queries. For more information about pricing, including how charges accrue and minimum charges, see Concurrency Scaling pricing.

Topics

- AWS Regions for concurrency scaling
- Concurrency scaling candidates
- Configuring concurrency scaling queues
- Monitoring concurrency scaling
- Concurrency scaling system views

Concurrency scaling capabilities

When you turn on concurrency scaling for a WLM queue, it works for read operations, such as dashboard queries. It also works for commonly used write operations, such as statements for data ingestion and processing.

Concurrency scaling capabilities for write operations

Concurrency scaling supports frequently used write operations, such as extract, transform, and load (ETL) statements. Concurrency scaling for write operations is especially useful when you want to maintain consistent response times when your cluster receives a large number of requests. It improves throughput for write operations contending for resources on the main cluster.

Concurrency scaling supports COPY, INSERT, DELETE, UPDATE, and CREATE TABLE AS (CTAS) statements. Additionally, concurrency scaling supports manual refresh of materialized views (MVs). Other data-manipulation language (DML) statements and data-definition language (DDL) statements aren't supported. When non-supported write statements, such as CREATE without TABLE AS, are included in an explicit transaction before the supported write statements, none of the write statements will run on concurrency-scaling clusters.

When you accrue credit for concurrency scaling, this credit accrual applies to both read and write operations.

Limitations for concurrency scaling

The following are limitations for using Amazon Redshift concurrency scaling:

- It doesn't support queries on tables that use interleaved sort keys.
- It doesn't support queries on temporary tables.
- It doesn't support queries that access external resources that are protected by restrictive network or virtual private cloud (VPC) configurations.

- It doesn't support queries that contain Python user-defined functions (UDFs) and Lambda UDFs.
- It doesn't support queries that access system tables, PostgreSQL catalog tables, or no-backup tables.
- It doesn’t support COPY or UNLOAD queries that access an external resource when restrictive IAM policy permissions are in place. This includes permissions applied either to the resource, like an Amazon S3 bucket or DynamoDB table, or to the source. IAM sources can include the following:
  - `aws:sourceVpc` – A source VPC.
  - `aws:sourceVpce` – A source VPC endpoint.
  - `aws:sourceIp` – A source IP address.

  In some cases, you might need to remove permissions that restrict either the resource or the source, so that COPY and UNLOAD queries accessing the resource are sent to the concurrency-scaling cluster.

  For more information about resource policies, see Policy types in the AWS Identity and Access Management user guide and Controlling access from VPC endpoints with bucket policies.
- Amazon Redshift concurrency scaling for write operations is not supported for DDL operations, such as CREATE TABLE or ALTER TABLE.
- It doesn't support ANALYZE for the COPY command.
- It doesn't support write operations on a target table where DISTSTYLE is set to ALL.
- It doesn't support COPY from the following file formats:
  - Parquet
  - ORC
- It doesn't support write operations on tables with identity columns.
- Amazon Redshift supports concurrency scaling for write operations on only Amazon Redshift RA3 nodes. Concurrency scaling for write operations isn't supported on other node types.

AWS Regions for concurrency scaling

With Amazon Redshift, you can use concurrency scaling to manage concurrent workload demands across Redshift clusters. This topic details in which regions you can use concurrency scaling with Amazon Redshift.

Concurrency scaling is available in these AWS Regions:

- US East (N. Virginia) Region (us-east-1)
- US East (Ohio) Region (us-east-2)
- US West (N. California) Region (us-west-1)
- US West (Oregon) Region (us-west-2)
- Asia Pacific (Mumbai) Region (ap-south-1)
- Asia Pacific (Seoul) Region (ap-northeast-2)
- Asia Pacific (Singapore) Region (ap-southeast-1)
- Asia Pacific (Sydney) Region (ap-southeast-2)
- Asia Pacific (Malaysia) Region (ap-southeast-5)
- Asia Pacific (New Zealand) Region (ap-southeast-6)
- Asia Pacific (Taipei) Region (ap-east-2)
- Asia Pacific (Tokyo) Region (ap-northeast-1)
- Canada (Central) Region (ca-central-1)
- Canada West (Calgary) Region (ca-west-1)
- China (Beijing) Region (cn-north-1)
- China (Ningxia) Region (cn-northwest-1)
- Europe (Frankfurt) Region (eu-central-1)
- Europe (Ireland) Region (eu-west-1)
- Europe (London) Region (eu-west-2)
- Europe (Paris) Region (eu-west-3)
- Europe (Stockholm) Region (eu-north-1)
- Europe (Zurich) Region (eu-central-2)
- Europe (Spain) Region (eu-south-2)
- Israel (Tel Aviv) Region (il-central-1)
- South America (São Paulo) Region (sa-east-1)
- AWS GovCloud (US-East)

Concurrency scaling candidates

With Amazon Redshift, you can scale out query processing to accelerate execution of concurrent queries. The following topic describes the criteria that Amazon Redshift uses to determine what queries to route to concurrency scaling.

Queries are routed to the concurrency scaling cluster only when the main cluster meets the following requirements:

- EC2-VPC platform.
- Node type must be dc2.8xlarge, dc2.large, ra3.large, ra3.xlplus, ra3.4xlarge, or ra3.16xlarge. Concurrency scaling for write operations is supported on only Amazon Redshift RA3 nodes.
- Maximum of 32 compute nodes for clusters with ra3.xlplus, ra3.4xlarge, or ra3.16xlarge node types. In addition, the number of nodes of the main cluster can't be larger than 32 nodes when the cluster was originally created. For example, even if a cluster currently has 20 nodes, but was originally created with 40, it does not meet the requirements for concurrency scaling. Conversely, if a DC2 cluster currently has 40 nodes, but was originally created with 20, it does meet the requirements for concurrency scaling.
- Not a single-node cluster.

Configuring concurrency scaling queues

With Amazon Redshift, you can manage concurrency and system resources by configuring concurrency scaling. Concurrency scaling queues allow you to set limits on the number of queries or user sessions that can be executed concurrently. The following section provides instructions on how to enable concurrency scaling queues in Amazon Redshift, enabling you to effectively handle concurrent queries and user sessions.

You route queries to concurrency scaling clusters by enabling concurrency scaling in a workload manager (WLM) queue. To turn on concurrency scaling for a queue, set the **Concurrency Scaling mode** value to **auto**.

When the number of queries routed to a queue with concurrency scaling enabled exceeds the queue's concurrency capacity, whether the capacity is configured manually or determined automatically, eligible queries are sent to the concurrency scaling cluster. When queue slots become available on the main cluster, queries are routed to and run on the main cluster. As with any WLM queue, you route queries to a concurrency scaling queue based on user groups, or by labeling queries with query group labels, or according to matching conditions defined in Assigning queries to queues. You can also route queries by defining WLM query monitoring rules. For example, you might route all queries that take longer than 5 seconds to a concurrency scaling queue. Keep in mind that queuing behavior can vary, depending on whether you're using automatic WLM or manual WLM. For more information, see Implementing automatic WLM or Implementing manual WLM.

The default number of concurrency scaling clusters is one. The number of concurrency scaling clusters that can be used is controlled by max_concurrency_scaling_clusters.

Monitoring concurrency scaling

With Amazon Redshift, you can monitor and manage concurrency scaling to optimize performance and cost efficiency for your data warehousing workloads. Concurrency scaling allows Amazon Redshift to automatically add additional cluster capacity when workload demands increase, and remove that capacity when demands decrease. The following section provides guidance on monitoring concurrency scaling for your Amazon Redshift clusters.

You can see whether a query is running on the main cluster or a concurrency scaling cluster by navigating to **Cluster** in the Amazon Redshift console and choosing a cluster. Then choose the **Query monitoring** tab and **Workload concurrency** to view information about running queries and queued queries.

To find execution times, query the STL_QUERY table and filter on the `concurrency_scaling_status` column. The following query compares the queue time and execution time for queries run on the concurrency scaling cluster and queries run on the main cluster.

```
SELECT w.service_class AS queue
, CASE WHEN q.concurrency_scaling_status = 1 THEN 'concurrency scaling cluster' ELSE
 'main cluster' END as concurrency_scaling_status
, COUNT( * ) AS queries
, SUM( q.aborted ) AS aborted
, SUM( ROUND( total_queue_time::NUMERIC / 1000000,2) ) AS queue_secs
, SUM( ROUND( total_exec_time::NUMERIC / 1000000,2) ) AS exec_secs
FROM stl_query q
JOIN stl_wlm_query w
USING (userid,query)
WHERE q.userid > 1
AND q.starttime > '2019-01-04 16:38:00'
```

```
AND q.endtime < '2019-01-04 17:40:00'
GROUP BY 1,2
ORDER BY 1,2;
```

Adjust the `starttime` and `endtime` values according to your requirements.

Concurrency scaling system views

With Amazon Redshift, you can use Concurrency scaling system views to monitor and manage concurrency scaling activity in your cluster. The following section describes querying these system views and interpreting the results to effectively leverage concurrency scaling in your Amazon Redshift environment.

A set of system views with the prefix SVCS provides details from the system log tables about queries on both the main and concurrency scaling clusters.

The following views have similar information as the corresponding STL views or SVL views:

- SVCS_ALERT_EVENT_LOG
- SVCS_COMPILE
- SVCS_EXPLAIN
- SVCS_PLAN_INFO
- SVCS_QUERY_SUMMARY
- SVCS_STREAM_SEGS

The following views are specific to concurrency scaling.

- SVCS_CONCURRENCY_SCALING_USAGE

For more information about concurrency scaling, see the following topics in the *Amazon Redshift Management Guide*.

- Viewing Concurrency Scaling Data
- Viewing Cluster Performance During Query Execution
- Viewing Query Details

Short query acceleration

Short query acceleration (SQA) prioritizes selected short-running queries ahead of longer-running queries. SQA runs short-running queries in a dedicated space, so that SQA queries aren't forced to wait in queues behind longer queries. SQA only prioritizes queries that are short-running and are in a user-defined queue. With SQA, short-running queries begin running more quickly and users see results sooner.

If you enable SQA, you can reduce workload management (WLM) queues that are dedicated to running short queries. In addition, long-running queries don't need to contend with short queries for slots in a queue, so you can configure your WLM queues to use fewer query slots. When you use lower concurrency, query throughput is increased and overall system performance is improved for most workloads.

CREATE TABLE AS (CTAS) statements and read-only queries, such as SELECT statements, are eligible for SQA.

Amazon Redshift uses a machine learning algorithm to analyze each eligible query and predict the query's execution time. By default, WLM dynamically assigns a value for the SQA maximum runtime based on analysis of your cluster's workload. Alternatively, you can specify a fixed value of 1–20 seconds. If the query's predicted run time is less than the defined or dynamically assigned SQA maximum runtime and the query is waiting in a WLM queue, SQA separates the query from the WLM queues and schedules it for priority execution. If a query runs longer than the SQA maximum runtime, WLM moves the query to the first matching WLM queue based on the WLM queue assignment rules. Over time, predictions improve as SQA learns from your query patterns.

SQA is enabled by default in the default parameter group and for all new parameter groups. To disable SQA in the Amazon Redshift console, edit the WLM configuration for a parameter group and deselect **Enable short query acceleration**. As a best practice, we recommend using a WLM query slot count of 15 or fewer to maintain optimum overall system performance. For information about modifying WLM configurations, see Configuring Workload Management in the *Amazon Redshift Management Guide*.

Maximum runtime for short queries

When you enable SQA, WLM sets the maximum runtime for short queries to dynamic by default. We recommend keeping the dynamic setting for SQA maximum runtime. You can override the default setting by specifying a fixed value of 1–20 seconds.

In some cases, you might consider using different values for the SQA maximum runtime values to improve your system performance. In such cases, analyze your workload to find the maximum execution time for most of your short-running queries. The following query returns the maximum runtime for queries at about the 70th percentile.

```
select least(greatest(percentile_cont(0.7)
within group (order by total_exec_time / 1000000) + 2, 2), 20)
from stl_wlm_query
where userid >= 100
and final_state = 'Completed';
```

After you identify a maximum runtime value that works well for your workload, you don't need to change it unless your workload changes significantly.

Monitoring SQA

To check whether SQA is enabled, run the following query. If the query returns a row, then SQA is enabled.

```
select * from stv_wlm_service_class_config
where service_class = 14;
```

The following query shows the number of queries that went through each query queue (service class). It also shows the average execution time, the number of queries with wait time at the 90th percentile, and the average wait time. SQA queries use in service class 14.

```
select final_state, service_class, count(*), avg(total_exec_time),
percentile_cont(0.9) within group (order by total_queue_time), avg(total_queue_time)
from stl_wlm_query where userid >= 100 group by 1,2 order by 2,1;
```

To find which queries were picked up by SQA and completed successfully, run the following query.

```
select a.queue_start_time, a.total_exec_time, label, trim(querytxt)
from stl_wlm_query a, stl_query b
where a.query = b.query and a.service_class = 14 and a.final_state = 'Completed'
order by b.query desc limit 5;
```

To find queries that SQA picked up but that timed out, run the following query.

```
select a.queue_start_time, a.total_exec_time, label, trim(querytxt)
from stl_wlm_query a, stl_query b
where a.query = b.query and a.service_class = 14 and a.final_state = 'Evicted'
order by b.query desc limit 5;
```

For more information about evicted queries and, more generally, rule-based actions that can be taken on queries, see WLM query monitoring rules.

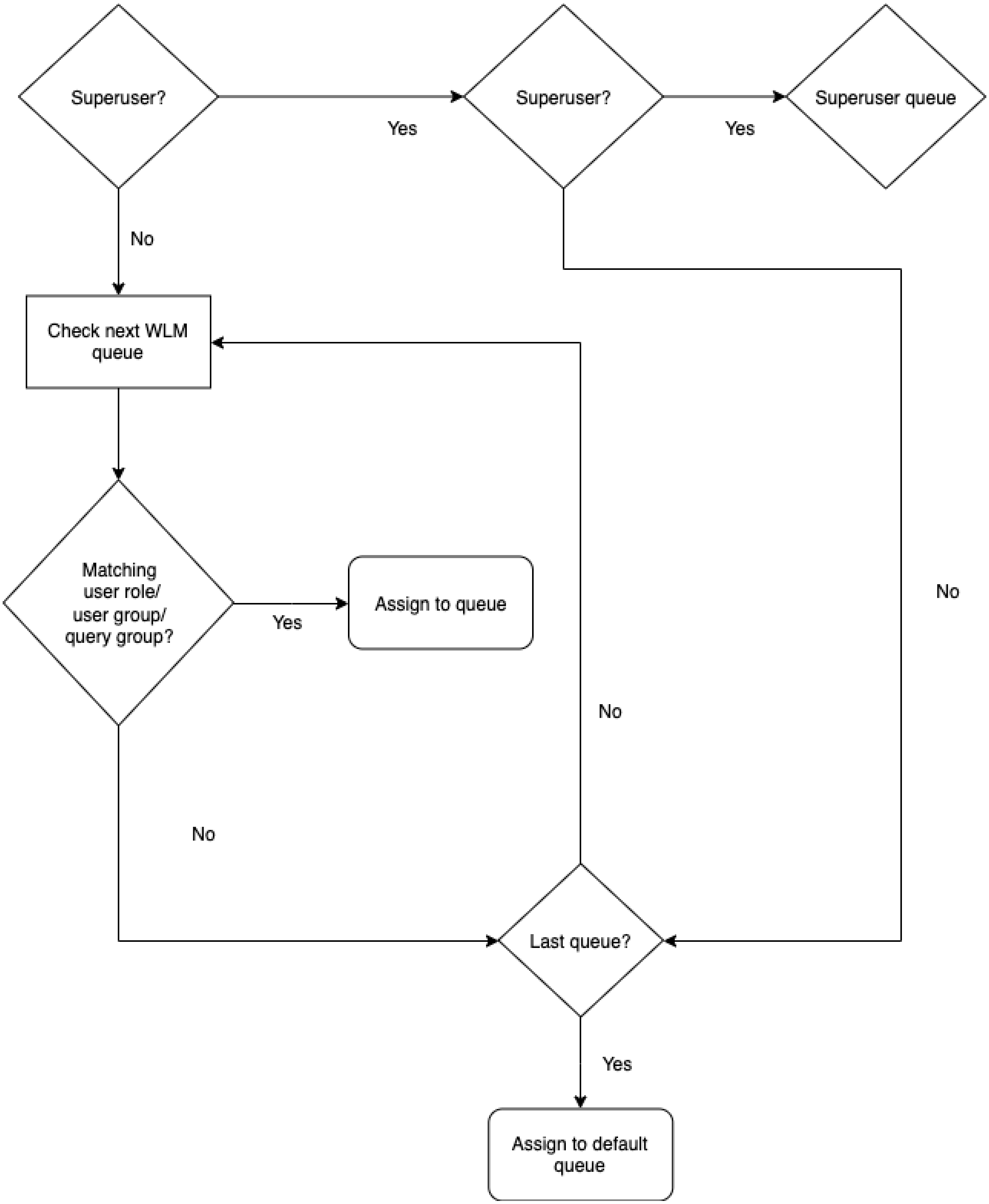
WLM queue assignment rules

With Amazon Redshift, you can control the allocation of memory and CPU resources to user queries by defining queue assignment rules in a workload management (WLM) configuration. The following section describes creating and managing WLM queue assignment rules to achieve efficient resource allocation and meet service-level agreements for diverse workloads in Amazon Redshift.

When a user runs a query, WLM assigns the query to the first matching queue, based on the WLM queue assignment rules:

1. If a user is logged in as a superuser and runs a query in the query group labeled superuser, the query is assigned to the superuser queue.
2. If a user is part of a role, belongs to a listed user group, or runs a query within a listed query group, the query is assigned to the first matching queue.
3. If a query doesn't meet any criteria, the query is assigned to the default queue, which is the last queue defined in the WLM configuration.

The following diagram illustrates how these rules work.

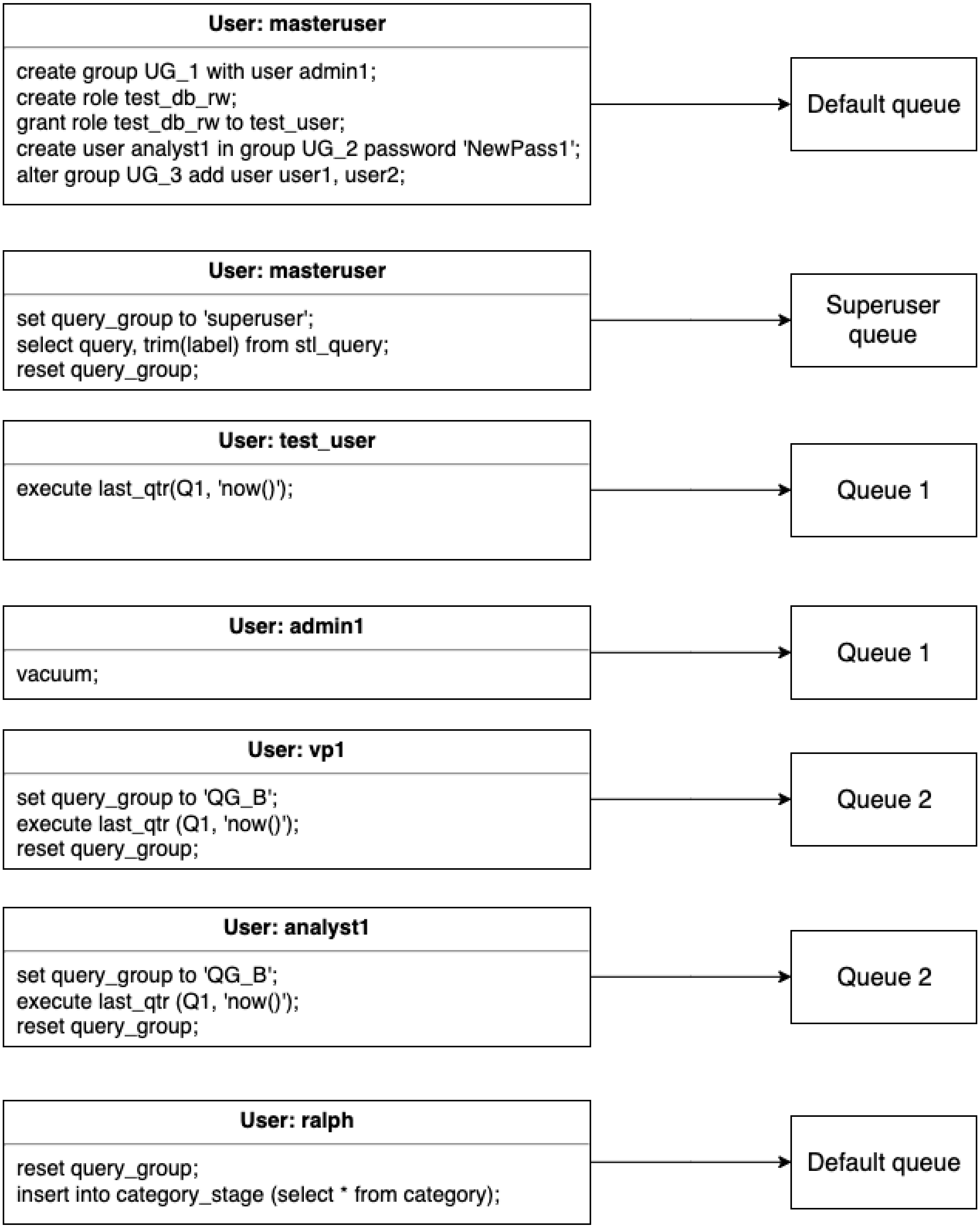

Superuser?
Yes
Superuser?
Yes
Superuser queue
No
Check next WLM queue
Matching user role/ user group/ query group?
Yes
Assign to queue
No
No
No
Last queue?
Yes
Assign to default queue

Queue assignments example

The following table shows a WLM configuration with the superuser queue and four user-defined queues.

Queue	Concurrency	User Roles	User Groups	Query Groups
Superuser	1			superuser
1	5	test_db_rw	UG_1	
2	5			QG_B
3	5		UG_2	QG_C
Default	5			

The following illustration shows how queries are assigned to the queues in the previous table according to user groups and query groups. For information about how to assign queries to user groups and query groups at runtime, see Assigning queries to queues later in this section.



In this example, WLM makes the following assignments:

1. The first set of statements shows three ways to assign users to user groups. The statements are run by the user `adminuser`, which is not a member of a user group listed in any WLM queue. No query group is set, so the statements are routed to the default queue.
2. The user `adminuser` is a superuser and the query group is set to `'superuser'`, so the query is assigned to the superuser queue.
3. The user `test_user` is assigned the role `test_db_rw` listed in queue 1, so the query is assigned to queue 1.
4. The user `admin1` is a member of the user group listed in queue 1, so the query is assigned to queue 1.
5. The user `vp1` is not a member of any listed user group. The query group is set to `'QG_B'`, so the query is assigned to queue 2.
6. The user `analyst1` is a member of the user group listed in queue 3, but `'QG_B'` matches queue 2, so the query is assigned to queue 2.
7. The user `ralph` is not a member of any listed user group and the query group was reset, so there is no matching queue. The query is assigned to the default queue.

Assigning queries to queues

With Amazon Redshift, you can manage workload concurrency and prioritize queries by assigning them to queues. Queues allow you to allocate resources like memory and CPU for different types of queries or users, ensuring critical queries get prioritized over less important ones. The following sections describe how to create queues, configure their properties, and assign incoming queries based on criteria you define.

The following examples assign queries to queues according to user roles, user groups, and query groups.

Assigning queries to queues based on user roles

If a user is assigned to a role and that role is attached to a queue, then queries run by that user are assigned to that queue. The following example creates a user role named `sales_rw` and assigns the user `test_user` to that role.

```
create role sales_rw;
grant role sales_rw to test_user;
```

You can also combine permissions of two roles by explicitly granting one role to another role. Assigning a nested role to a user grants permissions of both roles to the user.

```
create role sales_rw;
create role sales_ro;
grant role sales_ro to role sales_rw;
grant role sales_rw to test_user;
```

To see the list of users that have been granted roles in the cluster, query the SVV_USER_GRANTS table. To see the list of roles that have been granted roles in the cluster, query the SVV_ROLE_GRANTS table.

```
select * from svv_user_grants;
select * from svv_role_grants;
```

Assigning queries to queues based on user groups

If a user group name is listed in a queue definition, queries run by members of that user group are assigned to the corresponding queue. The following example creates user groups and adds users to groups by using the SQL commands CREATE USER, CREATE GROUP, and ALTER GROUP.

```
create group admin_group with user admin246, admin135, sec555;
create user vp1234 in group ad_hoc_group password 'vpPass1234';
alter group admin_group add user analyst44, analyst45, analyst46;
```

Assigning a query to a query group

You can assign a query to a queue at runtime by assigning your query to the appropriate query group. Use the SET command to begin a query group.

```
SET query_group TO group_label
```

Here, *group_label* is a query group label that is listed in the WLM configuration.

All queries that you run after the `SET query_group` command run as members of the specified query group until you either reset the query group or end your current login session. For information about setting and resetting Amazon Redshift objects, see SET and RESET in the SQL Command Reference.

The query group labels that you specify must be included in the current WLM configuration; otherwise, the *SET query_group* command has no effect on query queues.

The label defined in the TO clause is captured in the query logs so that you can use the label for troubleshooting. For information about the query_group configuration parameter, see query_group in the Configuration Reference.

The following example runs two queries as part of the query group 'priority' and then resets the query group.

```
set query_group to 'priority';
select count(*)from stv_blocklist;
select query, elapsed, substring from svl_qlog order by query desc limit 5;
reset query_group;
```

Assigning queries to the superuser queue

To assign a query to the superuser queue, log on to Amazon Redshift as a superuser and then run the query in the superuser group. When you are done, reset the query group so that subsequent queries do not run in the superuser queue.

The following example assigns two commands to run in the superuser queue.

```
set query_group to 'superuser';

analyze;
vacuum;
reset query_group;
```

To view a list of superusers, query the PG_USER system catalog table.

```
select * from pg_user where usesuper = 'true';
```

WLM dynamic and static configuration properties

The WLM configuration properties are either dynamic or static. You can apply dynamic properties to the database without a cluster reboot, but static properties require a cluster reboot for changes to take effect. However, if you change dynamic and static properties at the same time, then you must reboot the cluster for all the property changes to take effect. This is true whether the changed properties are dynamic or static.

While dynamic properties are being applied, your cluster status is `modifying`. Switching between automatic WLM and manual WLM is a static change and requires a cluster reboot to take effect.

The following table indicates which WLM properties are dynamic or static when using automatic WLM or manual WLM.

WLM Property	Automatic WLM	Manual WLM
Query groups	Dynamic	Static
Query group wildcard	Dynamic	Static
User groups	Dynamic	Static
User group wildcard	Dynamic	Static
User roles	Dynamic	Static
User role wildcard	Dynamic	Static
Concurrency on main	Not applicable	Dynamic
Concurrency Scaling mode	Dynamic	Dynamic
Enable short query accelerat ion	Not applicable	Dynamic
Maximum runtime for short queries	Dynamic	Dynamic
Percent of memory to use	Not applicable	Dynamic
Timeout	Not applicable	Dynamic
Priority	Dynamic	Not applicable
Adding or removing queues	Dynamic	Static

If you add a query monitoring rule (QMR), or modify or delete an existing QMR, the change happens automatically without the need to restart the cluster.

> **Note**
>
> When using manual WLM, if the timeout value is changed, the new value is applied to any query that begins running after the value is changed. If the concurrency or percent of memory to use are changed, Amazon Redshift changes to the new configuration dynamically. Thus, currently running queries aren't affected by the change. For more information, see WLM Dynamic Memory Allocation.

Topics

- WLM dynamic memory allocation
- Dynamic WLM example

WLM dynamic memory allocation

In each queue, WLM creates a number of query slots equal to the queue's concurrency level. The amount of memory allocated to a query slot equals the percentage of memory allocated to the queue divided by the slot count. If you change the memory allocation or concurrency, Amazon Redshift dynamically manages the transition to the new WLM configuration. Thus, active queries can run to completion using the currently allocated amount of memory. At the same time, Amazon Redshift ensures that total memory usage never exceeds 100 percent of available memory.

The workload manager uses the following process to manage the transition:

1. WLM recalculates the memory allocation for each new query slot.
2. If a query slot is not actively being used by a running query, WLM removes the slot, which makes that memory available for new slots.
3. If a query slot is actively in use, WLM waits for the query to finish.
4. As active queries complete, the empty slots are removed and the associated memory is freed.
5. As enough memory becomes available to add one or more slots, new slots are added.
6. When all queries that were running at the time of the change finish, the slot count equals the new concurrency level, and the transition to the new WLM configuration is complete.

In effect, queries that are running when the change takes place continue to use the original memory allocation. Queries that are queued when the change takes place are routed to new slots as they become available.

If the WLM dynamic properties are changed during the transition process, WLM immediately begins to transition to the new configuration, starting from the current state. To view the status of the transition, query the STV_WLM_SERVICE_CLASS_CONFIG system table.

Dynamic WLM example

With Amazon Redshift, you can automatically manage workload distribution and resource allocation across your Amazon Redshift clusters using Dynamic WLM (Workload Management). Dynamic WLM is an example of a Workload Management (WLM) configuration that dynamically adjusts memory allocations based on workload demands, allowing for optimal concurrency and performance. The following section provides details on implementing and configuring Dynamic WLM for your Amazon Redshift clusters.

Suppose that your cluster WLM is configured with two queues, using the following dynamic properties.

Queue	Concurrency	% Memory to Use
1	4	50%
2	4	50%

Now suppose that your cluster has 200 GB of memory available for query processing. (This number is arbitrary and used for illustration only.) As the following equation shows, each slot is allocated 25 GB.

```
(200 GB * 50% ) / 4 slots  = 25 GB
```

Next, you change your WLM to use the following dynamic properties.

Queue	Concurrency	% Memory to Use
1	3	75%

Queue	Concurrency	% Memory to Use
2	4	25%

As the following equation shows, the new memory allocation for each slot in queue 1 is 50 GB.

```
(200 GB * 75% ) / 3 slots = 50 GB
```

Suppose that queries A1, A2, A3, and A4 are running when the new configuration is applied, and queries B1, B2, B3, and B4 are queued. WLM dynamically reconfigures the query slots as follows.

Step	Queries Running	Current Slot Count	Target Slot Count	Allocated Memory	Available Memory
1	A1, A2, A3, A4	4	0	100 GB	50 GB
2	A2, A3, A4	3	0	75 GB	75 GB
3	A3, A4	2	0	50 GB	100 GB
4	A3, A4, B1	2	1	100 GB	50 GB
5	A4, B1	1	1	75 GB	75 GB
6	A4, B1, B2	1	2	125 GB	25 GB
7	B1, B2	0	2	100 GB	50 GB
8	B1, B2, B3	0	3	150 GB	0 GB

1. WLM recalculates the memory allocation for each query slot. Originally, queue 1 was allocated 100 GB. The new queue has a total allocation of 150 GB, so the new queue immediately has 50 GB available. Queue 1 is now using four slots, and the new concurrency level is three slots, so no new slots are added.

2. When one query finishes, the slot is removed and 25 GB is freed. Queue 1 now has three slots and 75 GB of available memory. The new configuration needs 50 GB for each new slot, but the new concurrency level is three slots, so no new slots are added.
3. When a second query finishes, the slot is removed, and 25 GB is freed. Queue 1 now has two slots and 100 GB of free memory.
4. A new slot is added using 50 GB of the free memory. Queue 1 now has three slots, and 50 GB free memory. Queued queries can now be routed to the new slot.
5. When a third query finishes, the slot is removed, and 25 GB is freed. Queue 1 now has two slots, and 75 GB of free memory.
6. A new slot is added using 50 GB of the free memory. Queue 1 now has three slots, and 25 GB free memory. Queued queries can now be routed to the new slot.
7. When the fourth query finishes, the slot is removed, and 25 GB is freed. Queue 1 now has two slots and 50 GB of free memory.
8. A new slot is added using the 50 GB of free memory. Queue 1 now has three slots with 50 GB each and all available memory has been allocated.

The transition is complete and all query slots are available to queued queries.

WLM query monitoring rules

In Amazon Redshift workload management (WLM), query monitoring rules define metrics-based performance boundaries for WLM queues and specify what action to take when a query goes beyond those boundaries. For example, for a queue dedicated to short running queries, you might create a rule that cancels queries that run for more than 60 seconds. To track poorly designed queries, you might have another rule that logs queries that contain nested loops.

You define query monitoring rules as part of your workload management (WLM) configuration. You can define up to 25 rules for each queue, with a limit of 25 rules for all queues. Each rule includes up to three conditions, or predicates, and one action. A *predicate* consists of a metric, a comparison condition (=, <, or >), and a value. If all of the predicates for any rule are met, that rule's action is triggered. Possible rule actions are log, hop, and abort, as discussed following.

The rules in a given queue apply only to queries running in that queue. A rule is independent of other rules.

WLM evaluates metrics every 10 seconds. Amazon Redshift applies query monitoring rules at the child query level when queries are automatically rewritten. If more than one rule is triggered during the same period, WLM chooses the rule with the most severe action. If the action for two rules has the same severity, WLM runs the rules in alphabetical order, based on the rule name. If the action is hop or abort, the action is logged and the query is evicted from the queue. If the action is log, the query continues to run in the queue. WLM initiates only one log action per query per rule. If the queue contains other rules, those rules remain in effect. If the action is hop and the query is routed to another queue, the rules for the new queue apply. For more information about query monitoring and tracking actions taken on specific queries, see the collection of samples at Short query acceleration.

When all of a rule's predicates are met, WLM writes a row to the STL_WLM_RULE_ACTION system table. In addition, Amazon Redshift records query metrics for currently running queries to STV_QUERY_METRICS. Metrics for completed queries are stored in STL_QUERY_METRICS.

Defining a query monitoring rule

You create query monitoring rules as part of your WLM configuration, which you define as part of your cluster's parameter group definition.

You can create rules using the AWS Management Console or programmatically using JSON.

> **Note**
>
> If you choose to create rules programmatically, we strongly recommend using the console to generate the JSON that you include in the parameter group definition. For more information, see Creating or modifying a query monitoring rule using the console and Configuring Parameter Values Using the AWS CLI in the *Amazon Redshift Management Guide*.

To define a query monitoring rule, you specify the following elements:

- A rule name – Rule names must be unique within the WLM configuration. Rule names can be up to 32 alphanumeric characters or underscores, and can't contain spaces or quotation marks. You can have up to 25 rules per queue, and the total limit for all queues is 25 rules.
- One or more predicates – You can have up to three predicates per rule. If all the predicates for any rule are met, the associated action is triggered. A predicate is defined by a metric name, an operator (=, <, or >), and a value. An example is `query_cpu_time > 100000`. For a list of metrics and examples of values for different metrics, see Query monitoring metrics for Amazon Redshift provisioned following in this section.

- An action – If more than one rule is triggered, WLM chooses the rule with the most severe action. Possible actions, in ascending order of severity, are:
  - Log – Record information about the query in the STL_WLM_RULE_ACTION system table. Use the Log action when you want to only write a log record. WLM creates at most one log per query, per rule. Following a log action, other rules remain in force and WLM continues to monitor the query.
  - Hop (only available with manual WLM) – Log the action and hop the query to the next matching queue. If there isn't another matching queue, the query is canceled. QMR hops only CREATE TABLE AS (CTAS) statements and read-only queries, such as SELECT statements. For more information, see WLM query queue hopping.
  - Abort – Log the action and cancel the query. QMR doesn't stop COPY statements and maintenance operations, such as ALTER, ANALYZE and VACUUM.
  - Change priority (only available with automatic WLM) – Change the priority of a query.

To limit the runtime of queries, we recommend creating a query monitoring rule instead of using WLM timeout. For example, you can set `max_execution_time` to 50,000 milliseconds as shown in the following JSON snippet.

```
"max_execution_time": 50000
```

But we recommend instead that you define an equivalent query monitoring rule. The following example demonstrates a query monitoring rule that sets `query_execution_time` to 50 seconds:

```
"rules":
[
    {
        "rule_name": "rule_query_execution",
        "predicate": [
            {
                "metric_name": "query_execution_time",
                "operator": ">",
                "value": 50
            }
        ],
        "action": "abort"
    }
]
```

For steps to create or modify a query monitoring rule, see Creating or modifying a query monitoring rule using the console and Properties in the wlm_json_configuration Parameter in the *Amazon Redshift Management Guide*.

You can find more information about query monitoring rules in the following topics:

- Query monitoring metrics for Amazon Redshift provisioned
- Query monitoring rules templates
- Creating a Rule Using the Console
- Configuring Workload Management
- System tables and views for query monitoring rules

Query monitoring metrics for Amazon Redshift provisioned

The following table describes the metrics used in query monitoring rules. (These metrics are distinct from the metrics stored in the STV_QUERY_METRICS and STL_QUERY_METRICS system tables.)

For a given metric, the performance threshold is tracked either at the query level or the segment level. For more information about segments and steps, see Query planning and execution workflow.

> **Note**
>
> The WLM timeout parameter is distinct from query monitoring rules.

Metric	Name	Description
Query CPU time	`query_cpu_time`	CPU time used by the query, in seconds. CPU time is distinct from `Query execution time`. Valid values are 0–999,999.
Blocks read	`query_blocks_read`	Number of 1 MB data blocks read by the query.

Metric	Name	Description
		Valid values are 0–1,048,575.
Scan row count	`scan_row_count`	The number of rows in a scan step. The row count is the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters. Valid values are 0–999,999,999,999,999.
Query execution time	`query_execution_time`	Elapsed execution time for a query, in seconds. Execution time doesn't include time spent waiting in a queue. Valid values are 0–86,399.
Query queue time	`query_queue_time`	Time spent waiting in a queue, in seconds. Valid values are 0–86,399.
CPU usage	`query_cpu_usage_percent`	Percent of CPU capacity used by the query. Valid values are 0–6,399.
Memory to disk	`query_temp_blocks_to_disk`	Temporary disk space used to write intermediate results, in 1 MB blocks. Valid values are 0–319,815,679.
CPU skew	`cpu_skew`	The ratio of maximum CPU usage for any slice to average CPU usage for all slices. This metric is defined at the segment level. Valid values are 0–99.

Metric	Name	Description
I/O skew	`io_skew`	The ratio of maximum blocks read (I/O) for any slice to average blocks read for all slices. This metric is defined at the segment level. Valid values are 0–99.
Rows joined	`join_row_count`	The number of rows processed in a join step. Valid values are 0–999,999,999,999,999.
Nested loop join row count	`nested_loop_join_row_count`	The number or rows in a nested loop join. Valid values are 0–999,999,999,999,999.
Return row count	`return_row_count`	The number of rows returned by the query. Valid values are 0–999,999,999,999,999.
Segment execution time	`segment_execution_time`	Elapsed execution time for a single segment, in seconds. To avoid or reduce sampling errors, include `segment_execution_time > 10` in your rules. Valid values are 0–86,388.
Spectrum scan row count	`spectrum_scan_row_count`	The number of rows of data in Amazon S3 scanned by an Amazon Redshift Spectrum query. Valid values are 0–999,999,999,999,999.
Spectrum scan size	`spectrum_scan_size_mb`	The size of data in Amazon S3, in MB, scanned by an Amazon Redshift Spectrum query. Valid values are 0–999,999,999,999,999.

Metric	Name	Description
Query priority	`query_priority`	The priority of the query. Valid values are `HIGHEST`, `HIGH`, `NORMAL`, `LOW`, and `LOWEST`. When comparing `query_priority` using greater than (>) and less than (<) operators, `HIGHEST` is greater than `HIGH`, `HIGH` is greater than `NORMAL`, and so on.

Note

- The hop action is not supported with the `query_queue_time` predicate. That is, rules defined to hop when a `query_queue_time` predicate is met are ignored.
- Short segment execution times can result in sampling errors with some metrics, such as `io_skew` and `query_cpu_usage_percent`. To avoid or reduce sampling errors, include segment execution time in your rules. A good starting point is `segment_execution_time > 10`.

The SVL_QUERY_METRICS view shows the metrics for completed queries. The SVL_QUERY_METRICS_SUMMARY view shows the maximum values of metrics for completed queries. Use the values in these views as an aid to determine threshold values for defining query monitoring rules.

Query monitoring metrics for Amazon Redshift Serverless

The following table describes the metrics used in query monitoring rules for Amazon Redshift Serverless.

Metric	Name	Description
Blocks read	`max_query_blocks_read`	Number of 1 MB data blocks read by the query. Valid values are 0–1,048,575.

Metric	Name	Description
Scan row count	`max_scan_row_count`	The number of rows in a scan step. The row count is the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters. Valid values are 0–999,999,999,999,999.
Query execution time	max_query_execution_time	Elapsed execution time for a query, in seconds. Execution time doesn't include time spent waiting in a queue. If a query exceeds the set execution time, Amazon Redshift Serverless stops the query. Valid values are 0–86,399.
Query queue time	`max_query_queue_time`	Time spent waiting in a queue, in seconds. Valid values are 0–86,399.
Memory to disk	`max_query_temp_blocks_to_disk`	Temporary disk space used to write intermediate results, in 1 MB blocks. Valid values are 0–319,815,679.
Rows joined	`max_join_row_count`	The number of rows processed in a join step. Valid values are 0–999,999,999,999,999.
Nested loop join row count	`max_nested_loop_join_row_count`	The number or rows in a nested loop join. Valid values are 0–999,999,999,999,999.

> **Note**
>
> - The hop action is not supported with the `max_query_queue_time` predicate. That is, rules defined to hop when a `max_query_queue_time` predicate is met are ignored.
> - Short segment execution times can result in sampling errors with some metrics, such as `max_io_skew` and `max_query_cpu_usage_percent`.

Query monitoring rules templates

When you add a rule using the Amazon Redshift console, you can choose to create a rule from a predefined template. Amazon Redshift creates a new rule with a set of predicates and populates the predicates with default values. The default action is log. You can modify the predicates and action to meet your use case.

The following table lists available templates.

Template Name	Predicates	Description
Nested loop join	`nested_loop_join_row_count > 100`	A nested loop join might indicate an incomplete join predicate, which often results in a very large return set (a Cartesian product). Use a low row count to find a potentially runaway query early.
Query returns a high number of rows	`return_row_count > 1000000`	If you dedicate a queue to simple, short running queries, you might include a rule that finds queries returning a high row count. The template uses a default of 1 million rows. For some systems, you might consider one million rows to be high, or in a larger system, a billion or more rows might be high.
Join with a high number of rows	`join_row_count > 1000000000`	A join step that involves an unusually high number of rows might indicate a need for more restrictive filters. The template uses a default of 1 billion rows. For an ad hoc (one-

Template Name	Predicates	Description
		time) queue that's intended for quick, simple queries, you might use a lower number.
High disk usage when writing intermediate results	`query_temp_blocks_to_disk > 100000`	When currently executing queries use more than the available system RAM, the query execution engine writes intermediate results to disk (spilled memory). Typically, this condition is the result of a rogue query, which usually is also the query that uses the most disk space. The acceptable threshold for disk usage varies based on the cluster node type and number of nodes. The template uses a default of 100,000 blocks, or 100 GB. For a small cluster, you might use a lower number.
Long running query with high I/O skew	`segment_execution_time > 120` and `io_skew > 1.30`	I/O skew occurs when one node slice has a much higher I/O rate than the other slices. As a starting point, a skew of 1.30 (1.3 times average) is considered high. High I/O skew is not always a problem, but when combined with a long running query time, it might indicate a problem with the distribution style or sort key.

System tables and views for query monitoring rules

When all of a rule's predicates are met, WLM writes a row to the STL_WLM_RULE_ACTION system table. This row contains details for the query that triggered the rule and the resulting action.

In addition, Amazon Redshift records query metrics the following system tables and views.

- The STV_QUERY_METRICS table displays the metrics for currently running queries.
- The STL_QUERY_METRICS table records the metrics for completed queries.
- The SVL_QUERY_METRICS view shows the metrics for completed queries.

- The SVL_QUERY_METRICS_SUMMARY view shows the maximum values of metrics for completed queries.

WLM system tables and views

WLM configures query queues according to WLM service classes, which are internally defined. Amazon Redshift creates several internal queues according to these service classes along with the queues defined in the WLM configuration. The terms *queue* and *service class* are often used interchangeably in the system tables. The superuser queue uses service class 5. User-defined queues use service class 6 and greater.

You can view the status of queries, queues, and service classes by using WLM-specific system tables. Query the following system tables to do the following:

- View which queries are being tracked and what resources are allocated by the workload manager.
- See which queue a query has been assigned to.
- View the status of a query that is currently being tracked by the workload manager.

Table Name	Description
STL_WLM_ERROR	Contains a log of WLM-related error events.
STL_WLM_QUERY	Lists queries that are being tracked by WLM.
STV_WLM_CLASSIFICATION_CONFIG	Shows the current classification rules for WLM.
STV_WLM_QUERY_QUEUE_STATE	Records the current state of the query queues.
STV_WLM_QUERY_STATE	Provides a snapshot of the current state of queries that are being tracked by WLM.
STV_WLM_QUERY_TASK_STATE	Contains the current state of query tasks.
STV_WLM_SERVICE_CLASS_CONFIG	Records the service class configurations for WLM.

Table Name	Description
STV_WLM_SERVICE_CLASS_STATE	Contains the current state of the service classes.
STL_WLM_RULE_ACTION	Records details about actions resulting from WLM query monitoring rules associated with user-defined queues.
STV_WLM_QMR_CONFIG	Records the configuration for WLM query monitoring rules (QMR).

You use the task ID to track a query in the system tables. The following example shows how to obtain the task ID of the most recently submitted user query:

```
select task from stl_wlm_query where exec_start_time =(select max(exec_start_time) from
 stl_wlm_query);

task
------
137
(1 row)
```

The following example displays queries that are currently executing or waiting in various service classes (queues). This query is useful in tracking the overall concurrent workload for Amazon Redshift:

```

select * from stv_wlm_query_state order by query;


xid |task|query|service_| wlm_start_  |  state   |queue_ | exec_
    |    |     |class   | time        |          |time   | time
----+----+-----+--------+-------------+---------+-------+--------
2645| 84 | 98  | 3      | 2010-10-... |Returning|   0   | 3438369
2650| 85 | 100 | 3      | 2010-10-... |Waiting  |   0   | 1645879
2660| 87 | 101 | 2      | 2010-10-... |Executing|   0   | 916046
2661| 88 | 102 | 1      | 2010-10-... |Executing|   0   | 13291
(4 rows)
```

WLM service class IDs

The following table lists the IDs assigned to service classes.

ID	Service class
1–4	Reserved for system use.
5	Used by the superuser queue.
6–13	Used by manual WLM queues that are defined in the WLM configuration.
14	Used by short query acceleration.
15	Reserved for maintenance activities run by Amazon Redshift.
100–107	Used by automatic WLM queue when **auto_wlm** is true.

Database security

You manage database security by controlling which users have access to which database objects. Users can be assigned roles or groups, and the permissions you grant to users, roles, or groups decides which database objects they can access.

Topics

Access to database objects depends on the permissions that you grant to users or roles. The following guidelines summarize how database security works:

- By default, permissions are granted only to the object owner.
- Amazon Redshift database users are named users that can connect to a database. A user is granted permissions in two ways: explicitly, by having those permissions assigned directly to the account, or implicitly, by being a member of a group that is granted permissions.
- Groups are collections of users that can be collectively assigned permissions for streamlined security maintenance.
- Schemas are collections of database tables and other database objects. Schemas are similar to file system directories, except that schemas cannot be nested. Users can be granted access to a single schema or to multiple schemas.

Additionally, Amazon Redshift employs the following features to give you finer control over which users have access to which database objects:

- Role-based access control (RBAC) lets you assign permissions to roles which you can then apply to users, letting you control permissions for large groups of users. Unlike groups, roles can inherit permissions from other roles.

  Row-level security (RLS) lets you define policies that restrict access to rows of your choosing, then apply those policies to users or groups.

  Dynamic data masking (DDM) further protects your data by transforming it at query runtime so that you can allow users access to data without exposing sensitive details.

For examples of security implementation, see Example for controlling user and group access.

For more information about protecting your data, see Security in Amazon Redshift in the *Amazon Redshift Management Guide*.

Amazon Redshift security overview

Amazon Redshift database security is distinct from other types of Amazon Redshift security. In addition to database security, which is described in this section, Amazon Redshift provides these features to manage security:

- **Sign-in credentials** — Access to your Amazon Redshift AWS Management Console is controlled by your AWS account permissions. For more information, see Sign-in credentials.
- **Access management** — To control access to specific Amazon Redshift resources, you define AWS Identity and Access Management (IAM) accounts. For more information, see Controlling access to Amazon Redshift resources.
- **Cluster security groups** — To grant other users inbound access to an Amazon Redshift cluster, you define a cluster security group and associate it with a cluster. For more information, see Amazon Redshift cluster security groups.
- **VPC** — To protect access to your cluster by using a virtual networking environment, you can launch your cluster in an Amazon Virtual Private Cloud (VPC). For more information, see Managing clusters in Virtual Private Cloud (VPC).
- **Cluster encryption** — To encrypt the data in all your user-created tables, you can turn on cluster encryption when you launch the cluster. For more information, see Amazon Redshift clusters.

- **SSL connections** — To encrypt the connection between your SQL client and your cluster, you can use secure sockets layer (SSL) encryption. For more information, see Connect to your cluster using SSL.
- **Load data encryption** — To encrypt your table load data files when you upload them to Amazon S3, you can use either server-side encryption or client-side encryption. When you load from server-side encrypted data, Amazon S3 handles decryption transparently. When you load from client-side encrypted data, the Amazon Redshift COPY command decrypts the data as it loads the table. For more information, see Uploading encrypted data to Amazon S3.
- **Data in transit** — To protect your data in transit within the AWS Cloud, Amazon Redshift uses hardware accelerated SSL to communicate with Amazon S3 or Amazon DynamoDB for COPY, UNLOAD, backup, and restore operations.
- **Column-level access control** — To have column-level access control for data in Amazon Redshift, use column-level grant and revoke statements without having to implement views-based access control or use another system.
- **Row-level security control** — To have row-level security control for data in Amazon Redshift, create and attach policies to roles or users that restrict access to rows defined in the policy.

Default database user permissions

When you create a database object, you are its owner. By default, only a superuser or the owner of an object can query, modify, or grant permissions on the object. For users to use an object, you must grant the necessary permissions to the user or the group that contains the user. Database superusers have the same permissions as database owners.

Amazon Redshift supports the following permissions: SELECT, INSERT, UPDATE, DELETE, REFERENCES, CREATE, TEMPORARY, and USAGE. Different permissions are associated with different object types. For information about database object permissions supported by Amazon Redshift, see the GRANT command.

Only the owner has the permission to modify or destroy an object.

By default, all users have CREATE and USAGE permissions on the PUBLIC schema of a database. To disallow users from creating objects in the PUBLIC schema of a database, use the REVOKE command to remove that permission.

To revoke a permission that was previously granted, use the REVOKE command. The permissions of the object owner, such as DROP, GRANT, and REVOKE permissions, are implicit and cannot be granted or revoked. Object owners can revoke their own ordinary permissions, for example, to make a table read-only for themselves and others. Superusers retain all permissions regardless of GRANT and REVOKE commands.

Superusers

Database superusers have the same permissions as database owners for all databases.

The *admin* user, which is the user you created when you launched the cluster, is a superuser.

You must be a superuser to create a superuser.

Amazon Redshift system tables and system views are either visible only to superusers or visible to all users. Only superusers can query system tables and system views that are designated "visible to superusers." For information, see SYS monitoring views.

Superusers can view all catalog tables. For information, see System catalog tables.

A database superuser bypasses all permission checks. Superusers retain all permissions regardless of GRANT and REVOKE commands. Be careful when using a superuser role. We recommend that you do most of your work as a role that is not a superuser. You can create an administrator role with more restrictive permissions. For more information about creating roles, see Role-based access control (RBAC)

To create a new database superuser, log on to the database as a superuser and issue a CREATE USER command or an ALTER USER command with the CREATEUSER permission.

```
CREATE USER adminuser CREATEUSER PASSWORD '1234Admin';
ALTER USER adminuser CREATEUSER;
```

To create, alter, or drop a superuser, use the same commands to manage users. For more information, see Creating, altering, and deleting users.

Users

You can create and manage database users using the Amazon Redshift SQL commands CREATE USER and ALTER USER. Or you can configure your SQL client with custom Amazon Redshift JDBC or ODBC drivers. These manage the process of creating database users and temporary passwords as part of the database logon process.

The drivers authenticate database users based on AWS Identity and Access Management (IAM) authentication. If you already manage user identities outside of AWS, you can use a SAML 2.0-compliant identity provider (IdP) to manage access to Amazon Redshift resources. You use an IAM role to configure your IdP and AWS to permit your federated users to generate temporary database credentials and log on to Amazon Redshift databases. For more information, see Using IAM authentication to generate database user credentials.

Amazon Redshift users can only be created and dropped by a database superuser. Users are authenticated when they log on to Amazon Redshift. They can own databases and database objects (for example, tables). They can also grant permissions on those objects to users, groups, and schemas to control who has access to which object. Users with CREATE DATABASE rights can create databases and grant permissions to those databases. Superusers have database ownership permissions for all databases.

Creating, altering, and deleting users

Database users are global across a data warehouse cluster (and not for each individual database).

- To create a user, use the CREATE USER command.
- To create a superuser, use the CREATE USER command with the CREATEUSER option.
- To remove an existing user, use the DROP USER command.
- To change a user, for example changing a password, use the ALTER USER command.
- To view a list of users, query the PG_USER catalog table.

```
select * from pg_user;

  usename    | usesysid | usecreatedb | usesuper | usecatupd |  passwd  | valuntil |
 useconfig
------------+----------+-------------+----------+-----------+----------+----------
+-----------
 rdsdb      |        1 | t           | t        | t         | ******** |          |
 masteruser |      100 | t           | t        | f         | ******** |          |
 dwuser     |      101 | f           | f        | f         | ******** |          |
 simpleuser |      102 | f           | f        | f         | ******** |          |
 poweruser  |      103 | f           | t        | f         | ******** |          |
 dbuser     |      104 | t           | f        | f         | ******** |          |
(6 rows)
```

Groups

Groups are collections of users who are all granted whatever permissions are associated with the group. You can use groups to assign permissions. For example, you can create different groups for sales, administration, and support and give the users in each group the appropriate access to the data they need for their work. You can grant or revoke permissions at the group level, and those changes will apply to all members of the group, except for superusers.

To view all user groups, query the PG_GROUP system catalog table:

```
select * from pg_group;
```

For example, to list all database users by group, run the following SQL.

```
SELECT u.usesysid
,g.groname
,u.usename
FROM pg_user u
LEFT JOIN pg_group g ON u.usesysid = ANY (g.grolist)
```

Creating, altering, and deleting groups

Only a superuser can create, alter, or drop groups.

You can perform the following actions:

- To create a group, use the CREATE GROUP command.
- To add users to or remove users from an existing group, use the ALTER GROUP command.
- To delete a group, use the DROP GROUP command. This command only drops the group, not its member users.

Example for controlling user and group access

This example creates user groups and users and then grants them various permissions for an Amazon Redshift database that connects to a web application client. This example assumes three groups of users: regular users of a web application, power users of a web application, and web developers.

For information about how to remove a user from a group, see ALTER GROUP.

1. Create the groups where the users will be assigned. The following set of commands creates three different user groups:

```
create group webappusers;

create group webpowerusers;

create group webdevusers;
```

2. Create several database users with different permissions and add them to the groups.

   a. Create two users and add them to the WEBAPPUSERS group:

   ```
   create user webappuser1 password 'webAppuser1pass'
   in group webappusers;

   create user webappuser2 password 'webAppuser2pass'
   in group webappusers;
   ```

   b. Create a web developer user and add it to the WEBDEVUSERS group:

   ```
   create user webdevuser1 password 'webDevuser2pass'
   in group webdevusers;
   ```

   c. Create a superuser. This user will have administrative rights to create other users:

   ```
   create user webappadmin  password 'webAppadminpass1'
   createuser;
   ```

3. Create a schema to be associated with the database tables used by the web application, and grant the various user groups access to this schema:

   a. Create the WEBAPP schema:

   ```
   create schema webapp;
   ```

   b. Grant USAGE permissions to the WEBAPPUSERS group:

   ```
   grant usage on schema webapp to group webappusers;
   ```

   c. Grant USAGE permissions to the WEBPOWERUSERS group:

```
grant usage on schema webapp to group webpowerusers;
```

d. Grant ALL permissions to the WEBDEVUSERS group:

```
grant all on schema webapp to group webdevusers;
```

The basic users and groups are now set up. You can now alter the users and groups.

4. For example, the following command alters the search_path parameter for the WEBAPPUSER1.

```
alter user webappuser1 set search_path to webapp, public;
```

The SEARCH_PATH specifies the schema search order for database objects, such as tables and functions, when the object is referenced by a simple name with no schema specified.

5. You can also add users to a group after creating the group, such as adding WEBAPPUSER2 to the WEBPOWERUSERS group:

```
alter group webpowerusers add user webappuser2;
```

Schemas

A database contains one or more named schemas. Each schema in a database contains tables and other kinds of named objects. By default, a database has a single schema, which is named PUBLIC. You can use schemas to group database objects under a common name. Schemas are similar to file system directories, except that schemas cannot be nested.

Identical database object names can be used in different schemas in the same database without conflict. For example, both MY_SCHEMA and YOUR_SCHEMA can contain a table named MYTABLE. Users with the necessary permissions can access objects across multiple schemas in a database.

By default, an object is created within the first schema in the search path of the database. For information, see Search path later in this section.

Schemas can help with organization and concurrency issues in a multiuser environment in the following ways:

- To let many developers work in the same database without interfering with each other.

- To organize database objects into logical groups to make them more manageable.
- To give applications the ability to put their objects into separate schemas so that their names will not collide with the names of objects used by other applications.

Search path

The search path is defined in the search_path parameter with a comma-separated list of schema names. The search path specifies the order in which schemas are searched when an object, such as a table or function, is referenced by a simple name that does not include a schema qualifier.

If an object is created without specifying a target schema, the object is added to the first schema that is listed in search path. When objects with identical names exist in different schemas, an object name that does not specify a schema will refer to the first schema in the search path that contains an object with that name.

To change the default schema for the current session, use the SET command.

For more information, see the search_path description in the Configuration Reference.

Creating, altering, and deleting schemas

Any user can create schemas and alter or drop schemas they own.

You can perform the following actions:

- To create a schema, use the CREATE SCHEMA command.
- To change the owner of a schema, use the ALTER SCHEMA command.
- To delete a schema and its objects, use the DROP SCHEMA command.
- To create a table within a schema, create the table with the format *schema_name.table_name*.

To view a list of all schemas, query the PG_NAMESPACE system catalog table:

```
select * from pg_namespace;
```

To view a list of tables that belong to a schema, query the PG_TABLE_DEF system catalog table. For example, the following query returns a list of tables in the PG_CATALOG schema.

```
select distinct(tablename) from pg_table_def
```

```
where schemaname = 'pg_catalog';
```

Schema-based permissions

Schema-based permissions are determined by the owner of the schema:

- By default, all users have CREATE and USAGE permissions on the PUBLIC schema of a database. To disallow users from creating objects in the PUBLIC schema of a database, use the REVOKE command to remove that permission.
- Unless they are granted the USAGE permission by the object owner, users cannot access any objects in schemas they do not own.
- If users have been granted the CREATE permission to a schema that was created by another user, those users can create objects in that schema.

Role-based access control (RBAC)

By using role-based access control (RBAC) to manage database permissions in Amazon Redshift, you can simplify the management of security permissions in Amazon Redshift. You can secure the access to sensitive data by controlling what users can do both at a broad or fine level. You can also control user access to tasks that are normally restricted to superusers. By assigning different permissions to different roles and assigning them to different users, you can have more granular control of user access.

Users with an assigned role can perform only the tasks that are specified by the assigned role that they are authorized with. For example, a user with the assigned role that has the CREATE TABLE and DROP TABLE permissions is only authorized to perform those tasks. You can control user access by granting different levels of security permissions to different users to access the data they require for their work.

RBAC applies the principle of least permissions to users based on their role requirements, regardless of the types of objects that are involved. Granting and revoking of permissions is performed at the role level, without the need to update permissions on individual database objects.

With RBAC, you can create roles with permissions to run commands that used to require superuser permissions. Users can run these commands, as long as they are authorized with a role that includes these permissions. Similarly, you can also create roles to limit the access to certain commands, and assign the role to either superusers or users that have been authorized with the role.

To learn how Amazon Redshift RBAC works, watch the following video: Introducing Role-based access control (RBAC) in Amazon Redshift.

Role hierarchy

Roles are collections of permissions that you can assign to a user or another role. You can assign system or database permissions to a role. A user inherits permissions from an assigned role.

In RBAC, users can have nested roles. You can grant roles to both users and roles. When granting a role to a user, you authorize the user with all the permissions that this role includes. When granting a role r1 to a user, you authorize the user with permissions from r1. The user now has permissions from r1 and also any existing permissions they already have.

When granting a role (r1) to another role (r2), you authorize r2 with all the permissions from r1. Also, when granting r2 to another role (r3), the permissions of r3 are the combination of the permissions from r1 and r2. Role hierarchy has r2 inherit permissions from r1. Amazon Redshift propagates permissions with each role authorization. Granting r1 to r2 and then r2 to r3 authorizes r3 with all the permissions from the three roles. Thus, by granting r3 to a user, the user has all the permissions from the three roles.

Amazon Redshift doesn't allow the creation of a role authorization cycle. A role authorization cycle happens when a nested role is assigned back to a role earlier in the role hierarchy, such as r3 being assigned back to r1. For more information about how to create roles and manage role assignments, see Managing roles in RBAC.

Role assignment

Superusers and regular users with the CREATE ROLE permissions can use the CREATE ROLE statement to create roles. Superusers and role administrators can use the GRANT ROLE statement to grant a role to others. They can use the REVOKE ROLE statement to revoke a role from others, and the DROP ROLE statement to drop roles. Role administrators include role owners and users who have been granted the role with the ADMIN OPTION permission.

Only superusers or role administrators can grant and revoke roles. You can grant or revoke one or more roles to or from one or more roles or users. Use the WITH ADMIN OPTION option in the GRANT ROLE statement to provide the administration options for all the granted roles to all the grantees.

Amazon Redshift supports different combinations of role assignments, such as granting multiple roles or having multiple grantees. The WITH ADMIN OPTION only applies to users and not to roles. Similarly, use the WITH ADMIN OPTION option in the REVOKE ROLE statement to remove the role and the administrative authorization from the grantee. When used with the ADMIN OPTION, only the administrative authorization is revoked from the role.

The following example revokes the administrative authorization of the `sample_role2` role from `user2`.

```
REVOKE ADMIN OPTION FOR sample_role2 FROM user2;
```

For more information about how to create roles and manage role assignments, see Managing roles in RBAC.

Amazon Redshift system-defined roles

Amazon Redshift provides a few system-defined roles that are defined with specific permissions. System-specific roles start with a `sys:` prefix. Only users with appropriate access can alter system-defined roles or create custom system-defined roles. You can't use the `sys:` prefix for a custom system-defined role.

The following table summarizes the roles and their permissions.

Role name	Description		
`sys:monitor`	This role has the permission to access catalog or system tables.		
`sys:operator`	This role has the permissions to access catalog or system tables, analyze, vacuum, or cancel queries.		
`sys:dba`	This role has the permissions to create		

Role name	Description		
	schemas, create tables, drop schemas, drop tables, and truncate tables. It has the permissions to create or replace stored procedures, drop procedures, create or replace functions, create or replace external functions, create views, and drop views. Also, this role inherits all the permissions from the sys:operator role.		
`sys:superuser`	This role has all the supported system permissions defined in [System permissions for RBAC]().		

Role name	Description		
`sys:secadmin`	• This role has the permissions to create users, alter users, drop users, create roles, drop roles, and grant roles. • This role has permissions to turn RLS ON or OFF on a relation and permissions to manage RLS and DDM policies (CREATE, DROP, ATTACH, DETACH, and ALTER). Also, note that EXPLAIN RLS, IGNORE RLS, and EXPLAIN MASKING permissions are granted to this role by default. • This role can have access to user tables only when the permission is explicitly granted to the role.		

System-defined roles and users for data sharing

Amazon Redshift creates roles and users for internal use that correspond to datashares and datashare consumers. Each internal role name and user name has the reserved namespace prefix `ds:`. They have the following format:

Name	Description		
`ds:`*`sharename`*	A system role that corresponds with a datashare.		
`ds:`*`sharename_consumer`*	A system user that corresponds with a datashare consumer.		

A data sharing role is created for each datashare. It holds all permissions currently granted to the datashare. A data sharing user is created for each consumer of a datashare. It is granted permission to a single data sharing role. A consumer added to multiple datashares will have a data sharing user created for each datashare.

These users and roles are required for data sharing to work properly. They cannot be modified or dropped and they cannot be accessed or used for any tasks run by customers. You can safely ignore them. For more information about data sharing, see Sharing data across clusters in Amazon Redshift.

> **Note**
>
> You can't use the `ds:` prefix to create user-defined roles or users.

System permissions for RBAC

Following is a list of system permissions that you can grant to or revoke from a role.

Command	You must have permission by one of the following ways to run the command		
CREATE ROLE	• Superuser. • Users with the CREATE ROLE permission.		
DROP ROLE	• Superuser. • Role owner who is either the user that created the role or a user that has been granted the role with the WITH ADMIN OPTION permission.		
CREATE USER	• Superuser. • Users with the CREATE USER permission. These users can't create superusers.		
DROP USER	• Superuser. • Users with the DROP USER permission.		
ALTER USER	• Superuser. • Users with the ALTER USER permission. These		

Command	You must have permission by one of the following ways to run the command		
	users can't change users to superuser s or change superusers to users. • Current user who wants to change their own password.		
CREATE SCHEMA	• Superuser. • Users with the CREATE SCHEMA permission.		
DROP SCHEMA	• Superuser. • Users with the DROP SCHEMA permission. • Schema owner.		

Command	You must have permission by one of the following ways to run the command		
ALTER DEFAULT PRIVILEGES	• Superuser. • Users with the ALTER DEFAULT PRIVILEGES permission. • Users changing their own default access permissions. • Users setting permissions for schemas that they have access permissions to.		
ACCESS CATALOG	• Superuser. • Users with the ACCESS CATALOG permission.		
ACCESS SYSTEM TABLE	• Superuser. • Users with the ACCESS SYSTEM TABLE permission.		
CREATE TABLE	• Superuser. • Users with the CREATE TABLE permission. • Users with the CREATE permission on schemas.		

Command	You must have permission by one of the following ways to run the command		
DROP TABLE	• Superuser. • Users with the DROP TABLE permission. • Table owner with the USAGE permission on the schema.		
ALTER TABLE	• Superuser. • Users with the ALTER TABLE permission. • Table owner with the USAGE permission on the schema.		

Command	You must have permission by one of the following ways to run the command		
CREATE OR REPLACE FUNCTION	• For CREATE FUNCTION: • Superuser. • Users with the CREATE OR REPLACE FUNCTION permission. • Users with the USAGE permission on language. • For REPLACE FUNCTION: • Superuser. • Users with the CREATE OR REPLACE FUNCTION permission. • Function owner.		
CREATE OR REPLACE EXTERNAL FUNCTION	• Superuser. • Users with the CREATE OR REPLACE EXTERNAL FUNCTION permission.		

Command	You must have permission by one of the following ways to run the command		
DROP FUNCTION	- Superuser. - Users with the DROP FUNCTION permission. - Function owner.		
CREATE OR REPLACE PROCEDURE	- For CREATE PROCEDURE: - Superuser. - Users with the CREATE OR REPLACE PROCEDURE permission. - Users with the USAGE permission on language. - For REPLACE PROCEDURE: - Superuser. - Users with the CREATE OR REPLACE PROCEDURE permission. - Procedure owner.		

Command	You must have permission by one of the following ways to run the command		
DROP PROCEDURE	• Superuser. • Users with the DROP PROCEDURE permission. • Procedure owner.		
CREATE OR REPLACE VIEW	• For CREATE VIEW: • Superuser. • Users with the CREATE OR REPLACE VIEW permission. • Users with the CREATE permission on schemas. • For REPLACE VIEW: • Superuser. • Users with the CREATE OR REPLACE VIEW permission. • View owner.		
DROP VIEW	• Superuser. • Users with the DROP VIEW permission. • View owner.		

Command	You must have permission by one of the following ways to run the command		
CREATE MODEL	• Superuser. • Users with the CREATE MODEL system permission, who should be able to read the relation of the CREATE MODEL. • Users with the CREATE MODEL permission.		
DROP MODEL	• Superuser. • Users with the DROP MODEL permission. • Model owner. • Schema owner.		
CREATE DATASHARE	• Superuser. • Users with the CREATE DATASHARE permission. • Database owner.		

Command	You must have permission by one of the following ways to run the command		
ALTER DATASHARE	• Superuser. • User with the ALTER DATASHARE permission. • Users who have the ALTER or ALL permission on the datashare. • To add specific objects to a datashare, these users must have the permission on the objects. Users should be the owners of objects or have SELECT, USAGE, or ALL permissions on the objects.		
DROP DATASHARE	• Superuser. • Users with the DROP DATASHARE permission. • Database owner.		

Command	You must have permission by one of the following ways to run the command		
CREATE LIBRARY	• Superuser. • Users with the CREATE LIBRARY permission or with the permission of the specified language.		
DROP LIBRARY	• Superuser. • Users with the DROP LIBRARY permission. • Library owner.		
ANALYZE	• Superuser. • Users with the ANALYZE permission. • Owner of the relation. • Database owner whom the table is shared to.		

Command	You must have permission by one of the following ways to run the command		
CANCEL	• Superuser canceling their own query. • Superuser canceling a user's query. • Users with the CANCEL permission canceling a user's query. • User canceling their own query.		
TRUNCATE TABLE	• Superuser. • Users with the TRUNCATE TABLE permission. • Table owner.		
VACUUM	• Superuser. • Users with the VACUUM permission. • Table owner. • Database owner whom the table is shared to.		

Command	You must have permission by one of the following ways to run the command		
IGNORE RLS	• Superuser. • Users within the `sys:secadmin` role.		
EXPLAIN RLS	• Superuser. • Users within the `sys:secadmin` role.		
EXPLAIN MASKING	• Superuser. • Users within the `sys:secadmin` role.		

Database object permissions

Apart from system permissions, Amazon Redshift includes database object permissions that define access options. These include such options as the ability to read data in tables and views, write data, create tables, and drop tables. For more information, see GRANT.

By using RBAC, you can assign database object permissions to roles, similarly to how you can with system permissions. Then you can assign roles to users, authorize users with system permissions, and authorize users with database permissions.

ALTER DEFAULT PRIVILEGES for RBAC

Use the ALTER DEFAULT PRIVILEGES statement to define the default set of access permissions to be applied to objects that are created in the future by the specified user. By default, users can change only their own default access permissions. With RBAC, you can set the default access permissions for roles. For more information, see the ALTER DEFAULT PRIVILEGES command.

RBAC enables you to assign database object permissions to roles, similarly to system permissions. Then you can assign roles to users, authorize users with system and/or database permissions.

Considerations for role usage in RBAC

When working with RBAC roles, consider the following:

- Amazon Redshift doesn't allow cycles of role authorizations. You can't grant r1 to r2 and then grant r2 to r1.
- RBAC works for both native Amazon Redshift objects and Amazon Redshift Spectrum tables.
- As an Amazon Redshift administrator, you can turn on RBAC by upgrading your cluster to the latest maintenance patch to get started.
- Only superusers and users with the CREATE ROLE system permission can create roles.
- Only superusers and role administrators can modify or drop roles.
- A role name can't be the same as a user name.
- A role name can't contain invalid characters, such as “:/\n.”
- A role name can't be a reserved word, such as PUBLIC.
- The role name can't start with the reserved prefix for default roles, `sys:`.
- You can't drop a role that has the RESTRICT parameter when it is granted to another role. The default setting is RESTRICT. Amazon Redshift throws an error when you try to drop a role that has inherited another role.
- Users that don't have admin permissions on a role can't grant or revoke a role.
- RBAC isn't fully supported for system tables and views. RBAC permissions for system tables and views don’t persist through upgrades, downgrades, or resizes. We recommend using Amazon Redshift system-defined roles to manage system table and view permissions. For more information on system tables, go to System tables and views reference.

Managing roles in RBAC

To perform the following actions, use the following commands:

- To create a role, use the CREATE ROLE command.
- To rename a role or change the owner of the role, use the ALTER ROLE command.
- To delete a role, use the DROP ROLE command.

- To grant a role to a user, use the GRANT command.
- To revoke a role from a user, use the REVOKE command.
- To grant system permissions to a role, use the GRANT command.
- To revoke system permissions from a role, use the REVOKE command.

To view a list of roles in your cluster or workgroup, see SVV_ROLES.

Tutorial: Creating roles and querying with RBAC

With RBAC, you can create roles with permissions to run commands that used to require superuser permissions. Users can run these commands, as long as they are authorized with a role that includes these permissions.

In this tutorial, you use role-based access control (RBAC) to manage permissions in a database you create. You then connect to the database and query the database from two different roles to test the functionality of RBAC.

The two roles that you create and use to query the database are the `sales_ro` and `sales_rw`. You create the `sales_ro` role and query data as a user with the `sales_ro` role. The `sales_ro` user can only use the SELECT command but cannot use the UPDATE command. Then, you create the `sales_rw` role and query data as a user with the `sales_rw` role. The `sales_rw` user can use the SELECT command and the UPDATE command.

Additionally, you can create roles to limit the access to certain commands, and assign the role to either superusers or users.

Tasks

Prerequisites

- Create an Amazon Redshift cluster or serverless workgroup that is loaded with the TICKIT sample database. To create a serverless workgroup, see Get started with Redshift Serverless data warehouses. To create a cluster, see Create a sample Amazon Redshift cluster. For more information about the TICKIT sample database, see Sample database.
- Have access to a user with superuser or role administrator permissions. Only superusers or role administrators can grant or revoke roles. For more information about permissions required for RBAC, see System permissions for RBAC.
- Review the Considerations for role usage in RBAC.

Step 1: Create an administrator user

To set up for this tutorial, you create a database admin role and attach it to a database administrator user in this step. You must create the database administrator as a superuser or role administrator.

Run all queries in the Amazon Redshift query editor v2.

1. To create the administrator role db_admin, use the following example.

```
CREATE ROLE db_admin;
```

2. To create a database user named dbadmin, use the following example.

```
CREATE USER dbadmin PASSWORD 'Test12345';
```

3. To grant the system defined role named sys:dba to the db_admin role, use the following example. When granted the sys:dba role, the dbadmin user can create schemas and tables. For more information, see Amazon Redshift system-defined roles.

Step 2: Set up schemas

In this step, you connect to your database as the database administrator. Then, you create two schemas and add data to them.

1. Connect to the dev database as the dbadmin user using query editor v2. For more information about connecting to a database, see Working with query editor v2.
2. To create the sales and marketing database schemas, use the following example.

```
CREATE SCHEMA sales;
CREATE SCHEMA marketing;
```

3. To create and insert values into tables in the sales schema, use the following example.

```
CREATE TABLE sales.cat(
catid smallint,
catgroup varchar(10),
catname varchar(10),
catdesc varchar(50)
);
INSERT INTO sales.cat(SELECT * FROM category);

CREATE TABLE sales.dates(
dateid smallint,
caldate date,
day char(3),
week smallint,
month char(5),
qtr char(5),
year smallint,
holiday boolean
);
INSERT INTO sales.dates(SELECT * FROM date);

CREATE TABLE sales.events(
eventid integer,
venueid smallint,
catid smallint,
dateid smallint,
eventname varchar(200),
starttime timestamp
);
```

```
INSERT INTO sales.events(SELECT * FROM event);

 CREATE TABLE sales.sale(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp
);
INSERT INTO sales.sale(SELECT * FROM sales);
```

4. To create and insert values into tables in the marketing schema, use the following example.

```
CREATE TABLE marketing.cat(
catid smallint,
catgroup varchar(10),
catname varchar(10),
catdesc varchar(50)
);
INSERT INTO marketing.cat(SELECT * FROM category);

CREATE TABLE marketing.dates(
dateid smallint,
caldate date,
day char(3),
week smallint,
month char(5),
qtr char(5),
year smallint,
holiday boolean
);
INSERT INTO marketing.dates(SELECT * FROM date);

CREATE TABLE marketing.events(
eventid integer,
venueid smallint,
catid smallint,
dateid smallint,
eventname varchar(200),
```

```
starttime timestamp
);
INSERT INTO marketing.events(SELECT * FROM event);

CREATE TABLE marketing.sale(
marketingid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp
);
INSERT INTO marketing.sale(SELECT * FROM marketing);
```

Step 3: Create a read-only user

In this step, you create a read-only role and a salesanalyst user for the read-only role. The sales analyst only needs read-only access to the tables in the sales schema to accomplish their assigned task of finding the events that resulted in the largest commissions.

1. Connect to the database as the dbadmin user.
2. To create the sales_ro role, use the following example.

```
CREATE ROLE sales_ro;
```

3. To create the salesanalyst user, use the following example.

```
CREATE USER salesanalyst PASSWORD 'Test12345';
```

4. To grant the sales_ro role usage and select access to objects of the sales schema, use the following example.

```
GRANT USAGE ON SCHEMA sales TO ROLE sales_ro;
GRANT SELECT ON ALL TABLES IN SCHEMA sales TO ROLE sales_ro;
```

5. To grant the salesanalyst user the sales_ro role, use the following example.

```
GRANT ROLE sales_ro TO salesanalyst;
```

Step 4: Query the data as the read-only user

In this step, the salesanalyst user queries data from the sales schema. Then, the salesanalyst user attempts to update a table and read tables in the marketing schema.

1. Connect to the database as the salesanalyst user.
2. To find the 10 sales with the highest commissions, use the following example.

```
SET SEARCH_PATH TO sales;
SELECT DISTINCT events.dateid, sale.commission, cat.catname
FROM sale, events, dates, cat
WHERE events.dateid=dates.dateid AND events.dateid=sale.dateid AND events.catid =
 cat.catid
ORDER BY 2 DESC LIMIT 10;

+--------+------------+----------+
| dateid | commission | catname  |
+--------+------------+----------+
|   1880 |     1893.6 | Pop      |
|   1880 |     1893.6 | Opera    |
|   1880 |     1893.6 | Plays    |
|   1880 |     1893.6 | Musicals |
|   1861 |       1500 | Plays    |
|   2003 |       1500 | Pop      |
|   1861 |       1500 | Opera    |
|   2003 |       1500 | Plays    |
|   1861 |       1500 | Musicals |
|   1861 |       1500 | Pop      |
+--------+------------+----------+
```

3. To select 10 events from the events table in the sales schema, use the following example.

```
SELECT * FROM sales.events LIMIT 10;

+---------+---------+-------+--------+--------------------+---------------------+
| eventid | venueid | catid | dateid |     eventname      |      starttime      |
+---------+---------+-------+--------+--------------------+---------------------+
|    4836 |      73 |     9 |   1871 | Soulfest           | 2008-02-14 19:30:00 |
```

```
|     5739 |       41 |       9 |    1871 | Fab Faux           | 2008-02-14 19:30:00 |
|      627 |      229 |       6 |    1872 | High Society       | 2008-02-15 14:00:00 |
|     2563 |      246 |       7 |    1872 | Hamlet             | 2008-02-15 20:00:00 |
|     7703 |       78 |       9 |    1872 | Feist              | 2008-02-15 14:00:00 |
|     7903 |       90 |       9 |    1872 | Little Big Town    | 2008-02-15 19:30:00 |
|     7925 |      101 |       9 |    1872 | Spoon              | 2008-02-15 19:00:00 |
|     8113 |       17 |       9 |    1872 | Santana            | 2008-02-15 15:00:00 |
|      463 |      303 |       8 |    1873 | Tristan und Isolde | 2008-02-16 19:00:00 |
|      613 |      236 |       6 |    1873 | Pal Joey           | 2008-02-16 15:00:00 |
+----------+----------+---------+--------+--------------------+---------------------+
```

4. To attempt to update the eventname for eventid 1, run the following example. This example will result in a permission denied error because the salesanalyst user only has SELECT permissions on the events table in the sales schema. To update the events table, you must grant the sales_ro role permissions to UPDATE. For more information about granting permissions to update a table, see the UPDATE parameter for GRANT. For more information about the UPDATE command, see UPDATE.

```
UPDATE sales.events
SET eventname = 'Comment event'
WHERE eventid = 1;

ERROR: permission denied for relation events
```

5. To attempt to select all from the events table in the marketing schema, use the following example. This example will result in a permission denied error because the salesanalyst user only has SELECT permissions for the events table in the sales schema. To select data from the events table in the marketing schema, you must grant the sales_ro role SELECT permissions on the events table in the marketing schema.

```
SELECT * FROM marketing.events;

               ERROR: permission denied for schema marketing
```

Step 5: Create a read-write user

In this step, the sales engineer who is responsible for building the extract, transform, and load (ETL) pipeline for data processing in the sales schema will be given read-only access, but will later be given read and write access to perform their tasks.

1. Connect to the database as the dbadmin user.
2. To create the sales_rw role in the sales schema, use the following example.

```
CREATE ROLE sales_rw;
```

3. To create the salesengineer user, use the following example.

```
CREATE USER salesengineer PASSWORD 'Test12345';
```

4. To grant the sales_rw role usage and select access to objects of the sales schema by assigning the sales_ro role to it, use the following example. For more information on how roles inherit permissions in Amazon Redshift, see Role hierarchy.

```
GRANT ROLE sales_ro TO ROLE sales_rw;
```

5. To assign the sales_rw role to the salesengineer user, use the following example.

```
GRANT ROLE sales_rw TO salesengineer;
```

Step 6: Query the data as the user with the inherited read-only role

In this step, the salesengineer user attempts to update the events table before they are granted read permissions.

1. Connect to the database as the salesengineer user.
2. The salesengineer user can successfully read data from the events table of the sales schema. To select the event with eventid 1 from the events table in the sales schema, use the following example.

```
SELECT * FROM sales.events where eventid=1;

+---------+---------+-------+--------+-----------------+---------------------+
| eventid | venueid | catid | dateid |    eventname    |      starttime      |
+---------+---------+-------+--------+-----------------+---------------------+
|       1 |     305 |     8 |   1851 | Gotterdammerung | 2008-01-25 14:30:00 |
+---------+---------+-------+--------+-----------------+---------------------+
```

3. To attempt to select all from the events table in the marketing schema, use the following example. The salesengineer user doesn't have permissions for tables in the marketing schema,

so this query will result in a permission denied error. To select data from the events table in the marketing schema, you must grant the sales_rw role SELECT permissions on the events table in the marketing schema.

```
SELECT * FROM marketing.events;

ERROR: permission denied for schema marketing
```

4. To attempt to update the eventname for eventid 1, run the following example. This example will result in a permission denied error because the salesengineer user only has select permissions on the events table in the sales schema. To update the events table, you must grant the sales_rw role permissions to UPDATE.

```
UPDATE sales.events
SET eventname = 'Comment event'
WHERE eventid = 1;

ERROR: permission denied for relation events
```

Step 7: Grant update and insert permissions to the read-write role

In this step, you grant update and insert permissions to the sales_rw role.

1. Connect to the database as the dbadmin user.
2. To grant UPDATE, INSERT, and DELETE permissions to the sales_rw role, use the following example.

```
GRANT UPDATE, INSERT, ON ALL TABLES IN SCHEMA sales TO role sales_rw;
```

Step 8: Query the data as the read-write user

In this step, the salesengineer successfully updates the table after their role is granted insert and update permissions. Next, the salesengineer attempts to analyze and vacuum the events table but fails to do so.

1. Connect to the database as the salesengineer user.
2. To update the eventname for eventid 1, run the following example.

```
UPDATE sales.events
SET eventname = 'Comment event'
WHERE eventid = 1;
```

3. To view the change made in the previous query, use the following example to select the event with eventid 1 from the events table in the sales schema.

```
SELECT * FROM sales.events WHERE eventid=1;

+---------+---------+-------+--------+---------------+---------------------+
| eventid | venueid | catid | dateid |   eventname   |      starttime      |
+---------+---------+-------+--------+---------------+---------------------+
|       1 |     305 |     8 |   1851 | Comment event | 2008-01-25 14:30:00 |
+---------+---------+-------+--------+---------------+---------------------+
```

4. To analyze the updated events table in the sales schema, use the following example. This example will result in a permission denied error because the salesengineer user does not have the necessary permissions and isn't the owner of the events table in the sales schema. To analyze the events table, you must grant the sales_rw role permissions to ANALYZE using the GRANT command. For more information about the ANALYZE command, see ANALYZE.

```
ANALYZE sales.events;

               ERROR: skipping "events" --- only table or database owner can analyze
```

5. To vacuum the updated events table, use the following example. This example will result in a permission denied error because the salesengineer user does not have the necessary permissions and isn't the owner of the events table in the sales schema. To vacuum the events table, you must grant the sales_rw role permissions to VACUUM using the GRANT command. For more information about the VACUUM command, see VACUUM.

```
VACUUM sales.events;

ERROR: skipping "events" --- only table or database owner can vacuum it
```

Step 9: Analyze and vacuum tables in a database as the administrator user

In this step, the dbadmin user analyzes and vacuums all of the tables. The user has administrator permissions on this database, so they are able to run these commands.

1. Connect to the database as the dbadmin user.
2. To analyze the events table in the sales schema, use the following example.

```
ANALYZE sales.events;
```

3. To vacuum the events table in the sales schema, use the following example.

```
VACUUM sales.events;
```

4. To analyze the events table in the marketing schema, use the following example.

```
ANALYZE marketing.events;
```

5. To vacuum the events table in the marketing schema, use the following example.

```
VACUUM marketing.events;
```

Step 10: Truncate tables as the read-write user

In this step, the salesengineer user attempts to truncate the events table in the sales schema, but only succeeds when granted truncate permissions by the dbadmin user.

1. Connect to the database as the salesengineer user.
2. To try to delete all of the rows from the events table in the sales schema, use the following example. This example will result in an error because the salesengineer user does not have the necessary permissions and isn't the owner of the events table in the sales schema. To truncate the events table, you must grant the sales_rw role permissions to TRUNCATE using the GRANT command. For more information about the TRUNCATE command, see TRUNCATE.

```
TRUNCATE sales.events;

ERROR: must be owner of relation events
```

3. Connect to the database as the dbadmin user.
4. To grant truncate table privileges to the sales_rw role, use the following example.

```
GRANT TRUNCATE TABLE TO role sales_rw;
```

5. Connect to the database as the salesengineer user using query editor v2.

6. To read the first 10 events from the events table in the sales schema, use the following example.

```
SELECT * FROM sales.events ORDER BY eventid LIMIT 10;

+---------+---------+-------+--------+-----------------------------
+---------------------+
| eventid | venueid | catid | dateid |          eventname          |      starttime
    |
+---------+---------+-------+--------+-----------------------------
+---------------------+
|       1 |     305 |     8 |   1851 | Comment event               | 2008-01-25
 14:30:00 |
|       2 |     306 |     8 |   2114 | Boris Godunov               | 2008-10-15
 20:00:00 |
|       3 |     302 |     8 |   1935 | Salome                      | 2008-04-19
 14:30:00 |
|       4 |     309 |     8 |   2090 | La Cenerentola (Cinderella) | 2008-09-21
 14:30:00 |
|       5 |     302 |     8 |   1982 | Il Trovatore                | 2008-06-05
 19:00:00 |
|       6 |     308 |     8 |   2109 | L Elisir d Amore            | 2008-10-10
 19:30:00 |
|       7 |     309 |     8 |   1891 | Doctor Atomic               | 2008-03-06
 14:00:00 |
|       8 |     302 |     8 |   1832 | The Magic Flute             | 2008-01-06
 20:00:00 |
|       9 |     308 |     8 |   2087 | The Fly                     | 2008-09-18
 19:30:00 |
|      10 |     305 |     8 |   2079 | Rigoletto                   | 2008-09-10
 15:00:00 |
+---------+---------+-------+--------+-----------------------------
+---------------------+
```

7. To truncate the events table in the sales schema, use the following example.

```
TRUNCATE sales.events;
```

8. To read the data from the updated events table in the sales schema, use the following example.

```
SELECT * FROM sales.events ORDER BY eventid LIMIT 10;

+---------+---------+-------+--------+-----------------------------
+---------------------+
```

```
| eventid | venueid | catid | dateid |           eventname           |      starttime
    |
+---------+---------+-------+--------+-----------------------------
+---------------------+
```

Create read-only and read-write roles for the marketing schema (optional)

In this step, you create read-only and read-write roles for the marketing schema.

1. Connect to the database as the dbadmin user.
2. To create read-only and read-write roles for the marketing schema, use the following example.

```
CREATE ROLE marketing_ro;

CREATE ROLE marketing_rw;

GRANT USAGE ON SCHEMA marketing TO ROLE marketing_ro, ROLE marketing_rw;

GRANT SELECT ON ALL TABLES IN SCHEMA marketing TO ROLE marketing_ro;

GRANT ROLE marketing_ro TO ROLE marketing_rw;

GRANT INSERT, UPDATE, DELETE ON ALL TABLES IN SCHEMA marketing TO ROLE marketing_rw;

CREATE USER marketinganalyst PASSWORD 'Test12345';

CREATE USER marketingengineer PASSWORD 'Test12345';

GRANT ROLE marketing_ro TO marketinganalyst;

GRANT ROLE marketing_rw TO marketingengineer;
```

System functions for RBAC (optional)

Amazon Redshift has two functions to provide system information about user membership and role membership in additional groups or roles: role_is_member_of and user_is_member_of. These functions are available to superusers and regular users. Superusers can check all role memberships. Regular users can only check membership for roles that they have been granted access to.

To use the role_is_member_of function

1. Connect to the database as the salesengineer user.
2. To check if the sales_rw role is a member of the sales_ro role, use the following example.

```
SELECT role_is_member_of('sales_rw', 'sales_ro');

+-------------------+
| role_is_member_of |
+-------------------+
| true              |
+-------------------+
```

3. To check if the sales_ro role is a member of the sales_rw role, use the following example.

```
SELECT role_is_member_of('sales_ro', 'sales_rw');

+-------------------+
| role_is_member_of |
+-------------------+
| false             |
+-------------------+
```

To use the user_is_member_of function

1. Connect to the database as the salesengineer user.
2. The following example attempts to check the user membership for the salesanalyst user. This query results in an error because salesengineer does not have access to salesanalyst. To run this command successfully, connect to the database as the salesanalyst user and use the example.

```
SELECT user_is_member_of('salesanalyst', 'sales_ro');

ERROR
```

3. Connect to the database as a superuser.
4. To check the membership of the salesanalyst user when connected as a superuser, use the following example.

```
SELECT user_is_member_of('salesanalyst', 'sales_ro');
```

```
+-------------------+
| user_is_member_of |
+-------------------+
| true              |
+-------------------+
```

5. Connect to the database as the dbadmin user.
6. To check the membership of the salesengineer user, use the following example.

```
SELECT user_is_member_of('salesengineer', 'sales_ro');

+-------------------+
| user_is_member_of |
+-------------------+
| true              |
+-------------------+

SELECT user_is_member_of('salesengineer', 'marketing_ro');

+-------------------+
| user_is_member_of |
+-------------------+
| false             |
+-------------------+

SELECT user_is_member_of('marketinganalyst', 'sales_ro');

+-------------------+
| user_is_member_of |
+-------------------+
| false             |
+-------------------+
```

System views for RBAC (optional)

To view the roles, the assignment of roles to users, the role hierarchy, and the privileges for database objects via roles, use the system views for Amazon Redshift. These views are available to superusers and regular users. Superusers can check all role details. Regular users can only check details for roles that they have been granted access to.

1. To view a list of users that are explicitly granted roles in the cluster, use the following example.

```
SELECT * FROM svv_user_grants;
```

2. To view a list of roles that are explicitly granted roles in the cluster, use the following example.

```
SELECT * FROM svv_role_grants;
```

For the full list of system views, refer to SVV metadata views.

Use row-level security with RBAC (optional)

To have granular access control over your sensitive data, use row-level security (RLS). For more information about RLS, see Row-level security.

In this section, you create a RLS policy that gives the `salesengineer` user permissions to only view rows in the `cat` table that have the `catdesc` value of Major League Baseball. You then query the database as the `salesengineer` user.

1. Connect to the database as the `salesengineer` user.
2. To view the first 5 entries in the `cat` table, use the following example.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+---------------------------------+
| catid | catgroup | catname |             catdesc             |
+-------+----------+---------+---------------------------------+
|     1 | Sports   | MLB     | Major League Baseball           |
|     2 | Sports   | NHL     | National Hockey League          |
|     3 | Sports   | NFL     | National Football League        |
|     4 | Sports   | NBA     | National Basketball Association |
|     5 | Sports   | MLS     | Major League Soccer             |
+-------+----------+---------+---------------------------------+
```

3. Connect to the database as the `dbadmin` user.
4. To create a RLS policy for the `catdesc` column in the `cat` table, use the following example.

```
CREATE RLS POLICY policy_mlb_engineer
```

```
WITH (catdesc VARCHAR(50))
USING (catdesc = 'Major League Baseball');
```

5. To attach the RLS policy to the `sales_rw` role, use the following example.

```
ATTACH RLS POLICY policy_mlb_engineer ON sales.cat TO ROLE sales_rw;
```

6. To alter the table to turn on RLS, use the following example.

```
ALTER TABLE sales.cat ROW LEVEL SECURITY ON;
```

7. Connect to the database as the `salesengineer` user.
8. To attempt to view the first 5 entries in the `cat` table, use the following example. Note that only entries only appear when the `catdesc` column is `Major League Baseball`.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+-----------------------+
| catid | catgroup | catname |        catdesc        |
+-------+----------+---------+-----------------------+
|     1 | Sports   | MLB     | Major League Baseball |
+-------+----------+---------+-----------------------+
```

9. Connect to the database as the `salesanalyst` user.
10. To attempt to view the first 5 entries in the `cat` table, use the following example. Note that no entries appear because the default deny all policy is applied.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+-----------------------+
| catid | catgroup | catname |        catdesc        |
+-------+----------+---------+-----------------------+
```

11. Connect to the database as the `dbadmin` user.

12. To grant the IGNORE RLS permission to the `sales_ro` role, use the following example. This grants the `salesanalyst` user the permissions to ignore RLS policies since they are a member of the `sales_ro` role.

```
GRANT IGNORE RLS TO ROLE sales_ro;
```

13. Connect to the database as the `salesanalyst` user.

14. To view the first 5 entries in the `cat` table, use the following example.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+---------------------------------+
| catid | catgroup | catname |             catdesc             |
+-------+----------+---------+---------------------------------+
|     1 | Sports   | MLB     | Major League Baseball           |
|     2 | Sports   | NHL     | National Hockey League          |
|     3 | Sports   | NFL     | National Football League        |
|     4 | Sports   | NBA     | National Basketball Association |
|     5 | Sports   | MLS     | Major League Soccer             |
+-------+----------+---------+---------------------------------+
```

15. Connect to the database as the `dbadmin` user.

16. To revoke the IGNORE RLS permission from the `sales_ro` role, use the following example.

```
REVOKE IGNORE RLS FROM ROLE sales_ro;
```

17. Connect to the database as the `salesanalyst` user.

18. To attempt to view the first 5 entries in the `cat` table, use the following example. Note that no entries appear because the default deny all policy is applied.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+-----------------------+
| catid | catgroup | catname |        catdesc        |
```

```
+-------+----------+---------+-----------------------+
```

19. Connect to the database as the `dbadmin` user.

20. To detach the RLS policy from the `cat` table, use the following example.

```
DETACH RLS POLICY policy_mlb_engineer ON cat FROM ROLE sales_rw;
```

21. Connect to the database as the `salesanalyst` user.

22. To attempt to view the first 5 entries in the `cat` table, use the following example. Note that no entries appear because the default deny all policy is applied.

```
SELECT *
FROM sales.cat
ORDER BY catid ASC
LIMIT 5;

+-------+----------+---------+---------------------------------+
| catid | catgroup | catname |             catdesc             |
+-------+----------+---------+---------------------------------+
|     1 | Sports   | MLB     | Major League Baseball           |
|     2 | Sports   | NHL     | National Hockey League          |
|     3 | Sports   | NFL     | National Football League        |
|     4 | Sports   | NBA     | National Basketball Association |
|     5 | Sports   | MLS     | Major League Soccer             |
+-------+----------+---------+---------------------------------+
```

23. Connect to the database as the `dbadmin` user.

24. To drop the RLS policy, use the following example.

```
DROP RLS POLICY policy_mlb_engineer;
```

25. To remove RLS, use the following example.

```
ALTER TABLE cat ROW LEVEL SECURITY OFF;
```

Related topics

For more information about RBAC, see the following documentation:

- Role hierarchy

- Role assignment
- Database object permissions
- ALTER DEFAULT PRIVILEGES for RBAC

Row-level security

Using row-level security (RLS) in Amazon Redshift, you can have granular access control over your sensitive data. You can decide which users or roles can access specific records of data within schemas or tables, based on security policies that are defined at the database objects level. In addition to column-level security, where you can grant users permissions to a subset of columns, use RLS policies to further restrict access to particular rows of the visible columns. For more information about column-level security, see Usage notes for column-level access control.

When you enforce RLS policies on tables, you can restrict returned result sets when users run queries.

When creating RLS policies, you can specify expressions that dictate whether Amazon Redshift returns any existing rows in a table in a query. By creating RLS policies to limit access, you don't have to add or externalize additional conditions in your queries.

When creating RLS policies, we recommend that you create simple policies and avoid complex statements in policies. When defining RLS policies, don't use excessive table joins in the policy definition that are based on policies.

When a policy refers to a lookup table, Amazon Redshift scans the additional table, in addition to the table on which the policy exists. There will be performance differences between the same query for a user with an RLS policy attached, and a user without any policy attached.

Using RLS policies in SQL statements

When using RLS policies in SQL statements, Amazon Redshift applies the following rules:

- Amazon Redshift applies RLS policies to the SELECT, UPDATE, and DELETE statements by default.
- For SELECT and UNLOAD, Amazon Redshift filters rows according to your defined policy.
- For UPDATE, Amazon Redshift updates only the rows that are visible to you. If a policy restricts a subset of the rows in a table, then you can't update them.
- For DELETE, you can delete only the rows that are visible to you. If a policy restricts a subset of the rows in a table, then you can't delete them. For TRUNCATE, you can still truncate the table.

- For CREATE TABLE LIKE, tables created with the LIKE options won't inherit permission settings from the source table. Similarly, the target table won't inherit the RLS policies from source table.

Combining multiple policies per user

RLS in Amazon Redshift supports attaching multiple policies per user and object. When there are multiple policies defined for a user, Amazon Redshift applies all the policies with either AND or OR syntax depending on the RLS CONJUNCTION TYPE setting for the table. For more information about conjunction type, see ALTER TABLE.

Multiple policies on a table can be associated with you. Either multiple policies are directly attached to you, or you belong to multiple roles, and the roles have different policies attached to them.

When the multiple policies should restrict rows access in a given relation, you can set RLS CONJUNCTION TYPE of the relation to AND. Consider the following example. Alice can only see Sports event that has a "catname" of NBA as the policy specified.

```
-- Create an analyst role and grant it to a user named Alice.
CREATE ROLE analyst;
CREATE USER alice WITH PASSWORD 'Name_is_alice_1';
GRANT ROLE analyst TO alice;

-- Create an RLS policy that only lets the user see sports.
CREATE RLS POLICY policy_sports
WITH (catgroup VARCHAR(10))
USING (catgroup = 'Sports');

-- Create an RLS policy that only lets the user see NBA.
CREATE RLS POLICY policy_nba
WITH (catname VARCHAR(10))
USING (catname = 'NBA');

-- Attach both to the analyst role.
ATTACH RLS POLICY policy_sports ON category TO ROLE analyst;
ATTACH RLS POLICY policy_nba ON category TO ROLE analyst;

-- Activate RLS on the category table with AND CONJUNCTION TYPE.
ALTER TABLE category ROW LEVEL SECURITY ON CONJUNCTION TYPE AND;

-- Change session to Alice.
```

```
SET SESSION AUTHORIZATION alice;

-- Select all from the category table.
SELECT catgroup, catname
FROM category;

 catgroup | catname
---------+---------
 Sports   | NBA
(1 row)
```

When the multiple policies should permit the users to see more rows in a given relation, user can set RLS CONJUNCTION TYPE of the relation to OR. Consider the following example. Alice can only see "Concerts" and "Sports" as the policy specified.

```
-- Create an analyst role and grant it to a user named Alice.
CREATE ROLE analyst;
CREATE USER alice WITH PASSWORD 'Name_is_alice_1';
GRANT ROLE analyst TO alice;

-- Create an RLS policy that only lets the user see concerts.
CREATE RLS POLICY policy_concerts
WITH (catgroup VARCHAR(10))
USING (catgroup = 'Concerts');

-- Create an RLS policy that only lets the user see sports.
CREATE RLS POLICY policy_sports
WITH (catgroup VARCHAR(10))
USING (catgroup = 'Sports');

-- Attach both to the analyst role.
ATTACH RLS POLICY policy_concerts ON category TO ROLE analyst;
ATTACH RLS POLICY policy_sports ON category TO ROLE analyst;

-- Activate RLS on the category table with OR CONJUNCTION TYPE.
ALTER TABLE category ROW LEVEL SECURITY ON CONJUNCTION TYPE OR;

-- Change session to Alice.
SET SESSION AUTHORIZATION alice;

-- Select all from the category table.
SELECT catgroup, count(*)
FROM category
```

```
GROUP BY catgroup ORDER BY catgroup;

 catgroup | count
---------+-------
 Concerts |  3
 Sports   |  5
(2 rows)
```

RLS policy ownership and management

As a superuser, security administrator, or user that has the sys:secadmin role, you can create, modify, attach, and detach RLS policies. RLS policies can be attached to tables, views, late binding views (LBVs), and materialized views (MVs). At the object level, you can turn row-level security on or off without modifying the schema definition for tables.

To get started with row-level security, following are SQL statements that you can use:

- Use the ALTER TABLE statement to turn on or off RLS on a table, view, or late binding view. For more information, see ALTER TABLE.
- Use the ALTER MATERIALIZED VIEW statement to statement to turn on or off RLS on a materialized view (MV). For more information, see ALTER MATERIALIZED VIEW.
- Use the CREATE RLS POLICY statement to create a security policy for one or more tables, and specify one or more users or roles in the policy.

  For more information, see CREATE RLS POLICY.
- Use the ALTER RLS POLICY statement to alter the policy, such as changing the policy definition. You can use the same policy for multiple tables or views.

  For more information, see ALTER RLS POLICY.
- Use the ATTACH RLS POLICY statement to attach a policy to one or more relations, to one or more users, or to roles.

  For more information, see ATTACH RLS POLICY.
- Use the DETACH RLS POLICY statement to detach a policy from one or more relations, from one or more users, or from roles.

  For more information, see DETACH RLS POLICY.
- Use the DROP RLS POLICY statement to drop a policy.

For more information, see DROP RLS POLICY.

- Use the GRANT and REVOKE statements to explicitly grant and revoke SELECT permissions to RLS policies that reference lookup tables. For more information, see GRANT and REVOKE.

To monitor the policies created, sys:secadmin can view the SVV_RLS_POLICY and SVV_RLS_ATTACHED_POLICY.

To list RLS-protected relations, sys:secadmin can view SVV_RLS_RELATION.

To trace the application of RLS policies on queries that reference RLS-protected relations, a superuser, sys:operator, or any user with the system permission ACCESS SYSTEM TABLE can view SVV_RLS_APPLIED_POLICY. Note that sys:secadmin is not granted these permissions by default.

To allow users full access to an RLS-protected relation, you can grant the IGNORE RLS permission. Superusers or sys:secadmin are automatically granted IGNORE RLS. For more information, see GRANT.

To explain the RLS policy filters of a query in the EXPLAIN plan to troubleshoot RLS-related queries, you can grant the permission EXPLAIN RLS to any user. For more information, see GRANT and EXPLAIN.

Policy-dependent objects and principles

To provide security for applications and to prevent policy objects from becoming stale or invalid, Amazon Redshift doesn't permit dropping or altering objects referenced by RLS policies.

Following lists schema object dependencies that Amazon Redshift tracks for RLS policies.

- When tracking schema object dependency for the target table, Amazon Redshift follows these rules:
  - Amazon Redshift detaches the policy from a relation, user, role, or public when you drop a target table.
  - When you rename a target table name, there is no impact to the attached policies.
  - You can only drop the columns of the target table referenced inside the policy definition if you drop or detach the policy first. This also applies when the CASCADE option is specified. You can drop other columns in the target table.
  - You can't rename the referred columns of the target table. To rename referred columns, detach the policy first. This also applies when the CASCADE option is specified.

  - You can't change the type of the referred column, even when you specify the CASCADE option.
- When tracking schema object dependency for the lookup table, Amazon Redshift follows these rules:
  - You can't drop a lookup table. To drop a lookup table, first drop the policy in which the lookup table is referred.
  - You can't rename a lookup table. To rename a lookup table, first drop the policy in which the lookup table is referred. This also applies when the CASCADE option is specified.
  - You can't drop the lookup table columns used in the policy definition. To drop the lookup table columns used in the policy definition, first drop the policy in which the lookup table is referred. This also applies when the CASCADE option is specified in the ALTER TABLE DROP COLUMN statement. You can drop other columns in the lookup table.
  - You can't rename the referred columns of the lookup table. To rename referred columns, first drop the policy in which the lookup table is referred. This also applies when the CASCADE option is specified.
  - You can't change the type of the referred column.
- When a user or role is dropped, Amazon Redshift detaches all policies attached to the user or role automatically.
- When you use the CASCADE option in the DROP SCHEMA statement, Amazon Redshift also drops the relations in the schema. It also drops the relations in any other schemas that are dependent on relations in the dropped schema. For a relation that is a lookup table in a policy, Amazon Redshift fails the DROP SCHEMA DDL. For any relations dropped by the DROP SCHEMA statement, Amazon Redshift detaches all policies that are attached to those relations.
- You can only drop a lookup function (a function that is referred inside a policy definition) when you also drop the policy. This also applies when the CASCADE option is specified.
- When a policy is attached to a table, Amazon Redshift checks if this table is a lookup table in a different policy. If this is the case, Amazon Redshift won't allow attaching a policy to this table.
- While creating an RLS policy, Amazon Redshift checks if this table is a target table for any other RLS policy. If this is the case, Amazon Redshift won't allow creating a policy on this table.

Example

The following example illustrates how schema dependency is tracked.

```
-- The CREATE and ATTACH policy statements for `policy_events` references some
```

```
-- target and lookup tables.
-- Target tables are tickit_event_redshift and target_schema.target_event_table.
-- Lookup table is tickit_sales_redshift.
-- Policy `policy_events` has following dependencies:
--   table tickit_sales_redshift column eventid, qtysold
--   table tickit_event_redshift column eventid
--   table target_event_table column eventid
--   schema public and target_schema
CREATE RLS POLICY policy_events
WITH (eventid INTEGER)
USING (
    eventid IN (SELECT eventid FROM tickit_sales_redshift WHERE qtysold <3)
);

ATTACH RLS POLICY policy_events ON tickit_event_redshift TO ROLE analyst;

ATTACH RLS POLICY policy_events ON target_schema.target_event_table TO ROLE consumer;
```

Considerations and limitations using RLS policies

Considerations

Following are considerations for working with RLS policies:

- Amazon Redshift applies RLS policies to SELECT, UPDATE, or DELETE statements.
- Amazon Redshift doesn't apply RLS policies to INSERT, COPY, ALTER TABLE APPEND statements.
- RLS policies can be attached to tables, views, late binding views (LBVs), and materialized views (MVs).
- Row-level security works with column-level security to protect your data.
- When RLS is turned on for the source relation, Amazon Redshift supports the ALTER TABLE APPEND statement for superusers, users that have been explicitly granted the system permission IGNORE RLS, or the sys:secadmin role. In this case, you can run the ALTER TABLE APPEND statement to append rows to a target table by moving data from an existing source table. Amazon Redshift moves all tuples from the source relation into the target relation. The RLS status of the target relation doesn't affect the ALTER TABLE APPEND statement.
- To facilitate migration from other data warehouse systems, you can set and retrieve customized session context variables for a connection by specifying the variable name and value.

  The following example sets session context variables for a row-level security (RLS) policy.

```
-- Set a customized context variable.
SELECT set_config('app.category', 'Concerts', FALSE);

-- Create a RLS policy using current_setting() to get the value of a customized
 context variable.
CREATE RLS POLICY policy_categories
WITH (catgroup VARCHAR(10))
USING (catgroup = current_setting('app.category', FALSE));

-- Set correct roles and attach the policy on the target table to one or more roles.
ATTACH RLS POLICY policy_categories ON tickit_category_redshift TO ROLE analyst, ROLE
 dbadmin;
```

For details on how to set and retrieve customized session context variables, go to SET, SET_CONFIG, SHOW, CURRENT_SETTING, and RESET. For more information on modifying the server configuration in general, go to Modifying the server configuration.

Important

When using session context variables within RLS policies, the security policy is reliant on the user or role that invokes the policy. Be careful to avoid security vulnerabilities when using session context variables in RLS policies.

- Changing session user using SET SESSION AUTHORIZATION between DECLARE and FETCH or between subsequent FETCH statements won't refresh the already prepared plan based on the user policies at DECLARE time. Avoid changing session user when cursors are used with RLS-protected tables.
- When the base objects inside a view object are RLS-protected, policies attached to the user running the query are applied on the respective base objects. This is different from object-level permission checks, where the view owner's permissions are checked against the view base objects. You can view the RLS-protected relations of a query in its EXPLAIN plan output.
- When a user-defined function (UDF) is referenced in a RLS policy of a relation attached to a user, the user must have the EXECUTE permission over the UDF to query the relation.
- Row-level security might limit query optimization. We recommend carefully evaluating query performance before deploying RLS-protected views on large datasets.
- Row-level security policies applied to late-binding views might be pushed into federated tables. These RLS policies might be visible in external processing engine logs.

Limitations

Following are the limitations when working with RLS policies:

- RLS policies can't be attached to external tables and several other relation types. For more information, see ATTACH RLS POLICY.
- Amazon Redshift supports SELECT statements for certain RLS policies with lookups that have complex joins, but doesn't support UPDATE or DELETE statements. In cases with UPDATE or DELETE statements, Amazon Redshift returns the following error:

```
ERROR: One of the RLS policies on target relation is not supported in UPDATE/DELETE.
```

- Whenever a user-defined function (UDF) is referenced in a RLS policy of a relation attached to a user, the user must have the EXECUTE permission over the UDF to query the relation.
- Correlated subqueries aren't supported. Amazon Redshift returns the following error:

```
ERROR: RLS policy could not be rewritten.
```

- Amazon Redshift doesn't support datasharing with RLS. If a relation doesn't have RLS turned off for datashares, the query fails on the consumer cluster with the following error:

```
RLS-protected relation "rls_protected_table" cannot be accessed via datasharing
 query.
```

  You can turn off RLS for datashares using the ALTER TABLE command with the parameter ROW LEVEL SECURITY OFF FOR DATASHARES. For more information about using ALTER TABLE to enable or disable RLS, go to ALTER TABLE.
- In cross-database queries, Amazon Redshift blocks reads to RLS-protected relations. Users with the IGNORE RLS permission can access the protected relation using cross-database queries. When a user without the IGNORE RLS permission accesses RLS-protected relation through a cross-database query, the following error appears:

```
RLS-protected relation "rls_protected_table" cannot be accessed via cross-database
 query.
```

- ALTER RLS POLICY only supports modifying a RLS policy using the USING (using_predicate_exp) clause. You can't modify a RLS policy with a WITH clause when running ALTER RLS POLICY.

- You can't query relations that have row-level security turned on if the values for any of the following configuration options don't match the default value of the session:
  - `enable_case_sensitive_super_attribute`
  - `enable_case_sensitive_identifier`
  - `downcase_delimited_identifier`

  Consider resetting your session’s configuration options if you attempt to query a relation with row-level security on and see the message "RLS protected relation does not support session level config on case sensitivity being different from its default value."
- When your provisioned cluster or serverless namespace has any row-level security policies, the following commands are blocked for regular users:

```
ALTER <current_user> SET enable_case_sensitive_super_attribute/
enable_case_sensitive_identifier/downcase_delimited_identifier
```

  When you create RLS policies, we recommend that you change the default configuration option settings for regular users to match the session’s configuration option settings at the time the policy was created. Superusers and users with the ALTER USER privilege can do this by using parameter group settings or the ALTER USER command. For information about parameter groups, see Amazon Redshift parameter groups in the *Amazon Redshift Management Guide*. For information about the ALTER USER command, see ALTER USER.
- Views and late-binding views with row-level security policies can't be replaced by regular users using the CREATE VIEW command. To replace views or LBVs with RLS policies, first detach any RLS policies attached to them, replace the views or LBVs, and reattach the policies. Superusers and users with the `sys:secadmin permission` can use CREATE VIEW on views or LBVs with RLS policies without detaching the policies.
- Views with row-level security policies can't reference system tables and system views.
- A late-binding view that's referenced by a regular view can't be RLS protected.
- RLS-protected relations and nested data from data lakes can't be accessed in the same query.

Best practices for RLS performance

Following are best practices to ensure better performance from Amazon Redshift on tables protected by RLS.

Safety of operators and functions

When querying RLS-protected tables, the usage of certain operators or functions may lead to performance degradation. Amazon Redshift classifies operators and functions either as safe or unsafe for querying RLS-protected tables. A function or operator is classified as RLS-safe when it doesn't have any observable side-effects depending on the inputs. In particular, a RLS-safe function or operator can't be one of the following:

- Outputs an input value, or any value that is dependent on the input value, with or without an error message.
- Fails or returns errors that are dependent on the input value.

RLS-unsafe operators include:

- Arithmetic operators — +, -, /, *, %.
- Text operators — LIKE and SIMILAR TO.
- Cast operators.
- UDFs.

Use the following SELECT statement to check the safety of operators and functions.

```
SELECT proname, proc_is_rls_safe(oid) FROM pg_proc;
```

Amazon Redshift imposes restrictions on the order of evaluation of user predicates containing RLS-unsafe operators and functions when planning queries on RLS-protected tables. Queries referencing RLS-unsafe operators or functions might cause performance degradation when querying RLS-protected tables. Performance can degrade significantly when Amazon Redshift can't push RLS-unsafe predicates down to base table scans to take advantage of sort keys. For better performance, avoid queries using RLS-unsafe predicates that take advantage of a sort key. To verify that Amazon Redshift is able to push down operators and functions, you can use EXPLAIN statements in combination with the system permission EXPLAIN RLS.

Result caching

To reduce query runtime and improve system performance, Amazon Redshift caches the results of certain types of queries in the memory on the leader node.

Amazon Redshift uses cached results for a new query scanning RLS-protected tables when all the conditions for unprotected tables are true and when all of the following are true:

- The tables or views in the policy haven't been modified.
- The policy doesn't use a function that must be evaluated each time it's run, such as GETDATE or CURRENT_USER.

For better performance, avoid using policy predicates that don't satisfy the preceding conditions.

For more information about result caching in Amazon Redshift, see [Result caching](#).

Complex policies

For better performance, avoid using complex policies with subqueries that join multiple tables.

Row-level security end-to-end example

The following is an end-to-end example to illustrate how a superuser creates some users and roles. Then, a user with the secadmin role creates, attaches, detaches, and drops RLS policies. This example uses the tickit sample database. For more information, see Load data from Amazon S3 to Amazon Redshift in the *Amazon Redshift Getting Started Guide*.

```
-- Create users and roles referenced in the policy statements.
CREATE ROLE analyst;
CREATE ROLE consumer;
CREATE ROLE dbadmin;
CREATE ROLE auditor;
CREATE USER bob WITH PASSWORD 'Name_is_bob_1';
CREATE USER alice WITH PASSWORD 'Name_is_alice_1';
CREATE USER joe WITH PASSWORD 'Name_is_joe_1';
CREATE USER molly WITH PASSWORD 'Name_is_molly_1';
CREATE USER bruce WITH PASSWORD 'Name_is_bruce_1';
GRANT ROLE sys:secadmin TO bob;
GRANT ROLE analyst TO alice;
GRANT ROLE consumer TO joe;
GRANT ROLE dbadmin TO molly;
GRANT ROLE auditor TO bruce;
GRANT ALL ON TABLE tickit_category_redshift TO PUBLIC;
GRANT ALL ON TABLE tickit_sales_redshift TO PUBLIC;
GRANT ALL ON TABLE tickit_event_redshift TO PUBLIC;

-- Create table and schema referenced in the policy statements.
```

```
CREATE SCHEMA target_schema;
GRANT ALL ON SCHEMA target_schema TO PUBLIC;
CREATE TABLE target_schema.target_event_table (LIKE tickit_event_redshift);
GRANT ALL ON TABLE target_schema.target_event_table TO PUBLIC;

-- Change session to analyst alice.
SET SESSION AUTHORIZATION alice;

-- Check the tuples visible to analyst alice.
-- Should contain all 3 categories.
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Change session to security administrator bob.
SET SESSION AUTHORIZATION bob;

CREATE RLS POLICY policy_concerts
WITH (catgroup VARCHAR(10))
USING (catgroup = 'Concerts');

SELECT poldb, polname, polalias, polatts, polqual, polenabled, polmodifiedby FROM
 svv_rls_policy WHERE poldb = CURRENT_DATABASE();

ATTACH RLS POLICY policy_concerts ON tickit_category_redshift TO ROLE analyst, ROLE
 dbadmin;

ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON;

SELECT * FROM svv_rls_attached_policy;

-- Change session to analyst alice.
SET SESSION AUTHORIZATION alice;

-- Check that tuples with only `Concert` category will be visible to analyst alice.
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Change session to consumer joe.
SET SESSION AUTHORIZATION joe;

-- Although the policy is attached to a different role, no tuples will be
-- visible to consumer joe because the default deny all policy is applied.
```

```
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Change session to dbadmin molly.
SET SESSION AUTHORIZATION molly;

-- Check that tuples with only `Concert` category will be visible to dbadmin molly.
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Check that EXPLAIN output contains RLS SecureScan to prevent disclosure of
-- sensitive information such as RLS filters.
EXPLAIN SELECT catgroup, count(*) FROM tickit_category_redshift GROUP BY catgroup ORDER
 BY catgroup;

-- Change session to security administrator bob.
SET SESSION AUTHORIZATION bob;

-- Grant IGNORE RLS permission so that RLS policies do not get applicable to role
 dbadmin.
GRANT IGNORE RLS TO ROLE dbadmin;

-- Grant EXPLAIN RLS permission so that anyone in role auditor can view complete
 EXPLAIN output.
GRANT EXPLAIN RLS TO ROLE auditor;

-- Change session to dbadmin molly.
SET SESSION AUTHORIZATION molly;

-- Check that all tuples are visible to dbadmin molly because `IGNORE RLS` is granted
 to role dbadmin.
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Change session to auditor bruce.
SET SESSION AUTHORIZATION bruce;

-- Check explain plan is visible to auditor bruce because `EXPLAIN RLS` is granted to
 role auditor.
EXPLAIN SELECT catgroup, count(*) FROM tickit_category_redshift GROUP BY catgroup ORDER
 BY catgroup;
```

```
-- Change session to security administrator bob.
SET SESSION AUTHORIZATION bob;

DETACH RLS POLICY policy_concerts ON tickit_category_redshift FROM ROLE analyst, ROLE
 dbadmin;

-- Change session to analyst alice.
SET SESSION AUTHORIZATION alice;

-- Check that no tuples are visible to analyst alice.
-- Although the policy is detached, no tuples will be visible to analyst alice
-- because of default deny all policy is applied if the table has RLS on.
SELECT catgroup, count(*)
FROM tickit_category_redshift
GROUP BY catgroup ORDER BY catgroup;

-- Change session to security administrator bob.
SET SESSION AUTHORIZATION bob;

CREATE RLS POLICY policy_events
WITH (eventid INTEGER) AS ev
USING (
    ev.eventid IN (SELECT eventid FROM tickit_sales_redshift WHERE qtysold <3)
);

ATTACH RLS POLICY policy_events ON tickit_event_redshift TO ROLE analyst;
ATTACH RLS POLICY policy_events ON target_schema.target_event_table TO ROLE consumer;

RESET SESSION AUTHORIZATION;

-- Can not cannot alter type of dependent column.
ALTER TABLE target_schema.target_event_table ALTER COLUMN eventid TYPE float;
ALTER TABLE tickit_event_redshift ALTER COLUMN eventid TYPE float;
ALTER TABLE tickit_sales_redshift ALTER COLUMN eventid TYPE float;
ALTER TABLE tickit_sales_redshift ALTER COLUMN qtysold TYPE float;

-- Can not cannot rename dependent column.
ALTER TABLE target_schema.target_event_table RENAME COLUMN eventid TO renamed_eventid;
ALTER TABLE tickit_event_redshift RENAME COLUMN eventid TO renamed_eventid;
ALTER TABLE tickit_sales_redshift RENAME COLUMN eventid TO renamed_eventid;
ALTER TABLE tickit_sales_redshift RENAME COLUMN qtysold TO renamed_qtysold;

-- Can not drop dependent column.
```

```
ALTER TABLE target_schema.target_event_table DROP COLUMN eventid CASCADE;
ALTER TABLE tickit_event_redshift DROP COLUMN eventid CASCADE;
ALTER TABLE tickit_sales_redshift DROP COLUMN eventid CASCADE;
ALTER TABLE tickit_sales_redshift DROP COLUMN qtysold CASCADE;

-- Can not drop lookup table.
DROP TABLE tickit_sales_redshift CASCADE;

-- Change session to security administrator bob.
SET SESSION AUTHORIZATION bob;

DROP RLS POLICY policy_concerts;
DROP RLS POLICY IF EXISTS policy_events;

ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY OFF;

RESET SESSION AUTHORIZATION;

-- Drop users and roles.
DROP USER bob;
DROP USER alice;
DROP USER joe;
DROP USER molly;
DROP USER bruce;
DROP ROLE analyst;
DROP ROLE consumer;
DROP ROLE auditor FORCE;
DROP ROLE dbadmin FORCE;
```

Metadata security

Like Amazon Redshift's row-level security, metadata security gives you more granular control over your metadata. If metadata security is enabled for your provisioned cluster or serverless workgroup, users can see metadata for the objects for which they have viewing access. Metadata security lets you separate visibility based on your needs. For example, you can use a single data warehouse to centralize all of your data storage. However, if you store data for multiple sectors, managing security can become troublesome. With metadata security enabled, you can configure your visibility. Users of one sector can have more visibility over their objects, while you restrict viewing access to users of another sector. Metadata security supports all object types, such as schemas, tables, views, materialized views, stored procedures, user-defined functions, and machine learning models.

Users can see metadata of objects under the following circumstances:

- If object access is granted to the user.
- If object access is granted to a group or a role that the user is a part of.
- The object is public.
- The user is the owner of the database object.

To enable metadata security, use the ALTER SYSTEM command. The following is the syntax of how to use the ALTER SYSTEM command with metadata security.

```
ALTER SYSTEM SET metadata_security=[true|t|on|false|f|off];
```

When you enable metadata security, all users who have the necessary permissions can see the relevant metadata of objects that they have access to. If you want only certain users to be able to see metadata security, grant the `ACCESS CATALOG` permission to a role, and then assign the role to the user. For more information about using roles to better control security, see Role-based access control.

The following example demonstrates how to grant the `ACCESS CATALOG` permission to a role, and then assigns the role to a user. For more information about granting permissions, see the GRANT command.

```
CREATE ROLE sample_metadata_viewer;

GRANT ACCESS CATALOG TO ROLE sample_metadata_viewer;

GRANT ROLE sample_metadata_viewer to salesadmin;
```

If you prefer to use already defined roles, the system-defined roles `operator`, `secadmin`, `dba`, and `superuser` all have the necessary permissions to view object metadata. By default, superusers can see the complete catalog.

```
GRANT ROLE operator to sample_user;
```

If you're using roles to control metadata security, you have access to all of the system views and functions that come with role-based access control. For example, you can query the SVV_ROLES view to see all roles. To see if a user is a member of a role or group, use the USER_IS_MEMBER_OF function. For a full list of SVV views, see SVV metadata views. For a list of system information functions, see System information functions.

Dynamic data masking

> **Note**
>
> Amazon Redshift automatically masks certain system table columns when logging information about queries made to Data Catalog views to prevent exposure of sensitive metadata. For more information, see Secure logging in the *Amazon Redshift Management Guide*.

Using dynamic data masking (DDM) in Amazon Redshift, you can protect sensitive data in your data warehouse. You can manipulate how Amazon Redshift shows sensitive data to the user at query time, without transforming it in the database. You control access to data through masking policies that apply custom obfuscation rules to a given user or role. In that way, you can respond to changing privacy requirements without altering underlying data or editing SQL queries.

Dynamic data masking policies hide, obfuscate, or pseudonymize data that matches a given format. When attached to a table, the masking expression is applied to one or more of its columns. You can further modify masking policies to only apply them to certain users, or to user-defined roles that you can create with Role-based access control (RBAC). Additionally, you can apply DDM on the cell level by using conditional columns when creating your masking policy. For more information about conditional masking, see Conditional dynamic data masking.

You can apply multiple masking policies with varying levels of obfuscation to the same column in a table and assign them to different roles. To avoid conflicts when you have different roles with different policies applying to one column, you can set priorities for each application. In that way, you can control what data a given user or role can access. DDM policies can partially or completely redact data, or hash it by using user-defined functions written in SQL, Python, or with AWS Lambda. By masking data using hashes, you can apply joins on this data without access to potentially sensitive information.

SQL commands for managing dynamic data masking policies

You can perform the following actions to create, attach, detach, and delete dynamic data masking policies:

- To create a DDM policy, use the CREATE MASKING POLICY command.

  The following is an example of creating a masking policy using a SHA-2 hash function.

  ```
  CREATE MASKING POLICY hash_credit
  WITH (credit_card varchar(256))
  USING (sha2(credit_card + 'testSalt', 256));
  ```

- To alter an existing DDM policy, use the ALTER MASKING POLICY command.

  The following is an example of altering an existing masking policy.

  ```
  ALTER MASKING POLICY hash_credit
  USING (sha2(credit_card + 'otherTestSalt', 256));
  ```

- To attach a DDM policy on a table to one or more users or roles, use the ATTACH MASKING POLICY command.

  The following is an example of attaching a masking policy to a column/role pair.

  ```
   ATTACH MASKING POLICY hash_credit
  ON credit_cards (credit_card)
  TO ROLE science_role
  PRIORITY 30;
  ```

  The PRIORITY clause determines which masking policy applies to a user session when multiple policies are attached to the same column. For example, if the user in the preceding example has another masking policy attached to the same credit card column with a priority of 20, science_role's policy is the one that applies, as it has the higher priority of 30.

- To detach a DDM policy on a table from one or more users or roles, use the DETACH MASKING POLICY command.

  The following is an example of detaching a masking policy from a column/role pair.

  ```
  DETACH MASKING POLICY hash_credit
  ON credit_cards(credit_card)
  FROM ROLE science_role;
  ```

- To drop a DDM policy from all databases, use the DROP MASKING POLICY command.

  The following is an example of dropping a masking policy from all databases.

```
DROP MASKING POLICY hash_credit;
```

Dynamic data masking policy hierarchy

When attaching multiple masking policies, consider the following:

- You can attach multiple masking policies to a single column.
- When multiple masking policies are applicable to a query, the highest priority policy attached to each respective column applies. Consider the following example.

  ```
  ATTACH MASKING POLICY partial_hash
  ON credit_cards(address, credit_card)
  TO ROLE analytics_role
  PRIORITY 20;

  ATTACH MASKING POLICY full_hash
  ON credit_cards(credit_card, ssn)
  TO ROLE auditor_role
  PRIORITY 30;

  SELECT address, credit_card, ssn
  FROM credit_cards;
  ```

  When running the SELECT statement, a user with both the analytics and auditor roles sees the address column with the `partial_hash` masking policy applied. They see the credit card and SSN columns with the `full_hash` masking policy applied because the `full_hash` policy has the higher priority on the credit card column.
- If you don't specify a priority when attaching a masking policy, the default priority is 0.
- You can't attach two policies to the same column with equal priority.
- You can't attach two policies to the same combination of user and column or role and column.
- When multiple masking policies are applicable along the same SUPER path while attached to the same user or role, only the highest priority attachment takes effect. Consider the following examples.

  The first example shows two masking policies attached on the same path, with the higher priority policy taking effect.

```
ATTACH MASKING POLICY hide_name
ON employees(col_person.name)
TO PUBLIC
PRIORITY 20;

ATTACH MASKING POLICY hide_last_name
ON employees(col_person.name.last)
TO PUBLIC
PRIORITY 30;

--Only the hide_last_name policy takes effect.
SELECT employees.col_person.name FROM employees;
```

The second example shows two masking policies attached to different paths in the same SUPER object, with no conflict between the policies. Both attachments will apply at the same time.

```
ATTACH MASKING POLICY hide_first_name
ON employees(col_person.name.first)
TO PUBLIC
PRIORITY 20;

ATTACH MASKING POLICY hide_last_name
ON employees(col_person.name.last)
TO PUBLIC
PRIORITY 20;

--Both col_person.name.first and col_person.name.last are masked.
SELECT employees.col_person.name FROM employees;
```

To confirm which masking policy applies to a given user and column or role and column combination, users with the `sys:secadmin` role can look up the column/role or column/user pair in the SVV_ATTACHED_MASKING_POLICY system view. For more information, see Dynamic data masking system views.

Using dynamic data masking with SUPER data type paths

Amazon Redshift supports attaching dynamic data masking policies to paths of SUPER type columns. For more information about the SUPER data type, see Semi-structured data in Amazon Redshift.

When attaching masking policies to paths of SUPER type columns, consider the following.

- When attaching a masking policy to a path on a column, that column must be defined as the SUPER data type. You can only apply masking policies to *scalar* values on the SUPER path. You can't apply masking policies to complex structures or arrays.
- You can apply different masking policies to multiple scalar values on a single SUPER column, as long as the SUPER paths don't conflict. For example, the SUPER paths `a.b` and `a.b.c` conflict because they are on the same path, with `a.b` being the parent of `a.b.c`. The SUPER paths `a.b.c` and `a.b.d` don’t conflict.
- Amazon Redshift can’t check that the paths that a masking policy attaches to exist in the data and are of the expected type until the policy is applied at user query runtime. For example, when you attach a masking policy that masks TEXT values to a SUPER path that contains an INT value, Amazon Redshift will attempt to cast the type of the value at the path.

  In such situations, the behavior of Amazon Redshift at runtime depends on your configuration settings for querying SUPER objects. By default, Amazon Redshift is in lax mode, and will resolve missing paths and invalid casts as `NULL` for the given SUPER path. For more information about SUPER-related configuration settings, see SUPER configurations.
- SUPER is a schemaless type, which means that Amazon Redshift can’t confirm the existence of the value at a given SUPER path. If you attach a masking policy to a SUPER path that doesn’t exist and Amazon Redshift is in lax mode, Amazon Redshift will resolve the path to a `NULL` value. We recommend that you consider the expected format of SUPER objects and the likelihood of them having unexpected attributes when attaching masking policies to paths of SUPER columns. If you think there might be an unexpected schema in your SUPER column, consider attaching your masking policies directly to the SUPER column. You can use SUPER type information functions to check attributes and types, and using `OBJECT_TRANSFORM` to mask the values. For more information about SUPER type information functions, see SUPER type information functions.

Examples

Attaching masking policies to SUPER paths

The following example attaches multiple masking policies onto multiple SUPER type paths in one column.

```
CREATE TABLE employees (
```

```
    col_person SUPER
);

INSERT INTO employees
VALUES
    (
        json_parse('
            {
                "name": {
                    "first": "John",
                    "last": "Doe"
                },
                "age": 25,
                "ssn": "111-22-3333",
                "company": "Company Inc."
            }
        ')
    ),
    (
        json_parse('
            {
                "name": {
                    "first": "Jane",
                    "last": "Appleseed"
                },
                "age": 34,
                "ssn": "444-55-7777",
                "company": "Organization Org."
            }
        ')
    )
;
GRANT ALL ON ALL TABLES IN SCHEMA "public" TO PUBLIC;

-- Create the masking policies.

-- This policy converts the given name to all uppercase letters.
CREATE MASKING POLICY mask_first_name
WITH(first_name TEXT)
USING ( UPPER(first_name) );

-- This policy replaces the given name with the fixed string 'XXXX'.
CREATE MASKING POLICY mask_last_name
WITH(last_name TEXT)
```

```
USING ( 'XXXX'::TEXT );

-- This policy rounds down the given age to the nearest 10.
CREATE MASKING POLICY mask_age
WITH(age INT)
USING ( (FLOOR(age::FLOAT / 10) * 10)::INT );

-- This policy converts the first five digits of the given SSN to 'XXX-XX'.
CREATE MASKING POLICY mask_ssn
WITH(ssn TEXT)
USING ( 'XXX-XX-'::TEXT || SUBSTRING(ssn::TEXT FROM 8 FOR 4) );

-- Attach the masking policies to the employees table.
ATTACH MASKING POLICY mask_first_name
ON employees(col_person.name.first)
TO PUBLIC;

ATTACH MASKING POLICY mask_last_name
ON employees(col_person.name.last)
TO PUBLIC;

ATTACH MASKING POLICY mask_age
ON employees(col_person.age)
TO PUBLIC;

ATTACH MASKING POLICY mask_ssn
ON employees(col_person.ssn)
TO PUBLIC;

-- Verify that your masking policies are attached.
SELECT
    policy_name,
    TABLE_NAME,
    priority,
    input_columns,
    output_columns
FROM
    svv_attached_masking_policy;

   policy_name   | table_name | priority |           input_columns           |
 output_columns
-----------------+------------+----------+-----------------------------------
+-----------------------------------
```

```
 mask_age        | employees  |        0 | ["col_person.\"age\""]             |
 ["col_person.\"age\""]
 mask_first_name | employees  |        0 | ["col_person.\"name\".\"first\""] |
 ["col_person.\"name\".\"first\""]
 mask_last_name  | employees  |        0 | ["col_person.\"name\".\"last\""]  |
 ["col_person.\"name\".\"last\""]
 mask_ssn        | employees  |        0 | ["col_person.\"ssn\""]             |
 ["col_person.\"ssn\""]
(4 rows)

-- Observe the masking policies taking effect.
SELECT col_person FROM employees ORDER BY col_person.age;

-- This result is formatted for ease of reading.
         col_person
--------------------------------
{
    "name": {
        "first": "JOHN",
        "last": "XXXX"
    },
    "age": 20,
    "ssn": "XXX-XX-3333",
    "company": "Company Inc."
}
{
    "name": {
        "first": "JANE",
        "last": "XXXX"
    },
    "age": 30,
    "ssn": "XXX-XX-7777",
    "company": "Organization Org."
}
```

Following are some examples of invalid masking policy attachments to SUPER paths.

```
-- This attachment fails because there is already a policy
-- with equal priority attached to employees.name.last, which is
-- on the same SUPER path as employees.name.
ATTACH MASKING POLICY mask_ssn
ON employees(col_person.name)
TO PUBLIC;
```

```
ERROR:  DDM policy "mask_last_name" is already attached on relation "employees" column
 "col_person."name"."last"" with same priority

-- Create a masking policy that masks DATETIME objects.
CREATE MASKING POLICY mask_date
WITH(INPUT DATETIME)
USING ( INPUT );

-- This attachment fails because SUPER type columns can't contain DATETIME objects.
ATTACH MASKING POLICY mask_date
ON employees(col_person.company)
TO PUBLIC;
ERROR:  cannot attach masking policy for output of type "timestamp without time zone"
 to column "col_person."company"" of type "super
```

Following is an example of attaching a masking policy to a SUPER path that doesn't exist. By default, Amazon Redshift will resolve the path to NULL.

```
ATTACH MASKING POLICY mask_first_name
ON employees(col_person.not_exists)
TO PUBLIC;

SELECT col_person FROM employees LIMIT 1;

-- This result is formatted for ease of reading.
         col_person
-----------------------------------
{
    "name": {
        "first": "JOHN",
        "last": "XXXX"
    },
    "age": 20,
    "ssn": "XXX-XX-3333",
    "company": "Company Inc.",
    "not_exists": null
}
```

Conditional dynamic data masking

You can mask data at the cell level by creating masking policies with conditional expressions in the masking expression. For example, you can create a masking policy that applies different masks to a value, depending on another column's value in that row.

The following is an example of using conditional data masking to create and attach a masking policy that partially redacts credit card numbers involved in fraud, while completely hiding all other credit card numbers. You must be a superuser or have the `sys:secadmin` role to run this example.

```
--Create an analyst role.
CREATE ROLE analyst;

--Create a credit card table. The table contains an is_fraud boolean column,
--which is TRUE if the credit card number in that row was involved in a fraudulent
 transaction.
CREATE TABLE credit_cards (id INT, is_fraud BOOLEAN, credit_card_number VARCHAR(16));

--Create a function that partially redacts credit card numbers.
CREATE FUNCTION REDACT_CREDIT_CARD (credit_card VARCHAR(16))
RETURNS VARCHAR(16) IMMUTABLE
AS $$
    import re
    regexp = re.compile("^([0-9]{6})[0-9]{5,6}([0-9]{4})")

    match = regexp.search(credit_card)
    if match != None:
        first = match.group(1)
        last = match.group(2)
    else:
        first = "000000"
        last = "0000"

    return "{}XXXXX{}".format(first, last)
$$ LANGUAGE plpythonu;

--Create a masking policy that partially redacts credit card numbers if the is_fraud
 value for that row is TRUE,
--and otherwise blanks out the credit card number completely.
CREATE MASKING POLICY card_number_conditional_mask
    WITH (fraudulent BOOLEAN, pan varchar(16))
```

```
    USING (CASE WHEN fraudulent THEN REDACT_CREDIT_CARD(pan)
                ELSE Null
            END);

--Attach the masking policy to the credit_cards/analyst table/role pair.
ATTACH MASKING POLICY card_number_conditional_mask ON credit_cards (credit_card_number)
 USING (is_fraud, credit_card_number)
 TO ROLE analyst PRIORITY 100;
```

Dynamic data masking system views

Superusers, users with the `sys:operator` role, and users with the ACCESS SYSTEM TABLE permission can access the following DDM-related system views.

- SVV_MASKING_POLICY

  Use SVV_MASKING_POLICY to view all masking policies created on the cluster or workgroup.
- SVV_ATTACHED_MASKING_POLICY

  Use SVV_ATTACHED_MASKING_POLICY to view all the relations and users or roles with policies attached on the currently connected database.
- SYS_APPLIED_MASKING_POLICY_LOG

  Use SYS_APPLIED_MASKING_POLICY_LOG to trace the application of masking policies on queries that reference DDM-protected relations.

Following are some examples of the information that you can find using system views.

```
--Select all policies associated with specific users, as opposed to roles
SELECT policy_name,
       schema_name,
       table_name,
       grantee
FROM svv_attached_masking_policy
WHERE grantee_type = 'user';

--Select all policies attached to a specific user
SELECT policy_name,
       schema_name,
       table_name,
       grantee
```

```
FROM svv_attached_masking_policy
WHERE grantee = 'target_grantee_name'

--Select all policies attached to a given table
SELECT policy_name,
       schema_name,
       table_name,
       grantee
FROM svv_attached_masking_policy
WHERE table_name = 'target_table_name'
      AND schema_name = 'target_schema_name';

--Select the highest priority policy attachment for a given role
SELECT samp.policy_name,
       samp.priority,
       samp.grantee,
       smp.policy_expression
FROM svv_masking_policy AS smp
JOIN svv_attached_masking_policy AS samp
    ON samp.policy_name = smp.policy_name
WHERE
    samp.grantee_type = 'role' AND
    samp.policy_name = mask_get_policy_for_role_on_column(
        'target_schema_name',
        'target_table_name',
        'target_column_name',
        'target_role_name')
ORDER BY samp.priority desc
LIMIT 1;

--See which policy a specific user will see on a specific column in a given relation
SELECT samp.policy_name,
       samp.priority,
       samp.grantee,
       smp.policy_expression
FROM svv_masking_policy AS smp
JOIN svv_attached_masking_policy AS samp
    ON samp.policy_name = smp.policy_name
WHERE
    samp.grantee_type = 'role' AND
    samp.policy_name = mask_get_policy_for_user_on_column(
        'target_schema_name',
        'target_table_name',
        'target_column_name',
```

```
        'target_user_name')
ORDER BY samp.priority desc;

 --Select all policies attached to a given relation.
SELECT policy_name,
schema_name,
relation_name,
database_name
FROM sys_applied_masking_policy_log
WHERE relation_name = 'relation_name'
AND schema_name = 'schema_name';
```

Considerations when using dynamic data masking

When using dynamic data masking, consider the following:

- When querying objects created from tables, such as views, users will see results based on their own masking policies, not the policies of the user who created the objects. For example, a user with the analyst role querying a view created by a secadmin would see results with masking policies attached to the analyst role.
- To prevent the EXPLAIN command from potentially exposing sensitive masking policy filters, only users with the SYS_EXPLAIN_DDM permission can see masking policies applied in EXPLAIN outputs. Users don't have the SYS_EXPLAIN_DDM permission by default.

  The following is the syntax for granting the permission to a role.

  ```
  GRANT EXPLAIN MASKING TO ROLE rolename
  ```

  For more information about the EXPLAIN command, see EXPLAIN.
- Users with different roles can see differing results based on the filter conditions or join conditions used. For example, running a SELECT command on a table using a specific column value will fail if the user running the command has a masking policy applied that obfuscates that column.
- DDM policies must be applied ahead of any predicate operations, or projections. Masking polices can include the following:
  - Low cost constant operations such as converting a value to null
  - Moderate cost operations such as HMAC hashing
  - High cost operations such as calls to external Lambda user defined functions

As such, we recommend that you use simple masking expressions when possible.

- You can use DDM policies for roles with row-level security policies, but note that RLS policies are applied before DDM. A dynamic data masking expression won't be able to read a row that was protected by RLS. For more information about RLS, see Row-level security.
- When using the COPY command to copy from parquet to protected target tables, you should explicitly specify columns in the COPY statement. For more information about mapping columns with COPY, see Column mapping options.
- DDM policies can't attach to the following relations:
  - System tables and catalogs
  - External tables
  - Datasharing tables
  - Cross-DB relations
  - Temporary tables
  - Correlated queries
- DDM policies can contain lookup tables. Lookup tables can be present in the USING clause. The following relation types can’t be used as lookup tables:
  - System tables and catalogs
  - External tables
  - Datasharing tables
  - Views, materialized views, and late-binding views
  - Cross-DB relations
  - Temporary tables
  - Correlated queries

  Following is an example of attaching a masking policy to a lookup table.

```
--Create a masking policy referencing a lookup table
CREATE MASKING POLICY lookup_mask_credit_card WITH (credit_card TEXT) USING (
  CASE
    WHEN
      credit_card IN (SELECT credit_card_lookup FROM credit_cards_lookup)
    THEN '000000XXXX0000'
    ELSE REDACT_CREDIT_CARD(credit_card)
    END
```

```
  );

--Provides access to the lookup table via a policy attached to a role
GRANT SELECT ON TABLE credit_cards_lookup TO MASKING POLICY lookup_mask_credit_card;
```

- You can't attach a masking policy that would produce an output incompatible with the target column's type and size. For example, you can’t attach a masking policy that outputs a 12 character long string to a VARCHAR(10) column. Amazon Redshift supports the following exceptions:
  - A masking policy with the input type INTN can be attached to a policy with size INTM as long as M < N. For example, a BIGINT (INT8) input policy can be attached to a smallint (INT4) column.
  - A masking policy with the input type NUMERIC or DECIMAL can always be attached to a FLOAT column.
- You can't use DDM policies with data sharing. If the datashare's data producer attaches a DDM policy to a table in the datashare, the table becomes inaccessible to users from the data consumer who are trying to query the table. Attempting to add the relation to a datashare fails on the producer-side cluster or namespace with the following error:

```
<ddm_protected_relation> or a relation dependent on it is protected by a masking
 policy and cannot be added to a datashare
```

  If you attach a masking policy to a relation on the producer side and the relation is already included in a datashare, attempting to query the relation on the consumer side fails with the following error:

```
cross-cluster query of the masked relation <ddm_protected_relation> is not supported.
```

  You can turn off DDM for datashares using the ALTER TABLE command with the MASKING OFF FOR DATASHARES parameter. For more information, see ALTER TABLE.
- You can't query relations that have attached DDM policies if your values for any of the following configuration options don't match the default value of the session:
  - `enable_case_sensitive_super_attribute`
  - `enable_case_sensitive_identifier`
  - `downcase_delimited_identifier`

Consider resetting your session’s configuration options if you attempt to query a relation with a DDM policy attached and see the message "DDM protected relation does not support session level config on case sensitivity being different from its default value."

- When your provisioned cluster or serverless namespace has any dynamic data masking policies, the following commands are blocked for regular users:

```
ALTER <current_user> SET enable_case_sensitive_super_attribute/
enable_case_sensitive_identifier/downcase_delimited_identifier
```

  When you create DDM policies, we recommend that you change the default configuration option settings for regular users to match the session’s configuration option settings at the time the policy was created. Superusers and users with the ALTER USER privilege can do this by using parameter group settings or the ALTER USER command. For information about parameter groups, see Amazon Redshift parameter groups in the *Amazon Redshift Management Guide*. For information about the ALTER USER command, see ALTER USER.

- Views and late-binding views with attached DDM policies can't be replaced by regular users using the CREATE VIEW command. To replace views or LBVs with DDM policies, first detach any DDM policies attached to them, replace the views or LBVs, and reattach the policies. Superusers and users with the `sys:secadmin` permission can use CREATE VIEW on views or LBVs with DDM policies without detaching the policies.
- Views with attached DDM policies can't reference system tables and views. Late-binding views can reference system tables and views.
- Late-binding views with attached DDM policies can't reference nested data in data lakes, such as JSON documents.
- Late-binding views can't have DDM policies attached if that late-binding view is referenced by any view.
- DDM policies attached to late-binding views are attached by column name. At query time, Amazon Redshift validates that all masking policies attached to the late-binding view have been applied successfully, and that the late-binding view's output column type matches the types in the attached masking policies. If the validation fails, Amazon Redshift returns an error for the query.
- You can use customized session context variables when creating DDM policies. The following example sets session context variables for a DDM policy.

```
-- Set a customized context variable.
```

```
SELECT set_config('app.city', 'XXXX', FALSE);

-- Create a MASKING policy using current_setting() to get the value of a customized
 context variable.
CREATE MASKING POLICY city_mask
WITH (city VARCHAR(30))
USING (current_setting('app.city')::VARCHAR(30));

-- Attach the policy on the target table to one or more roles.
ATTACH MASKING POLICY city_mask
ON tickit_users_redshift(city)
TO ROLE analyst, ROLE dbadmin;
```

For details on how to set and retrieve customized session context variables, go to SET, SET_CONFIG, SHOW, CURRENT_SETTING, and RESET. For more information on modifying the server configuration in general, go to Modifying the server configuration.

Important

When using session context variables within DDM policies, the security policy is reliant on the user or role that invokes the policy. Be careful to avoid security vulnerabilities when using session context variables in DDM policies.

Dynamic data masking end-to-end example

The following is an end-to-end example showing how you can create and attach masking policies to a column. These policies let users access a column and see different values, depending on the degree of obfuscation in the policies attached to their roles. You must be a superuser or have the `sys:secadmin` role to run this example.

Creating a masking policy

First, create a table and populate it with credit card values.

```
--create the table
CREATE TABLE credit_cards (
  customer_id INT,
  credit_card TEXT
);
```

```
--populate the table with sample values
INSERT INTO credit_cards
VALUES
  (100, '4532993817514842'),
  (100, '4716002041425888'),
  (102, '5243112427642649'),
  (102, '6011720771834675'),
  (102, '6011378662059710'),
  (103, '373611968625635')
;

--run GRANT to grant permission to use the SELECT statement on the table
GRANT SELECT ON credit_cards TO PUBLIC;

--create two users
CREATE USER regular_user WITH PASSWORD '1234Test!';

CREATE USER analytics_user WITH PASSWORD '1234Test!';

--create the analytics_role role and grant it to analytics_user
--regular_user does not have a role
CREATE ROLE analytics_role;

GRANT ROLE analytics_role TO analytics_user;
```

Next, create a masking policy to apply to the analytics role.

```
--create a masking policy that fully masks the credit card number
CREATE MASKING POLICY mask_credit_card_full
WITH (credit_card VARCHAR(256))
USING ('000000XXXX0000'::TEXT);

--create a user-defined function that partially obfuscates credit card data
CREATE FUNCTION REDACT_CREDIT_CARD (credit_card TEXT)
RETURNS TEXT IMMUTABLE
AS $$
    import re
    regexp = re.compile("^([0-9]{6})[0-9]{5,6}([0-9]{4})")

    match = regexp.search(credit_card)
    if match != None:
        first = match.group(1)
        last = match.group(2)
```

```
    else:
        first = "000000"
        last = "0000"

    return "{}XXXXX{}".format(first, last)
$$ LANGUAGE plpythonu;

--create a masking policy that applies the REDACT_CREDIT_CARD function
CREATE MASKING POLICY mask_credit_card_partial
WITH (credit_card VARCHAR(256))
USING (REDACT_CREDIT_CARD(credit_card));

--confirm the masking policies using the associated system views
SELECT * FROM svv_masking_policy;

SELECT * FROM svv_attached_masking_policy;
```

Attaching a masking policy

Attach the masking policies to the credit card table.

```
--attach mask_credit_card_full to the credit card table as the default policy
--all users will see this masking policy unless a higher priority masking policy is
 attached to them or their role
ATTACH MASKING POLICY mask_credit_card_full
ON credit_cards(credit_card)
TO PUBLIC;

--attach mask_credit_card_partial to the analytics role
--users with the analytics role can see partial credit card information
ATTACH MASKING POLICY mask_credit_card_partial
ON credit_cards(credit_card)
TO ROLE analytics_role
PRIORITY 10;

--confirm the masking policies are applied to the table and role in the associated
 system view
SELECT * FROM svv_attached_masking_policy;

--confirm the full masking policy is in place for normal users by selecting from the
 credit card table as regular_user
SET SESSION AUTHORIZATION regular_user;
```

```
SELECT * FROM credit_cards;

--confirm the partial masking policy is in place for users with the analytics role by
 selecting from the credit card table as analytics_user
SET SESSION AUTHORIZATION analytics_user;

SELECT * FROM credit_cards;
```

Altering a masking policy

The following section shows how to alter a dynamic data masking policy.

```
--reset session authorization to the default
RESET SESSION AUTHORIZATION;

--alter the mask_credit_card_full policy
ALTER MASKING POLICY mask_credit_card_full
USING ('00000000000000'::TEXT);

--confirm the full masking policy is in place after altering the policy, and that
 results are altered from '000000XXXX0000' to '00000000000000'
SELECT * FROM credit_cards;
```

Detaching and dropping a masking policy

The following section shows how to detach and drop masking policies by removing all dynamic data masking policies from the table.

```
--reset session authorization to the default
RESET SESSION AUTHORIZATION;

--detach both masking policies from the credit_cards table
DETACH MASKING POLICY mask_credit_card_full
ON credit_cards(credit_card)
FROM PUBLIC;

DETACH MASKING POLICY mask_credit_card_partial
ON credit_cards(credit_card)
FROM ROLE analytics_role;

--drop both masking policies
DROP MASKING POLICY mask_credit_card_full;
```

```
DROP MASKING POLICY mask_credit_card_partial;
```

Scoped permissions

Scoped permissions let you grant permissions to a user or role on all objects of a type within a database or schema. Users and roles with scoped permissions have the specified permissions on all current and future objects within the database or schema.

You can view the scope of database-level scoped permissions in SVV_DATABASE_PRIVILEGES. You can view the scope of schema-level scoped permissions in SVV_SCHEMA_PRIVILEGES.

For more information on applying scoped permissions, see GRANT and REVOKE.

Considerations for using scoped permissions

When using scoped permissions, consider the following:

- You can use scoped permissions to grant or revoke permissions on a database or schema scope to or from a specified user or role.
- You can't grant scoped permissions to user groups.
- Granting or revoking scoped permissions changes permissions for all current and future objects in the scope.
- Scoped permissions and object-level permissions operate independently of each other. For example, a user will maintain permissions on a table in both of the following cases.
  - The user is granted SELECT on the table schema1.table1 and SELECT scoped permission on schema1. The user then has SELECT revoked for all tables in schema schema1. The user retains SELECT on schema1.table1.
  - The user is granted SELECT on the table schema1.table1 and SELECT scoped permission on schema1. The user then has SELECT revoked for schema1.table1. The user retains SELECT on schema1.table1.
- To grant or revoke scoped permissions, you must meet one of the following criteria:
  - Superusers.
  - Users with the grant option for that permission. For more information on grant options, go to the WITH GRANT OPTION parameter in GRANT.
- Scoped permissions can only be granted to or revoked from objects for the connected database, or from databases imported from a datashare.

- You can use scoped permissions to set the default permissions on a database created from a datashare. A consumer-side datashare user who is granted scoped permissions on a shared database will automatically gain those permissions for any new object added to the datashare on the producer side.
- Producers can grant scoped permissions on objects within a schema to a datashare. (preview)

SQL reference

With Amazon Redshift, you can leverage SQL to efficiently query and analyze vast amounts of data stored in your data warehouse. The SQL reference covers the syntax and usage of SQL commands, data types, functions, operators, and more, empowering you to extract insights and make data-driven decisions. You can consult this reference to write optimized queries, create and manage database objects, and perform complex data transformations. The following reference provides comprehensive details on utilizing SQL within the Amazon Redshift environment to fulfill your data analysis requirements.

Topics

Amazon Redshift SQL

Topics

Amazon Redshift is built around industry-standard SQL, with added functionality to manage very large datasets and support high-performance analysis and reporting of those data.

> **Note**
>
> The maximum size for a single Amazon Redshift SQL statement is 16 MB.

SQL functions supported on the leader node

Some Amazon Redshift queries are distributed and run on the compute nodes, and other queries run exclusively on the leader node.

The leader node distributes SQL to the compute nodes whenever a query references user-created tables or system tables (tables with an STL or STV prefix and system views with an SVL or SVV prefix). A query that references only catalog tables (tables with a PG prefix, such as PG_TABLE_DEF, which reside on the leader node) or that does not reference any tables, runs exclusively on the leader node.

Some Amazon Redshift SQL functions are supported only on the leader node and are not supported on the compute nodes. A query that uses a leader-node function must run exclusively on the leader node, not on the compute nodes, or it will return an error.

The documentation for each function that must run exclusively on the leader node includes a note stating that the function will return an error if it references user-defined tables or Amazon Redshift system tables. See Leader node–only functions for a list of functions that run exclusively on the leader node.

Examples

The following examples use the sample TICKIT database. For more information on the sample database, go to Sample database.

CURRENT_SCHEMA

The CURRENT_SCHEMA function is a leader-node only function. In this example, the query does not reference a table, so it runs exclusively on the leader node.

```
select current_schema();

current_schema
---------------
public
```

In the next example, the query references a system catalog table, so it runs exclusively on the leader node.

```
select * from pg_table_def
where schemaname = current_schema() limit 1;

 schemaname | tablename | column |   type   | encoding | distkey | sortkey | notnull
------------+-----------+--------+----------+----------+---------+---------+---------
 public     | category  | catid  | smallint | none     | t       |       1 | t
```

In the next example, the query references an Amazon Redshift system table that resides on the compute nodes, so it returns an error.

```
select current_schema(), userid from users;

INFO:  Function "current_schema()" not supported.
ERROR:  Specified types or functions (one per INFO message) not supported on Amazon
 Redshift tables.
```

SUBSTR

SUBSTR is also a leader-node only function. In the following example, the query runs exclusive on the leader node because it does not reference a table.

```
SELECT SUBSTR('amazon', 5);

+--------+
| substr |
+--------+
| on     |
+--------+
```

In the following example, the query references a table that resides on the compute nodes. This results in an error.

```
SELECT SUBSTR(catdesc, 1) FROM category LIMIT 1;

ERROR: SUBSTR() function is not supported (Hint: use SUBSTRING instead)
```

To successfully run the previous query, use SUBSTRING.

```
SELECT SUBSTRING(catdesc, 1) FROM category LIMIT 1;

+-------------------------------+
|           substring           |
+-------------------------------+
| National Basketball Association |
+-------------------------------+
```

FACTORIAL()

FACTORIAL() is a leader-node only function. In the following example, the query runs exclusive on the leader node because it does not reference a table.

```
SELECT FACTORIAL(5);

 factorial
-------------
 120
```

In the following example, the query references a table that resides on the compute nodes. This results in an error when run using query editor v2.

```
create table t(a int);
insert into t values (5);
select factorial(a) from t;

ERROR: Specified types or functions (one per INFO message) not supported on Redshift
 tables.
Info: Function "factorial(bigint)" not supported.
```

Amazon Redshift and PostgreSQL

Topics

- Amazon Redshift and PostgreSQL JDBC and ODBC
- Features that are implemented differently
- Unsupported PostgreSQL features
- Unsupported PostgreSQL data types
- Unsupported PostgreSQL functions

Amazon Redshift is based on PostgreSQL. Amazon Redshift and PostgreSQL have a number of very important differences that you must be aware of as you design and develop your data warehouse applications.

Amazon Redshift is specifically designed for online analytic processing (OLAP) and business intelligence (BI) applications, which require complex queries against large datasets. Because it addresses very different requirements, the specialized data storage schema and query execution engine that Amazon Redshift uses are completely different from the PostgreSQL implementation. For example, where online transaction processing (OLTP) applications typically store data in rows, Amazon Redshift stores data in columns, using specialized data compression encodings for optimum memory usage and disk I/O. Some PostgreSQL features that are suited to smaller-scale OLTP processing, such as secondary indexes and efficient single-row data manipulation operations, have been omitted to improve performance.

See Amazon Redshift architecture for a detailed explanation of the Amazon Redshift data warehouse system architecture.

PostgreSQL 9.x includes some features that are not supported in Amazon Redshift. In addition, there are important differences between Amazon Redshift SQL and PostgreSQL that you must be aware of. This section highlights the differences between Amazon Redshift and PostgreSQL and provides guidance for developing a data warehouse that takes full advantage of the Amazon Redshift SQL implementation.

Amazon Redshift and PostgreSQL JDBC and ODBC

Because Amazon Redshift is based on PostgreSQL, we previously recommended using JDBC4 Postgresql driver version 8.4.703 and psqlODBC version 9.x drivers. If you are currently using those drivers, we recommend moving to the new Amazon Redshift–specific drivers going forward. For more information about drivers and configuring connections, see JDBC and ODBC Drivers for Amazon Redshift in the *Amazon Redshift Management Guide*.

To avoid client-side out-of-memory errors when retrieving large data sets using JDBC, you can enable your client to fetch data in batches by setting the JDBC fetch size parameter. For more information, see Setting the JDBC fetch size parameter.

Amazon Redshift does not recognize the JDBC maxRows parameter. Instead, specify a LIMIT clause to restrict the result set. You can also use an OFFSET clause to skip to a specific starting point in the result set.

Features that are implemented differently

Many Amazon Redshift SQL language elements have different performance characteristics and use syntax and semantics and that are quite different from the equivalent PostgreSQL implementation.

> **Important**
>
> Do not assume that the semantics of elements that Amazon Redshift and PostgreSQL have in common are identical. Make sure to consult the *Amazon Redshift Developer Guide* SQL commands to understand the often subtle differences.

One example in particular is the VACUUM command, which is used to clean up and reorganize tables. VACUUM functions differently and uses a different set of parameters than the PostgreSQL version. See Vacuuming tables for more about information about using VACUUM in Amazon Redshift.

Often, database management and administration features and tools are different as well. For example, Amazon Redshift maintains a set of system tables and views that provide information about how the system is functioning. See SYS monitoring views for more information.

The following list includes some examples of SQL features that are implemented differently in Amazon Redshift.

- CREATE TABLE

  Amazon Redshift does not support tablespaces, table partitioning, inheritance, and certain constraints. The Amazon Redshift implementation of CREATE TABLE enables you to define the sort and distribution algorithms for tables to optimize parallel processing.

  Amazon Redshift Spectrum supports table partitioning using the CREATE EXTERNAL TABLE command.

- ALTER TABLE

  Only a subset of ALTER COLUMN actions are supported.

  ADD COLUMN supports adding only one column in each ALTER TABLE statement.

- COPY

  The Amazon Redshift COPY command is highly specialized to enable the loading of data from Amazon S3 buckets and Amazon DynamoDB tables and to facilitate automatic compression. See the Loading data in Amazon Redshift section and the COPY command reference for details.

- VACUUM

  The parameters for VACUUM are entirely different. For example, the default VACUUM operation in PostgreSQL simply reclaims space and makes it available for re-use; however, the default VACUUM operation in Amazon Redshift is VACUUM FULL, which reclaims disk space and resorts all rows.

- Trailing spaces in VARCHAR values are ignored when string values are compared. For more information, see Significance of trailing blanks.

Unsupported PostgreSQL features

These PostgreSQL features are not supported in Amazon Redshift.

> **Important**
>
> Do not assume that the semantics of elements that Amazon Redshift and PostgreSQL have in common are identical. Make sure to consult the *Amazon Redshift Developer Guide* SQL commands to understand the often subtle differences.

- The query tool *psql* is unsupported. The Amazon Redshift RSQL client is supported.
- Table partitioning (range and list partitioning)
- Tablespaces
- Constraints
  - Unique
  - Foreign key
  - Primary key
  - Check constraints
  - Exclusion constraints

  Unique, primary key, and foreign key constraints are permitted, but they are informational only. They are not enforced by the system, but they are used by the query planner.
- Inheritance
- PostgreSQL system columns

  Amazon Redshift SQL does not implicitly define system columns. However, the following PostgreSQL system column names cannot be used as names of user-defined columns: `oid`, `tableoid`, `xmin`, `cmin`, `xmax`, `cmax`, and `ctid`. For more information, see https://www.postgresql.org/docs/8.0/static/ddl-system-columns.html.
- Indexes
- NULLS clause in Window functions
- Collations

  Amazon Redshift does not support locale-specific or user-defined collation sequences. See Collation sequences.

- Value expressions
  - Subscripted expressions
  - Array constructors
  - Row constructors
- Triggers
- Management of External Data (SQL/MED)
- Table functions
- VALUES list used as constant tables
- Sequences
- Full text search
- The RULE and TRIGGER permissions.

  Amazon Redshift grants or revokes these permissions when you run GRANT ALL or REVOKE ALL, but the presence or absence of the RULE and TRIGGER permissions doesn't affect the grantee's access permissions in any way.

Unsupported PostgreSQL data types

Generally, if a query attempts to use an unsupported data type, including explicit or implicit casts, it will return an error. However, some queries that use unsupported data types will run on the leader node but not on the compute nodes. See SQL functions supported on the leader node.

For a list of the supported data types, see Data types.

These PostgreSQL data types are not supported in Amazon Redshift.

- Arrays
- BIT, BIT VARYING
- BYTEA
- Composite Types
- Enumerated Types
- Geometric Types (Amazon Redshift implementation of geometric types differs from PostgreSQL)
- HSTORE
- JSON

- Network Address Types
- Numeric Types
  - SERIAL, BIGSERIAL, SMALLSERIAL
  - MONEY
- Object Identifier Types
- Pseudo-Types
- Range Types
- Special Character Types
  - "char" – A single-byte internal type (where the data type named char is enclosed in quotation marks).
  - name – An internal type for object names.

  For more information about these types, see Special Character Types in the PostgreSQL documentation.
- Text Search Types
- TXID_SNAPSHOT
- UUID
- XML

Unsupported PostgreSQL functions

Many functions that are not excluded have different semantics or usage. For example, some supported functions will run only on the leader node. Also, some unsupported functions will not return an error when run on the leader node. The fact that these functions do not return an error in some cases should not be taken to indicate that the function is supported by Amazon Redshift.

> **Important**
>
> Do not assume that the semantics of elements that Amazon Redshift and PostgreSQL have in common are identical. Make sure to consult the *Amazon Redshift Database Developer Guide* SQL commands to understand the often subtle differences.

For more information, see SQL functions supported on the leader node.

These PostgreSQL functions are not supported in Amazon Redshift.

- Access privilege inquiry functions
- Advisory lock functions
- Aggregate functions
  - STRING_AGG()
  - ARRAY_AGG()
  - EVERY()
  - XML_AGG()
  - CORR()
  - COVAR_POP()
  - COVAR_SAMP()
  - REGR_AVGX(), REGR_AVGY()
  - REGR_COUNT()
  - REGR_INTERCEPT()
  - REGR_R2()
  - REGR_SLOPE()
  - REGR_SXX(), REGR_SXY(), REGR_SYY()
- Array functions and operators
- Backup control functions
- Comment information functions
- Database object location functions
- Database object size functions
- Date/Time functions and operators
  - CLOCK_TIMESTAMP()
  - JUSTIFY_DAYS(), JUSTIFY_HOURS(), JUSTIFY_INTERVAL()
  - PG_SLEEP()
  - TRANSACTION_TIMESTAMP()
- ENUM support functions
- Geometric functions and operators
- Generic file access functions

- IS DISTINCT FROM
- Network address functions and operators
- Mathematical functions
  - DIV()
  - SETSEED()
  - WIDTH_BUCKET()
- Set returning functions
  - GENERATE_SERIES()
  - GENERATE_SUBSCRIPTS()
- Range functions and operators
- Recovery control functions
- Recovery information functions
- ROLLBACK TO SAVEPOINT function
- Schema visibility inquiry functions
- Server signaling functions
- Snapshot synchronization functions
- Sequence manipulation functions
- String functions
  - BIT_LENGTH()
  - OVERLAY()
  - CONVERT(), CONVERT_FROM(), CONVERT_TO()
  - ENCODE()
  - FORMAT()
  - QUOTE_NULLABLE()
  - REGEXP_MATCHES()
  - REGEXP_SPLIT_TO_ARRAY()
  - REGEXP_SPLIT_TO_TABLE()
- System catalog information functions
- System information functions
  - CURRENT_CATALOG CURRENT_QUERY()

  - INET_CLIENT_ADDR()
  - INET_CLIENT_PORT()
  - INET_SERVER_ADDR() INET_SERVER_PORT()
  - PG_CONF_LOAD_TIME()
  - PG_IS_OTHER_TEMP_SCHEMA()
  - PG_LISTENING_CHANNELS()
  - PG_MY_TEMP_SCHEMA()
  - PG_POSTMASTER_START_TIME()
  - PG_TRIGGER_DEPTH()
  - SHOW VERSION()
- Text search functions and operators
- Transaction IDs and snapshots functions
- Trigger functions
- XML functions

Using SQL

Topics

The SQL language consists of commands and functions that you use to work with databases and database objects. The language also enforces rules regarding the use of data types, expressions, and literals.

SQL reference conventions

This section explains the conventions that are used to write the syntax for the SQL expressions, commands, and functions described in the SQL reference section.

Character	Description
CAPS	Words in capital letters are key words.
[ ]	Brackets denote optional arguments. Multiple arguments in brackets indicate that you can choose any number of the arguments. In addition, arguments in brackets on separate lines indicate that the Amazon Redshift parser expects the arguments to be in the order that they are listed in the syntax. For an example, see SELECT.
{ }	Braces indicate that you are required to choose one of the arguments inside the braces.
|	Pipes indicate that you can choose between the arguments.
italics	Words in italics indicate placeholders. You must insert the appropriate value in place of the word in italics.
. . .	An ellipsis indicates that you can repeat the preceding element.
'	Words in single quotation marks indicate that you must type the quotes.

Basic elements

Topics

- Names and identifiers
- Literals
- Nulls
- Data types
- Collation sequences

This section covers the rules for working with database object names, literals, nulls, and data types.

Names and identifiers

Names identify database objects, including tables and columns, as well as users and passwords. The terms *name* and *identifier* can be used interchangeably. There are two types of identifiers, standard identifiers and quoted or delimited identifiers. Identifiers must consist of only UTF-8 printable characters. ASCII letters in standard and delimited identifiers are case-insensitive and are folded to lowercase in the database. In query results, column names are returned as lowercase by default. To return column names in uppercase, set the describe_field_name_in_uppercase configuration parameter to **`true`**.

Standard identifiers

Standard SQL identifiers adhere to a set of rules and must:

- Begin with an ASCII single-byte alphabetic character or underscore character, or a UTF-8 multibyte character two to four bytes long.
- Subsequent characters can be ASCII single-byte alphanumeric characters, underscores, or dollar signs, or UTF-8 multibyte characters two to four bytes long.
- Be between 1 and 127 bytes in length, not including quotation marks for delimited identifiers.
- Contain no quotation marks and no spaces.
- Not be a reserved SQL key word.

Delimited identifiers

Delimited identifiers (also known as quoted identifiers) begin and end with double quotation marks ("). If you use a delimited identifier, you must use the double quotation marks for every reference to that object. The identifier can contain any standard UTF-8 printable characters other than the double quotation mark itself. Therefore, you can create column or table names that include otherwise illegal characters, such as spaces or the percent symbol.

ASCII letters in delimited identifiers are case-insensitive and are folded to lowercase. To use a double quotation mark in a string, you must precede it with another double quotation mark character.

Case-sensitive identifiers

Case-sensitive identifiers (also known as mixed-case identifiers) can contain both uppercase and lowercase letters. To use case-sensitive identifiers, you can set the configuration `enable_case_sensitive_identifier` to `true`. You can set this configuration for the cluster or for a session. For more information, see Default parameter values in the *Amazon Redshift Management Guide* and enable_case_sensitive_identifier.

System column names

The following PostgreSQL system column names can't be used as column names in user-defined columns. For more information, see https://www.postgresql.org/docs/8.0/static/ddl-system-columns.html.

- `oid`
- `tableoid`
- `xmin`
- `cmin`
- `xmax`
- `cmax`
- `ctid`

Examples

This table shows examples of delimited identifiers, the resulting output, and a discussion:

Syntax	Result	Discussion
"group"	group	GROUP is a reserved word, so usage of it within an identifier requires double quotation marks.
"""WHERE"""	"where"	WHERE is also a reserved word. To include quotation marks in the string, escape each double quotation mark character with additional double quotation mark characters.
"This name"	this name	Double quotation marks are required to preserve the space.
"This ""IS IT"""	this "is it"	The quotation marks surrounding IS IT must each be preceded by an extra quotation mark in order to become part of the name.

To create a table named group with a column named this "is it":

```
create table "group" (
"This ""IS IT""" char(10));
```

The following queries return the same result:

```
select "This ""IS IT"""
from "group";

this "is it"
--------------
(0 rows)
```

```
select "this ""is it"""
from "group";

this "is it"
--------------
(0 rows)
```

The following fully qualified `table.column` syntax also returns the same result:

```
select "group"."this ""is it"""
from "group";

this "is it"
--------------
(0 rows)
```

The following CREATE TABLE command creates a table with a slash in a column name:

```
create table if not exists city_slash_id(
                  "city/id" integer not null,
                  state char(2) not null);
```

Literals

A literal or constant is a fixed data value, composed of a sequence of characters or a numeric constant. Amazon Redshift supports several types of literals, including:

- Numeric literals for integer, decimal, and floating-point numbers. For more information, see Integer and floating-point literals.
- Character literals, also referred to as strings, character strings, or character constants
- Datetime and interval literals, used with datetime data types. For more information, see Date, time, and timestamp literals and Interval data types and literals.

Nulls

If a column in a row is missing, unknown, or not applicable, it is a null value or is said to contain null. Nulls can appear in fields of any data type that are not restricted by primary key or NOT NULL constraints. A null is not equivalent to the value zero or to an empty string.

Any arithmetic expression containing a null always evaluates to a null. All operators return a null when given a null argument or operand.

To test for nulls, use the comparison conditions IS NULL and IS NOT NULL. Because null represents a lack of data, a null is not equal or unequal to any value or to another null.

Data types

Topics

- Multibyte characters
- Numeric types
- Character types
- Datetime types
- Boolean type
- HLLSKETCH type
- SUPER type
- VARBYTE type
- Type compatibility and conversion

Each value that Amazon Redshift stores or retrieves has a data type with a fixed set of associated properties. Data types are declared when tables are created. A data type constrains the set of values that a column or argument can contain.

The following table lists the data types that you can use in Amazon Redshift tables.

Data type	Aliases	Description
SMALLINT	INT2	Signed two-byte integer
INTEGER	INT, INT4	Signed four-byte integer
BIGINT	INT8	Signed eight-byte integer
DECIMAL	NUMERIC	Exact numeric of selectable precision
REAL	FLOAT4	Single precision floating-point number
DOUBLE PRECISION	FLOAT8, FLOAT	Double precision floating-point number
CHAR	CHARACTER, NCHAR, BPCHAR	Fixed-length character string
VARCHAR	CHARACTER VARYING, NVARCHAR, TEXT	Variable-length character string with a user-defined limit
DATE		Calendar date (year, month, day)
TIME	TIME WITHOUT TIME ZONE	Time of day
TIMETZ	TIME WITH TIME ZONE	Time of day with time zone
TIMESTAMP	TIMESTAMP WITHOUT TIME ZONE	Date and time (without time zone)
TIMESTAMPTZ	TIMESTAMP WITH TIME ZONE	Date and time (with time zone)
INTERVAL YEAR TO MONTH		Time duration in year to month order

Data type	Aliases	Description
INTERVAL DAY TO SECOND		Time duration in day to second order
BOOLEAN	BOOL	Logical Boolean (true/false)
HLLSKETCH		Type used with HyperLogLog sketches.
SUPER		A superset data type that encompasses all scalar types of Amazon Redshift including complex types such as ARRAY and STRUCTS.
VARBYTE	VARBINARY, BINARY VARYING	Variable-length binary value
GEOMETRY		Spatial data
GEOGRAPHY		Spatial data

Note

For information about unsupported data types, such as "char" (notice that char is enclosed in quotation marks), see Unsupported PostgreSQL data types.

Multibyte characters

The VARCHAR data type supports UTF-8 multibyte characters up to a maximum of four bytes. Five-byte or longer characters are not supported. To calculate the size of a VARCHAR column that contains multibyte characters, multiply the number of characters by the number of bytes per character. For example, if a string has four Chinese characters, and each character is three bytes long, then you will need a VARCHAR(12) column to store the string.

The VARCHAR data type doesn't support the following invalid UTF-8 codepoints:

`0xD800 - 0xDFFF` (Byte sequences: `ED A0 80` – `ED BF BF`)

The CHAR data type doesn't support multibyte characters.

Numeric types

Topics

Numeric data types include integers, decimals, and floating-point numbers.

Integer types

Use the SMALLINT, INTEGER, and BIGINT data types to store whole numbers of various ranges. You cannot store values outside of the allowed range for each type.

Name	Storage	Range
SMALLINT or INT2	2 bytes	-32768 to +32767
INTEGER, INT, or INT4	4 bytes	-2147483648 to +2147483647
BIGINT or INT8	8 bytes	-9223372036854775808 to 9223372036854775807

DECIMAL or NUMERIC type

Use the DECIMAL or NUMERIC data type to store values with a *user-defined precision*. The DECIMAL and NUMERIC keywords are interchangeable. In this document, *decimal* is the preferred term for this data type. The term *numeric* is used generically to refer to integer, decimal, and floating-point data types.

Storage	Range
Variable, up to 128 bits for uncompressed DECIMAL types.	128-bit signed integers with up to 38 digits of precision.

Define a DECIMAL column in a table by specifying a *precision* and *scale*:

```
decimal(precision, scale)
```

precision

The total number of significant digits in the whole value: the number of digits on both sides of the decimal point. For example, the number `48.2891` has a precision of 6 and a scale of 4. The default precision, if not specified, is 18. The maximum precision is 38.

If the number of digits to the left of the decimal point in an input value exceeds the precision of the column minus its scale, the value cannot be copied into the column (or inserted or updated). This rule applies to any value that falls outside the range of the column definition. For example, the allowed range of values for a `numeric(5,2)` column is `-999.99` to `999.99`.

scale

The number of decimal digits in the fractional part of the value, to the right of the decimal point. Integers have a scale of zero. In a column specification, the scale value must be less than or equal to the precision value. The default scale, if not specified, is 0. The maximum scale is 37.

If the scale of an input value that is loaded into a table is greater than the scale of the column, the value is rounded to the specified scale. For example, the PRICEPAID column in the SALES table is a DECIMAL(8,2) column. If a DECIMAL(8,4) value is inserted into the PRICEPAID column, the value is rounded to a scale of 2.

```
insert into sales
values (0, 8, 1, 1, 2000, 14, 5, 4323.8951, 11.00, null);

select pricepaid, salesid from sales where salesid=0;
```

```
pricepaid | salesid
-----------+---------
4323.90 |       0
(1 row)
```

However, results of explicit casts of values selected from tables are not rounded.

Note

The maximum positive value that you can insert into a DECIMAL(19,0) column is `9223372036854775807` (2^{63} -1). The maximum negative value is `-9223372036854775808`. For example, an attempt to insert the value `9999999999999999999` (19 nines) will cause an overflow error. Regardless of the placement of the decimal point, the largest string that Amazon Redshift can represent as a DECIMAL number is `9223372036854775807`. For example, the largest value that you can load into a DECIMAL(19,18) column is `9.223372036854775807`.
These rules are because DECIMAL values with 19 or fewer significant digits of precision are stored internally as 8-byte integers, while DECIMAL values with 20 to 38 significant digits of precision are stored as 16-byte integers.

Notes about using 128-bit DECIMAL or NUMERIC columns

Do not arbitrarily assign maximum precision to DECIMAL columns unless you are certain that your application requires that precision. 128-bit values use twice as much disk space as 64-bit values and can slow down query execution time.

Floating-Point types

Use the REAL and DOUBLE PRECISION data types to store numeric values with *variable precision*. These types are *inexact* types, meaning that some values are stored as approximations, such that storing and returning a specific value may result in slight discrepancies. If you require exact storage and calculations (such as for monetary amounts), use the DECIMAL data type.

REAL represents the single-precision floating point format, according to the IEEE Standard 754 for Binary Floating-Point Arithmetic. It has a precision of about 6 digits, and a range of around 1E-37 to 1E+37. You can also specify this data type as FLOAT4.

DOUBLE PRECISION represents the double-precision floating point format, according to the IEEE Standard 754 for Binary Floating-Point Arithmetic. It has a precision of about 15 digits, and a range of around 1E-307 to 1E+308. You can also specify this data type as FLOAT or FLOAT8.

In addition to ordinary numeric values, the floating-point types have several special values. Use single quotation marks around these values when using them in SQL:

- `NaN` – not-a-number
- `Infinity` – infinity
- `-Infinity` – negative infinity

For example, to insert not-a-number in column `day_charge` of table `customer_activity` run the following SQL:

```
insert into customer_activity(day_charge) values('NaN');
```

Computations with numeric values

In this context, *computation* refers to binary mathematical operations: addition, subtraction, multiplication, and division. This section describes the expected return types for these operations, as well as the specific formula that is applied to determine precision and scale when DECIMAL data types are involved.

When numeric values are computed during query processing, you might encounter cases where the computation is impossible and the query returns a numeric overflow error. You might also encounter cases where the scale of computed values varies or is unexpected. For some operations, you can use explicit casting (type promotion) or Amazon Redshift configuration parameters to work around these problems.

For information about the results of similar computations with SQL functions, see Aggregate functions.

Return types for computations

Given the set of numeric data types supported in Amazon Redshift, the following table shows the expected return types for addition, subtraction, multiplication, and division operations. The first column on the left side of the table represents the first operand in the calculation, and the top row represents the second operand.

Operand 1	Operand 2	Return type
INT2	INT2	INT2
INT2	INT4	INT4
INT2	INT8	INT8
INT2	DECIMAL	DECIMAL
INT2	FLOAT4	FLOAT8
INT2	FLOAT8	FLOAT8
INT4	INT4	INT4
INT4	INT8	INT8
INT4	DECIMAL	DECIMAL
INT4	FLOAT4	FLOAT8
INT4	FLOAT8	FLOAT8
INT8	INT8	INT8
INT8	DECIMAL	DECIMAL
INT8	FLOAT4	FLOAT8
INT8	FLOAT8	FLOAT8
DECIMAL	DECIMAL	DECIMAL
DECIMAL	FLOAT4	FLOAT8
DECIMAL	FLOAT8	FLOAT8
FLOAT4	FLOAT8	FLOAT8
FLOAT8	FLOAT8	FLOAT8

Precision and scale of computed DECIMAL results

The following table summarizes the rules for computing resulting precision and scale when mathematical operations return DECIMAL results. In this table, `p1` and `s1` represent the precision and scale of the first operand in a calculation and `p2` and `s2` represent the precision and scale of the second operand. (Regardless of these calculations, the maximum result precision is 38, and the maximum result scale is 38.)

Operation	Result precision and scale
+ or -	Scale = `max(s1,s2)` Precision = `max(p1-s1,p2-s2)+1+scale`
*	Scale = `s1+s2` Precision = `p1+p2+1`
/	Scale = `max(4,s1+p2-s2+1)` Precision = `p1-s1+ s2+scale`

For example, the PRICEPAID and COMMISSION columns in the SALES table are both DECIMAL(8,2) columns. If you divide PRICEPAID by COMMISSION (or vice versa), the formula is applied as follows:

```
Precision = 8-2 + 2 + max(4,2+8-2+1)
= 6 + 2 + 9 = 17

Scale = max(4,2+8-2+1) = 9

Result = DECIMAL(17,9)
```

The following calculation is the general rule for computing the resulting precision and scale for operations performed on DECIMAL values with set operators such as UNION, INTERSECT, and EXCEPT or functions such as COALESCE and DECODE:

```
Scale = max(s1,s2)
Precision = min(max(p1-s1,p2-s2)+scale,19)
```

For example, a DEC1 table with one DECIMAL(7,2) column is joined with a DEC2 table with one DECIMAL(15,3) column to create a DEC3 table. The schema of DEC3 shows that the column becomes a NUMERIC(15,3) column.

```
create table dec3 as select * from dec1 union select * from dec2;
```

Result

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'dec3';

column |     type      | encoding | distkey | sortkey
-------+---------------+----------+---------+---------
c1     | numeric(15,3) | none     | f       | 0
```

In the above example, the formula is applied as follows:

```
Precision = min(max(7-2,15-3) + max(2,3), 19)
= 12 + 3 = 15

Scale = max(2,3) = 3

Result = DECIMAL(15,3)
```

Notes on division operations

For division operations, divide-by-zero conditions return errors.

The scale limit of 100 is applied after the precision and scale are calculated. If the calculated result scale is greater than 100, division results are scaled as follows:

- Precision = `precision - (scale - max_scale)`
- Scale = `max_scale`

If the calculated precision is greater than the maximum precision (38), the precision is reduced to 38, and the scale becomes the result of: `max((38 + scale - precision), min(4, 100))`

Overflow conditions

Overflow is checked for all numeric computations. DECIMAL data with a precision of 19 or less is stored as 64-bit integers. DECIMAL data with a precision that is greater than 19 is stored as 128-bit integers. The maximum precision for all DECIMAL values is 38, and the maximum scale is 37. Overflow errors occur when a value exceeds these limits, which apply to both intermediate and final result sets:

- Explicit casting results in runtime overflow errors when specific data values do not fit the requested precision or scale specified by the cast function. For example, you cannot cast all values from the PRICEPAID column in the SALES table (a DECIMAL(8,2) column) and return a DECIMAL(7,3) result:

  ```
  select pricepaid::decimal(7,3) from sales;
  ERROR:  Numeric data overflow (result precision)
  ```

  This error occurs because *some* of the larger values in the PRICEPAID column cannot be cast.

- Multiplication operations produce results in which the result scale is the sum of the scale of each operand. If both operands have a scale of 4, for example, the result scale is 8, leaving only 10 digits for the left side of the decimal point. Therefore, it is relatively easy to run into overflow conditions when multiplying two large numbers that both have significant scale.

  The following example results in an overflow error.

  ```
  SELECT CAST(1 AS DECIMAL(38, 20)) * CAST(10 AS DECIMAL(38, 20));
  ERROR: 128 bit numeric data overflow (multiplication)
  ```

  You can work around the overflow error by using division instead of multiplication. Use the following example to divide by 1 divided by the original divisor.

  ```
  SELECT CAST(1 AS DECIMAL(38, 20)) / (1 / CAST(10 AS DECIMAL(38, 20)));
  +----------+
  | ?column? |
  +----------+
  | 10       |
  +----------+
  ```

Numeric calculations with INTEGER and DECIMAL types

When one of the operands in a calculation has an INTEGER data type and the other operand is DECIMAL, the INTEGER operand is implicitly cast as a DECIMAL:

- INT2 (SMALLINT) is cast as DECIMAL(5,0)
- INT4 (INTEGER) is cast as DECIMAL(10,0)
- INT8 (BIGINT) is cast as DECIMAL(19,0)

For example, if you multiply SALES.COMMISSION, a DECIMAL(8,2) column, and SALES.QTYSOLD, a SMALLINT column, this calculation is cast as:

```
DECIMAL(8,2) * DECIMAL(5,0)
```

Integer and floating-point literals

Literals or constants that represent numbers can be integer or floating-point.

Integer literals

An integer constant is a sequence of the digits 0-9, with an optional positive (+) or negative (-) sign preceding the digits.

Syntax

```
[ + | - ] digit ...
```

Examples

Valid integers include the following:

```
23
-555
+17
```

Floating-point literals

Floating-point literals (also referred to as decimal, numeric, or fractional literals) are sequences of digits that can include a decimal point, and optionally the exponent marker (e).

Syntax

```
[ + | - ] digit ... [ . ] [ digit ...]
[ e | E [ + | - ] digit ... ]
```

Arguments

e | E

e or E indicates that the number is specified in scientific notation.

Examples

Valid floating-point literals include the following:

```
3.14159
-37.
2.0e19
-2E-19
```

Examples with numeric types

CREATE TABLE statement

The following CREATE TABLE statement demonstrates the declaration of different numeric data types:

```
create table film (
film_id integer,
language_id smallint,
original_language_id smallint,
rental_duration smallint default 3,
rental_rate numeric(4,2) default 4.99,
length smallint,
replacement_cost real default 25.00);
```

Attempt to insert an integer that is out of range

The following example attempts to insert the value 33000 into a SMALLINT column.

```
insert into film(language_id) values(33000);
```

The range for SMALLINT is -32768 to +32767, so Amazon Redshift returns an error.

```
An error occurred when executing the SQL command:
insert into film(language_id) values(33000)

ERROR: smallint out of range [SQL State=22003]
```

Insert a decimal value into an integer column

The following example inserts the a decimal value into an INT column.

```
insert into film(language_id) values(1.5);
```

This value is inserted but rounded up to the integer value 2.

Insert a decimal that succeeds because its scale is rounded

The following example inserts a decimal value that has higher precision that the column.

```
insert into film(rental_rate) values(35.512);
```

In this case, the value `35.51` is inserted into the column.

Attempt to insert a decimal value that is out of range

In this case, the value `350.10` is out of range. The number of digits for values in DECIMAL columns is equal to the column's precision minus its scale (4 minus 2 for the RENTAL_RATE column). In other words, the allowed range for a `DECIMAL(4,2)` column is `-99.99` through `99.99`.

```
insert into film(rental_rate) values (350.10);
ERROR:  numeric field overflow
DETAIL:  The absolute value is greater than or equal to 10^2 for field with precision
 4, scale 2.
```

Insert variable-precision values into a REAL column

The following example inserts variable-precision values into a REAL column.

```
insert into film(replacement_cost) values(1999999.99);

insert into film(replacement_cost) values(1999.99);
```

```
select replacement_cost from film;

+-------------------+
| replacement_cost |
+-------------------+
| 2000000          |
| 1999.99          |
+-------------------+
```

The value `1999999.99` is converted to `2000000` to meet the precision requirement for the REAL column. The value `1999.99` is loaded as is.

Character types

Topics

- Storage and ranges
- CHAR or CHARACTER
- VARCHAR or CHARACTER VARYING
- NCHAR and NVARCHAR types
- TEXT and BPCHAR types
- Significance of trailing blanks
- Examples with character types

Character data types include CHAR (character) and VARCHAR (character varying).

Storage and ranges

CHAR and VARCHAR data types are defined in terms of bytes, not characters. A CHAR column can only contain single-byte characters, so a CHAR(10) column can contain a string with a maximum length of 10 bytes. A VARCHAR can contain multibyte characters, up to a maximum of four bytes per character. For example, a VARCHAR(12) column can contain 12 single-byte characters, 6 two-byte characters, 4 three-byte characters, or 3 four-byte characters.

Name	Storage	Range (width of column)
CHAR, CHARACTER or NCHAR	Length of string, including trailing blanks (if any)	4096 bytes

Name	Storage	Range (width of column)
VARCHAR, CHARACTER VARYING, or NVARCHAR	4 bytes + total bytes for characters, where each character can be 1 to 4 bytes.	65535 bytes (64K -1)
BPCHAR	Converted to fixed-length CHAR(256).	256 bytes
TEXT	Converted to VARCHAR(256).	260 bytes

Note

The CREATE TABLE syntax supports the MAX keyword for character data types. For example:

```
create table test(col1 varchar(max));
```

The MAX setting defines the width of the column as 4096 bytes for CHAR or 65535 bytes for VARCHAR.

CHAR or CHARACTER

Use a CHAR or CHARACTER column to store fixed-length strings. These strings are padded with blanks, so a CHAR(10) column always occupies 10 bytes of storage.

```
char(10)
```

A CHAR column without a length specification results in a CHAR(1) column.

VARCHAR or CHARACTER VARYING

Use a VARCHAR or CHARACTER VARYING column to store variable-length strings with a fixed limit. These strings are not padded with blanks, so a VARCHAR(120) column consists of a maximum of 120 single-byte characters, 60 two-byte characters, 40 three-byte characters, or 30 four-byte characters.

```
varchar(120)
```

If you use the VARCHAR data type without a length specifier in a CREATE TABLE statement, the default length is 256. If used in an expression, the size of the output is determined using the input expression (up to 65535).

NCHAR and NVARCHAR types

You can create columns with the NCHAR and NVARCHAR types (also known as NATIONAL CHARACTER and NATIONAL CHARACTER VARYING types). These types are converted to CHAR and VARCHAR types, respectively, and are stored in the specified number of bytes.

An NCHAR column without a length specification is converted to a CHAR(1) column.

An NVARCHAR column without a length specification is converted to a VARCHAR(256) column.

TEXT and BPCHAR types

You can create an Amazon Redshift table with a TEXT column, but it is converted to a VARCHAR(256) column that accepts variable-length values with a maximum of 256 characters.

You can create an Amazon Redshift column with a BPCHAR (blank-padded character) type, which Amazon Redshift converts to a fixed-length CHAR(256) column.

Significance of trailing blanks

Both CHAR and VARCHAR data types store strings up to *n* bytes in length. An attempt to store a longer string into a column of these types results in an error, unless the extra characters are all spaces (blanks), in which case the string is truncated to the maximum length. If the string is shorter than the maximum length, CHAR values are padded with blanks, but VARCHAR values store the string without blanks.

Trailing blanks in CHAR values are always semantically insignificant. They are disregarded when you compare two CHAR values, not included in LENGTH calculations, and removed when you convert a CHAR value to another string type.

Trailing spaces in VARCHAR and CHAR values are treated as semantically insignificant when values are compared.

Length calculations return the length of VARCHAR character strings with trailing spaces included in the length. Trailing blanks are not counted in the length for fixed-length character strings.

Examples with character types

CREATE TABLE statement

The following CREATE TABLE statement demonstrates the use of VARCHAR and CHAR data types:

```
create table address(
address_id integer,
address1 varchar(100),
address2 varchar(50),
district varchar(20),
city_name char(20),
state char(2),
postal_code char(5)
);
```

The following examples use this table.

Trailing blanks in variable-length character strings

Because ADDRESS1 is a VARCHAR column, the trailing blanks in the second inserted address are semantically insignificant. In other words, these two inserted addresses *match*.

```
insert into address(address1) values('9516 Magnolia Boulevard');

insert into address(address1) values('9516 Magnolia Boulevard  ');
```

```
select count(*) from address
where address1='9516 Magnolia Boulevard';

count
-------
2
(1 row)
```

If the ADDRESS1 column were a CHAR column and the same values were inserted, the COUNT(*) query would recognize the character strings as the same and return 2.

Results of the LENGTH function

The LENGTH function recognizes trailing blanks in VARCHAR columns:

```
select length(address1) from address;

length
--------
23
25
(2 rows)
```

A value of `Augusta` in the CITY_NAME column, which is a CHAR column, would always return a length of 7 characters, regardless of any trailing blanks in the input string.

Values that exceed the length of the column

Character strings are not truncated to fit the declared width of the column:

```
insert into address(city_name) values('City of South San Francisco');
ERROR: value too long for type character(20)
```

A workaround for this problem is to cast the value to the size of the column:

```
insert into address(city_name)
values('City of South San Francisco'::char(20));
```

In this case, the first 20 characters of the string (`City of South San Fr`) would be loaded into the column.

Datetime types

Topics

- Storage and ranges
- DATE
- TIME

Datetime data types include DATE, TIME, TIMETZ, TIMESTAMP, and TIMESTAMPTZ.

Storage and ranges

Name	Storage	Range	Resolution
DATE	4 bytes	4713 BC to 294276 AD	1 day
TIME	8 bytes	00:00:00 to 24:00:00	1 microsecond
TIMETZ	8 bytes	00:00:00+1459 to 00:00:00+1459	1 microsecond
TIMESTAMP	8 bytes	4713 BC to 294276 AD	1 microsecond
TIMESTAMPTZ	8 bytes	4713 BC to 294276 AD	1 microsecond

DATE

Use the DATE data type to store simple calendar dates without timestamps.

TIME

TIME is an alias of TIME WITHOUT TIME ZONE.

Use the TIME data type to store the time of day.

TIME columns store values with up to a maximum of six digits of precision for fractional seconds.

By default, TIME values are Coordinated Universal Time (UTC) in both user tables and Amazon Redshift system tables.

TIMETZ

TIMETZ is an alias of TIME WITH TIME ZONE.

Use the TIMETZ data type to store the time of day with a time zone.

TIMETZ columns store values with up to a maximum of six digits of precision for fractional seconds.

By default, TIMETZ values are UTC in both user tables and Amazon Redshift system tables.

TIMESTAMP

TIMESTAMP is an alias of TIMESTAMP WITHOUT TIME ZONE.

Use the TIMESTAMP data type to store complete timestamp values that include the date and the time of day.

TIMESTAMP columns store values with up to a maximum of six digits of precision for fractional seconds.

If you insert a date into a TIMESTAMP column, or a date with a partial timestamp value, the value is implicitly converted into a full timestamp value. This full timestamp value has default values (00) for missing hours, minutes, and seconds. Time zone values in input strings are ignored.

By default, TIMESTAMP values are UTC in both user tables and Amazon Redshift system tables.

TIMESTAMPTZ

TIMESTAMPTZ is an alias of TIMESTAMP WITH TIME ZONE.

Use the TIMESTAMPTZ data type to input complete timestamp values that include the date, the time of day, and a time zone. When an input value includes a time zone, Amazon Redshift uses the time zone to convert the value to UTC and stores the UTC value.

To view a list of supported time zone names, run the following command.

```
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, run the following command.

```
select pg_timezone_abbrevs();
```

You can also find current information about time zones in the IANA Time Zone Database.

The following table has examples of time zone formats.

Format	Example
dd mon hh:mi:ss yyyy tz	17 Dec 07:37:16 1997 PST
mm/dd/yyyy hh:mi:ss.ss tz	12/17/1997 07:37:16.00 PST
mm/dd/yyyy hh:mi:ss.ss tz	12/17/1997 07:37:16.00 US/Pacific
yyyy-mm-dd hh:mi:ss+/-tz	1997-12-17 07:37:16-08
dd.mm.yyyy hh:mi:ss tz	17.12.1997 07:37:16.00 PST

TIMESTAMPTZ columns store values with up to a maximum of six digits of precision for fractional seconds.

If you insert a date into a TIMESTAMPTZ column, or a date with a partial timestamp, the value is implicitly converted into a full timestamp value. This full timestamp value has default values (00) for missing hours, minutes, and seconds.

TIMESTAMPTZ values are UTC in user tables.

Examples with datetime types

Following, you can find examples for working with datetime types supported by Amazon Redshift.

Date examples

The following examples insert dates that have different formats and display the output.

```
create table datetable (start_date date, end_date date);
```

```
insert into datetable values ('2008-06-01','2008-12-31');

insert into datetable values ('Jun 1,2008','20081231');
```

```
select * from datetable order by 1;

start_date |  end_date
```

```
-----------------------
2008-06-01 | 2008-12-31
2008-06-01 | 2008-12-31
```

If you insert a timestamp value into a DATE column, the time portion is ignored and only the date is loaded.

Time examples

The following examples insert TIME and TIMETZ values that have different formats and display the output.

```
create table timetable (start_time time, end_time timetz);
```

```
insert into timetable values ('19:11:19','20:41:19 UTC');
insert into timetable values ('191119', '204119 UTC');
```

```
select * from timetable order by 1;
start_time |  end_time
------------------------
 19:11:19  | 20:41:19+00
 19:11:19  | 20:41:19+00
```

Time stamp examples

If you insert a date into a TIMESTAMP or TIMESTAMPTZ column, the time defaults to midnight. For example, if you insert the literal `20081231`, the stored value is `2008-12-31 00:00:00`.

To change the time zone for the current session, use the SET command to set the timezone configuration parameter.

The following example inserts timestamps that have different formats and display the resulting table.

```
create table tstamp(timeofday timestamp, timeofdaytz timestamptz);

insert into tstamp values('Jun 1,2008  09:59:59', 'Jun 1,2008 09:59:59 EST' );
insert into tstamp values('Dec 31,2008 18:20','Dec 31,2008 18:20');
insert into tstamp values('Jun 1,2008  09:59:59 EST', 'Jun 1,2008 09:59:59');

SELECT * FROM tstamp;
```

```
+---------------------+------------------------+
|      timeofday      |      timeofdaytz       |
+---------------------+------------------------+
| 2008-06-01 09:59:59 | 2008-06-01 14:59:59+00 |
| 2008-12-31 18:20:00 | 2008-12-31 18:20:00+00 |
| 2008-06-01 09:59:59 | 2008-06-01 09:59:59+00 |
+---------------------+------------------------+
```

Date, time, and timestamp literals

Following are rules for working with date, time, and timestamp literals supported by Amazon Redshift.

Dates

The following input dates are all valid examples of literal date values for the DATE data type that you can load into Amazon Redshift tables. The default `MDY DateStyle` mode is assumed to be in effect. This mode means that the month value precedes the day value in strings such as `1999-01-08` and `01/02/00`.

> **Note**
> A date or timestamp literal must be enclosed in quotation marks when you load it into a table.

Input date	Full date
January 8, 1999	January 8, 1999
1999-01-08	January 8, 1999
1/8/1999	January 8, 1999
01/02/00	January 2, 2000
2000-Jan-31	January 31, 2000
Jan-31-2000	January 31, 2000

Input date	Full date
31-Jan-2000	January 31, 2000
20080215	February 15, 2008
080215	February 15, 2008
2008.366	December 31, 2008 (the three-digit part of date must be between 001 and 366)

Times

The following input times are all valid examples of literal time values for the TIME and TIMETZ data types that you can load into Amazon Redshift tables.

Input times	Description (of time part)
04:05:06.789	4:05 AM and 6.789 seconds
04:05:06	4:05 AM and 6 seconds
04:05	4:05 AM exactly
040506	4:05 AM and 6 seconds
04:05 AM	4:05 AM exactly; AM is optional
04:05 PM	4:05 PM exactly; the hour value must be less than 12
16:05	4:05 PM exactly

Timestamps

The following input timestamps are all valid examples of literal time values for the TIMESTAMP and TIMESTAMPTZ data types that you can load into Amazon Redshift tables. All of the valid date literals can be combined with the following time literals.

Input timestamps (concatenated dates and times)	Description (of time part)
20080215 04:05:06.789	4:05 AM and 6.789 seconds
20080215 04:05:06	4:05 AM and 6 seconds
20080215 04:05	4:05 AM exactly
20080215 040506	4:05 AM and 6 seconds
20080215 04:05 AM	4:05 AM exactly; AM is optional
20080215 04:05 PM	4:05 PM exactly; the hour value must be less than 12
20080215 16:05	4:05 PM exactly
20080215	Midnight (by default)

Special datetime values

The following special values can be used as datetime literals and as arguments to date functions. They require single quotation marks and are converted to regular timestamp values during query processing.

Special value	Description
`now`	Evaluates to the start time of the current transaction and returns a timestamp with microsecond precision.
`today`	Evaluates to the appropriate date and returns a timestamp with zeroes for the time parts.
`tomorrow`	Evaluates to the appropriate date and returns a timestamp with zeroes for the time parts.

Special value	Description
`yesterday`	Evaluates to the appropriate date and returns a timestamp with zeroes for the time parts.

The following examples show how `now` and `today` work with the DATEADD function.

```
select dateadd(day,1,'today');

date_add
---------------------
2009-11-17 00:00:00
(1 row)

select dateadd(day,1,'now');

date_add
----------------------------
2009-11-17 10:45:32.021394
(1 row)
```

Interval data types and literals

You can use an interval data type to store durations of time in units such as, `seconds`, `minutes`, `hours`, `days`, `months`, and `years`. Interval data types and literals can be used in datetime calculations, such as, adding intervals to dates and timestamps, summing intervals, and subtracting an interval from a date or timestamp. Interval literals can be used as input values to interval data type columns in a table.

Syntax of interval data type

To specify an interval data type to store a duration of time in years and months:

```
INTERVAL year_to_month_qualifier
```

To specify an interval data type to store a duration in days, hours, minutes, and seconds:

```
INTERVAL day_to_second_qualifier [ (fractional_precision) ]
```

Syntax of interval literal

To specify an interval literal to define a duration of time in years and months:

```
INTERVAL quoted-string year_to_month_qualifier
```

To specify an interval literal to define a duration in days, hours, minutes, and seconds:

```
INTERVAL quoted-string day_to_second_qualifier [ (fractional_precision) ]
```

Arguments

quoted-string

Specifies a positive or negative numeric value specifying a quantity and the datetime unit as an input string. If the *quoted-string* contains only a numeric, then Amazon Redshift determines the units from the *year_to_month_qualifier* or *day_to_second_qualifier*. For example, `'23' MONTH` represents `1 year 11 months`, `'-2' DAY` represents `-2 days 0 hours 0 minutes 0.0 seconds`, `'1-2' MONTH` represents `1 year 2 months`, and `'13 day 1 hour 1 minute 1.123 seconds' SECOND` represents `13 days 1 hour 1 minute 1.123 seconds`. For more information about output formats of an interval, see Interval styles.

year_to_month_qualifier

Specifies the range of the interval. If you use a qualifier and create an interval with time units smaller than the qualifier, Amazon Redshift truncates and discards the smaller parts of the interval. Valid values for *year_to_month_qualifier* are:

- `YEAR`
- `MONTH`
- `YEAR TO MONTH`

day_to_second_qualifier

Specifies the range of the interval. If you use a qualifier and create an interval with time units smaller than the qualifier, Amazon Redshift truncates and discards the smaller parts of the interval. Valid values for *day_to_second_qualifier* are:

- `DAY`
- `HOUR`
- `MINUTE`

- SECOND
- DAY TO HOUR
- DAY TO MINUTE
- DAY TO SECOND
- HOUR TO MINUTE
- HOUR TO SECOND
- MINUTE TO SECOND

The output of the INTERVAL literal is truncated to the smallest INTERVAL component specified. For example, when using a MINUTE qualifier, Amazon Redshift discards the time units smaller than MINUTE.

```
select INTERVAL '1 day 1 hour 1 minute 1.123 seconds' MINUTE
```

The resulting value is truncated to `'1 day 01:01:00'`.

fractional_precision

Optional parameter that specifies the number of fractional digits allowed in the interval. The *fractional_precision* argument should only be specified if your interval contains SECOND. For example, `SECOND(3)` creates an interval that allows only three fractional digits, such as 1.234 seconds. The maximum number of fractional digits is six.

The session configuration `interval_forbid_composite_literals` determines whether an error is returned when an interval is specified with both YEAR TO MONTH and DAY TO SECOND parts. For more information, see interval_forbid_composite_literals.

Interval arithmetic

You can use interval values with other datetime values to perform arithmetic operations. The following tables describe the available operations and what data type results from each operation.

> **Note**
>
> Operations that can produce both `date` and `timestamp` results do so based on the smallest unit of time involved in the equation. For example, when you add an `interval` to a `date` the result is a `date` if it is a YEAR TO MONTH interval, and a timestamp if it is a DAY TO SECOND interval.

Operations where the first operand is an `interval` produce the following results for the given second operand:

Operator	Date	Timestamp	Interval	Numeric
-	N/A	N/A	Interval	N/A
+	Date	Date/Timestamp	Interval	N/A
*	N/A	N/A	N/A	Interval
/	N/A	N/A	N/A	Interval

Operations where the first operand is a `date` produce the following results for the given second operand:

Operator	Date	Timestamp	Interval	Numeric
-	Numeric	Interval	Date/Timestamp	Date
+	N/A	N/A	N/A	N/A

Operations where the first operand is a `timestamp` produce the following results for the given second operand:

Operator	Date	Timestamp	Interval	Numeric
-	Numeric	Interval	Timestamp	Timestamp
+	N/A	N/A	N/A	N/A

Interval styles

You can use the SQL the section called “SET” command to change the output display format of your interval values. When you use the interval data type in SQL, cast it to text to see the expected interval style, for example, `YEAR TO MONTH::text`. Available values to SET the `IntervalStyle` value are:

- `postgres` – follows PostgreSQL style. This is the default.
- `postgres_verbose` – follows PostgreSQL verbose style.
- `sql_standard` – follows the SQL standard interval literals style.

The following command sets the interval style to `sql_standard`.

```
SET IntervalStyle to 'sql_standard';
```

postgres output format

The following is the output format for `postgres` interval style. Each numeric value can be negative.

```
'<numeric> <unit> [, <numeric> <unit> ...]'
```

```
select INTERVAL '1-2' YEAR TO MONTH::text

varchar
---------------
1 year 2 mons
```

```
select INTERVAL '1 2:3:4.5678' DAY TO SECOND::text

varchar
------------------
1 day 02:03:04.5678
```

postgres_verbose output format

postgres_verbose syntax is similar to postgres, but postgres_verbose outputs also contain the unit of time.

```
'[@] <numeric> <unit> [, <numeric> <unit> ...] [direction]'
```

```
select INTERVAL '1-2' YEAR TO MONTH::text

varchar
-----------------
```

```
@ 1 year 2 mons
```

```
select INTERVAL '1 2:3:4.5678' DAY TO SECOND::text

varchar
---------------------------
@ 1 day 2 hours 3 mins 4.56 secs
```

sql_standard output format

Interval year to month values are formatted as the following. Specifying a negative sign before the interval indicates the interval is a negative value and applies to the entire interval.

```
'[-]yy-mm'
```

Interval day to second values are formatted as the following.

```
'[-]dd hh:mm:ss.ffffff'
```

```
SELECT INTERVAL '1-2' YEAR TO MONTH::text

varchar
-------
1-2
```

```
select INTERVAL '1 2:3:4.5678' DAY TO SECOND::text

varchar
---------------
1 2:03:04.5678
```

Examples of interval data type

The following examples demonstrate how to use INTERVAL data types with tables.

```
create table sample_intervals (y2m interval month, h2m interval hour to minute);
insert into sample_intervals values (interval '20' month, interval '2 days
 1:1:1.123456' day to second);
select y2m::text, h2m::text from sample_intervals;
```

```
      y2m      |       h2m
---------------+-----------------
 1 year 8 mons | 2 days 01:01:00
```

```
update sample_intervals set y2m = interval '2' year where y2m = interval '1-8' year to
 month;
select * from sample_intervals;

   y2m   |       h2m
---------+-----------------
 2 years | 2 days 01:01:00
```

```
delete from sample_intervals where h2m = interval '2 1:1:0' day to second;
select * from sample_intervals;

 y2m | h2m
-----+-----
```

Examples of interval literals

The following examples are run with interval style set to `postgres`.

The following example demonstrates how to create an INTERVAL literal of 1 year.

```
select INTERVAL '1' YEAR

intervaly2m
---------------
1 years 0 mons
```

If you specify a *quoted-string* that exceeds the qualifier, the remaining units of time are truncated from the interval. In the following example, an interval of 13 months becomes 1 year and 1 month, but the remaining 1 month is left out because of the YEAR qualifier.

```
select INTERVAL '13 months' YEAR

intervaly2m
---------------
1 years 0 mons
```

If you use a qualifier lower than your interval string, leftover units are included.

```
select INTERVAL '13 months' MONTH

intervaly2m
---------------
1 years 1 mons
```

Specifying a precision in your interval truncates the number of fractional digits to the specified precision.

```
select INTERVAL '1.234567' SECOND (3)

intervald2s
--------------------------------
0 days 0 hours 0 mins 1.235 secs
```

If you don't specify a precision, Amazon Redshift uses the maximum precision of 6.

```
select INTERVAL '1.23456789' SECOND

intervald2s
-----------------------------------
0 days 0 hours 0 mins 1.234567 secs
```

The following example demonstrates how to create a ranged interval.

```
select INTERVAL '2:2' MINUTE TO SECOND

intervald2s
------------------------------
0 days 0 hours 2 mins 2.0 secs
```

Qualifiers dictate the units that you're specifying. For example, even though the following example uses the same *quoted-string* of '2:2' as the previous example, Amazon Redshift recognizes that it uses different units of time because of the qualifier.

```
select INTERVAL '2:2' HOUR TO MINUTE

intervald2s
```

```
------------------------------
0 days 2 hours 2 mins 0.0 secs
```

Abbreviations and plurals of each unit are also supported. For example, `5s`, `5 second`, and `5 seconds` are equivalent intervals. Supported units are years, months, hours, minutes, and seconds.

```
select INTERVAL '5s' SECOND

intervald2s
------------------------------
0 days 0 hours 0 mins 5.0 secs
```

```
select INTERVAL '5 HOURS' HOUR

intervald2s
------------------------------
0 days 5 hours 0 mins 0.0 secs
```

```
select INTERVAL '5 h' HOUR

intervald2s
------------------------------
0 days 5 hours 0 mins 0.0 secs
```

Examples of interval literals without qualifier syntax

> **Note**
>
> The following examples demonstrate using an interval literal without a `YEAR TO MONTH` or `DAY TO SECOND` qualifier. For information about using the recommended interval literal with a qualifier, see Interval data types and literals.

Use an interval literal to identify specific periods of time, such as `12 hours` or `6 months`. You can use these interval literals in conditions and calculations that involve datetime expressions.

An interval literal is expressed as a combination of the INTERVAL keyword with a numeric quantity and a supported date part, for example `INTERVAL '7 days'` or `INTERVAL '59 minutes'`. You can connect several quantities and units to form a more precise interval, for example: `INTERVAL`

'7 days, 3 hours, 59 minutes'. Abbreviations and plurals of each unit are also supported; for example: 5 s, 5 second, and 5 seconds are equivalent intervals.

If you don't specify a date part, the interval value represents seconds. You can specify the quantity value as a fraction (for example: 0.5 days).

The following examples show a series of calculations with different interval values.

The following adds 1 second to the specified date.

```
select caldate + interval '1 second' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 00:00:01
(1 row)
```

The following adds 1 minute to the specified date.

```
select caldate + interval '1 minute' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 00:01:00
(1 row)
```

The following adds 3 hours and 35 minutes to the specified date.

```
select caldate + interval '3 hours, 35 minutes' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 03:35:00
(1 row)
```

The following adds 52 weeks to the specified date.

```
select caldate + interval '52 weeks' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2009-12-30 00:00:00
```

```
(1 row)
```

The following adds 1 week, 1 hour, 1 minute, and 1 second to the specified date.

```
select caldate + interval '1w, 1h, 1m, 1s' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2009-01-07 01:01:01
(1 row)
```

The following adds 12 hours (half a day) to the specified date.

```
select caldate + interval '0.5 days' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 12:00:00
(1 row)
```

The following subtracts 4 months from February 15, 2023 and the result is October 15, 2022.

```
select date '2023-02-15' - interval '4 months';

?column?
---------------------
2022-10-15 00:00:00
```

The following subtracts 4 months from March 31, 2023 and the result is November 30, 2022. The calculation considers the number of days in a month.

```
select date '2023-03-31' - interval '4 months';

?column?
---------------------
2022-11-30 00:00:00
```

Boolean type

Use the BOOLEAN data type to store true and false values in a single-byte column. The following table describes the three possible states for a Boolean value and the literal values that result in that state. Regardless of the input string, a Boolean column stores and outputs "t" for true and "f" for false.

State	Valid literal values	Storage
True	`TRUE 't' 'true' 'y' 'yes' '1'`	1 byte
False	`FALSE 'f' 'false' 'n' 'no' '0'`	1 byte
Unknown	`NULL`	1 byte

You can use an IS comparison to check a Boolean value only as a predicate in the WHERE clause. You can't use the IS comparison with a Boolean value in the SELECT list.

Examples

You could use a BOOLEAN column to store an "Active/Inactive" state for each customer in a CUSTOMER table.

```
create table customer(
custid int,
active_flag boolean default true);
```

```
insert into customer values(100, default);
```

```
select * from customer;
custid | active_flag
-------+--------------
   100 | t
```

If no default value (`true` or `false`) is specified in the CREATE TABLE statement, inserting a default value means inserting a null.

In this example, the query selects users from the USERS table who like sports but do not like theatre:

```
select firstname, lastname, likesports, liketheatre
from users
where likesports is true and liketheatre is false
order by userid limit 10;

firstname |  lastname  | likesports | liketheatre
----------+------------+------------+-------------
Lars      | Ratliff    | t          | f
Mufutau   | Watkins    | t          | f
Scarlett  | Mayer      | t          | f
Shafira   | Glenn      | t          | f
Winifred  | Cherry     | t          | f
Chase     | Lamb       | t          | f
Liberty   | Ellison    | t          | f
Aladdin   | Haney      | t          | f
Tashya    | Michael    | t          | f
Lucian    | Montgomery | t          | f
(10 rows)
```

The following example selects users from the USERS table for whom is it unknown whether they like rock music.

```
select firstname, lastname, likerock
from users
where likerock is unknown
order by userid limit 10;

firstname | lastname | likerock
----------+----------+----------
Rafael    | Taylor   |
Vladimir  | Humphrey |
Barry     | Roy      |
Tamekah   | Juarez   |
Mufutau   | Watkins  |
Naida     | Calderon |
Anika     | Huff     |
Bruce     | Beck     |
Mallory   | Farrell  |
Scarlett  | Mayer    |
```

```
(10 rows)
```

The following example returns an error because it uses an IS comparison in the SELECT list.

```
select firstname, lastname, likerock is true as "check"
from users
order by userid limit 10;

[Amazon](500310) Invalid operation: Not implemented
```

The following example succeeds because it uses an equal comparison (=) in the SELECT list instead of the IS comparison.

```
select firstname, lastname, likerock = true as "check"
from users
order by userid limit 10;

firstname | lastname  | check
----------+-----------+------
Rafael    | Taylor    |
Vladimir  | Humphrey  |
Lars      | Ratliff   | true
Barry     | Roy       |
Reagan    | Hodge     | true
Victor    | Hernandez | true
Tamekah   | Juarez    |
Colton    | Roy       | false
Mufutau   | Watkins   |
Naida     | Calderon  |
```

HLLSKETCH type

Use the HLLSKETCH data type for HyperLogLog sketches. Amazon Redshift supports HyperLogLog sketch representations that are either sparse or dense. Sketches begin as sparse and switch to dense when the dense format is more efficient to minimize the memory footprint that is used.

Amazon Redshift automatically transitions a sparse HyperLogLog sketch when importing, exporting, or printing sketches in the following JSON format.

```
{"logm":15,"sparse":{"indices":[4878,9559,14523],"values":[1,2,1]}}
```

Amazon Redshift uses a string representation in a Base64 format to represent a dense HyperLogLog sketch.

Amazon Redshift uses the following string representation in a Base64 format to represent a dense HyperLogLog sketch.

```
"ABAABA..."
```

The maximum size of a HLLSKETCH object is 24,580 bytes when used in raw compression.

SUPER type

Use the SUPER data type to store semi-structured data or documents as values. Although Amazon Redshift is capable of storing such values using VARCHAR, we recommend that you use the SUPER data type instead.

Semi-structured data doesn't conform to the rigid and tabular structure of the relational data model used in SQL databases. It contains tags that reference distinct entities within the data. They can contain complex values such as arrays, nested structures, and other complex structures that are associated with serialization formats, such as JSON. The SUPER data type is a set of schemaless array and structure values that encompass all other scalar types of Amazon Redshift.

The SUPER data type supports up to 16 MB of data for an individual SUPER object. For more information on the SUPER data type, including examples of implementing it in a table, see Semi-structured data in Amazon Redshift.

Amazon Redshift provides built-in support to ingest the following semi-structured data formats using the COPY command:

- JSON
- ARRAY
- TEXT
- CSV

SUPER objects larger than 1MB can only be ingested from the following file formats:

- Parquet
- JSON

- TEXT
- CSV

The SUPER data type has the following properties:

- An Amazon Redshift scalar value:
  - A null
  - A boolean
  - A number, such as smallint, integer, bigint, decimal, or floating point (such as float4 or float8)
  - A string value, such as varchar or char
- A complex value:
  - An array of values, including scalar or complex
  - A structure, also known as tuple or object, that is a map of attribute names and values (scalar or complex)

Any of the two types of complex values contain their own scalars or complex values without having any restrictions for regularity.

The default compression encoding for the SUPER data type is ZSTD. For more information on compression encoding, see Compression encodings.

The SUPER data type supports the persistence of semi-structured data in a schemaless form. Although hierarchical data model can change, the old versions of data can coexist in the same SUPER column.

Amazon Redshift uses PartiQL to enable navigation into arrays and structures. Amazon Redshift also uses the PartiQL syntax to iterate over SUPER arrays. For more information, see PartiQL – an SQL-compatible query language for Amazon Redshift.

Amazon Redshift uses dynamic typing to process schemaless SUPER data without needing to declare the data types before you use them in your query. For more information, see Dynamic typing.

You can apply dynamic data masking policies to scalar values on the paths of SUPER type columns. For more information about dynamic data masking, see Dynamic data masking. For information about using dynamic data masking with the SUPER data type, see Using dynamic data masking with SUPER data type paths.

We recommend that you set the `r_enable_case_sensitive_super_attribute` configuration option to true when working with SUPER data. For more information, see enable_case_sensitive_super_attribute.

VARBYTE type

Use a VARBYTE, VARBINARY, or BINARY VARYING column to store variable-length binary value with a fixed limit.

```
varbyte [ (n) ]
```

The maximum number of bytes (*n*) can range from 1 – 16,777,216. The default is 64,000.

Some examples where you might want to use a VARBYTE data type are as follows:

- Joining tables on VARBYTE columns.
- Creating materialized views that contain VARBYTE columns. Incremental refresh of materialized views that contain VARBYTE columns is supported. However, aggregate functions other than COUNT, MIN, and MAX and GROUP BY on VARBYTE columns don't support incremental refresh.

To ensure that all bytes are printable characters, Amazon Redshift uses the hex format to print VARBYTE values. For example, the following SQL converts the hexadecimal string 6162 into a binary value. Even though the returned value is a binary value, the results are printed as hexadecimal 6162.

```
select from_hex('6162');

 from_hex
----------
 6162
```

Amazon Redshift supports casting between VARBYTE and the following data types:

- CHAR
- VARCHAR
- SMALLINT
- INTEGER

- BIGINT

When casting with CHAR and VARCHAR the UTF-8 format is used. For more information about the UTF-8 format, see TO_VARBYTE. When casting from SMALLINT, INTEGER, and BIGINT the number of bytes of the original data type is maintained. That is two bytes for SMALLINT, four bytes for INTEGER, and eight bytes for BIGINT.

The following SQL statement casts a VARCHAR string to a VARBYTE. Even though the returned value is a binary value, the results are printed as hexadecimal 616263.

```
select 'abc'::varbyte;

 varbyte
---------
 616263
```

The following SQL statement casts a CHAR value in a column to a VARBYTE. This example creates a table with a CHAR(10) column (c), inserts character values that are shorter than the length of 10. The resulting cast pads the result with a space characters (hex'20') to the defined column size. Even though the returned value is a binary value, the results are printed as hexadecimal.

```
create table t (c char(10));
insert into t values ('aa'), ('abc');
select c::varbyte from t;
          c
----------------------
 6161202020202020202020
 6162632020202020202020
```

The following SQL statement casts a SMALLINT string to a VARBYTE. Even though the returned value is a binary value, the results are printed as hexadecimal `0005`, which is two bytes or four hexadecimal characters.

```
select 5::smallint::varbyte;

 varbyte
---------
 0005
```

The following SQL statement casts an INTEGER to a VARBYTE. Even though the returned value is a binary value, the results are printed as hexadecimal `00000005`, which is four bytes or eight hexadecimal characters.

```
select 5::int::varbyte;

 varbyte
----------
 00000005
```

The following SQL statement casts a BIGINT to a VARBYTE. Even though the returned value is a binary value, the results are printed as hexadecimal `0000000000000005`, which is eight bytes or 16 hexadecimal characters.

```
select 5::bigint::varbyte;

     varbyte
------------------
 0000000000000005
```

Amazon Redshift features that support the VARBYTE data type include:

- VARBYTE operators
- CONCAT
- LEN
- LENGTH function
- OCTET_LENGTH
- SUBSTRING function
- FROM_HEX
- TO_HEX
- FROM_VARBYTE
- TO_VARBYTE
- GETBIT
- Loading a column of the VARBYTE data type
- Unloading a column of the VARBYTE data type

Limitations when using the VARBYTE data type with Amazon Redshift

The following are limitations when using the VARBYTE data type with Amazon Redshift:

- Amazon Redshift Spectrum supports the VARBYTE data type only for Parquet and ORC files.
- Amazon Redshift query editor and Amazon Redshift query editor v2 don't yet fully support VARBYTE data type. Therefore, use a different SQL client when working with VARBYTE expressions.

  As a workaround to use the query editor, if the length of your data is below 64 KB and the content is valid UTF-8, you can cast the VARBYTE values to VARCHAR, for example:

  ```
  select to_varbyte('6162', 'hex')::varchar;
  ```
- You can't use VARBYTE data types with Python or Lambda user-defined functions (UDFs).
- You can't create a HLLSKETCH column from a VARBYTE column or use APPROXIMATE COUNT DISTINCT on a VARBYTE column.
- VARBYTE values larger than 1 MB can only be ingested from the following file formats:
  - Parquet
  - Text
  - Comma-separated values (CSV)

Type compatibility and conversion

Following, you can find a discussion about how type conversion rules and data type compatibility work in Amazon Redshift.

Compatibility

Data type matching and matching of literal values and constants to data types occurs during various database operations, including the following:

- Data manipulation language (DML) operations on tables
- UNION, INTERSECT, and EXCEPT queries
- CASE expressions
- Evaluation of predicates, such as LIKE and IN
- Evaluation of SQL functions that do comparisons or extractions of data

- Comparisons with mathematical operators

The results of these operations depend on type conversion rules and data type compatibility. *Compatibility* implies that a one-to-one matching of a certain value and a certain data type is not always required. Because some data types are *compatible*, an implicit conversion, or *coercion*, is possible (for more information, see Implicit conversion types). When data types are incompatible, you can sometimes convert a value from one data type to another by using an explicit conversion function.

General compatibility and conversion rules

Note the following compatibility and conversion rules:

- In general, data types that fall into the same type category (such as different numeric data types) are compatible and can be implicitly converted.

  For example, with implicit conversion you can insert a decimal value into an integer column. The decimal is rounded to produce a whole number. Or you can extract a numeric value, such as `2008`, from a date and insert that value into an integer column.
- Numeric data types enforce overflow conditions that occur when you attempt to insert out-of-range values. For example, a decimal value with a precision of 5 does not fit into a decimal column that was defined with a precision of 4. An integer or the whole part of a decimal is never truncated; however, the fractional part of a decimal can be rounded up or down, as appropriate. However, results of explicit casts of values selected from tables are not rounded.
- Different types of character strings are compatible; VARCHAR column strings containing single-byte data and CHAR column strings are comparable and implicitly convertible. VARCHAR strings that contain multibyte data are not comparable. Also, you can convert a character string to a date, time, timestamp, or numeric value if the string is an appropriate literal value; any leading or trailing spaces are ignored. Conversely, you can convert a date, time, timestamp, or numeric value to a fixed-length or variable-length character string.

> **Note**
>
> A character string that you want to cast to a numeric type must contain a character representation of a number. For example, you can cast the strings `'1.0'` or `'5.9'` to decimal values, but you cannot cast the string `'ABC'` to any numeric type.

- If you compare DECIMAL values with character strings, Amazon Redshift attempts to convert the character string to a DECIMAL value. When comparing all other numeric values with character strings, the numeric values are converted to character strings. To enforce the opposite conversion (for example, converting character strings to integers, or converting DECIMAL values to character strings), use an explicit function, such as CAST.
- To convert 64-bit DECIMAL or NUMERIC values to a higher precision, you must use an explicit conversion function such as the CAST or CONVERT functions.
- When converting DATE or TIMESTAMP to TIMESTAMPTZ, or converting TIME to TIMETZ, the time zone is set to the current session time zone. The session time zone is UTC by default. For more information about setting the session time zone, see timezone.
- Similarly, TIMESTAMPTZ is converted to DATE, TIME, or TIMESTAMP based on the current session time zone. The session time zone is UTC by default. After the conversion, time zone information is dropped.
- Character strings that represent a timestamp with time zone specified are converted to TIMESTAMPTZ using the current session time zone, which is UTC by default. Likewise, character strings that represent a time with time zone specified are converted to TIMETZ using the current session time zone, which is UTC by default.

Implicit conversion types

There are two types of implicit conversions:

- Implicit conversions in assignments, such as setting values in INSERT or UPDATE commands.
- Implicit conversions in expressions, such as performing comparisons in the WHERE clause.

The table following lists the data types that can be converted implicitly in assignments or expressions. You can also use an explicit conversion function to perform these conversions.

From type	To type
BIGINT (INT8)	BOOLEAN
	CHAR
	DECIMAL (NUMERIC)

From type	To type
	DOUBLE PRECISION (FLOAT8)
	INTEGER (INT, INT4)
	REAL (FLOAT4)
	SMALLINT (INT2)
	VARCHAR
CHAR	VARCHAR
DATE	CHAR
	VARCHAR
	TIMESTAMP
	TIMESTAMPTZ
DECIMAL (NUMERIC)	BIGINT (INT8)
	CHAR
	DOUBLE PRECISION (FLOAT8)
	INTEGER (INT, INT4)
	REAL (FLOAT4)
	SMALLINT (INT2)
	VARCHAR
DOUBLE PRECISION (FLOAT8)	BIGINT (INT8)
	CHAR
	DECIMAL (NUMERIC)

From type	To type
	INTEGER (INT, INT4)
	REAL (FLOAT4)
	SMALLINT (INT2)
	VARCHAR
INTEGER (INT, INT4)	BIGINT (INT8)
	BOOLEAN
	CHAR
	DECIMAL (NUMERIC)
	DOUBLE PRECISION (FLOAT8)
	REAL (FLOAT4)
	SMALLINT (INT2)
	VARCHAR
REAL (FLOAT4)	BIGINT (INT8)
	CHAR
	DECIMAL (NUMERIC)
	INTEGER (INT, INT4)
	SMALLINT (INT2)
	VARCHAR
SMALLINT (INT2)	BIGINT (INT8)
	BOOLEAN

From type	To type
	CHAR
	DECIMAL (NUMERIC)
	DOUBLE PRECISION (FLOAT8)
	INTEGER (INT, INT4)
	REAL (FLOAT4)
	VARCHAR
TIMESTAMP	CHAR
	DATE
	VARCHAR
	TIMESTAMPTZ
	TIME
TIMESTAMPTZ	CHAR
	DATE
	VARCHAR
	TIMESTAMP
	TIMETZ
TIME	VARCHAR
	TIMETZ
	INTERVAL DAY TO SECOND
TIMETZ	VARCHAR

From type	To type
	TIME
GEOMETRY	GEOGRAPHY
GEOGRAPHY	GEOMETRY

Note

Implicit conversions between TIMESTAMPTZ, TIMESTAMP, DATE, TIME, TIMETZ, or character strings use the current session time zone. For information about setting the current time zone, see timezone.

The GEOMETRY and GEOGRAPHY data types can't be implicitly converted to any other data type, except each other. For more information, see CAST function.

The VARBYTE data type can't be implicitly converted to any other data type. For more information, see CAST function.

Using dynamic typing for the SUPER data type

Amazon Redshift uses dynamic typing to process schemaless SUPER data without the need to declare the data types before you use them in your query. Dynamic typing uses the results of navigating into SUPER data columns without having to explicitly cast them into Amazon Redshift types. For more information about using dynamic typing for SUPER data type, see Dynamic typing.

You can cast SUPER values to and from other data types with some exceptions. For more information, see Limitations.

Collation sequences

Amazon Redshift doesn’t support locale-specific or user-defined collation sequences. In general, the results of any predicate in any context could be affected by the lack of locale-specific rules for sorting and comparing data values. For example, ORDER BY expressions and functions such as MIN, MAX, and RANK return results based on binary UTF8 ordering of the data that does not take locale-specific characters into account.

Expressions

Topics

An expression is a combination of one or more values, operators, or functions that evaluate to a value. The data type of an expression is generally that of its components.

Simple expressions

A simple expression is one of the following:

- A constant or literal value
- A column name or column reference
- A scalar function
- An aggregate (set) function
- A window function
- A scalar subquery

Examples of simple expressions include:

```
5+12
dateid
sales.qtysold * 100
sqrt (4)
max (qtysold)
(select max (qtysold) from sales)
```

Compound expressions

A compound expression is a series of simple expressions joined by arithmetic operators. A simple expression used in a compound expression must return a numeric value.

Syntax

```
expression
operator
expression | (compound_expression)
```

Arguments

expression

A simple expression that evaluates to a value.

operator

A compound arithmetic expression can be constructed using the following operators, in this order of precedence:

- ( ) : parentheses to control the order of evaluation
- + , - : positive and negative sign/operator
- ^ , |/ , ||/ : exponentiation, square root, cube root
- * , / , % : multiplication, division, and modulo operators
- @ : absolute value
- + , - : addition and subtraction
- & , |, #, ~, <<, >> : AND, OR, NOT, shift left, shift right bitwise operators
- ||: concatenation

(compound_expression)

Compound expressions can be nested using parentheses.

Examples

Examples of compound expressions include the following.

```
('SMITH' || 'JONES')
sum(x) / y
sqrt(256) * avg(column)
rank() over (order by qtysold) / 100
(select (pricepaid - commission) from sales where dateid = 1882) * (qtysold)
```

Some functions can also be nested within other functions. For example, any scalar function can nest within another scalar function. The following example returns the sum of the absolute values of a set of numbers:

```
sum(abs(qtysold))
```

Window functions cannot be used as arguments for aggregate functions or other window functions. The following expression would return an error:

```
avg(rank() over (order by qtysold))
```

Window functions can have a nested aggregate function. The following expression sums sets of values and then ranks them:

```
rank() over (order by sum(qtysold))
```

Expression lists

An expression list is a combination of expressions, and can appear in membership and comparison conditions (WHERE clauses) and in GROUP BY clauses.

Syntax

```
expression , expression , ... | (expression, expression, ...)
```

Arguments

expression

A simple expression that evaluates to a value. An expression list can contain one or more comma-separated expressions or one or more sets of comma-separated expressions. When there are multiple sets of expressions, each set must contain the same number of expressions, and be separated by parentheses. The number of expressions in each set must match the number of expressions before the operator in the condition.

Examples

The following are examples of expression lists in conditions:

```
(1, 5, 10)
('THESE', 'ARE', 'STRINGS')
(('one', 'two', 'three'), ('blue', 'yellow', 'green'))
```

The number of expressions in each set must match the number in the first part of the statement:

```
select * from venue
where (venuecity, venuestate) in (('Miami', 'FL'), ('Tampa', 'FL'))
order by venueid;

venueid |        venuename        | venuecity | venuestate | venueseats
---------+-------------------------+-----------+------------+------------
28 | American Airlines Arena | Miami     | FL         |          0
54 | St. Pete Times Forum    | Tampa     | FL         |          0
91 | Raymond James Stadium   | Tampa     | FL         |      65647
(3 rows)
```

Scalar subqueries

A scalar subquery is a regular SELECT query in parentheses that returns exactly one value: one row with one column. The query is run and the returned value is used in the outer query. If the subquery returns zero rows, the value of the subquery expression is null. If it returns more than one row, Amazon Redshift returns an error. The subquery can refer to variables from the parent query, which will act as constants during any one invocation of the subquery.

You can use scalar subqueries in most statements that call for an expression. Scalar subqueries are not valid expressions in the following cases:

- As default values for expressions
- In GROUP BY and HAVING clauses

Example

The following subquery computes the average price paid per sale across the entire year of 2008, then the outer query uses that value in the output to compare against the average price per sale per quarter:

```
select qtr, avg(pricepaid) as avg_saleprice_per_qtr,
(select avg(pricepaid)
from sales join date on sales.dateid=date.dateid
```

```
where year = 2008) as avg_saleprice_yearly
from sales join date on sales.dateid=date.dateid
where year = 2008
group by qtr
order by qtr;
qtr  | avg_saleprice_per_qtr | avg_saleprice_yearly
-------+-----------------------+----------------------
1     |                647.64 |               642.28
2     |                646.86 |               642.28
3     |                636.79 |               642.28
4     |                638.26 |               642.28
(4 rows)
```

Function expressions

Syntax

Any built-in can be used as an expression. The syntax for a function call is the name of a function followed by its argument list in parentheses.

```
function ( [expression [, expression...]] )
```

Arguments

function

Any built-in function. For some example functions, see SQL functions reference.

expression

Any expression(s) matching the data type and parameter count expected by the function.

Examples

```
abs (variable)
select avg (qtysold + 3) from sales;
select dateadd (day,30,caldate) as plus30days from date;
```

Conditions

Topics

- Syntax

A condition is a statement of one or more expressions and logical operators that evaluates to true, false, or unknown. Conditions are also sometimes referred to as predicates.

> **Note**
>
> All string comparisons and LIKE pattern matches are case-sensitive. For example, 'A' and 'a' do not match. However, you can do a case-insensitive pattern match by using the ILIKE predicate.

Syntax

```
comparison_condition
| logical_condition
| range_condition
| pattern_matching_condition
| null_condition
| EXISTS_condition
| IN_condition
```

Comparison condition

Comparison conditions state logical relationships between two values. All comparison conditions are binary operators with a Boolean return type. Amazon Redshift supports the comparison operators described in the following table:

Operator	Syntax	Description
<	`a < b`	Value a is less than value b.

Operator	Syntax	Description
>	`a > b`	Value a is greater than value b.
<=	`a <= b`	Value a is less than or equal to value b.
>=	`a >= b`	Value a is greater than or equal to value b.
=	`a = b`	Value a is equal to value b.
<> or !=	`a <> b or a != b`	Value a is not equal to value b.
ANY | SOME	`a = ANY(subquery)`	Value a is equal to any value returned by the subquery.
ALL	`a <> ALL or != ALL (subquery))`	Value a is not equal to any value returned by the subquery.
IS TRUE | FALSE | UNKNOWN	`a IS TRUE`	Value a is Boolean TRUE.

Usage notes

= ANY | SOME

The ANY and SOME keywords are synonymous with the *IN* condition, and return true if the comparison is true for at least one value returned by a subquery that returns one or more values. Amazon Redshift supports only the = (equals) condition for ANY and SOME. Inequality conditions are not supported.

> **Note**
>
> The ALL predicate is not supported.

<> ALL

The ALL keyword is synonymous with NOT IN (see IN condition condition) and returns true if the expression is not included in the results of the subquery. Amazon Redshift supports only the <> or != (not equals) condition for ALL. Other comparison conditions are not supported.

IS TRUE/FALSE/UNKNOWN

Non-zero values equate to TRUE, 0 equates to FALSE, and null equates to UNKNOWN. See the Boolean type data type.

Examples

Here are some simple examples of comparison conditions:

```
a = 5
a < b
min(x) >= 5
qtysold = any (select qtysold from sales where dateid = 1882
```

The following query returns venues with more than 10000 seats from the VENUE table:

```
select venueid, venuename, venueseats from venue
where venueseats > 10000
order by venueseats desc;

venueid |           venuename             | venueseats
---------+-------------------------------+------------
83 | FedExField                      |      91704
 6 | New York Giants Stadium         |      80242
79 | Arrowhead Stadium               |      79451
78 | INVESCO Field                   |      76125
69 | Dolphin Stadium                 |      74916
67 | Ralph Wilson Stadium            |      73967
76 | Jacksonville Municipal Stadium |      73800
89 | Bank of America Stadium         |      73298
72 | Cleveland Browns Stadium        |      73200
86 | Lambeau Field                   |      72922
...
(57 rows)
```

This example selects the users (USERID) from the USERS table who like rock music:

```
select userid from users where likerock = 't' order by 1 limit 5;

userid
--------
3
5
6
13
16
(5 rows)
```

This example selects the users (USERID) from the USERS table where it is unknown whether they like rock music:

```
select firstname, lastname, likerock
from users
where likerock is unknown
order by userid limit 10;

firstname | lastname | likerock
----------+----------+----------
Rafael    | Taylor   |
Vladimir  | Humphrey |
Barry     | Roy      |
Tamekah   | Juarez   |
Mufutau   | Watkins  |
Naida     | Calderon |
Anika     | Huff     |
Bruce     | Beck     |
Mallory   | Farrell  |
Scarlett  | Mayer    |
(10 rows
```

Examples with a TIME column

The following example table TIME_TEST has a column TIME_VAL (type TIME) with three values inserted.

```
select time_val from time_test;

time_val
---------------------
```

```
20:00:00
00:00:00.5550
00:58:00
```

The following example extracts the hours from each timetz_val.

```
select time_val from time_test where time_val < '3:00';
   time_val
---------------
 00:00:00.5550
 00:58:00
```

The following example compares two time literals.

```
select time '18:25:33.123456' = time '18:25:33.123456';
 ?column?
----------
 t
```

Examples with a TIMETZ column

The following example table TIMETZ_TEST has a column TIMETZ_VAL (type TIMETZ) with three values inserted.

```
select timetz_val from timetz_test;

timetz_val
------------------
04:00:00+00
00:00:00.5550+00
05:58:00+00
```

The following example selects only the TIMETZ values less than `3:00:00` UTC. The comparison is made after converting the value to UTC.

```
select timetz_val from timetz_test where timetz_val < '3:00:00 UTC';

   timetz_val
---------------
 00:00:00.5550+00
```

The following example compares two TIMETZ literals. The time zone is ignored for the comparison.

```
select time '18:25:33.123456 PST' < time '19:25:33.123456 EST';

 ?column?
----------
 t
```

Logical conditions

Logical conditions combine the result of two conditions to produce a single result. All logical conditions are binary operators with a Boolean return type.

Syntax

```
expression
{ AND | OR }
expression
NOT expression
```

Logical conditions use a three-valued Boolean logic where the null value represents an unknown relationship. The following table describes the results for logical conditions, where E1 and E2 represent expressions:

E1	E2	E1 AND E2	E1 OR E2	NOT E2
TRUE	TRUE	TRUE	TRUE	FALSE
TRUE	FALSE	FALSE	TRUE	TRUE
TRUE	UNKNOWN	UNKNOWN	TRUE	UNKNOWN
FALSE	TRUE	FALSE	TRUE	
FALSE	FALSE	FALSE	FALSE	
FALSE	UNKNOWN	FALSE	UNKNOWN	
UNKNOWN	TRUE	UNKNOWN	TRUE	
UNKNOWN	FALSE	FALSE	UNKNOWN	

E1	E2	E1 AND E2	E1 OR E2	NOT E2
UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	

The NOT operator is evaluated before AND, and the AND operator is evaluated before the OR operator. Any parentheses used may override this default order of evaluation.

Examples

The following example returns USERID and USERNAME from the USERS table where the user likes both Las Vegas and sports:

```
select userid, username from users
where likevegas = 1 and likesports = 1
order by userid;

userid | username
--------+----------
1 | JSG99FHE
67 | TWU10MZT
87 | DUF19VXU
92 | HYP36WEQ
109 | FPL38HZK
120 | DMJ24GUZ
123 | QZR22XGQ
130 | ZQC82ALK
133 | LBN45WCH
144 | UCX04JKN
165 | TEY68OEB
169 | AYQ83HGO
184 | TVX65AZX
...
(2128 rows)
```

The next example returns the USERID and USERNAME from the USERS table where the user likes Las Vegas, or sports, or both. This query returns all of the output from the previous example plus the users who like only Las Vegas or sports.

```
select userid, username from users
where likevegas = 1 or likesports = 1
order by userid;
```

```
userid | username
--------+----------
1 | JSG99FHE
2 | PGL08LJI
3 | IFT66TXU
5 | AEB55QTM
6 | NDQ15VBM
9 | MSD36KVR
10 | WKW41AIW
13 | QTF33MCG
15 | OWU78MTR
16 | ZMG93CDD
22 | RHT62AGI
27 | KOY02CVE
29 | HUH27PKK
...
(18968 rows)
```

The following query uses parentheses around the OR condition to find venues in New York or California where Macbeth was performed:

```
select distinct venuename, venuecity
from venue join event on venue.venueid=event.venueid
where (venuestate = 'NY' or venuestate = 'CA') and eventname='Macbeth'
order by 2,1;

venuename                |   venuecity
----------------------------------------+---------------
Geffen Playhouse                        | Los Angeles
Greek Theatre                           | Los Angeles
Royce Hall                              | Los Angeles
American Airlines Theatre               | New York City
August Wilson Theatre                   | New York City
Belasco Theatre                         | New York City
Bernard B. Jacobs Theatre               | New York City
...
```

Removing the parentheses in this example changes the logic and results of the query.

The following example uses the NOT operator:

```
select * from category
```

```
where not catid=1
order by 1;

catid | catgroup |  catname  |                    catdesc
-------+----------+-----------+--------------------------------------------
2 | Sports   | NHL       | National Hockey League
3 | Sports   | NFL       | National Football League
4 | Sports   | NBA       | National Basketball Association
5 | Sports   | MLS       | Major League Soccer
...
```

The following example uses a NOT condition followed by an AND condition:

```
select * from category
where (not catid=1) and catgroup='Sports'
order by catid;

catid | catgroup | catname |             catdesc
-------+----------+---------+---------------------------------
2 | Sports   | NHL     | National Hockey League
3 | Sports   | NFL     | National Football League
4 | Sports   | NBA     | National Basketball Association
5 | Sports   | MLS     | Major League Soccer
(4 rows)
```

Pattern-matching conditions

Topics

- LIKE
- SIMILAR TO
- POSIX operators

A pattern-matching operator searches a string for a pattern specified in the conditional expression and returns true or false depend on whether it finds a match. Amazon Redshift uses three methods for pattern matching:

- LIKE expressions

The LIKE operator compares a string expression, such as a column name, with a pattern that uses the wildcard characters % (percent) and _ (underscore). LIKE pattern matching always covers the entire string. LIKE performs a case-sensitive match and ILIKE performs a case-insensitive match.

- SIMILAR TO regular expressions

  The SIMILAR TO operator matches a string expression with a SQL standard regular expression pattern, which can include a set of pattern-matching metacharacters that includes the two supported by the LIKE operator. SIMILAR TO matches the entire string and performs a case-sensitive match.

- POSIX-style regular expressions

  POSIX regular expressions provide a more powerful means for pattern matching than the LIKE and SIMILAR TO operators. POSIX regular expression patterns can match any portion of the string and performs a case-sensitive match.

Regular expression matching, using SIMILAR TO or POSIX operators, is computationally expensive. We recommend using LIKE whenever possible, especially when processing a very large number of rows. For example, the following queries are functionally identical, but the query that uses LIKE runs several times faster than the query that uses a regular expression:

```
select count(*) from event where eventname SIMILAR TO '%(Ring|Die)%';
select count(*) from event where eventname LIKE '%Ring%' OR eventname LIKE '%Die%';
```

LIKE

The LIKE operator compares a string expression, such as a column name, with a pattern that uses the wildcard characters % (percent) and _ (underscore). LIKE pattern matching always covers the entire string. To match a sequence anywhere within a string, the pattern must start and end with a percent sign.

LIKE is case-sensitive; ILIKE is case-insensitive.

Syntax

```
expression [ NOT ] LIKE | ILIKE pattern [ ESCAPE 'escape_char' ]
```

Arguments

expression

A valid UTF-8 character expression, such as a column name.

LIKE | ILIKE

LIKE performs a case-sensitive pattern match. ILIKE performs a case-insensitive pattern match for single-byte UTF-8 (ASCII) characters. To perform a case-insensitive pattern match for multibyte characters, use the LOWER function on *expression* and *pattern* with a LIKE condition.

In contrast to comparison predicates, such as = and <>, LIKE and ILIKE predicates do not implicitly ignore trailing spaces. To ignore trailing spaces, use RTRIM or explicitly cast a CHAR column to VARCHAR.

The `~~` operator is equivalent to LIKE, and `~~*` is equivalent to ILIKE. Also the `!~~` and `!~~*` operators are equivalent to NOT LIKE and NOT ILIKE.

pattern

A valid UTF-8 character expression with the pattern to be matched.

escape_char

A character expression that will escape metacharacters characters in the pattern. The default is two backslashes ('\\').

If *pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

Either of the character expressions can be CHAR or VARCHAR data types. If they differ, Amazon Redshift converts *pattern* to the data type of *expression*.

LIKE supports the following pattern-matching metacharacters:

Operator	Description
%	Matches any sequence of zero or more characters.
_	Matches any single character.

Examples

The following table shows examples of pattern matching using LIKE:

Expression	Returns
`'abc' LIKE 'abc'`	True
`'abc' LIKE 'a%'`	True
`'abc' LIKE '_B_'`	False
`'abc' ILIKE '_B_'`	True
`'abc' LIKE 'c%'`	False

The following example finds all cities whose names start with "E":

```
select distinct city from users
where city like 'E%' order by city;
city
---------------
East Hartford
East Lansing
East Rutherford
East St. Louis
Easthampton
Easton
Eatontown
Eau Claire
...
```

The following example finds users whose last name contains "ten" :

```
select distinct lastname from users
where lastname like '%ten%' order by lastname;
lastname
-------------
Christensen
Wooten
...
```

The following example demonstrates how to match multiple patterns.

```
select distinct lastname from tickit.users
where lastname like 'Chris%' or lastname like '%Wooten' order by lastname;
lastname
-------------
Christensen
Christian
Wooten
...
```

The following example finds cities whose third and fourth characters are "ea". The command uses ILIKE to demonstrate case insensitivity:

```
select distinct city from users where city ilike '__EA%' order by city;
city
-------------
Brea
Clearwater
Great Falls
Ocean City
Olean
Wheaton
(6 rows)
```

The following example uses the default escape string (\\) to search for strings that include "start_" (the text `start` followed by an underscore _):

```
select tablename, "column" from pg_table_def
where "column" like '%start\\_%'
limit 5;

     tablename     |    column
-------------------+---------------
 stl_s3client      | start_time
 stl_tr_conflict   | xact_start_ts
 stl_undone        | undo_start_ts
 stl_unload_log    | start_time
 stl_vacuum_detail | start_row
(5 rows)
```

The following example specifies '^' as the escape character, then uses the escape character to search for strings that include "start_" (the text `start` followed by an underscore _):

```
select tablename, "column" from pg_table_def
where "column" like '%start^_%' escape '^'
limit 5;

     tablename     |    column
-------------------+---------------
 stl_s3client      | start_time
 stl_tr_conflict   | xact_start_ts
 stl_undone        | undo_start_ts
 stl_unload_log    | start_time
 stl_vacuum_detail | start_row
(5 rows)
```

The following example uses the ~~* operator to do a case-insensitive (ILIKE) search for cities that start with "Ag".

```
select distinct city from users where city ~~* 'Ag%' order by city;

city
------------
Agat
Agawam
Agoura Hills
Aguadilla
```

SIMILAR TO

The SIMILAR TO operator matches a string expression, such as a column name, with a SQL standard regular expression pattern. A SQL regular expression pattern can include a set of pattern-matching metacharacters, including the two supported by the LIKE operator.

The SIMILAR TO operator returns true only if its pattern matches the entire string, unlike POSIX regular expression behavior, where the pattern can match any portion of the string.

SIMILAR TO performs a case-sensitive match.

> **Note**
>
> Regular expression matching using SIMILAR TO is computationally expensive. We recommend using LIKE whenever possible, especially when processing a very large number of rows. For example, the following queries are functionally identical, but the query that uses LIKE runs several times faster than the query that uses a regular expression:
>
> ```
> select count(*) from event where eventname SIMILAR TO '%(Ring|Die)%';
> select count(*) from event where eventname LIKE '%Ring%' OR eventname LIKE '%Die
> %';
> ```

Syntax

```
expression [ NOT ] SIMILAR TO pattern [ ESCAPE 'escape_char' ]
```

Arguments

expression

A valid UTF-8 character expression, such as a column name.

SIMILAR TO

SIMILAR TO performs a case-sensitive pattern match for the entire string in *expression*.

pattern

A valid UTF-8 character expression representing a SQL standard regular expression pattern.

escape_char

A character expression that will escape metacharacters in the pattern. The default is two backslashes ('\\').

If *pattern* does not contain metacharacters, then the pattern only represents the string itself.

Either of the character expressions can be CHAR or VARCHAR data types. If they differ, Amazon Redshift converts *pattern* to the data type of *expression*.

SIMILAR TO supports the following pattern-matching metacharacters:

Operator	Description
`%`	Matches any sequence of zero or more characters.
`_`	Matches any single character.
`|`	Denotes alternation (either of two alternatives).
`*`	Repeat the previous item zero or more times.
`+`	Repeat the previous item one or more times.
`?`	Repeat the previous item zero or one time.
`{m}`	Repeat the previous item exactly *m* times.
`{m,}`	Repeat the previous item *m* or more times.
`{m,n}`	Repeat the previous item at least *m* and not more than *n* times.
`()`	Parentheses group items into a single logical item.
`[...]`	A bracket expression specifies a character class, just as in POSIX regular expressions.

Examples

The following table shows examples of pattern matching using SIMILAR TO:

Expression	Returns
`'abc' SIMILAR TO 'abc'`	True
`'abc' SIMILAR TO '_b_'`	True
`'abc' SIMILAR TO '_A_'`	False
`'abc' SIMILAR TO '%(b|d)%'`	True
`'abc' SIMILAR TO '(b|c)%'`	False

Expression	Returns
`'AbcAbcdefgefg12efgefg12' SIMILAR TO '((Ab)?c)+d((efg)+(12))+'`	True
`'aaaaaab11111xy' SIMILAR TO 'a{6}_[0-9]{5}(x|y){2}'`	True
`'$0.87' SIMILAR TO '$[0-9]+(.[0-9][0-9])?'`	True

The following example finds cities whose names contain "E" or "H":

```
SELECT DISTINCT city FROM users
WHERE city SIMILAR TO '%E%|%H%' ORDER BY city LIMIT 5;

      city
-----------------
 Agoura Hills
 Auburn Hills
 Benton Harbor
 Beverly Hills
 Chicago Heights
```

The following example uses the default escape string ('\\') to search for strings that include "_":

```
SELECT tablename, "column" FROM pg_table_def
WHERE "column" SIMILAR TO '%start\\_%'
ORDER BY tablename, "column" LIMIT 5;

        tablename         |       column
--------------------------+---------------------
 stcs_abort_idle          | idle_start_time
 stcs_abort_idle          | txn_start_time
 stcs_analyze_compression | start_time
 stcs_auto_worker_levels  | start_level
 stcs_auto_worker_levels  | start_wlm_occupancy
```

The following example specifies '^' as the escape string, then uses the escape string to search for strings that include "_":

```
SELECT tablename, "column" FROM pg_table_def
WHERE "column" SIMILAR TO '%start^_%' ESCAPE '^'
ORDER BY tablename, "column" LIMIT 5;

        tablename         |       column
-------------------------+--------------------
 stcs_abort_idle          | idle_start_time
 stcs_abort_idle          | txn_start_time
 stcs_analyze_compression | start_time
 stcs_auto_worker_levels  | start_level
 stcs_auto_worker_levels  | start_wlm_occupancy
```

POSIX operators

A POSIX regular expression is a sequence of characters that specifies a match pattern. A string matches a regular expression if it is a member of the regular set described by the regular expression.

POSIX regular expressions provide a more powerful means for pattern matching than the LIKE and SIMILAR TO operators. POSIX regular expression patterns can match any portion of a string, unlike the SIMILAR TO operator, which returns true only if its pattern matches the entire string.

> **Note**
>
> Regular expression matching using POSIX operators is computationally expensive. We recommend using LIKE whenever possible, especially when processing a very large number of rows. For example, the following queries are functionally identical, but the query that uses LIKE runs several times faster than the query that uses a regular expression:
>
> ```
> select count(*) from event where eventname ~ '.*(Ring|Die).*';
> select count(*) from event where eventname LIKE '%Ring%' OR eventname LIKE '%Die
> %';
> ```

Syntax

```
expression [ ! ] ~ pattern
```

Arguments

expression

A valid UTF-8 character expression, such as a column name.

!

Negation operator. Does not match the regular expression.

~

Perform a case-sensitive match for any substring of *expression*.

> **Note**
>
> A ~~ is a synonym for LIKE.

pattern

A string literal that represents a regular expression pattern.

If *pattern* does not contain wildcard characters, then the pattern only represents the string itself.

To search for strings that include metacharacters, such as `'. * | ? '`, and so on, escape the character using two backslashes (' \\ '). Unlike `SIMILAR TO` and `LIKE`, POSIX regular expression syntax does not support a user-defined escape character.

Either of the character expressions can be CHAR or VARCHAR data types. If they differ, Amazon Redshift converts *pattern* to the data type of *expression*.

All of the character expressions can be CHAR or VARCHAR data types. If the expressions differ in data type, Amazon Redshift converts them to the data type of *expression*.

POSIX pattern matching supports the following metacharacters:

POSIX	Description
.	Matches any single character.
*	Matches zero or more occurrences.

POSIX	Description
+	Matches one or more occurrences.
?	Matches zero or one occurrence.
|	Specifies alternative matches; for example, `E | H` means E or H.
^	Matches the beginning-of-line character.
$	Matches the end-of-line character.
$	Matches the end of the string.
`[ ]`	Brackets specify a matching list, that should match one expression in the list. A caret (^) precedes a nonmatching list, which matches any character except for the expressions represented in the list.
`( )`	Parentheses group items into a single logical item.
`{m}`	Repeat the previous item exactly *m* times.
`{m,}`	Repeat the previous item *m* or more times.
`{m,n}`	Repeat the previous item at least *m* and not more than *n* times.
`[: :]`	Matches any character within a POSIX character class. In the following character classes, Amazon Redshift supports only ASCII characters: `[:alnum:]` , `[:alpha:]` , `[:lower:]` , `[:upper:]`

Amazon Redshift supports the following POSIX character classes.

Character Class	Description
`[[:alnum:]]`	All ASCII alphanumeric characters
`[[:alpha:]]`	All ASCII alphabetic characters
`[[:blank:]]`	All blank space characters

Character Class	Description
[[:cntrl:]]	All control characters (nonprinting)
[[:digit:]]	All numeric digits
[[:lower:]]	All lowercase ASCII alphabetic characters
[[:punct:]]	All punctuation characters
[[:space:]]	All space characters (nonprinting)
[[:upper:]]	All uppercase ASCII alphabetic characters
[[:xdigit:]]	All valid hexadecimal characters

Amazon Redshift supports the following Perl-influenced operators in regular expressions. Escape the operator using two backslashes ('\\').

Operator	Description	Equivalent character class expression
`\\d`	A digit character	`[[:digit:]]`
`\\D`	A nondigit character	`[^[:digit:]]`
`\\w`	A word character	`[[:word:]]`
`\\W`	A nonword character	`[^[:word:]]`
`\\s`	A white space character	`[[:space:]]`
`\\S`	A non–white space character	`[^[:space:]]`
`\\b`	A boundary word	

Examples

The following table shows examples of pattern matching using POSIX operators:

<table>
<tr><th>Expression</th><th>Returns</th></tr>
<tr><td>'abc' ~ 'abc'</td><td>True</td></tr>
<tr><td>'abc' ~ 'a'</td><td>True</td></tr>
<tr><td>'abc' ~ 'A'</td><td>False</td></tr>
<tr><td>'abc' ~ '.*(b|d).*'</td><td>True</td></tr>
<tr><td>'abc' ~ '(b|c).*'</td><td>True</td></tr>
<tr><td>'AbcAbcdefgefg12efgefg12' ~ '((Ab)?c)+d((efg)+(12))+'</td><td>True</td></tr>
<tr><td>'aaaaaab11111xy' ~ 'a{6}.[1]{5}(x|y){2}'</td><td>True</td></tr>
<tr><td>'$0.87' ~ '\\$[0-9]+(\\.[0-9][0-9])?'</td><td>True</td></tr>
<tr><td>'ab c' ~ '[[:space:]]'</td><td>True</td></tr>
<tr><td>'ab c' ~ '\\s'</td><td>True</td></tr>
<tr><td>' ' ~ '\\S'</td><td>False</td></tr>
</table>

The following example finds cities whose names contain E or H:

```
SELECT DISTINCT city FROM users
WHERE city ~ '.*E.*|.*H.*' ORDER BY city LIMIT 5;

      city
-----------------
 Agoura Hills
 Auburn Hills
 Benton Harbor
 Beverly Hills
 Chicago Heights
```

The following example finds cities whose names don't contain E or H:

```
SELECT DISTINCT city FROM users WHERE city !~ '.*E.*|.*H.*' ORDER BY city LIMIT 5;

      city
-----------------
 Aberdeen
 Abilene
 Ada
 Agat
 Agawam
```

The following example uses the escape string ('\\') to search for strings that include a period.

```
SELECT venuename FROM venue
WHERE venuename ~ '.*\\..*'
ORDER BY venueid;

          venuename
------------------------------
 St. Pete Times Forum
 Jobing.com Arena
 Hubert H. Humphrey Metrodome
 U.S. Cellular Field
 Superpages.com Center
 E.J. Nutter Center
 Bernard B. Jacobs Theatre
 St. James Theatre
```

BETWEEN range condition

A BETWEEN condition tests expressions for inclusion in a range of values, using the keywords BETWEEN and AND.

Syntax

```
expression [ NOT ] BETWEEN expression AND expression
```

Expressions can be numeric, character, or datetime data types, but they must be compatible. The range is inclusive.

Examples

The first example counts how many transactions registered sales of either 2, 3, or 4 tickets:

```
select count(*) from sales
where qtysold between 2 and 4;

count
--------
104021
(1 row)
```

The range condition includes the begin and end values.

```
select min(dateid), max(dateid) from sales
where dateid between 1900 and 1910;

min  | max
-----+-----
1900 | 1910
```

The first expression in a range condition must be the lesser value and the second expression the greater value. The following example will always return zero rows due to the values of the expressions:

```
select count(*) from sales
where qtysold between 4 and 2;

count
-------
0
(1 row)
```

However, applying the NOT modifier will invert the logic and produce a count of all rows:

```
select count(*) from sales
where qtysold not between 4 and 2;

count
--------
172456
```

```
(1 row)
```

The following query returns a list of venues with 20000 to 50000 seats:

```
select venueid, venuename, venueseats from venue
where venueseats between 20000 and 50000
order by venueseats desc;

venueid |       venuename               | venueseats
---------+-------------------------------+------------
116 | Busch Stadium                 |      49660
106 | Rangers BallPark in Arlington |      49115
96 | Oriole Park at Camden Yards   |      48876
...
(22 rows)
```

The following example demonstrates using BETWEEN for date values:

```
select salesid, qtysold, pricepaid, commission, saletime
from sales
where eventid between 1000 and 2000
   and saletime between '2008-01-01' and '2008-01-03'
order by saletime asc;

salesid | qtysold | pricepaid | commission |   saletime
--------+---------+-----------+------------+---------------
  65082 |       4 |       472 |       70.8 | 1/1/2008 06:06
 110917 |       1 |       337 |      50.55 | 1/1/2008 07:05
 112103 |       1 |       241 |      36.15 | 1/2/2008 03:15
 137882 |       3 |      1473 |     220.95 | 1/2/2008 05:18
  40331 |       2 |        58 |        8.7 | 1/2/2008 05:57
 110918 |       3 |      1011 |     151.65 | 1/2/2008 07:17
  96274 |       1 |       104 |       15.6 | 1/2/2008 07:18
 150499 |       3 |       135 |      20.25 | 1/2/2008 07:20
  68413 |       2 |       158 |       23.7 | 1/2/2008 08:12
```

Note that although BETWEEN's range is inclusive, dates default to having a time value of 00:00:00. The only valid January 3 row for the sample query would be a row with a saletime of `1/3/2008 00:00:00`.

Null condition

The null condition tests for nulls, when a value is missing or unknown.

Syntax

```
expression IS [ NOT ] NULL
```

Arguments

expression

Any expression such as a column.

IS NULL

Is true when the expression's value is null and false when it has a value.

IS NOT NULL

Is false when the expression's value is null and true when it has a value.

Example

This example indicates how many times the SALES table contains null in the QTYSOLD field:

```
select count(*) from sales
where qtysold is null;
count
-------
0
(1 row)
```

EXISTS condition

EXISTS conditions test for the existence of rows in a subquery, and return true if a subquery returns at least one row. If NOT is specified, the condition returns true if a subquery returns no rows.

Syntax

```
[ NOT ] EXISTS (table_subquery)
```

Arguments

EXISTS

Is true when the *table_subquery* returns at least one row.

NOT EXISTS

Is true when the *table_subquery* returns no rows.

table_subquery

A subquery that evaluates to a table with one or more columns and one or more rows.

Example

This example returns all date identifiers, one time each, for each date that had a sale of any kind:

```
select dateid from date
where exists (
select 1 from sales
where date.dateid = sales.dateid
)
order by dateid;

dateid
--------
1827
1828
1829
...
```

IN condition

An IN condition tests a value for membership in a set of values or in a subquery.

Syntax

```
expression [ NOT ] IN (expr_list | table_subquery)
```

Arguments

expression

A numeric, character, or datetime expression that is evaluated against the *expr_list* or *table_subquery* and must be compatible with the data type of that list or subquery.

expr_list

One or more comma-delimited expressions, or one or more sets of comma-delimited expressions bounded by parentheses.

table_subquery

A subquery that evaluates to a table with one or more rows, but is limited to only one column in its select list.

IN | NOT IN

IN returns true if the expression is a member of the expression list or query. NOT IN returns true if the expression is not a member. IN and NOT IN return NULL and no rows are returned in the following cases: If *expression* yields null; or if there are no matching *expr_list* or *table_subquery* values and at least one of these comparison rows yields null.

Examples

The following conditions are true only for those values listed:

```
qtysold in (2, 4, 5)
date.day in ('Mon', 'Tues')
date.month not in ('Oct', 'Nov', 'Dec')
```

Optimization for Large IN Lists

To optimize query performance, an IN list that includes more than 10 values is internally evaluated as a scalar array. IN lists with fewer than 10 values are evaluated as a series of OR predicates. This optimization is supported for SMALLINT, INTEGER, BIGINT, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, and TIMESTAMPTZ data types.

Look at the EXPLAIN output for the query to see the effect of this optimization. For example:

```
explain select * from sales
```

```
QUERY PLAN
--------------------------------------------------------------------
XN Seq Scan on sales  (cost=0.00..6035.96 rows=86228 width=53)
Filter: (salesid = ANY ('{1,2,3,4,5,6,7,8,9,10,11}'::integer[]))
(2 rows)
```

SQL commands

The SQL language consists of commands that you use to create and manipulate database objects, run queries, load tables, and modify the data in tables.

Amazon Redshift is based on PostgreSQL. Amazon Redshift and PostgreSQL have a number of important differences that you must be aware of as you design and develop your data warehouse applications. For more information about how Amazon Redshift SQL differs from PostgreSQL, see Amazon Redshift and PostgreSQL.

> **Note**
>
> The maximum size for a single SQL statement is 16 MB.

Topics

- ALTER PROCEDURE
- ALTER SCHEMA
- ALTER SYSTEM
- ALTER TABLE
- ALTER TABLE APPEND
- ALTER USER
- ANALYZE
- ANALYZE COMPRESSION
- ATTACH MASKING POLICY
- ATTACH RLS POLICY
- BEGIN
- CALL
- CANCEL
- CLOSE
- COMMENT
- COMMIT
- COPY
- CREATE DATABASE
- CREATE DATASHARE
- CREATE EXTERNAL FUNCTION
- CREATE EXTERNAL MODEL
- CREATE EXTERNAL SCHEMA
- CREATE EXTERNAL TABLE
- CREATE EXTERNAL VIEW
- CREATE FUNCTION
- CREATE GROUP
- CREATE IDENTITY PROVIDER
- CREATE LIBRARY
- CREATE MASKING POLICY
- CREATE MATERIALIZED VIEW

- CREATE MODEL
- CREATE PROCEDURE
- CREATE RLS POLICY
- CREATE ROLE
- CREATE SCHEMA
- CREATE TABLE
- CREATE TABLE AS
- CREATE USER
- CREATE VIEW
- DEALLOCATE
- DECLARE
- DELETE
- DESC DATASHARE
- DESC IDENTITY PROVIDER
- DETACH MASKING POLICY
- DETACH RLS POLICY
- DROP DATABASE
- DROP DATASHARE
- DROP EXTERNAL VIEW
- DROP FUNCTION
- DROP GROUP
- DROP IDENTITY PROVIDER
- DROP LIBRARY
- DROP MASKING POLICY
- DROP MODEL
- DROP MATERIALIZED VIEW
- DROP PROCEDURE
- DROP RLS POLICY
- DROP ROLE
- DROP SCHEMA

- DROP TABLE
- DROP USER
- DROP VIEW
- END
- EXECUTE
- EXPLAIN
- FETCH
- GRANT
- INSERT
- INSERT (external table)
- LOCK
- MERGE
- PREPARE
- REFRESH MATERIALIZED VIEW
- RESET
- REVOKE
- ROLLBACK
- SELECT
- SELECT INTO
- SET
- SET SESSION AUTHORIZATION
- SET SESSION CHARACTERISTICS
- SHOW
- SHOW COLUMNS
- SHOW EXTERNAL TABLE
- SHOW DATABASES
- SHOW GRANTS
- SHOW MODEL
- SHOW DATASHARES
- SHOW PROCEDURE

ABORT

Stops the currently running transaction and discards all updates made by that transaction. ABORT has no effect on already completed transactions.

This command performs the same function as the ROLLBACK command. For information, see ROLLBACK.

Syntax

```
ABORT [ WORK | TRANSACTION ]
```

Parameters

WORK

Optional keyword.

TRANSACTION

Optional keyword; WORK and TRANSACTION are synonyms.

Example

The following example creates a table then starts a transaction where data is inserted into the table. The ABORT command then rolls back the data insertion to leave the table empty.

The following command creates an example table called MOVIE_GROSS:

```
create table movie_gross( name varchar(30), gross bigint );
```

The next set of commands starts a transaction that inserts two data rows into the table:

```
begin;

insert into movie_gross values ( 'Raiders of the Lost Ark', 23400000);

insert into movie_gross values ( 'Star Wars', 10000000 );
```

Next, the following command selects the data from the table to show that it was successfully inserted:

```
select * from movie_gross;
```

The command output shows that both rows are successfully inserted:

```
         name           |  gross
------------------------+----------
Raiders of the Lost Ark | 23400000
Star Wars               | 10000000
(2 rows)
```

This command now rolls back the data changes to where the transaction began:

```
abort;
```

Selecting data from the table now shows an empty table:

```
select * from movie_gross;

 name | gross
------+-------
(0 rows)
```

ALTER DATABASE

Changes the attributes of a database.

Required privileges

To use ALTER DATABASE, one of the following privileges is required..

- Superuser
- Users with the ALTER DATABASE privilege
- Database owner

Syntax

```
ALTER DATABASE database_name
{
  RENAME TO new_name
  | OWNER TO new_owner
  | [ CONNECTION LIMIT { limit | UNLIMITED } ]
    [ COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI } ]
    [ ISOLATION LEVEL { SERIALIZABLE | SNAPSHOT } ]
| INTEGRATION
 {
  REFRESH { { ALL | INERROR } TABLES [ IN SCHEMA schema [, ...] ] | TABLE schema.table
 [, ...] }
   | SET
     [ QUERY_ALL_STATES [=] { TRUE | FALSE } ]
     [ ACCEPTINVCHARS [=] { TRUE | FALSE } ]
     [ REFRESH_INTERVAL <interval> ]
     [ TRUNCATECOLUMNS [=] { TRUE | FALSE } ]
     [ HISTORY_MODE [=] {TRUE | FALSE} [ FOR { {ALL} TABLES [IN SCHEMA schema [, ...] ]
 | TABLE schema.table [, ...] } ] ]
 }
}
```

Parameters

database_name

Name of the database to alter. Typically, you alter a database that you are not currently connected to; in any case, the changes take effect only in subsequent sessions. You can change the owner of the current database, but you can't rename it:

```
alter database tickit rename to newtickit;
```

```
ERROR:  current database may not be renamed
```

RENAME TO

Renames the specified database. For more information about valid names, see Names and identifiers. You can't rename the dev, padb_harvest, template0, template1, or sys:internal databases, and you can't rename the current database. Only the database owner or a superuser (p. 920) can rename a database; non-superuser owners must also have the CREATEDB privilege.

new_name

New database name.

OWNER TO

Changes the owner of the specified database. You can change the owner of the current database or some other database. Only a superuser can change the owner.

new_owner

New database owner. The new owner must be an existing database user with write privileges. For more information about user privileges, see GRANT.

CONNECTION LIMIT { *limit* | UNLIMITED }

The maximum number of database connections users are permitted to have open concurrently. The limit is not enforced for superusers. Use the UNLIMITED keyword to permit the maximum number of concurrent connections. A limit on the number of connections for each user might also apply. For more information, see CREATE USER. The default is UNLIMITED. To view current connections, query the STV_SESSIONS system view.

> **Note**
>
> If both user and database connection limits apply, an unused connection slot must be available that is within both limits when a user attempts to connect.

COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI }

A clause that specifies whether string search or comparison is case-sensitive or case-insensitive.

You can change the case sensitivity of the current database even if it's empty.

You must have ALTER permission for the current database to change case sensitivity. Superusers or database owners with the CREATE DATABASE permission can also change database case sensitivity.

CASE_SENSITIVE and CS are interchangeable and yield the same results. Similarly, CASE_INSENSITIVE and CI are interchangeable and yield the same results.

ISOLATION LEVEL { SERIALIZABLE | SNAPSHOT }

A clause that specifies the isolation level used when queries run against a database.

- SERIALIZABLE isolation – provides full serializability for concurrent transactions. For more information, see Serializable isolation.
- SNAPSHOT isolation – provides an isolation level with protection against update and delete conflicts.

For more information about isolation levels, see CREATE DATABASE.

Consider the following items when altering the isolation level of a database:

- You must have the superuser or CREATE DATABASE privilege to the current database to change the database isolation level.
- You can't alter the isolation level of the `dev` database.
- You can't alter the isolation level within a transaction block.
- The alter isolation level command fails if other users are connected to the database.
- The alter isolation level command can alter the isolation level settings of the current session.

INTEGRATION

Alter a zero-ETL integration database.

REFRESH {{ ALL | INERROR } TABLES [IN SCHEMA *schema* [, ...]] | TABLE *schema.table* [, ...]}

A clause that specifies whether Amazon Redshift will refresh all tables or tables with errors in the specified schema or table. The refresh will trigger the tables in the specified schema or table to be fully replicated from the source database.

For more information, see Zero-ETL integrations in the *Amazon Redshift Management Guide*. For more information about integration states, see SVV_INTEGRATION_TABLE_STATE and SVV_INTEGRATION.

QUERY_ALL_STATES [=] { TRUE | FALSE }

The QUERY_ALL_STATES clause sets whether zero-ETL integration tables can be queried in all states (`Synced`, `Failed`, `ResyncRequired`, and `ResyncInitiated`). By default, a zero-ETL integration table can only be queried in `Synced` state.

ACCEPTINVCHARS [=] { TRUE | FALSE }

The ACCEPTINVCHARS clause sets whether zero-ETL integration tables continue with ingestion when invalid characters are detected for the VARCHAR data type. When invalid characters are encountered, the invalid character is replaced with a default `?` character.

REFRESH_INTERVAL <interval>

The REFRESH_INTERVAL clause sets the approximate time interval, in seconds, to refresh data from the zero-ETL source to the target database. The `interval` can be set 0–432,000 seconds (5 days) for zero-ETL integrations whose source type is Aurora MySQL, Aurora PostgreSQL, or RDS for MySQL. For Amazon DynamoDB zero-ETL integrations, the `interval` can be set 900–432,000 seconds (15 minutes –5 days).

For more information about creating databases with zero-ETL integrations, see [Creating destination databases in Amazon Redshift]() in the *Amazon Redshift Management Guide*.

TRUNCATECOLUMNS [=] { TRUE | FALSE }

The TRUNCATECOLUMNS clause sets whether zero-ETL integration tables continue with ingestion when the values for the VARCHAR column or SUPER column attributes are beyond the limit. When `TRUE`, the values are truncated to fit into the column and the values of overflowing JSON attributes are truncated to fit into the SUPER column.

HISTORY_MODE [=] {TRUE | FALSE} [FOR { {ALL} TABLES [IN SCHEMA schema [, ...]] | TABLE schema.table [, ...]}]

A clause that specifies whether Amazon Redshift will set history mode for all tables or tables in the specified schema that participate in zero-ETL integration. This option is only applicable for databases created for zero-ETL integration.

The HISTORY_MODE clause can be set to `TRUE` or `FALSE`. The default is `FALSE`. Switching history mode on and off is only applicable to tables that are in the `Synced` state. For information about HISTORY_MODE, see [History mode]() in the *Amazon Redshift Management Guide*.

Usage notes

ALTER DATABASE commands apply to subsequent sessions not current sessions. You must reconnect to the altered database to see the effect of the change.

Examples

The following example renames a database named TICKIT_SANDBOX to TICKIT_TEST:

```
alter database tickit_sandbox rename to tickit_test;
```

The following example changes the owner of the TICKIT database (the current database) to DWUSER:

```
alter database tickit owner to dwuser;
```

The following example changes the database case sensitivity of the sampledb database:

```
ALTER DATABASE sampledb COLLATE CASE_INSENSITIVE;
```

The following example alters a database named **sampledb** with SNAPSHOT isolation level.

```
ALTER DATABASE sampledb ISOLATION LEVEL SNAPSHOT;
```

The following example refreshes the tables **schema1.sample_table1** and **schema2.sample_table2** in the database **sample_integration_db** in your zero-ETL integration.

```
ALTER DATABASE sample_integration_db INTEGRATION REFRESH TABLE schema1.sample_table1,
 schema2.sample_table2;
```

The following example refreshes all synced and failed tables within your zero-ETL integration.

```
ALTER DATABASE sample_integration_db INTEGRATION REFRESH ALL tables;
```

The following example sets the refresh interval for zero-ETL integrations to 600 seconds..

```
ALTER DATABASE sample_integration_db INTEGRATION SET REFRESH_INTERVAL 600;
```

The following example refreshes all tables that are in the ErrorState in the schema **sample_schema**.

```
ALTER DATABASE sample_integration_db INTEGRATION REFRESH INERROR TABLES in SCHEMA
 sample_schema;
```

The following example switches history mode on for table myschema.table1.

```
ALTER DATABASE sample_integration_db INTEGRATION SET HISTORY_MODE = true FOR TABLE
 myschema.table1
```

The following example switches history mode on for all tables in myschema.

```
ALTER DATABASE sample_integration_db INTEGRATION SET HISTORY_MODE = true for ALL TABLES
 IN SCHEMA myschema
```

ALTER DATASHARE

Changes the definition of a datashare. You can add objects or remove objects using ALTER DATASHARE. You can only change a datashare in the current database. Add or remove objects from the associated database to a datashare. The owner of the datashare with the required permissions on the datashare objects to be added or removed can alter the datashare.

Required privileges

Following are required privileges for ALTER DATASHARE:

- Superuser.
- User with the ALTER DATASHARE privilege.
- Users who have the ALTER or ALL privilege on the datashare.
- To add specific objects to a datashare, users must have the privilege on the objects. For this case, users should be the owners of objects or have SELECT, USAGE, or ALL privileges on the objects.

Syntax

The following syntax illustrates how to add or remove objects to the datashare.

```
ALTER DATASHARE datashare_name { ADD | REMOVE } {
TABLE schema.table [, ...]
| SCHEMA schema [, ...]
| FUNCTION schema.sql_udf (argtype,...) [, ...]
| ALL TABLES IN SCHEMA schema [, ...]
| ALL FUNCTIONS IN SCHEMA schema [, ...] }
```

The following syntax illustrates how to configure the properties of the datashare.

```
ALTER DATASHARE datashare_name {
[ SET PUBLICACCESSIBLE [=] TRUE | FALSE ]
[ SET INCLUDENEW [=] TRUE | FALSE FOR SCHEMA schema ] }
```

Parameters

datashare_name

The name of the datashare to be altered.

ADD | REMOVE

A clause that specifies whether to add objects to or remove objects from the datashare.

TABLE *schema*.*table* [, ...]

The name of the table or view in the specified schema to add to the datashare.

SCHEMA *schema* [, ...]

The name of the schema to add to the datashare.

FUNCTION *schema*.*sql_udf* (argtype,...) [, ...]

The name of the user-defined SQL function with argument types to add to the datashare.

ALL TABLES IN SCHEMA *schema* [, ...]

A clause that specifies whether to add all tables and views in the specified schema to the datashare.

ALL FUNCTIONS IN SCHEMA *schema* [, ...] }

A clause that specifies adding all functions in the specified schema to the datashare.

[SET PUBLICACCESSIBLE [=] TRUE | FALSE]

A clause that specifies whether a datashare can be shared to clusters that are publicly accessible.

[SET INCLUDENEW [=] TRUE | FALSE FOR SCHEMA *schema*]

A clause that specifies whether to add any future tables, views, or SQL user-defined functions (UDFs) created in the specified schema to the datashare. Current tables, views, or SQL UDFs in the specified schema aren't added to the datashare. Only superusers can change this property for each datashare-schema pair. By default, the INCLUDENEW clause is false.

ALTER DATASHARE usage notes

- The following users can alter a datashare:
  - A superuser
  - The owner of the datashare
  - Users that have ALTER or ALL privilege on the datashare
- To add specific objects to a datashare, users must have the correct privileges on the objects. Users should be the owners of objects or have SELECT, USAGE, or ALL privileges on the objects.
- You can share schemas, tables, regular views, late-binding views, materialized views, and SQL user-defined functions (UDFs). Add a schema to a datashare first before adding objects in the schema.

  When you add a schema, Amazon Redshift doesn't add all the objects under it. You must add them explicitly.
- We recommend that you create AWS Data Exchange datashares with the publicly accessible setting turned on.
- In general, we recommend that you don't alter an AWS Data Exchange datashare to turn off public accessibility using the ALTER DATASHARE statement. If you do, the AWS accounts that have access to the datashare lose access if their clusters are publicly accessible. Performing this type of alteration can breach data product terms in AWS Data Exchange. For an exception to this recommendation, see following.

  The following example shows an error when an AWS Data Exchange datashare is created with the setting turned off.

```
ALTER DATASHARE salesshare SET PUBLICACCESSIBLE FALSE;
ERROR:  Alter of ADX-managed datashare salesshare requires session variable
 datashare_break_glass_session_var to be set to value 'c670ba4db22f4b'
```

To allow altering an AWS Data Exchange datashare to turn off the publicly accessible setting, set the following variable and run the ALTER DATASHARE statement again.

```
SET datashare_break_glass_session_var to 'c670ba4db22f4b';
```

```
ALTER DATASHARE salesshare SET PUBLICACCESSIBLE FALSE;
```

In this case, Amazon Redshift generates a random one-time value to set the session variable to allow ALTER DATASHARE SET PUBLICACCESSIBLE FALSE for an AWS Data Exchange datashare.

Examples

The following example adds the `public` schema to the datashare `salesshare`.

```
ALTER DATASHARE salesshare ADD SCHEMA public;
```

The following example adds the `public.tickit_sales_redshift` table to the datashare `salesshare`.

```
ALTER DATASHARE salesshare ADD TABLE public.tickit_sales_redshift;
```

The following example adds all tables to the datashare `salesshare`.

```
ALTER DATASHARE salesshare ADD ALL TABLES IN SCHEMA PUBLIC;
```

The following example removes the `public.tickit_sales_redshift` table from the datashare `salesshare`.

```
ALTER DATASHARE salesshare REMOVE TABLE public.tickit_sales_redshift;
```

ALTER DEFAULT PRIVILEGES

Defines the default set of access permissions to be applied to objects that are created in the future by the specified user. By default, users can change only their own default access permissions. Only a superuser can specify default permissions for other users.

You can apply default privileges to roles, users, or user groups. You can set default permissions globally for all objects created in the current database, or for objects created only in the specified schemas.

Default permissions apply only to new objects. Running ALTER DEFAULT PRIVILEGES doesn't change permissions on existing objects. To grant permissions on all current and future objects created by any user within a database or schema, see Scoped permissions.

To view information about the default privileges for database users, query the PG_DEFAULT_ACL system catalog table.

For more information about privileges, see GRANT.

Required privileges

Following are required privileges for ALTER DEFAULT PRIVILEGES:

- Superuser
- Users with the ALTER DEFAULT PRIVILEGES privilege
- Users changing their own default access privileges
- Users setting privileges for schemas that they have access privileges to

Syntax

```
ALTER DEFAULT PRIVILEGES
    [ FOR USER target_user [, ...] ]
    [ IN SCHEMA schema_name [, ...] ]
    grant_or_revoke_clause

where grant_or_revoke_clause is one of:

GRANT { { SELECT | INSERT | UPDATE | DELETE | DROP | REFERENCES | TRUNCATE } [,...] |
 ALL [ PRIVILEGES ] }
 ON TABLES
```

```
 TO { user_name [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
 ON FUNCTIONS
 TO { user_name [ WITH GRANT OPTION ] |  ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
 ON PROCEDURES
 TO { user_name [ WITH GRANT OPTION ] |  ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

REVOKE [ GRANT OPTION FOR ] { { SELECT | INSERT | UPDATE | DELETE | REFERENCES |
 TRUNCATE } [,...] | ALL [ PRIVILEGES ] }
 ON TABLES
 FROM user_name [, ...] [ RESTRICT ]

REVOKE  { { SELECT | INSERT | UPDATE | DELETE | REFERENCES | TRUNCATE } [,...] | ALL
 [ PRIVILEGES ] }
 ON TABLES
 FROM { ROLE role_name | GROUP group_name | PUBLIC } [, ...] [ RESTRICT ]

REVOKE [ GRANT OPTION FOR ] { EXECUTE | ALL [ PRIVILEGES ] }
 ON FUNCTIONS
 FROM user_name [, ...] [ RESTRICT ]

REVOKE { EXECUTE | ALL [ PRIVILEGES ] }
 ON FUNCTIONS
 FROM { ROLE role_name | GROUP group_name | PUBLIC } [, ...] [ RESTRICT ]

REVOKE [ GRANT OPTION FOR ] { EXECUTE | ALL [ PRIVILEGES ] }
 ON PROCEDURES
 FROM user_name [, ...] [ RESTRICT ]

REVOKE { EXECUTE | ALL [ PRIVILEGES ] }
 ON PROCEDURES
 FROM { ROLE role_name | GROUP group_name | PUBLIC } [, ...] [ RESTRICT ]
```

Parameters

FOR USER *target_user*

Optional. The name of the user for which default privileges are defined. Only a superuser can specify default privileges for other users. The default value is the current user.

IN SCHEMA *schema_name*

Optional. If an IN SCHEMA clause appears, the specified default privileges are applied to new objects created in the specified *schema_name*. In this case, the user or user group that is the target of ALTER DEFAULT PRIVILEGES must have CREATE privilege for the specified schema. Default privileges that are specific to a schema are added to existing global default privileges. By default, default privileges are applied globally to the entire database.

GRANT

The set of privileges to grant to the specified users or groups for all new tables and views, functions, or stored procedures created by the specified user. You can set the same privileges and options with the GRANT clause that you can with the GRANT command.

WITH GRANT OPTION

A clause that indicates that the user receiving the privileges can in turn grant the same privileges to others. You can't grant WITH GRANT OPTION to a group or to PUBLIC.

TO *user_name* | ROLE *role_name* | GROUP *group_name*

The name of the user, role, or user group to which the specified default privileges are applied.

REVOKE

The set of privileges to revoke from the specified users or groups for all new tables, functions, or stored procedures created by the specified user. You can set the same privileges and options with the REVOKE clause that you can with the REVOKE command.

GRANT OPTION FOR

A clause that revokes only the option to grant a specified privilege to other users and doesn't revoke the privilege itself. You can't revoke GRANT OPTION from a group or from PUBLIC.

FROM *user_name* | ROLE *role_name* | GROUP *group_name*

The name of the user, role, or user group from which the specified privileges are revoked by default.

RESTRICT

The RESTRICT option revokes only those privileges that the user directly granted. This is the default.

Examples

Suppose that you want to allow any user in the user group `report_readers` to view all tables and views created by the user `report_admin`. In this case, run the following command as a superuser.

```
alter default privileges for user report_admin grant select on tables to group
 report_readers;
```

In the following example, the first command grants SELECT privileges on all new tables that you create. Anytime you create a new view, you must explicitly grant privileges to the view or re-run the `alter default privileges` command again.

```
alter default privileges grant select on tables to public;
```

The following example grants INSERT privilege to the `sales_admin` user group for all new tables and views that you create in the `sales` schema.

```
alter default privileges in schema sales grant insert on tables to group sales_admin;
```

The following example reverses the ALTER DEFAULT PRIVILEGES command in the preceding example.

```
alter default privileges in schema sales revoke insert on tables from group
 sales_admin;
```

By default, the PUBLIC user group has execute permission for all new user-defined functions. To revoke `public` execute permissions for your new functions and then grant execute permission only to the `dev_test` user group, run the following commands.

```
alter default privileges revoke execute on functions from public;
alter default privileges grant execute on functions to group dev_test;
```

ALTER EXTERNAL SCHEMA

Alters an existing external schema in the current database. Only schema owners, super-users, or users with ALTER privileges on the schema can alter it. Only external schemas created from DATA CATALOG, KAFKA, or MSK can be altered.

The owner of this schema is the issuer of the CREATE EXTERNAL SCHEMA command. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner. To grant access to the schema to other users or user groups, use the GRANT command.

You can't use the GRANT or REVOKE commands for permissions on an external table. Instead, grant or revoke the permissions on the external schema.

For more information, see the following:

- ALTER SCHEMA
- GRANT
- REVOKE
- CREATE EXTERNAL SCHEMA
- Enabling mTLS authentication for an existing external schema

To view details for external schemas, query the SVV_EXTERNAL_SCHEMAS system view. For more information, see SVV_EXTERNAL_SCHEMAS.

Syntax

```
ALTER EXTERNAL SCHEMA schema_name
[ IAM_ROLE [ default | 'SESSION' | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ] ]
[ AUTHENTICATION [ none | iam | mtls] ]
[ AUTHENTICATION_ARN 'acm-certificate-arn' | SECRET_ARN 'asm-secret-arn' ]
[ URI 'Kafka bootstrap URL' ]
```

If you have an existing external schema that you use for streaming ingestion and you want to implement mutual TLS for authentication, you can run a command such as the following, which specifies mTLS authentication and the ACM certificate ARN in ACM.

```
ALTER EXTERNAL SCHEMA schema_name
```

```
AUTHENTICATION mtls
AUTHENTICATION_ARN 'arn:aws:acm:us-east-1:444455556666:certificate/certificate_ID';
```

Or you can modify mTLS authentication, with reference to the secret ARN in Secrets Manager.

```
ALTER EXTERNAL SCHEMA schema_name
AUTHENTICATION mtls
SECRET_ARN 'arn:aws:secretsmanager:us-east-1:012345678910:secret:myMTLSSecret';
```

The following example shows how to modify the URI for ALTER EXTERNAL SCHEMA:

```
ALTER EXTERNAL SCHEMA schema_name
URI 'lkc-ghidef-67890.centralus.azure.glb.confluent.cloud:9092';
```

The following example shows how to modify the IAM role for ALTER EXTERNAL SCHEMA:

```
ALTER EXTERNAL SCHEMA schema_name
IAM_ROLE 'arn:aws:iam::012345678901:role/testrole';
```

Parameters

IAM_ROLE[default | 'SESSION' | 'arn:aws:iam::<AWS account-id>:role/<role-name>']

Use the `default` keyword to have Amazon Redshift use the IAM role that is set as default.

Use `'SESSION'` if you connect to your Amazon Redshift cluster using a federated identity and access the tables from the external schema created using this command.

See CREATE EXTERNAL SCHEMA for more information.

AUTHENTICATION

The authentication type defined for streaming ingestion. Streaming ingestion with authentication types works with Apache Kafka, Confluent Cloud, and Amazon Managed Streaming for Apache Kafka. See CREATE EXTERNAL SCHEMA for more information.

AUTHENTICATION_ARN

The ARN of the AWS Certificate Manager certificate used by Amazon Redshift for mtls authentication with Apache Kafka, Confluent Cloud, or Amazon Managed Streaming for Apache

Kafka (Amazon MSK). The ARN is available in the ACM console when you choose the issued certificate.

SECRET_ARN

The Amazon Resource Name (ARN) of a supported secret created using AWS Secrets Manager. For information about how to create and retrieve an ARN for a secret, see Manage secrets with AWS Secrets Manager in the *AWS Secrets Manager User Guide*, and Retrieving the Amazon Resource Name (ARN) of the secret in Amazon Redshift.

URI

The bootstrap URL of the Apache Kafka, Confluent Cloud or Amazon Managed Streaming for Apache Kafka (Amazon MSK) cluster. The endpoint must be reachable (routable) from the Amazon Redshift cluster. See CREATE EXTERNAL SCHEMA for more information.

ALTER EXTERNAL VIEW

Use the ALTER EXTERNAL VIEW command to update your external view. Depending on which parameters you use, other SQL engines such as Amazon Athena and Amazon EMR Spark that can also reference this view might be affected. For more information about Data Catalog views, see AWS Glue Data Catalog views.

Syntax

```
ALTER EXTERNAL VIEW schema_name.view_name
{catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name |
 external_schema_name.view_name}
[FORCE] { AS (query_definition) | REMOVE DEFINITION }
```

Parameters

schema_name.view_name

The schema that's attached to your AWS Glue database, followed by the name of the view.

catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name | external_schema_name.view_name

The notation of the schema to use when altering the view. You can specify to use the AWS Glue Data Catalog, a Glue database that you created, or an external schema that you created. See CREATE DATABASE and CREATE EXTERNAL SCHEMA for more information.

FORCE

Whether AWS Lake Formation should update the definition of the view even if the objects referenced in the table are inconsistent with other SQL engines. If Lake Formation updates the view, the view is considered stale for the other SQL engines until those engines are updated as well.

AS query_definition

The definition of the SQL query that Amazon Redshift runs to alter the view.

REMOVE DEFINITION

Whether to drop and recreate the views. Views must be dropped and recreated to mark them as `PROTECTED`.

Examples

The following example alters a Data Catalog view named sample_schema.glue_data_catalog_view.

```
ALTER EXTERNAL VIEW sample_schema.glue_data_catalog_view
FORCE
REMOVE DEFINITION
```

ALTER FUNCTION

Renames a function or changes the owner. Both the function name and data types are required. Only the owner or a superuser can rename a function. Only a superuser can change the owner of a function.

Syntax

```
ALTER FUNCTION function_name ( { [ py_arg_name py_arg_data_type | sql_arg_data_type }
 [ , ... ] ] )
     RENAME TO new_name
```

```
ALTER FUNCTION function_name ( { [ py_arg_name py_arg_data_type | sql_arg_data_type }
 [ , ... ] ] )
     OWNER TO { new_owner | CURRENT_USER | SESSION_USER }
```

Parameters

function_name

The name of the function to be altered. Either specify the name of the function in the current search path, or use the format `schema_name.function_name` to use a specific schema.

py_arg_name py_arg_data_type | sql_arg_data_type

Optional. A list of input argument names and data types for the Python user-defined function, or a list of input argument data types for the SQL user-defined function.

new_name

A new name for the user-defined function.

new_owner | CURRENT_USER | SESSION_USER

A new owner for the user-defined function.

Examples

The following example changes the name of a function from `first_quarter_revenue` to `quarterly_revenue`.

```
ALTER FUNCTION first_quarter_revenue(bigint, numeric, int)
         RENAME TO quarterly_revenue;
```

The following example changes the owner of the `quarterly_revenue` function to `etl_user`.

```
ALTER FUNCTION quarterly_revenue(bigint, numeric) OWNER TO etl_user;
```

ALTER GROUP

Changes a user group. Use this command to add users to the group, drop users from the group, or rename the group.

Syntax

```
ALTER GROUP group_name
{
```

```
ADD USER username [, ... ] |
DROP USER username [, ... ] |
RENAME TO new_name
}
```

Parameters

group_name

Name of the user group to modify.

ADD

Adds a user to a user group.

DROP

Removes a user from a user group.

username

Name of the user to add to the group or drop from the group.

RENAME TO

Renames the user group. Group names beginning with two underscores are reserved for Amazon Redshift internal use. For more information about valid names, see Names and identifiers.

new_name

New name of the user group.

Examples

The following example adds a user named DWUSER to the ADMIN_GROUP group.

```
ALTER GROUP admin_group
ADD USER dwuser;
```

The following example renames the group ADMIN_GROUP to ADMINISTRATORS.

```
ALTER GROUP admin_group
```

```
RENAME TO administrators;
```

The following example adds two users to the group ADMIN_GROUP.

```
ALTER GROUP admin_group
ADD USER u1, u2;
```

The following example drops two users from the group ADMIN_GROUP.

```
ALTER GROUP admin_group
DROP USER u1, u2;
```

ALTER IDENTITY PROVIDER

Alters an identity provider to assign new parameters and values. When you run this command, all previously set parameter values are deleted before the new values are assigned. Only a superuser can alter an identity provider.

Syntax

```
ALTER IDENTITY PROVIDER identity_provider_name
[PARAMETERS parameter_string]
[NAMESPACE namespace]
[IAM_ROLE iam_role]
[AUTO_CREATE_ROLES
    [ TRUE [ { INCLUDE | EXCLUDE } GROUPS LIKE filter_pattern] |
      FALSE
    ]
[DISABLE | ENABLE]
```

Parameters

identity_provider_name

Name of the new identity provider. For more information about valid names, see [Names and identifiers](#).

parameter_string

A string containing a properly formatted JSON object that contains parameters and values required for the specific identity provider.

namespace

The organization namespace.

iam_role

The IAM role that provides permissions for the connection to IAM Identity Center. This parameter is applicable only when the identity-provider type is AWSIDC.

auto_create_roles

Enables or disables the auto-create role feature. If the value is TRUE, Amazon Redshift enables the auto-create role feature. If the value is FALSE, Amazon Redshift disables the auto-create role feature. If the value for this parameter isn't specified, Amazon Redshift determines the value using the following logic:

- If `AUTO_CREATE_ROLES` is provided but the value isn't specified, the value is set to TRUE.
- If `AUTO_CREATE_ROLES` isn't provided and the identity provider is AWSIDC, the value is set to FALSE.
- If `AUTO_CREATE_ROLES` isn't provided and the identity provider is Azure, the value is set to TRUE.

To include groups, specify `INCLUDE`. The default is empty, which means include all groups if `AUTO_CREATE_ROLES` is on.

To exclude groups, specify `EXCLUDE`. The default is empty, which means do not exclude any groups if `AUTO_CREATE_ROLES` is on.

filter_pattern

A valid UTF-8 character expression with a pattern to match group names. The LIKE option performs a case-sensitive match that supports the following pattern-matching metacharacters:

Metacharacter	Description
`%`	Matches any sequence of zero or more characters.
`_`	Matches any single character.

If *filter_pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

filter_pattern supports the following characters:

- Uppercase and lowercase alphabetic characters (A-Z and a-z)
- Numerals (0-9)
- The following special characters:

```
_ % ^ * + ? { } , $
```

DISABLE or ENABLE

Turns an identity provider on or off. The default is ENABLE.

Examples

The following example alters an identity provider named *oauth_standard*. It applies specifically to when Microsoft Azure AD is the identity provider.

```
ALTER IDENTITY PROVIDER oauth_standard
PARAMETERS '{"issuer":"https://sts.windows.net/2sdfdsf-d475-420d-b5ac-667adad7c702/",
"client_id":"87f4aa26-78b7-410e-bf29-57b39929ef9a",
"client_secret":"BUAH~ewrqewrqwerUUY^%tHe1oNZShoiU7",
"audience":["https://analysis.windows.net/powerbi/connector/AmazonRedshift"]
}'
```

The following sample shows how to set the identity-provider namespace. This can apply to Microsoft Azure AD, if it follows a statement like the previous sample, or to another identity provider. It can also apply to a case where you connect an existing Amazon Redshift provisioned cluster or Amazon Redshift Serverless workgroup to IAM Identity Center, if you have a connection set up through a managed application.

```
ALTER IDENTITY PROVIDER "my-redshift-idc-application"
NAMESPACE 'MYCO';
```

The following sample sets the IAM role and works in the use case for configuring Redshift integration with IAM Identity Center.

```
ALTER IDENTITY PROVIDER "my-redshift-idc-application"
IAM_ROLE 'arn:aws:iam::123456789012:role/myadministratorrole';
```

For more information about setting up a connection to IAM Identity Center from Redshift, see Connect Redshift with IAM Identity Center to give users a single sign-on experience.

Disabling an identity provider

The following sample statement shows how to disable an identity provider. When it's disabled, federated users from the identity provider can't login to the cluster until it's enabled again.

```
ALTER IDENTITY PROVIDER "redshift-idc-app" DISABLE;
```

ALTER MASKING POLICY

Alters an existing dynamic data masking policy. For more information on dynamic data masking, see Dynamic data masking.

Superusers and users or roles that have the sys:secadmin role can alter a masking policy.

Syntax

```
ALTER MASKING POLICY policy_name
   USING (masking_expression);
```

Parameters

policy_name

The name of the masking policy. This must be the name of a masking policy that already exists in the database.

masking_expression

The SQL expression used to transform the target columns. It can be written using data manipulation functions such as String manipulation functions, or in conjunction with user-defined functions written in SQL, Python, or with AWS Lambda.

The expression must match the original expression's input columns and data types. For example, if the original masking policy's input columns were `sample_1 FLOAT` and `sample_2 VARCHAR(10)`, you wouldn't be able to alter the masking policy to take a third column, or make the policy take a FLOAT and a BOOLEAN. If you use a constant as your masking expression, you must explicitly cast it to a type that matches the input type.

You must have the USAGE permission on any user-defined functions that you use in the masking expression.

ALTER MATERIALIZED VIEW

Changes the attributes of a materialized view.

Syntax

```
ALTER MATERIALIZED VIEW mv_name
{
AUTO REFRESH { YES | NO }
| ALTER DISTKEY column_name
| ALTER DISTSTYLE ALL
| ALTER DISTSTYLE EVEN
| ALTER DISTSTYLE KEY DISTKEY column_name
| ALTER DISTSTYLE AUTO
| ALTER [COMPOUND] SORTKEY ( column_name [,...] )
| ALTER SORTKEY AUTO
| ALTER SORTKEY NONE
| ROW LEVEL SECURITY { ON | OFF } [ CONJUNCTION TYPE { AND | OR } ] [FOR DATASHARES]
};
```

Parameters

mv_name

The name of the materialized view to alter.

AUTO REFRESH { YES | NO }

A clause that turns on or off automatic refreshing of a materialized view. For more information about automatic refresh of materialized views, see Refreshing a materialized view.

ALTER DISTSTYLE ALL

A clause that changes the existing distribution style of a relation to ALL. Consider the following:

- An ALTER DISTSTYLE, ALTER SORTKEY, and VACUUM can't run concurrently on the same relation.
  - If VACUUM is currently running, then running ALTER DISTSTYLE ALL returns an error.
  - If ALTER DISTSTYLE ALL is running, then a background vacuum doesn't start on a relation.

- The ALTER DISTSTYLE ALL command is not supported for relations with interleaved sort keys and temporary tables.
- If the distribution style was previously defined as AUTO, then the relation is no longer a candidate for automatic table optimization.

For more information about DISTSTYLE ALL, go to CREATE MATERIALIZED VIEW.

ALTER DISTSTYLE EVEN

A clause that changes the existing distribution style of a relation to EVEN. Consider the following:

- An ALTER DISTSYTLE, ALTER SORTKEY, and VACUUM can't run concurrently on the same relation.
  - If VACUUM is currently running, then running ALTER DISTSTYLE EVEN returns an error.
  - If ALTER DISTSTYLE EVEN is running, then a background vacuum doesn't start on a relation.
- The ALTER DISTSTYLE EVEN command is not supported for relations with interleaved sort keys and temporary tables.
- If the distribution style was previously defined as AUTO, then the relation is no longer a candidate for automatic table optimization.

For more information about DISTSTYLE EVEN, go to CREATE MATERIALIZED VIEW.

ALTER DISTKEY *column_name* or ALTER DISTSTYLE KEY DISTKEY *column_name*

A clause that changes the column used as the distribution key of a relation. Consider the following:

- VACUUM and ALTER DISTKEY can't run concurrently on the same relation.
  - If VACUUM is already running, then ALTER DISTKEY returns an error.
  - If ALTER DISTKEY is running, then background vacuum doesn't start on a relation.
  - If ALTER DISTKEY is running, then foreground vacuum returns an error.
- You can only run one ALTER DISTKEY command on a relation at a time.
- The ALTER DISTKEY command is not supported for relations with interleaved sort keys.
- If the distribution style was previously defined as AUTO, then the relation is no longer a candidate for automatic table optimization.

When specifying DISTSTYLE KEY, the data is distributed by the values in the DISTKEY column. For more information about DISTSTYLE, go to CREATE MATERIALIZED VIEW.

ALTER DISTSTYLE AUTO

A clause that changes the existing distribution style of a relation to AUTO.

When you alter a distribution style to AUTO, the distribution style of the relation is set to the following:

- A small relation with DISTSTYLE ALL is converted to AUTO(ALL).
- A small relation with DISTSTYLE EVEN is converted to AUTO(ALL).
- A small relation with DISTSTYLE KEY is converted to AUTO(ALL).
- A large relation with DISTSTYLE ALL is converted to AUTO(EVEN).
- A large relation with DISTSTYLE EVEN is converted to AUTO(EVEN).
- A large relation with DISTSTYLE KEY is converted to AUTO(KEY) and the DISTKEY is preserved. In this case, Amazon Redshift makes no changes to the relation.

If Amazon Redshift determines that a new distribution style or key will improve the performance of queries, then Amazon Redshift might change the distribution style or key of your relation in the future. For example, Amazon Redshift might convert a relation with a DISTSTYLE of AUTO(KEY) to AUTO(EVEN), or vice versa. For more information about behavior when distribution keys are altered, including data redistribution and locks, go to Amazon Redshift Advisor recommendations.

For more information about DISTSTYLE AUTO, go to CREATE MATERIALIZED VIEW.

To view the distribution style of a relation, query the SVV_TABLE_INFO system catalog view. For more information, go to SVV_TABLE_INFO. To view the Amazon Redshift Advisor recommendations for relations, query the SVV_ALTER_TABLE_RECOMMENDATIONS system catalog view. For more information, go to SVV_ALTER_TABLE_RECOMMENDATIONS. To view the actions taken by Amazon Redshift, query the SVL_AUTO_WORKER_ACTION system catalog view. For more information, go to SVL_AUTO_WORKER_ACTION.

ALTER [COMPOUND] SORTKEY (*column_name* [,...])

A clause that changes or adds the sort key used for a relation. ALTER SORTKEY isn't supported for temporary tables.

When you alter a sort key, the compression encoding of columns in the new or original sort key can change. If no encoding is explicitly defined for the relation, then Amazon Redshift automatically assigns compression encodings as follows:

- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR or VARCHAR are assigned LZO compression.

Consider the following:

- You can define a maximum of 400 columns for a sort key per relation.
- You can alter an interleaved sort key to a compound sort key or no sort key. However, you can't alter a compound sort key to an interleaved sort key.
- If the sort key was previously defined as AUTO, then the relation is no longer a candidate for automatic table optimization.
- Amazon Redshift recommends using RAW encoding (no compression) for columns defined as sort keys. When you alter a column to choose it as a sort key, the column's compression is changed to RAW compression (no compression). This can increase the amount of storage required by the relation. How much the relation size increases depend on the specific relation definition and relation contents. For more information about compression, go to Compression encodings.

When data is loaded into a relation, the data is loaded in the order of the sort key. When you alter the sort key, Amazon Redshift reorders the data. For more information about SORTKEY, go to CREATE MATERIALIZED VIEW.

ALTER SORTKEY AUTO

A clause that changes or adds the sort key of the target relation to AUTO. ALTER SORTKEY AUTO isn't supported for temporary tables.

When you alter a sort key to AUTO, Amazon Redshift preserves the existing sort key of the relation.

If Amazon Redshift determines that a new sort key will improve the performance of queries, then Amazon Redshift might change the sort key of your relation in the future.

For more information about SORTKEY AUTO, go to CREATE MATERIALIZED VIEW.

To view the sort key of a relation, query the SVV_TABLE_INFO system catalog view. For more information, go to SVV_TABLE_INFO. To view the Amazon Redshift Advisor recommendations for relations, query the SVV_ALTER_TABLE_RECOMMENDATIONS system catalog view. For more information, go to SVV_ALTER_TABLE_RECOMMENDATIONS. To view the actions taken by Amazon Redshift, query the SVL_AUTO_WORKER_ACTION system catalog view. For more information, go to SVL_AUTO_WORKER_ACTION.

ALTER SORTKEY NONE

A clause that removes the sort key of the target relation.

If the sort key was previously defined as AUTO, then the relation is no longer a candidate for automatic table optimization.

ROW LEVEL SECURITY { ON | OFF } [CONJUNCTION TYPE { AND | OR }] [FOR DATASHARES]

A clause that turns on or off row-level security for a relation.

When row-level security is turned on for a relation, you can only read the rows that the row-level security policy permits you to access. When there isn't any policy granting you access to the relation, you can't see any rows from the relation. Only superusers and users or roles that have the `sys:secadmin` role can set the ROW LEVEL SECURITY clause. For more information, see Row-level security.

- [CONJUNCTION TYPE { AND | OR }]

  A clause that allows you to choose the conjunction type of row-level security policy for a relation. When multiple row-level security policies are attached to a relation, you can combine the policies with the AND or OR clause. By default, Amazon Redshift combines RLS policies with the AND clause. Superusers, users, or roles that have the `sys:secadmin` role can use this clause to define the conjunction type of row-level security policy for a relation. For more information, see Combining multiple policies per user.

- FOR DATASHARES

  A clause that determines whether an RLS-protected relation can be accessed over datashares. By default, an RLS-protected relation can’t be accessed over a datashare. An ALTER MATERIALIZED VIEW ROW LEVEL SECURITY command run with this clause only affects the relation’s datashare accessibility property. The ROW LEVEL SECURITY property isn’t changed.

  If you make an RLS-protected relation accessible over datashares, the relation doesn’t have row-level security in the consumer-side datashared database. The relation retains its RLS property on the producer side.

Examples

The following example enables the `tickets_mv` materialized view to be automatically refreshed.

```
ALTER MATERIALIZED VIEW tickets_mv AUTO REFRESH YES
```

DISTSTYLE and SORTKEY examples for ALTER MATERIALIZED VIEW

The examples in this topic show you how to perform DISTSTYLE and SORTKEY changes, using ALTER MATERIALIZED VIEW.

The following example queries show how to alter a DISTSTYLE KEY DISTKEY column using a sample base table:

```
CREATE TABLE base_inventory(
  inv_date_sk int4 NOT NULL,
  inv_item_sk int4 NOT NULL,
  inv_warehouse_sk int4 NOT NULL,
  inv_quantity_on_hand int4
);

INSERT INTO base_inventory VALUES(1,1,1,1);

CREATE materialized VIEW inventory diststyle even AS SELECT * FROM base_inventory;
SELECT "table", diststyle FROM svv_table_info WHERE "table" = 'inventory';

ALTER materialized VIEW inventory ALTER diststyle KEY distkey inv_warehouse_sk;
SELECT "table", diststyle FROM svv_table_info WHERE "table" = 'inventory';

ALTER materialized VIEW inventory ALTER distkey inv_item_sk;
SELECT "table", diststyle FROM svv_table_info WHERE "table" = 'inventory';

DROP TABLE base_inventory CASCADE;
```

Alter a materialized view to DISTSTYLE ALL:

```
CREATE TABLE base_inventory(
  inv_date_sk int4 NOT NULL,
  inv_item_sk int4 NOT NULL,
  inv_warehouse_sk int4 NOT NULL,
  inv_quantity_on_hand int4
);
```

```
INSERT INTO base_inventory VALUES(1,1,1,1);

CREATE materialized VIEW inventory diststyle even AS SELECT * FROM base_inventory;
SELECT "table", diststyle FROM svv_table_info WHERE "table" = 'inventory';

ALTER MATERIALIZED VIEW inventory ALTER diststyle ALL;
SELECT "table", diststyle FROM svv_table_info WHERE "table" = 'inventory';

DROP TABLE base_inventory CASCADE;
```

The following commands show ALTER MATERIALIZED VIEW SORTKEY examples using a sample base table:

```
CREATE TABLE base_inventory (c0 int, c1 int);

INSERT INTO base_inventory VALUES(1,1);

CREATE materialized VIEW inventory interleaved sortkey(c0, c1) AS SELECT * FROM
 base_inventory;
SELECT "table", sortkey1 FROM svv_table_info WHERE "table" = 'inventory';

ALTER materialized VIEW inventory ALTER sortkey(c0, c1);
SELECT "table", diststyle, sortkey_num FROM svv_table_info WHERE "table" = 'inventory';

ALTER materialized VIEW inventory ALTER sortkey NONE;
SELECT "table", diststyle, sortkey_num FROM svv_table_info WHERE "table" = 'inventory';

ALTER materialized VIEW inventory ALTER sortkey(c0);
SELECT "table", diststyle, sortkey_num FROM svv_table_info WHERE "table" = 'inventory';

DROP TABLE base_inventory CASCADE;
```

ALTER RLS POLICY

Alter an existing row-level security policy on a table.

Superusers and users or roles that have the `sys:secadmin` role can alter a policy.

Syntax

```
ALTER RLS POLICY policy_name
```

```
USING ( using_predicate_exp );
```

Parameters

policy_name

The name of the policy.

USING (*using_predicate_exp*)

Specifies a filter that is applied to the WHERE clause of the query. Amazon Redshift applies a policy predicate before the query-level user predicates. For example, **`current_user = ‘joe’ and price > 10`** limits Joe to see only records with the price greater than $10.

The expression has access to the variables declared in the WITH clause of the CREATE RLS POLICY statement that was used to create the policy with name policy_name.

Examples

The following example alters a RLS policy.

```
-- First create an RLS policy that limits access to rows where catgroup is 'concerts'.
CREATE RLS POLICY policy_concerts
WITH (catgroup VARCHAR(10))
USING (catgroup = 'concerts');

-- Then, alter the RLS policy to only show rows where catgroup is 'piano concerts'.
ALTER RLS POLICY policy_concerts
USING (catgroup = 'piano concerts');
```

ALTER ROLE

Renames a role or changes the owner. For a list of Amazon Redshift system-defined roles, see the section called “Amazon Redshift system-defined roles”.

Required permissions

Following are the required permissions for ALTER ROLE:

- Superuser
- Users with the ALTER ROLE permissions

Syntax

```
ALTER ROLE role [ WITH ]
  { { RENAME TO role } | { OWNER TO user_name } }[, ...]
  [ EXTERNALID TO external_id ]
```

Parameters

role

The name of the role to be altered.

RENAME TO

A new name for the role.

OWNER TO *user_name*

A new owner for the role.

EXTERNALID TO *external_id*

A new external ID for the role, which is associated with an identity provider. For more information, see Native identity provider (IdP) federation for Amazon Redshift.

Examples

The following example changes the name of a role from `sample_role1` to `sample_role2`.

```
ALTER ROLE sample_role1 RENAME TO sample_role2;
```

The following example changes the owner of the role.

```
ALTER ROLE sample_role1 WITH OWNER TO user1
```

The syntax of the ALTER ROLE is similar to ALTER PROCEDURE following.

```
ALTER PROCEDURE first_quarter_revenue(bigint, numeric) RENAME TO quarterly_revenue;
```

The following example changes the owner of a procedure to `etl_user`.

```
ALTER PROCEDURE quarterly_revenue(bigint, numeric) OWNER TO etl_user;
```

The following example updates a role `sample_role1` with a new external ID that is associated with an identity provider.

```
ALTER ROLE sample_role1 EXTERNALID TO "XYZ456";
```

ALTER PROCEDURE

Renames a procedure or changes the owner. Both the procedure name and data types, or signature, are required. Only the owner or a superuser can rename a procedure. Only a superuser can change the owner of a procedure.

Syntax

```
ALTER PROCEDURE sp_name [ ( [ [ argname ] [ argmode ] argtype [, ...] ] ) ]
    RENAME TO new_name
```

```
ALTER PROCEDURE sp_name [ ( [ [ argname ] [ argmode ] argtype [, ...] ] ) ]
    OWNER TO { new_owner | CURRENT_USER | SESSION_USER }
```

Parameters

sp_name

The name of the procedure to be altered. Either specify just the name of the procedure in the current search path, or use the format `schema_name.sp_procedure_name` to use a specific schema.

[argname] [argmode] argtype

A list of argument names, argument modes, and data types. Only the input data types are required, which are used to identify the stored procedure. Alternatively, you can provide the full signature used to create the procedure including the input and output parameters with their modes.

new_name

A new name for the stored procedure.

new_owner **|** CURRENT_USER **|** SESSION_USER

A new owner for the stored procedure.

Examples

The following example changes the name of a procedure from `first_quarter_revenue` to `quarterly_revenue`.

```
ALTER PROCEDURE first_quarter_revenue(volume INOUT bigint, at_price IN numeric,
 result OUT int) RENAME TO quarterly_revenue;
```

This example is equivalent to the following.

```
ALTER PROCEDURE first_quarter_revenue(bigint, numeric) RENAME TO quarterly_revenue;
```

The following example changes the owner of a procedure to `etl_user`.

```
ALTER PROCEDURE quarterly_revenue(bigint, numeric) OWNER TO etl_user;
```

ALTER SCHEMA

Changes the definition of an existing schema. Use this command to rename a schema or change the owner of a schema. For example, rename an existing schema to preserve a backup copy of that schema when you plan to create a new version of that schema. For more information about schemas, see CREATE SCHEMA.

To view the configured schema quotas, see SVV_SCHEMA_QUOTA_STATE.

To view the records where schema quotas were exceeded, see STL_SCHEMA_QUOTA_VIOLATIONS.

Required privileges

Following are required privileges for ALTER SCHEMA:

- Superuser
- User with the ALTER SCHEMA privilege
- Schema owner

When you change a schema name, note that objects using the old name, such as stored procedures or materialized views, must be updated to use the new name.

Syntax

```
ALTER SCHEMA schema_name
{
RENAME TO new_name |
OWNER TO new_owner |
QUOTA { quota [MB | GB | TB] | UNLIMITED }
}
```

Parameters

schema_name

The name of the database schema to be altered.

RENAME TO

A clause that renames the schema.

new_name

The new name of the schema. For more information about valid names, see Names and identifiers.

OWNER TO

A clause that changes the owner of the schema.

new_owner

The new owner of the schema.

QUOTA

The maximum amount of disk space that the specified schema can use. This space is the collective size of all tables under the specified schema. Amazon Redshift converts the selected value to megabytes. Gigabytes is the default unit of measurement when you don't specify a value.

For more information about configuring schema quotas, see CREATE SCHEMA.

Examples

The following example renames the SALES schema to US_SALES.

```
alter schema sales
rename to us_sales;
```

The following example gives ownership of the US_SALES schema to the user DWUSER.

```
alter schema us_sales
owner to dwuser;
```

The following example changes the quota to 300 GB and removes the quota.

```
alter schema us_sales QUOTA 300 GB;
alter schema us_sales QUOTA UNLIMITED;
```

ALTER SYSTEM

Changes a system-level configuration option for the Amazon Redshift cluster or Redshift Serverless workgroup.

Required privileges

One of the following user types can run the ALTER SYSTEM command:

- Superuser
- Admin user

Syntax

```
ALTER SYSTEM SET system-level-configuration = {true| t | on | false | f | off}
```

Parameters

system-level-configuration

A system-level configuration. Valid value: `data_catalog_auto_mount` and `metadata_security`.

{true| t | on | false | f | off}

A value to activate or deactivate the system-level configuration. A `true`, `t`, or `on` indicates to activate the configuration. A `false`, `f`, or `off` indicates to deactivate the configuration.

Usage notes

For a provisioned cluster, changes to `data_catalog_auto_mount` take effect on the next reboot of the cluster. For more information, see Rebooting a cluster in the *Amazon Redshift Management Guide*.

For a serverless workgroup, changes to `data_catalog_auto_mount` do not take effect immediately.

Examples

The following example turns on automounting the AWS Glue Data Catalog.

```
ALTER SYSTEM SET data_catalog_auto_mount = true;
```

The following example turns on metadata security.

```
ALTER SYSTEM SET metadata_security = true;
```

Setting a default identity namespace

This example is specific to working with an identity provider. You can integrate Redshift with IAM Identity Center and an identity provider to centralize identity management for Redshift and other AWS services.

The following sample shows how to set the default identity namespace for the system. Doing this subsequently makes it more simple to run GRANT and CREATE statements, because you don't have to include the namespace as a prefix for each identity.

```
ALTER SYSTEM SET default_identity_namespace = 'MYCO';
```

After running the command, you can run statements like the following:

```
GRANT SELECT ON TABLE mytable TO alice;

GRANT UPDATE ON TABLE mytable TO salesrole;

CREATE USER bob password 'md50c983d1a624280812631c5389e60d48c';
```

The effect of setting the default identity namespace is that each identity doesn't require it as a prefix. In this example, `alice` is replaced with `MYCO:alice`. This happens with any identity included. For more information about using an identity provider with Redshift, see Connect Redshift with IAM Identity Center to give users a single sign-on experience.

For more information about settings that pertain to Redshift configuration with IAM Identity Center, see SET and ALTER IDENTITY PROVIDER.

ALTER TABLE

This command changes the definition of a Amazon Redshift table or Amazon Redshift Spectrum external table. This command updates the values and properties set by CREATE TABLE or CREATE EXTERNAL TABLE. You can use ALTER TABLE on a view for row-level security (RLS).

You can't run ALTER TABLE on an external table within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

ALTER TABLE locks the table for read and write operations until the transaction enclosing the ALTER TABLE operation completes, unless it's specifically stated in the documentation that you can query data or perform other operations on the table while it is altered.

Required privileges

The user that alters a table needs the proper privilege for the command to succeed. Depending on the ALTER TABLE command, one of the following privileges is required.

- Superuser
- Users with the ALTER TABLE privilege
- Table owner with the USAGE privilege on the schema

Syntax

```
ALTER TABLE table_name
{
ADD table_constraint
| DROP CONSTRAINT constraint_name [ RESTRICT | CASCADE ]
| OWNER TO new_owner
| RENAME TO new_name
| RENAME COLUMN column_name TO new_name
| ALTER COLUMN column_name TYPE updated_varchar_data_type_size
| ALTER COLUMN column_name ENCODE new_encode_type
| ALTER COLUMN column_name ENCODE encode_type,
| ALTER COLUMN column_name ENCODE encode_type, .....;
```

```
| ALTER DISTKEY column_name
| ALTER DISTSTYLE ALL
| ALTER DISTSTYLE EVEN
| ALTER DISTSTYLE KEY DISTKEY column_name
| ALTER DISTSTYLE AUTO
| ALTER [COMPOUND] SORTKEY ( column_name [,...] )
| ALTER SORTKEY AUTO
| ALTER SORTKEY NONE
| ALTER ENCODE AUTO
| ADD [ COLUMN ] column_name column_type
  [ DEFAULT default_expr ]
  [ ENCODE encoding ]
  [ NOT NULL | NULL ]
  [ COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI } ] |
| DROP [ COLUMN ] column_name [ RESTRICT | CASCADE ]
| ROW LEVEL SECURITY { ON | OFF } [ CONJUNCTION TYPE { AND | OR } ] [ FOR DATASHARES ]
| MASKING { ON | OFF } FOR DATASHARES }

where table_constraint is:

[ CONSTRAINT constraint_name ]
{ UNIQUE ( column_name [, ... ] )
| PRIMARY KEY ( column_name [, ... ] )
| FOREIGN KEY (column_name [, ... ] )
   REFERENCES  reftable [ ( refcolumn ) ]}

The following options apply only to external tables:

SET LOCATION { 's3://bucket/folder/' | 's3://bucket/manifest_file' }
| SET FILE FORMAT format |
| SET TABLE PROPERTIES ('property_name'='property_value')
| PARTITION ( partition_column=partition_value [, ...] )
  SET LOCATION { 's3://bucket/folder' |'s3://bucket/manifest_file' }
| ADD [IF NOT EXISTS]
    PARTITION ( partition_column=partition_value [, ...] ) LOCATION
 { 's3://bucket/folder' |'s3://bucket/manifest_file' }
    [, ... ]
| DROP PARTITION ( partition_column=partition_value [, ...] )
```

To reduce the time to run the ALTER TABLE command, you can combine some clauses of the ALTER TABLE command.

Amazon Redshift supports the following combinations of the ALTER TABLE clauses:

```
ALTER TABLE tablename ALTER SORTKEY (column_list), ALTER DISTKEY column_Id;
ALTER TABLE tablename ALTER DISTKEY column_Id, ALTER SORTKEY (column_list);
ALTER TABLE tablename ALTER SORTKEY (column_list), ALTER DISTSTYLE ALL;
ALTER TABLE tablename ALTER DISTSTYLE ALL, ALTER SORTKEY (column_list);
```

Parameters

table_name

The name of the table to alter. Either specify just the name of the table, or use the format *schema_name.table_name* to use a specific schema. External tables must be qualified by an external schema name. You can also specify a view name if you're using the ALTER TABLE statement to rename a view or change its owner. The maximum length for the table name is 127 bytes; longer names are truncated to 127 bytes. You can use UTF-8 multibyte characters up to a maximum of four bytes. For more information about valid names, see Names and identifiers.

ADD *table_constraint*

A clause that adds the specified constraint to the table. For descriptions of valid *table_constraint* values, see CREATE TABLE.

> **Note**
>
> You can't add a primary-key constraint to a nullable column. If the column was originally created with the NOT NULL constraint, you can add the primary-key constraint.

DROP CONSTRAINT *constraint_name*

A clause that drops the named constraint from the table. To drop a constraint, specify the constraint name, not the constraint type. To view table constraint names, run the following query.

```
select constraint_name, constraint_type
from information_schema.table_constraints;
```

RESTRICT

A clause that removes only the specified constraint. RESTRICT is an option for DROP CONSTRAINT. RESTRICT can't be used with CASCADE.

CASCADE

A clause that removes the specified constraint and anything dependent on that constraint. CASCADE is an option for DROP CONSTRAINT. CASCADE can't be used with RESTRICT.

OWNER TO *new_owner*

A clause that changes the owner of the table (or view) to the *new_owner* value.

RENAME TO *new_name*

A clause that renames a table (or view) to the value specified in *new_name*. The maximum table name length is 127 bytes; longer names are truncated to 127 bytes.

You can't rename a permanent table to a name that begins with '#'. A table name beginning with '#' indicates a temporary table.

You can't rename an external table.

ALTER COLUMN *column_name* TYPE *updated_varchar_data_type_size*

A clause that changes the size of a column defined as a VARCHAR data type. This clause only supports altering the size of a VARCHAR data type. Consider the following limitations:

- You can't alter a column with compression encodings BYTEDICT, RUNLENGTH, TEXT255, or TEXT32K.
- You can't decrease the size less than maximum size of existing data.
- You can't alter columns with default values.
- You can't alter columns with UNIQUE, PRIMARY KEY, or FOREIGN KEY.
- You can't alter columns within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

ALTER COLUMN *column_name* ENCODE *new_encode_type*

A clause that changes the compression encoding of a column. If you specify compression encoding for a column, the table is no longer set to ENCODE AUTO. For information on compression encoding, see Column compression to reduce the size of stored data.

When you change compression encoding for a column, the table remains available to query.

Consider the following limitations:

- You can't alter a column to the same encoding as currently defined for the column.
- You can't alter the encoding for a column in a table with an interleaved sortkey.

ALTER COLUMN *column_name* ENCODE *encode_type*, ALTER COLUMN *column_name* ENCODE *encode_type*, ...;

A clause that changes the compression encoding of multiple columns in a single command. For information on compression encoding, see Column compression to reduce the size of stored data.

When you change compression encoding for a column, the table remains available to query.

Consider the following limitations:

- You can't alter a column to the same or different encoding type multiple times in a single command.
- You can't alter a column to the same encoding as currently defined for the column.
- You can't alter the encoding for a column in a table with an interleaved sortkey.

ALTER DISTSTYLE ALL

A clause that changes the existing distribution style of a table to `ALL`. Consider the following:

- An ALTER DISTSTYLE, ALTER SORTKEY, and VACUUM can't run concurrently on the same table.
  - If VACUUM is currently running, then running ALTER DISTSTYLE ALL returns an error.
  - If ALTER DISTSTYLE ALL is running, then a background vacuum doesn't start on a table.
- The ALTER DISTSTYLE ALL command is not supported for tables with interleaved sort keys and temporary tables.
- If the distribution style was previously defined as AUTO, then the table is no longer a candidate for automatic table optimization.

For more information about DISTSTYLE ALL, see CREATE TABLE.

ALTER DISTSTYLE EVEN

A clause that changes the existing distribution style of a table to `EVEN`. Consider the following:

- An ALTER DISTSYTLE, ALTER SORTKEY, and VACUUM can't run concurrently on the same table.
  - If VACUUM is currently running, then running ALTER DISTSTYLE EVEN returns an error.
  - If ALTER DISTSTYLE EVEN is running, then a background vacuum doesn't start on a table.
- The ALTER DISTSTYLE EVEN command is not supported for tables with interleaved sort keys and temporary tables.
- If the distribution style was previously defined as AUTO, then the table is no longer a candidate for automatic table optimization.

For more information about DISTSTYLE EVEN, see CREATE TABLE.

ALTER DISTKEY *column_name* or ALTER DISTSTYLE KEY DISTKEY *column_name*

A clause that changes the column used as the distribution key of a table. Consider the following:

- VACUUM and ALTER DISTKEY can't run concurrently on the same table.
  - If VACUUM is already running, then ALTER DISTKEY returns an error.
  - If ALTER DISTKEY is running, then background vacuum doesn't start on a table.
  - If ALTER DISTKEY is running, then foreground vacuum returns an error.
- You can only run one ALTER DISTKEY command on a table at a time.
- The ALTER DISTKEY command is not supported for tables with interleaved sort keys.
- If the distribution style was previously defined as AUTO, then the table is no longer a candidate for automatic table optimization.

When specifying DISTSTYLE KEY, the data is distributed by the values in the DISTKEY column. For more information about DISTSTYLE, see CREATE TABLE.

ALTER DISTSTYLE AUTO

A clause that changes the existing distribution style of a table to AUTO.

When you alter a distribution style to AUTO, the distribution style of the table is set to the following:

- A small table with DISTSTYLE ALL is converted to AUTO(ALL).
- A small table with DISTSTYLE EVEN is converted to AUTO(ALL).
- A small table with DISTSTYLE KEY is converted to AUTO(ALL).

- A large table with DISTSTYLE ALL is converted to AUTO(EVEN).
- A large table with DISTSTYLE EVEN is converted to AUTO(EVEN).
- A large table with DISTSTYLE KEY is converted to AUTO(KEY) and the DISTKEY is preserved. In this case, Amazon Redshift makes no changes to the table.

If Amazon Redshift determines that a new distribution style or key will improve the performance of queries, then Amazon Redshift might change the distribution style or key of your table in the future. For example, Amazon Redshift might convert a table with a DISTSTYLE of AUTO(KEY) to AUTO(EVEN), or vice versa. For more information about behavior when distribution keys are altered, including data redistribution and locks, see Amazon Redshift Advisor recommendations.

For more information about DISTSTYLE AUTO, see CREATE TABLE.

To view the distribution style of a table, query the SVV_TABLE_INFO system catalog view. For more information, see SVV_TABLE_INFO. To view the Amazon Redshift Advisor recommendations for tables, query the SVV_ALTER_TABLE_RECOMMENDATIONS system catalog view. For more information, see SVV_ALTER_TABLE_RECOMMENDATIONS. To view the actions taken by Amazon Redshift, query the SVL_AUTO_WORKER_ACTION system catalog view. For more information, see SVL_AUTO_WORKER_ACTION.

ALTER [COMPOUND] SORTKEY (*column_name* [,...])

A clause that changes or adds the sort key used for a table. ALTER SORTKEY isn't supported for temporary tables.

When you alter a sort key, the compression encoding of columns in the new or original sort key can change. If no encoding is explicitly defined for the table, then Amazon Redshift automatically assigns compression encodings as follows:

- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR or VARCHAR are assigned LZO compression.

Consider the following:

- You can define a maximum of 400 columns for a sort key per table.
- You can alter an interleaved sort key to a compound sort key or no sort key. However, you can't alter a compound sort key to an interleaved sort key.
- If the sort key was previously defined as AUTO, then the table is no longer a candidate for automatic table optimization.
- Amazon Redshift recommends using RAW encoding (no compression) for columns defined as sort keys. When you alter a column to choose it as a sort key, the column's compression is changed to RAW compression (no compression). This can increase the amount of storage required by the table. How much the table size increases depend on the specific table definition and table contents. For more information about compression, see Compression encodings

When data is loaded into a table, the data is loaded in the order of the sort key. When you alter the sort key, Amazon Redshift reorders the data. For more information about SORTKEY, see CREATE TABLE.

ALTER SORTKEY AUTO

A clause that changes or adds the sort key of the target table to AUTO. ALTER SORTKEY AUTO isn't supported for temporary tables.

When you alter a sort key to AUTO, Amazon Redshift preserves the existing sort key of the table.

If Amazon Redshift determines that a new sort key will improve the performance of queries, then Amazon Redshift might change the sort key of your table in the future.

For more information about SORTKEY AUTO, see CREATE TABLE.

To view the sort key of a table, query the SVV_TABLE_INFO system catalog view. For more information, see SVV_TABLE_INFO. To view the Amazon Redshift Advisor recommendations for tables, query the SVV_ALTER_TABLE_RECOMMENDATIONS system catalog view. For more information, see SVV_ALTER_TABLE_RECOMMENDATIONS. To view the actions taken by Amazon Redshift, query the SVL_AUTO_WORKER_ACTION system catalog view. For more information, see SVL_AUTO_WORKER_ACTION.

ALTER SORTKEY NONE

A clause that removes the sort key of the target table.

If the sort key was previously defined as AUTO, then the table is no longer a candidate for automatic table optimization.

ALTER ENCODE AUTO

A clause that changes the encoding type of the target table columns to AUTO. When you alter encoding to AUTO, Amazon Redshift preserves the existing encoding type of the columns in the table. Then, if Amazon Redshift determines that a new encoding type can improve query performance, Amazon Redshift can change the encoding type of the table columns.

If you alter one or more columns to specify an encoding, Amazon Redshift no longer automatically adjusts encoding for all columns in the table. The columns retain the current encode settings.

The following actions don't affect the ENCODE AUTO setting for the table:

- Renaming the table.
- Altering the DISTSTYLE or SORTKEY setting for the table.
- Adding or dropping a column with an ENCODE setting.
- Using the COMPUPDATE option of the COPY command. For more information, see Data load operations.

To view the encoding of a table, query the SVV_TABLE_INFO system catalog view. For more information, see SVV_TABLE_INFO.

RENAME COLUMN *column_name* TO *new_name*

A clause that renames a column to the value specified in *new_name*. The maximum column name length is 127 bytes; longer names are truncated to 127 bytes. For more information about valid names, see Names and identifiers.

ADD [COLUMN] *column_name*

A clause that adds a column with the specified name to the table. You can add only one column in each ALTER TABLE statement.

You can't add a column that is the distribution key (DISTKEY) or a sort key (SORTKEY) of the table.

You can't use an ALTER TABLE ADD COLUMN command to modify the following table and column attributes:

- UNIQUE
- PRIMARY KEY
- REFERENCES (foreign key)
- IDENTITY or GENERATED BY DEFAULT AS IDENTITY

The maximum column name length is 127 bytes; longer names are truncated to 127 bytes. The maximum number of columns you can define in a single table is 1,600.

The following restrictions apply when adding a column to an external table:

- You can't add a column to an external table with the column constraints DEFAULT, ENCODE, NOT NULL, or NULL.
- You can't add columns to an external table that's defined using the AVRO file format.
- If pseudocolumns are enabled, the maximum number of columns that you can define in a single external table is 1,598. If pseudocolumns aren't enabled, the maximum number of columns that you can define in a single table is 1,600.

For more information, see CREATE EXTERNAL TABLE.

column_type

The data type of the column being added. For CHAR and VARCHAR columns, you can use the MAX keyword instead of declaring a maximum length. MAX sets the maximum length to 4,096 bytes for CHAR or 65,535 bytes for VARCHAR. The maximum size of a GEOMETRY object is 1,048,447 bytes.

For information about the data types that Amazon Redshift supports, see Data types.

DEFAULT *default_expr*

A clause that assigns a default data value for the column. The data type of *default_expr* must match the data type of the column. The DEFAULT value must be a variable-free expression. Subqueries, cross-references to other columns in the current table, and user-defined functions aren't allowed.

The *default_expr* is used in any INSERT operation that doesn't specify a value for the column. If no default value is specified, the default value for the column is null.

If a COPY operation encounters a null field on a column that has a DEFAULT value and a NOT NULL constraint, the COPY command inserts the value of the *default_expr*.

DEFAULT isn't supported for external tables.

ENCODE *encoding*

The compression encoding for a column. By default, Amazon Redshift automatically manages compression encoding for all columns in a table if you don't specify compression encoding for any column in the table or if you specify the ENCODE AUTO option for the table.

If you specify compression encoding for any column in the table or if you don't specify the ENCODE AUTO option for the table, Amazon Redshift automatically assigns compression encoding to columns for which you don't specify compression encoding as follows:

- All columns in temporary tables are assigned RAW compression by default.
- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, DOUBLE PRECISION, GEOMETRY, or GEOGRAPHY data type are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR, VARCHAR, or VARBYTE are assigned LZO compression.

> **Note**
> If you don't want a column to be compressed, explicitly specify RAW encoding.

The following compression encodings (p. 62) are supported:

- AZ64
- BYTEDICT
- DELTA
- DELTA32K
- LZO
- MOSTLY8
- MOSTLY16
- MOSTLY32
- RAW (no compression)

- RUNLENGTH
- TEXT255
- TEXT32K
- ZSTD

ENCODE isn't supported for external tables.

NOT NULL | NULL

NOT NULL specifies that the column isn't allowed to contain null values. NULL, the default, specifies that the column accepts null values.

NOT NULL and NULL aren't supported for external tables.

COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI }

A clause that specifies whether string search or comparison on the column is case sensitive or case insensitive. The default value is the same as the current case sensitivity configuration of the database.

To find the database collation information, use the following command:

```
SELECT db_collation();

db_collation
----------------
 case_sensitive
(1 row)
```

CASE_SENSITIVE and CS are interchangeable and yield the same results. Similarly, CASE_INSENSITIVE and CI are interchangeable and yield the same results.

DROP [COLUMN] *column_name*

The name of the column to delete from the table.

You can't drop the last column in a table. A table must have at least one column.

You can't drop a column that is the distribution key (DISTKEY) or a sort key (SORTKEY) of the table. The default behavior for DROP COLUMN is RESTRICT if the column has any dependent objects, such as a view, primary key, foreign key, or UNIQUE restriction.

The following restrictions apply when dropping a column from an external table:

- You can't drop a column from an external table if the column is used as a partition.
- You can't drop a column from an external table that is defined using the AVRO file format.
- RESTRICT and CASCADE are ignored for external tables.
- You can't drop the columns of the policy table referenced inside the policy definition unless you drop or detach the policy. This also applies when the CASCADE option is specified. You can drop other columns in the policy table.

For more information, see CREATE EXTERNAL TABLE.

RESTRICT

When used with DROP COLUMN, RESTRICT means that column to be dropped isn't dropped, in these cases:

- If a defined view references the column that is being dropped
- If a foreign key references the column
- If the column takes part in a multipart key

RESTRICT can't be used with CASCADE.

RESTRICT and CASCADE are ignored for external tables.

CASCADE

When used with DROP COLUMN, removes the specified column and anything dependent on that column. CASCADE can't be used with RESTRICT.

RESTRICT and CASCADE are ignored for external tables.

The following options apply only to external tables.

SET LOCATION { 's3://*bucket/folder/*' | 's3://*bucket/manifest_file*' }

The path to the Amazon S3 folder that contains the data files or a manifest file that contains a list of Amazon S3 object paths. The buckets must be in the same AWS Region as the Amazon Redshift cluster. For a list of supported AWS Regions, see Amazon Redshift Spectrum limitations. For more information about using a manifest file, see LOCATION in the CREATE EXTERNAL TABLE Parameters reference.

SET FILE FORMAT *format*

The file format for external data files.

Valid formats are as follows:

- AVRO
- PARQUET
- RCFILE
- SEQUENCEFILE
- TEXTFILE

SET TABLE PROPERTIES ('*property_name*'='*property_value*')

A clause that sets the table definition for table properties for an external table.

> **Note**
>
> Table properties are case-sensitive.

'numRows'='*row_count*'

A property that sets the numRows value for the table definition. To explicitly update an external table's statistics, set the numRows property to indicate the size of the table. Amazon Redshift doesn't analyze external tables to generate the table statistics that the query optimizer uses to generate a query plan. If table statistics aren't set for an external table, Amazon Redshift generates a query execution plan. This plan is based on an assumption that external tables are the larger tables and local tables are the smaller tables.

'skip.header.line.count'='*line_count*'

A property that sets number of rows to skip at the beginning of each source file.

PARTITION (*partition_column=partition_value* [, ...] SET LOCATION { 's3://*bucket/folder*' | 's3://*bucket/manifest_file*' }

A clause that sets a new location for one or more partition columns.

ADD [IF NOT EXISTS] PARTITION (*partition_column=partition_value* [, ...]) LOCATION { 's3://*bucket/folder*' | 's3://*bucket/manifest_file*' } [, ...]

A clause that adds one or more partitions. You can specify multiple PARTITION clauses using a single ALTER TABLE … ADD statement.

> **Note**
>
> If you use the AWS Glue catalog, you can add up to 100 partitions using a single ALTER TABLE statement.

The IF NOT EXISTS clause indicates that if the specified partition already exists, the command should make no changes. It also indicates that the command should return a message that the partition exists, rather than terminating with an error. This clause is useful when scripting, so the script doesn’t fail if ALTER TABLE tries to add a partition that already exists.

DROP PARTITION (*partition_column=partition_value* [, ...])

A clause that drops the specified partition. Dropping a partition alters only the external table metadata. The data on Amazon S3 isn't affected.

ROW LEVEL SECURITY { ON | OFF } [CONJUNCTION TYPE { AND | OR }] [FOR DATASHARES]

A clause that turns on or off row-level security for a relation.

When row-level security is turned on for a relation, you can only read the rows that the row-level security policy permits you to access. When there isn't any policy granting you access to the relation, you can't see any rows from the relation. Only superusers and users or roles that have the `sys:secadmin` role can set the ROW LEVEL SECURITY clause. For more information, see Row-level security.

- [CONJUNCTION TYPE { AND | OR }]

  A clause that allows you to choose the conjunction type of row-level security policy for a relation. When multiple row-level security policies are attached to a relation, you can combine the policies with the AND or OR clause. By default, Amazon Redshift combines RLS policies with the AND clause. Superusers, users, or roles that have the `sys:secadmin` role can use this clause to define the conjunction type of row-level security policy for a relation. For more information, see Combining multiple policies per user.

- FOR DATASHARES

  A clause that determines whether an RLS-protected relation can be accessed over datashares. By default, an RLS-protected relation can’t be accessed over a datashare. An ALTER TABLE ROW LEVEL SECURITY command run with this clause only affects the relation’s datashare accessibility property. The ROW LEVEL SECURITY property isn’t changed.

If you make an RLS-protected relation accessible over datashares, the relation doesn't have row-level security in the consumer-side datashared database. The relation retains its RLS property on the producer side.

MASKING { ON | OFF } FOR DATASHARES

A clause that determines whether a DDM-protected relation can be accessed over datashares. By default, a DDM-protected relation can't be accessed over a datashare. If you make a DDM-protected relation accessible over datashares, the relation won't have masking protection in the consumer-side datashared database. The relation retains its masking property on the producer side. Only superusers and users or roles that have the `sys:secadmin` role can set the MASKING FOR DATASHARES clause. For more information, see Dynamic data masking.

Examples

For examples that show how to use the ALTER TABLE command, see the following.

- ALTER TABLE examples
- ALTER EXTERNAL TABLE examples
- ALTER TABLE ADD and DROP COLUMN examples

ALTER TABLE examples

The following examples demonstrate basic usage of the ALTER TABLE command.

Rename a table or view

The following command renames the USERS table to USERS_BKUP:

```
alter table users
rename to users_bkup;
```

You can also use this type of command to rename a view.

Change the owner of a table or view

The following command changes the VENUE table owner to the user DWUSER:

```
alter table venue
```

```
owner to dwuser;
```

The following commands create a view, then change its owner:

```
create view vdate as select * from date;
alter table vdate owner to vuser;
```

Rename a column

The following command renames the VENUESEATS column in the VENUE table to VENUESIZE:

```
alter table venue
rename column venueseats to venuesize;
```

Drop a table constraint

To drop a table constraint, such as a primary key, foreign key, or unique constraint, first find the internal name of the constraint. Then specify the constraint name in the ALTER TABLE command. The following example finds the constraints for the CATEGORY table, then drops the primary key with the name `category_pkey`.

```
select constraint_name, constraint_type
from information_schema.table_constraints
where constraint_schema ='public'
and table_name = 'category';

constraint_name | constraint_type
----------------+----------------
category_pkey   | PRIMARY KEY

alter table category
drop constraint category_pkey;
```

Alter a VARCHAR column

To conserve storage, you can define a table initially with VARCHAR columns with the minimum size needed for your current data requirements. Later, to accommodate longer strings, you can alter the table to increase the size of the column.

The following example increases the size of the EVENTNAME column to VARCHAR(300).

```
alter table event alter column eventname type varchar(300);
```

Alter a VARBYTE column

To conserve storage, you can define a table initially with VARBYTE columns with the minimum size needed for your current data requirements. Later, to accommodate longer strings, you can alter the table to increase the size of the column.

The following example increases the size of the EVENTNAME column to VARBYTE(300).

```
alter table event alter column eventname type varbyte(300);
```

Alter the compression encoding for a column

You can alter the compression encoding of a column. Below, you can find a set of examples demonstrating this approach. The table definition for these examples is as follows.

```
create table t1(c0 int encode lzo, c1 bigint encode zstd, c2 varchar(16) encode lzo, c3
 varchar(32) encode zstd);
```

The following statement alters the compression encoding for column c0 from LZO encoding to AZ64 encoding.

```
alter table t1 alter column c0 encode az64;
```

The following statement alters the compression encoding for column c1 from Zstandard encoding to AZ64 encoding.

```
alter table t1 alter column c1 encode az64;
```

The following statement alters the compression encoding for column c2 from LZO encoding to Byte-dictionary encoding.

```
alter table t1 alter column c2 encode bytedict;
```

The following statement alters the compression encoding for column c3 from Zstandard encoding to Runlength encoding.

```
alter table t1 alter column c3 encode runlength;
```

Alter a DISTSTYLE KEY DISTKEY column

The following examples show how to change the DISTSTYLE and DISTKEY of a table.

Create a table with an EVEN distribution style. The SVV_TABLE_INFO view shows that the DISTSTYLE is EVEN.

```
create table inventory(
  inv_date_sk int4 not null ,
  inv_item_sk int4 not null ,
  inv_warehouse_sk int4 not null ,
  inv_quantity_on_hand int4
) diststyle even;

Insert into inventory values(1,1,1,1);

select "table", "diststyle" from svv_table_info;

   table   |   diststyle
-----------+----------------
 inventory |     EVEN
```

Alter the table DISTKEY to `inv_warehouse_sk`. The SVV_TABLE_INFO view shows the `inv_warehouse_sk` column as the resulting distribution key.

```
alter table inventory alter diststyle key distkey inv_warehouse_sk;

select "table", "diststyle" from svv_table_info;

   table   |       diststyle
-----------+-----------------------
 inventory | KEY(inv_warehouse_sk)
```

Alter the table DISTKEY to `inv_item_sk`. The SVV_TABLE_INFO view shows the `inv_item_sk` column as the resulting distribution key.

```
alter table inventory alter distkey inv_item_sk;

select "table", "diststyle" from svv_table_info;

   table   |       diststyle
-----------+-----------------------
```

```
 inventory | KEY(inv_item_sk)
```

Alter a table to DISTSTYLE ALL

The following examples show how to change a table to DISTSTYLE ALL.

Create a table with an EVEN distribution style. The SVV_TABLE_INFO view shows that the DISTSTYLE is EVEN.

```
create table inventory(
  inv_date_sk int4 not null ,
  inv_item_sk int4 not null ,
  inv_warehouse_sk int4 not null ,
  inv_quantity_on_hand int4
) diststyle even;

Insert into inventory values(1,1,1,1);

select "table", "diststyle" from svv_table_info;

   table   |   diststyle
-----------+----------------
 inventory |     EVEN
```

Alter the table DISTSTYLE to ALL. The SVV_TABLE_INFO view shows the changed DISTSYTLE.

```
alter table inventory alter diststyle all;

select "table", "diststyle" from svv_table_info;

   table   |   diststyle
-----------+----------------
 inventory |     ALL
```

Alter a table SORTKEY

You can alter a table to have a compound sort key or no sort key.

In the following table definition, table `t1` is defined with an interleaved sortkey.

```
create table t1 (c0 int, c1 int) interleaved sortkey(c0, c1);
```

The following command alters the table from an interleaved sort key to a compound sort key.

```
alter table t1 alter sortkey(c0, c1);
```

The following command alters the table to remove the interleaved sort key.

```
alter table t1 alter sortkey none;
```

In the following table definition, table `t1` is defined with column `c0` as a sortkey.

```
create table t1 (c0 int, c1 int) sortkey(c0);
```

The following command alters the table `t1` to a compound sort key.

```
alter table t1 alter sortkey(c0, c1);
```

Alter a table to ENCODE AUTO

The following example shows how to alter a table to ENCODE AUTO.

The table definition for this example follows. Column `c0` is defined with the encoding type AZ64, and column `c1` is defined with the encoding type LZO.

```
create table t1(c0 int encode AZ64, c1 varchar encode LZO);
```

For this table, the following statement alters the encoding to AUTO.

```
alter table t1 alter encode auto;
```

The following example shows how to alter a table to remove the ENCODE AUTO setting.

The table definition for this example follows. The table columns are defined without encoding. In this case, the encoding defaults to ENCODE AUTO.

```
create table t2(c0 int, c1 varchar);
```

For this table, the following statement alters the encoding of column c0 to LZO. The table encoding is no longer set to ENCODE AUTO.

```
alter table t2 alter column c0 encode lzo;;
```

Alter row-level security control

The following command turns RLS off for the table:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY OFF;
```

The following command turns RLS on for the table:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON;
```

The following command turns RLS on for the table and makes it accessible over datashares:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON;
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY FOR DATASHARES OFF;
```

The following command turns RLS on for the table and makes it inaccessible over datashares:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON;
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY FOR DATASHARES ON;
```

The following command turns RLS on and sets RLS conjunction type to OR for the table:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON CONJUNCTION TYPE OR;
```

The following command turns RLS on and sets RLS conjunction type to AND for the table:

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON CONJUNCTION TYPE AND;
```

ALTER EXTERNAL TABLE examples

The following examples use an Amazon S3 bucket located in the US East (N. Virginia) Region (`us-east-1`) AWS Region and the example tables created in Examples for CREATE TABLE. For more information about how to use partitions with external tables, see Partitioning Redshift Spectrum external tables.

The following example sets the numRows table property for the SPECTRUM.SALES external table to 170,000 rows.

```
alter table spectrum.sales
set table properties ('numRows'='170000');
```

The following example changes the location for the SPECTRUM.SALES external table.

```
alter table spectrum.sales
set location 's3://redshift-downloads/tickit/spectrum/sales/';
```

The following example changes the format for the SPECTRUM.SALES external table to Parquet.

```
alter table spectrum.sales
set file format parquet;
```

The following example adds one partition for the table SPECTRUM.SALES_PART.

```
alter table spectrum.sales_part
add if not exists partition(saledate='2008-01-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/';
```

The following example adds three partitions for the table SPECTRUM.SALES_PART.

```
alter table spectrum.sales_part add if not exists
partition(saledate='2008-01-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/'
partition(saledate='2008-02-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-02/'
partition(saledate='2008-03-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-03/';
```

The following example alters SPECTRUM.SALES_PART to drop the partition with `saledate='2008-01-01''`.

```
alter table spectrum.sales_part
drop partition(saledate='2008-01-01');
```

The following example sets a new Amazon S3 path for the partition with `saledate='2008-01-01'`.

```
alter table spectrum.sales_part
partition(saledate='2008-01-01')
set location 's3://redshift-downloads/tickit/spectrum/sales_partition/
saledate=2008-01-01/';
```

The following example changes the name of `sales_date` to `transaction_date`.

```
alter table spectrum.sales rename column sales_date to transaction_date;
```

The following example sets the column mapping to position mapping for an external table that uses optimized row columnar (ORC) format.

```
alter table spectrum.orc_example
set table properties('orc.schema.resolution'='position');
```

The following example sets the column mapping to name mapping for an external table that uses ORC format.

```
alter table spectrum.orc_example
set table properties('orc.schema.resolution'='name');
```

ALTER TABLE ADD and DROP COLUMN examples

The following examples demonstrate how to use ALTER TABLE to add and then drop a basic table column and also how to drop a column with a dependent object.

ADD then DROP a basic column

The following example adds a standalone FEEDBACK_SCORE column to the USERS table. This column simply contains an integer, and the default value for this column is NULL (no feedback score).

First, query the PG_TABLE_DEF catalog table to view the schema of the USERS table:

```
column        | type                   | encoding | distkey | sortkey
--------------+------------------------+----------+---------+--------
userid        | integer                | delta    | true    |       1
username      | character(8)           | lzo      | false   |       0
firstname     | character varying(30)  | text32k  | false   |       0
lastname      | character varying(30)  | text32k  | false   |       0
city          | character varying(30)  | text32k  | false   |       0
state         | character(2)           | bytedict | false   |       0
email         | character varying(100) | lzo      | false   |       0
phone         | character(14)          | lzo      | false   |       0
likesports    | boolean                | none     | false   |       0
liketheatre   | boolean                | none     | false   |       0
likeconcerts  | boolean                | none     | false   |       0
```

```
likejazz      | boolean                 | none     | false    |       0
likeclassical | boolean                 | none     | false    |       0
likeopera     | boolean                 | none     | false    |       0
likerock      | boolean                 | none     | false    |       0
likevegas     | boolean                 | none     | false    |       0
likebroadway  | boolean                 | none     | false    |       0
likemusicals  | boolean                 | none     | false    |       0
```

Now add the feedback_score column:

```
alter table users
add column feedback_score int
default NULL;
```

Select the FEEDBACK_SCORE column from USERS to verify that it was added:

```
select feedback_score from users limit 5;

feedback_score
----------------
NULL
NULL
NULL
NULL
NULL
```

Drop the column to reinstate the original DDL:

```
alter table users drop column feedback_score;
```

Dropping a column with a dependent object

The following example drops a column that has a dependent object. As a result, the dependent object is also dropped.

To start, add the FEEDBACK_SCORE column to the USERS table again:

```
alter table users
add column feedback_score int
default NULL;
```

Next, create a view from the USERS table called USERS_VIEW:

```
create view users_view as select * from users;
```

Now, try to drop the FEEDBACK_SCORE column from the USERS table. This DROP statement uses the default behavior (RESTRICT):

```
alter table users drop column feedback_score;
```

Amazon Redshift displays an error message that the column can't be dropped because another object depends on it.

Try dropping the FEEDBACK_SCORE column again, this time specifying CASCADE to drop all dependent objects:

```
alter table users
drop column feedback_score cascade;
```

ALTER TABLE APPEND

Appends rows to a target table by moving data from an existing source table. Data in the source table is moved to matching columns in the target table. Column order doesn't matter. After data is successfully appended to the target table, the source table is empty. ALTER TABLE APPEND is usually much faster than a similar CREATE TABLE AS or INSERT INTO operation because data is moved, not duplicated.

Note

ALTER TABLE APPEND moves data blocks between the source table and the target table. To improve performance, ALTER TABLE APPEND doesn't compact storage as part of the append operation. As a result, storage usage increases temporarily. To reclaim the space, run a VACUUM operation.

Columns with the same names must also have identical column attributes. If either the source table or the target table contains columns that don't exist in the other table, use the IGNOREEXTRA or FILLTARGET parameters to specify how extra columns should be managed.

You can't append an identity column. If both tables include an identity column, the command fails. If only one table has an identity column, include the FILLTARGET or IGNOREEXTRA parameter. For more information, see ALTER TABLE APPEND usage notes.

You can append a GENERATED BY DEFAULT AS IDENTITY column. You can update columns defined as GENERATED BY DEFAULT AS IDENTITY with values that you supply. For more information, see ALTER TABLE APPEND usage notes.

The target table must be a permanent table. However, the source can be a permanent table or a materialized view configured for streaming ingestion. Both objects must use the same distribution style and distribution key, if one is defined. If the objects are sorted, both objects must use the same sort style and define the same columns as sort keys.

An ALTER TABLE APPEND command automatically commits immediately upon completion of the operation. It can't be rolled back. You can't run ALTER TABLE APPEND within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

Required privileges

Depending on the ALTER TABLE APPEND command, one of the following privileges is required:

- Superuser
- Users with the ALTER TABLE system privilege
- Users with DELETE and SELECT privileges on the source table, and INSERT privilege on the target table

Syntax

```
ALTER TABLE target_table_name APPEND FROM [ source_table_name
 | source_materialized_view_name ]
[ IGNOREEXTRA | FILLTARGET ]
```

Appending from a materialized view works only in the case where your materialized view is configured for Streaming ingestion to a materialized view.

Parameters

target_table_name

The name of the table to which rows are appended. Either specify just the name of the table or use the format *schema_name.table_name* to use a specific schema. The target table must be an existing permanent table.

FROM *source_table_name*

The name of the table that provides the rows to be appended. Either specify just the name of the table or use the format *schema_name.table_name* to use a specific schema. The source table must be an existing permanent table.

FROM *source_materialized_view_name*

The name of a materialized view that provides the rows to be appended. Appending from a materialized view works only in the case where your materialized view is configured for Streaming ingestion to a materialized view. The source materialized view must already exist.

IGNOREEXTRA

A keyword that specifies that if the source table includes columns that are not present in the target table, data in the extra columns should be discarded. You can't use IGNOREEXTRA with FILLTARGET.

FILLTARGET

A keyword that specifies that if the target table includes columns that are not present in the source table, the columns should be filled with the DEFAULT column value, if one was defined, or NULL. You can't use IGNOREEXTRA with FILLTARGET.

ALTER TABLE APPEND usage notes

- ALTER TABLE APPEND moves only identical columns from the source table to the target table. Column order doesn't matter.
- If either the source table or the target table contains extra columns, use either FILLTARGET or IGNOREEXTRA according to the following rules:
  - If the source table contains columns that don't exist in the target table, include IGNOREEXTRA. The command ignores the extra columns in the source table.
  - If the target table contains columns that don't exist in the source table, include FILLTARGET. The command fills the extra columns in the target table with either the default column value or IDENTITY value, if one was defined, or NULL.
  - If both the source table and the target table contain extra columns, the command fails. You can't use both FILLTARGET and IGNOREEXTRA.
- If a column with the same name but different attributes exists in both tables, the command fails. Like-named columns must have the following attributes in common:

  - Data type
  - Column size
  - Compression encoding
  - Not null
  - Sort style
  - Sort key columns
  - Distribution style
  - Distribution key columns
- You can't append an identity column. If both the source table and the target table have identity columns, the command fails. If only the source table has an identity column, include the IGNOREEXTRA parameter so that the identity column is ignored. If only the target table has an identity column, include the FILLTARGET parameter so that the identity column is populated according to the IDENTITY clause defined for the table. For more information, see DEFAULT.
- You can append a default identity column with the ALTER TABLE APPEND statement. For more information, see CREATE TABLE.
- ALTER TABLE APPEND operations hold exclusive locks when run on Amazon Redshift streaming materialized views connected to any of the following:
  - An Amazon Kinesis data stream
  - An Amazon Managed Streaming for Apache Kafka topic
  - A supported external stream, such as a Confluent Cloud Kafka topic

  For more information, see Streaming ingestion to a materialized view.

ALTER TABLE APPEND examples

Suppose your organization maintains a table, SALES_MONTHLY, to capture current sales transactions. You want to move data from the transaction table to the SALES table, every month.

You can use the following INSERT INTO and TRUNCATE commands to accomplish the task.

```
insert into sales (select * from sales_monthly);
truncate sales_monthly;
```

However, you can perform the same operation much more efficiently by using an ALTER TABLE APPEND command.

First, query the PG_TABLE_DEF system catalog table to verify that both tables have the same columns with identical column attributes.

```
select trim(tablename) as table, "column", trim(type) as type,
encoding, distkey, sortkey, "notnull"
from pg_table_def where tablename like 'sales%';

table      | column     | type                        | encoding | distkey | sortkey |
 notnull
-----------+------------+-----------------------------+----------+---------+---------
+--------
sales      | salesid    | integer                     | lzo      | false   |       0 |
 true
sales      | listid     | integer                     | none     | true    |       1 |
 true
sales      | sellerid   | integer                     | none     | false   |       2 |
 true
sales      | buyerid    | integer                     | lzo      | false   |       0 |
 true
sales      | eventid    | integer                     | mostly16 | false   |       0 |
 true
sales      | dateid     | smallint                    | lzo      | false   |       0 |
 true
sales      | qtysold    | smallint                    | mostly8  | false   |       0 |
 true
sales      | pricepaid  | numeric(8,2)                | delta32k | false   |       0 |
 false
sales      | commission | numeric(8,2)                | delta32k | false   |       0 |
 false
sales      | saletime   | timestamp without time zone | lzo      | false   |       0 |
 false
salesmonth | salesid    | integer                     | lzo      | false   |       0 |
 true
salesmonth | listid     | integer                     | none     | true    |       1 |
 true
salesmonth | sellerid   | integer                     | none     | false   |       2 |
 true
salesmonth | buyerid    | integer                     | lzo      | false   |       0 |
 true
salesmonth | eventid    | integer                     | mostly16 | false   |       0 |
 true
salesmonth | dateid     | smallint                    | lzo      | false   |       0 |
 true
```

```
salesmonth | qtysold    | smallint                    | mostly8  | false    |        0 |
 true
salesmonth | pricepaid  | numeric(8,2)                | delta32k | false    |        0 |
 false
salesmonth | commission | numeric(8,2)                | delta32k | false    |        0 |
 false
salesmonth | saletime   | timestamp without time zone | lzo      | false    |        0 |
 false
```

Next, look at the size of each table.

```
select count(*) from sales_monthly;
 count
-------
  2000
(1 row)

select count(*) from sales;
 count
-------
 412,214
(1 row)
```

Now run the following ALTER TABLE APPEND command.

```
alter table sales append from sales_monthly;
```

Look at the size of each table again. The SALES_MONTHLY table now has 0 rows, and the SALES table has grown by 2000 rows.

```
select count(*) from sales_monthly;
 count
-------
     0
(1 row)

select count(*) from sales;
 count
-------
 414214
(1 row)
```

If the source table has more columns than the target table, specify the IGNOREEXTRA parameter. The following example uses the IGNOREEXTRA parameter to ignore extra columns in the SALES_LISTING table when appending to the SALES table.

```
alter table sales append from sales_listing ignoreextra;
```

If the target table has more columns than the source table, specify the FILLTARGET parameter. The following example uses the FILLTARGET parameter to populate columns in the SALES_REPORT table that don't exist in the SALES_MONTH table.

```
alter table sales_report append from sales_month filltarget;
```

The following example shows an example of how to use ALTER TABLE APPEND with a materialized view as a source.

```
ALTER TABLE target_tbl APPEND FROM my_streaming_materialized_view;
```

The table and materialized view names in this example are samples. Appending from a materialized view works only in the case where your materialized view is configured for Streaming ingestion to a materialized view. It moves all records in the source materialized view to a target table with the same schema as the materialized view and leaves the materialized view intact. This is the same behavior as when the source of the data is a table.

ALTER USER

Changes a database user.

Required privileges

Following are required privileges for ALTER USER:

- Superuser
- Users with the ALTER USER privilege
- Current user who wants to change their own password

Syntax

```
ALTER USER username [ WITH ] option [, ... ]
```

```
where option is

CREATEDB | NOCREATEDB
| CREATEUSER | NOCREATEUSER
| SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }
| PASSWORD { 'password' | 'md5hash' | 'sha256hash' | DISABLE }
[ VALID UNTIL 'expiration_date' ]
| RENAME TO new_name |
| CONNECTION LIMIT { limit | UNLIMITED }
| SESSION TIMEOUT limit | RESET SESSION TIMEOUT
| SET parameter { TO | = } { value | DEFAULT }
| RESET parameter
| EXTERNALID external_id
```

Parameters

username

Name of the user.

WITH

Optional keyword.

CREATEDB | NOCREATEDB

The CREATEDB option allows the user to create new databases. NOCREATEDB is the default.

CREATEUSER | NOCREATEUSER

The CREATEUSER option creates a superuser with all database privileges, including CREATE USER. The default is NOCREATEUSER. For more information, see superuser.

SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }

A clause that specifies the level of access that the user has to the Amazon Redshift system tables and views.

Regular users who have the SYSLOG ACCESS RESTRICTED permission can see only the rows generated by that user in user-visible system tables and views. The default is RESTRICTED.

Regular users who have the SYSLOG ACCESS UNRESTRICTED permission can see all rows in user-visible system tables and views, including rows generated by another user. UNRESTRICTED doesn't give a regular user access to superuser-visible tables. Only superusers can see superuser-visible tables.

> **Note**
>
> Giving a user unrestricted access to system tables gives the user visibility to data generated by other users. For example, STL_QUERY and STL_QUERYTEXT contain the full text of INSERT, UPDATE, and DELETE statements, which might contain sensitive user-generated data.

All rows in SVV_TRANSACTIONS are visible to all users.

For more information, see Visibility of data in system tables and views.

PASSWORD { '*password*' | '*md5hash*' | '*sha256hash*' | DISABLE }

Sets the user's password.

By default, users can change their own passwords, unless the password is disabled. To disable a user's password, specify DISABLE. When a user's password is disabled, the password is deleted from the system and the user can log on only using temporary AWS Identity and Access Management (IAM) user credentials. For more information, see Using IAM authentication to generate database user credentials. Only a superuser can enable or disable passwords. You can't disable a superuser's password. To enable a password, run ALTER USER and specify a password.

For details about using the PASSWORD parameter, see CREATE USER.

VALID UNTIL '*expiration_date*'

Specifies that the password has an expiration date. Use the value `'infinity'` to avoid having an expiration date. The valid data type for this parameter is timestamp.

Only superusers can use this parameter.

RENAME TO

Renames the user.

new_name

New name of the user. For more information about valid names, see Names and identifiers.

> **Important**
>
> When you rename a user, you must also reset the user’s password. The reset password doesn't have to be different from the previous password. The user name is used as part

of the password encryption, so when a user is renamed, the password is cleared. The user will not be able to log on until the password is reset. For example:

```
alter user newuser password 'EXAMPLENewPassword11';
```

CONNECTION LIMIT { *limit* | UNLIMITED }

The maximum number of database connections the user is permitted to have open concurrently. The limit isn't enforced for superusers. Use the UNLIMITED keyword to permit the maximum number of concurrent connections. A limit on the number of connections for each database might also apply. For more information, see CREATE DATABASE. The default is UNLIMITED. To view current connections, query the STV_SESSIONS system view.

Note

If both user and database connection limits apply, an unused connection slot must be available that is within both limits when a user attempts to connect.

SESSION TIMEOUT *limit* | RESET SESSION TIMEOUT

The maximum time in seconds that a session remains inactive or idle. The range is 60 seconds (one minute) to 1,728,000 seconds (20 days). If no session timeout is set for the user, the cluster setting applies. For more information, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

When you set the session timeout, it's applied to new sessions only.

To view information about active user sessions, including the start time, user name, and session timeout, query the STV_SESSIONS system view. To view information about user-session history, query the STL_SESSIONS view. To retrieve information about database users, including session-timeout values, query the SVL_USER_INFO view.

SET

Sets a configuration parameter to a new default value for all sessions run by the specified user.

RESET

Resets a configuration parameter to the original default value for the specified user.

parameter

Name of the parameter to set or reset.

value

New value of the parameter.

DEFAULT

Sets the configuration parameter to the default value for all sessions run by the specified user.

EXTERNALID *external_id*

The identifier for the user, which is associated with an identity provider. The user must have their password disabled. For more information, see Native identity provider (IdP) federation for Amazon Redshift.

Usage notes

- **Attempting to alter rdsdb** – You can't alter the user named `rdsdb`.
- **Creating an unknown password** – When using AWS Identity and Access Management (IAM) authentication to create database user credentials, you might want to create a superuser that is able to log in only using temporary credentials. You can't disable a superuser's password, but you can create an unknown password using a randomly generated MD5 hash string.

```
alter user iam_superuser password 'md51234567890123456780123456789012';
```

- **Setting search_path** – When you set the search_path parameter with the ALTER USER command, the modification takes effect on the specified user's next login. If you want to change the search_path value for the current user and session, use a SET command.
- **Setting the time zone** – When you use SET TIMEZONE with the ALTER USER command, the modification takes effect on the specified user's next login.
- **Working with dynamic data masking and row-level security policies** – When your provisioned cluster or serverless namespace has any dynamic data masking or row-level security policies, the following commands are blocked for regular users:

```
ALTER <current_user> SET enable_case_sensitive_super_attribute/
enable_case_sensitive_identifier/downcase_delimited_identifier
```

Only superusers and users with the ALTER USER privilege can set these configuration options. For information on row-level security, see Row-level security. For information on dynamic data masking, see Dynamic data masking.

Examples

The following example gives the user ADMIN the privilege to create databases:

```
alter user admin createdb;
```

The following example sets the password of the user ADMIN to `adminPass9` and sets an expiration date and time for the password:

```
alter user admin password 'adminPass9'
valid until '2017-12-31 23:59';
```

The following example renames the user ADMIN to SYSADMIN:

```
alter user admin rename to sysadmin;
```

The following example updates the idle-session timeout for a user to 300 seconds.

```
ALTER USER dbuser SESSION TIMEOUT 300;
```

Resets the user's idle-session timeout. When you reset it, the cluster setting applies. You must be a database superuser to run this command. For more information, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

```
ALTER USER dbuser RESET SESSION TIMEOUT;
```

The following example updates the external ID for a user named bob. The namespace is `myco_aad`. If the namespace isn't associated with a registered identity provider, it results in an error.

```
ALTER USER myco_aad:bob EXTERNALID "ABC123" PASSWORD DISABLE;
```

The following example sets the time zone for all sessions run by a specific database user. It changes the time zone for subsequent sessions, but not for the current session.

```
ALTER USER odie SET TIMEZONE TO 'Europe/Zurich';
```

The following example sets the maximum number of database connections that the user bob is allowed to have open.

```
ALTER USER bob CONNECTION LIMIT 10;
```

ANALYZE

Updates table statistics for use by the query planner.

Required privileges

Following are required privileges for ANALYZE:

- Superuser
- Users with the ANALYZE privilege
- Owner of the relation
- Database owner whom the table is shared to

Syntax

```
ANALYZE [ VERBOSE ]
[ [ table_name [ ( column_name [, ...] ) ] ]
[ PREDICATE COLUMNS | ALL  COLUMNS ]
```

Parameters

VERBOSE

A clause that returns progress information messages about the ANALYZE operation. This option is useful when you don't specify a table.

table_name

You can analyze specific tables, including temporary tables. You can qualify the table with its schema name. You can optionally specify a table_name to analyze a single table. You can't specify more than one *table_name* with a single ANALYZE *table_name* statement. If you don't specify a *table_name* value, all of the tables in the currently connected database are analyzed, including the persistent tables in the system catalog. Amazon Redshift skips analyzing a table if the percentage of rows that have changed since the last ANALYZE is lower than the analyze threshold. For more information, see Analyze threshold.

You don't need to analyze Amazon Redshift system tables (STL and STV tables).

column_name

If you specify a *table_name*, you can also specify one or more columns in the table (as a column-separated list within parentheses). If a column list is specified, only the listed columns are analyzed.

PREDICATE COLUMNS | ALL COLUMNS

Clauses that indicate whether ANALYZE should include only predicate columns. Specify PREDICATE COLUMNS to analyze only columns that have been used as predicates in previous queries or are likely candidates to be used as predicates. Specify ALL COLUMNS to analyze all columns. The default is ALL COLUMNS.

A column is included in the set of predicate columns if any of the following is true:

- The column has been used in a query as a part of a filter, join condition, or group by clause.
- The column is a distribution key.
- The column is part of a sort key.

If no columns are marked as predicate columns, for example because the table has not yet been queried, all of the columns are analyzed even when PREDICATE COLUMNS is specified. When this happens, Amazon Redshift might respond with a message like No predicate columns found for "`table-name`". Analyzing all columns. For more information about predicate columns, see Analyzing tables.

Usage notes

Amazon Redshift automatically runs ANALYZE on tables that you create with the following commands:

- CREATE TABLE AS
- CREATE TEMP TABLE AS
- SELECT INTO

You can't analyze an external table.

You don't need to run the ANALYZE command on these tables when they are first created. If you modify them, you should analyze them in the same way as other tables.

Analyze threshold

To reduce processing time and improve overall system performance, Amazon Redshift skips ANALYZE for a table if the percentage of rows that have changed since the last ANALYZE command run is lower than the analyze threshold specified by the analyze_threshold_percent parameter. By default, `analyze_threshold_percent` is 10. To change `analyze_threshold_percent` for the current session, run the SET command. The following example changes `analyze_threshold_percent` to 20 percent.

```
set analyze_threshold_percent to 20;
```

To analyze tables when only a small number of rows have changed, set `analyze_threshold_percent` to an arbitrarily small number. For example, if you set `analyze_threshold_percent` to 0.01, then a table with 100,000,000 rows aren't skipped if at least 10,000 rows have changed.

```
set analyze_threshold_percent to 0.01;
```

If ANALYZE skips a table because it doesn't meet the analyze threshold, Amazon Redshift returns the following message.

```
ANALYZE SKIP
```

To analyze all tables even if no rows have changed, set `analyze_threshold_percent` to 0.

To view the results of ANALYZE operations, query the STL_ANALYZE system table.

For more information about analyzing tables, see Analyzing tables.

Examples

Analyze all of the tables in the TICKIT database and return progress information.

```
analyze verbose;
```

Analyze the LISTING table only.

```
analyze listing;
```

Analyze the VENUEID and VENUENAME columns in the VENUE table.

```
analyze venue(venueid, venuename);
```

Analyze only predicate columns in the VENUE table.

```
analyze venue predicate columns;
```

ANALYZE COMPRESSION

Performs compression analysis and produces a report with the suggested compression encoding for the tables analyzed. For each column, the report includes an estimate of the potential reduction in disk space compared to the RAW encoding.

Syntax

```
ANALYZE COMPRESSION
[ [ table_name ]
[ ( column_name [, ...] ) ] ]
[COMPROWS numrows]
```

Parameters

table_name

You can analyze compression for specific tables, including temporary tables. You can qualify the table with its schema name. You can optionally specify a *table_name* to analyze a single table. If you don't specify a *table_name*, all of the tables in the currently connected database are analyzed. You can't specify more than one *table_name* with a single ANALYZE COMPRESSION statement.

column_name

If you specify a *table_name*, you can also specify one or more columns in the table (as a column-separated list within parentheses).

COMPROWS

Number of rows to be used as the sample size for compression analysis. The analysis is run on rows from each data slice. For example, if you specify COMPROWS 1000000 (1,000,000) and the system contains 4 total slices, no more than 250,000 rows per slice are read and analyzed. If COMPROWS isn't specified, the sample size defaults to 100,000 per slice. Values of COMPROWS lower than the default of 100,000 rows per slice are automatically upgraded to the default value. However, compression analysis doesn't produce recommendations if the amount of data in the table is insufficient to produce a meaningful sample. If the COMPROWS number is greater than the number of rows in the table, the ANALYZE COMPRESSION command still proceeds and runs the compression analysis against all of the available rows. Using COMPROWS results in an error if a table isn't specified.

numrows

Number of rows to be used as the sample size for compression analysis. The accepted range for *numrows* is a number between 1000 and 1000000000 (1,000,000,000).

Usage notes

ANALYZE COMPRESSION acquires an exclusive table lock, which prevents concurrent reads and writes against the table. Only run the ANALYZE COMPRESSION command when the table is idle.

Run ANALYZE COMPRESSION to get recommendations for column encoding schemes, based on a sample of the table's contents. ANALYZE COMPRESSION is an advisory tool and doesn't modify the column encodings of the table. You can apply the suggested encoding by recreating the table or by creating a new table with the same schema. Recreating an uncompressed table with appropriate encoding schemes can significantly reduce its on-disk footprint. This approach saves disk space and improves query performance for I/O-bound workloads.

ANALYZE COMPRESSION skips the actual analysis phase and directly returns the original encoding type on any column that is designated as a SORTKEY. It does this because range-restricted scans might perform poorly when SORTKEY columns are compressed much more highly than other columns.

Examples

The following example shows the encoding and estimated percent reduction for the columns in the LISTING table only:

```
analyze compression listing;

  Table  |     Column     | Encoding | Est_reduction_pct
---------+----------------+----------+-------------------
 listing | listid         | az64     | 40.96
 listing | sellerid       | az64     | 46.92
 listing | eventid        | az64     | 53.37
 listing | dateid         | raw      | 0.00
 listing | numtickets     | az64     | 65.66
 listing | priceperticket | az64     | 72.94
 listing | totalprice     | az64     | 68.05
 listing | listtime       | az64     | 49.74
```

The following example analyzes the QTYSOLD, COMMISSION, and SALETIME columns in the SALES table.

```
analyze compression sales(qtysold, commission, saletime);

 Table |   Column   | Encoding | Est_reduction_pct
-------+------------+----------+-------------------
 sales | salesid    | N/A      | 0.00
 sales | listid     | N/A      | 0.00
 sales | sellerid   | N/A      | 0.00
 sales | buyerid    | N/A      | 0.00
 sales | eventid    | N/A      | 0.00
 sales | dateid     | N/A      | 0.00
 sales | qtysold    | az64     | 83.06
 sales | pricepaid  | N/A      | 0.00
 sales | commission | az64     | 71.85
 sales | saletime   | az64     | 49.63
```

ATTACH MASKING POLICY

Attaches an existing dynamic data masking policy to a column. For more information on dynamic data masking, see Dynamic data masking.

Superusers and users or roles that have the sys:secadmin role can attach a masking policy.

Syntax

```
ATTACH MASKING POLICY policy_name
```

```
  ON { relation_name }
  ( {output_columns_names | output_path} ) [ USING ( {input_column_names | input_path
)} ]
  TO { user_name | ROLE role_name | PUBLIC }
  [ PRIORITY priority ];
```

Parameters

policy_name

The name of the masking policy to attach.

relation_name

The name of the relation to attach the masking policy to.

output_column_names

The names of the columns that the masking policy will apply to.

output_paths

The full path of the SUPER object that the masking policy will apply to, including the column name. For example, for a relation with a SUPER type column named `person`, *output_path* might be `person.name.first_name`.

input_column_names

The names of the columns that the masking policy will take as input. This parameter is optional. If not specified, the masking policy uses *output_column_names* as inputs.

input_paths

The full path of the SUPER object that the masking policy will take as input. This parameter is optional. If not specified, the masking policy uses *output_path* for inputs.

user_name

The name of the user to whom the masking policy will attach. You can't attach two policies to the same combination of user and column or role and column. You can attach a policy to a user and another policy to the user's role. In this case, the policy with the higher priority applies.

You can only set one of user_name, role_name, and PUBLIC in a single ATTACH MASKING POLICY command.

role_name

The name of the role to which the masking policy will attach. You can't attach two policies to the same column/role pair. You can attach a policy to a user and another policy to the user's role. In this case, the policy with the higher priority applies.

You can only set one of user_name, role_name, and PUBLIC in a single ATTACH MASKING POLICY command.

PUBLIC

Attaches the masking policy to all users accessing the table. You must give other masking policies attached to specific column/user or column/role pairs a higher priority than the PUBLIC policy for them to apply.

You can only set one of user_name, role_name, and PUBLIC in a single ATTACH MASKING POLICY command.

priority

The priority of the masking policy. When multiple masking policies apply to a given user's query, the highest priority policy applies.

You can't attach two different policies to the same column with equal priority, even if the two policies are attached to different users or roles. You can attach the same policy multiple times to the same set of table, output column, input column, and priority parameters, as long as the user or role the policy attaches to is different each time.

You can't apply a policy to a column with the same priority as another policy attached to that column, even if they're for different roles. This field is optional. If you don't specify a priority, the masking policy defaults to attaching with a priority of 0.

ATTACH RLS POLICY

Attach a row-level security policy on a table to one or more users or roles.

Superusers and users or roles that have the `sys:secadmin` role can attach a policy.

Syntax

```
ATTACH RLS POLICY policy_name ON [TABLE] table_name [, ...]
```

```
TO { user_name | ROLE role_name | PUBLIC } [, ...]
```

Parameters

policy_name

The name of the policy.

ON [TABLE] *table_name* [, ...]

The relation that the row-level security policy is attached to.

TO { *user_name* | ROLE *role_name* | PUBLIC} [, ...]

Specifies whether the policy is attached to one or more specified users or roles.

Usage notes

When working with the ATTACH RLS POLICY statement, observe the following:

- The table being attached should have all the columns listed in the WITH clause of the policy creation statement.
- Amazon Redshift RLS supports attaching RLS policies to the following objects:
  - Tables
  - Views
  - Late-binding views
  - Materialized views
- Amazon Redshift RLS doesn't support attaching RLS policies to the following objects:
  - Catalog tables
  - Cross-database relations
  - External tables
  - Temporary tables
  - Policy lookup tables
  - Materialized view base tables
- RLS policies that are attached to superusers or to users with the `sys:secadmin` permission are ignored.

Examples

The following example attaches a policy on a table to a role.

```
ATTACH RLS POLICY policy_concerts ON tickit_category_redshift TO ROLE analyst, ROLE
 dbadmin;
```

BEGIN

Starts a transaction. Synonymous with START TRANSACTION.

A transaction is a single, logical unit of work, whether it consists of one command or multiple commands. In general, all commands in a transaction run on a snapshot of the database whose starting time is determined by the value set for the `transaction_snapshot_begin` system configuration parameter.

By default, individual Amazon Redshift operations (queries, DDL statements, loads) are automatically committed to the database. If you want to suspend the commit for an operation until subsequent work is completed, you need to open a transaction with the BEGIN statement, then run the required commands, then close the transaction with a COMMIT or END statement. If necessary, you can use a ROLLBACK statement to stop a transaction that is in progress. An exception to this behavior is the TRUNCATE command, which commits the transaction in which it is run and can't be rolled back.

Syntax

```
BEGIN [ WORK | TRANSACTION ] [ ISOLATION LEVEL option ] [ READ WRITE | READ ONLY ]

START TRANSACTION [ ISOLATION LEVEL option ] [ READ WRITE | READ ONLY ]

Where option is

SERIALIZABLE
| READ UNCOMMITTED
| READ COMMITTED
| REPEATABLE READ

Note: READ UNCOMMITTED, READ COMMITTED, and REPEATABLE READ have no
operational impact and map to SERIALIZABLE in Amazon Redshift. You can see database
 isolation levels on your cluster
```

```
by querying the stv_db_isolation_level table.
```

Parameters

WORK

Optional keyword.

TRANSACTION

Optional keyword; WORK and TRANSACTION are synonyms.

ISOLATION LEVEL SERIALIZABLE

Serializable isolation is supported by default, so the behavior of the transaction is the same whether or not this syntax is included in the statement. For more information, see Managing concurrent write operations. No other isolation levels are supported.

> **Note**
>
> The SQL standard defines four levels of transaction isolation to prevent *dirty reads* (where a transaction reads data written by a concurrent uncommitted transaction), *nonrepeatable reads* (where a transaction re-reads data it read previously and finds that data was changed by another transaction that committed since the initial read), and *phantom reads* (where a transaction re-runs a query, returns a set of rows that satisfy a search condition, and then finds that the set of rows has changed because of another recently committed transaction):
>
> - Read uncommitted: Dirty reads, nonrepeatable reads, and phantom reads are possible.
> - Read committed: Nonrepeatable reads and phantom reads are possible.
> - Repeatable read: Phantom reads are possible.
> - Serializable: Prevents dirty reads, nonrepeatable reads, and phantom reads.
>
> Though you can use any of the four transaction isolation levels, Amazon Redshift processes all isolation levels as serializable.

READ WRITE

Gives the transaction read and write permissions.

READ ONLY

Gives the transaction read-only permissions.

Examples

The following example starts a serializable transaction block:

```
begin;
```

The following example starts the transaction block with a serializable isolation level and read and write permissions:

```
begin read write;
```

CALL

Runs a stored procedure. The CALL command must include the procedure name and the input argument values. You must call a stored procedure by using the CALL statement.

> **Note**
>
> CALL can't be part of any regular queries.

Syntax

```
CALL sp_name ( [ argument ] [, ...] )
```

Parameters

sp_name

The name of the procedure to run.

argument

The value of the input argument. This parameter can also be a function name, for example `pg_last_query_id()`. You can't use queries as CALL arguments.

Usage notes

Amazon Redshift stored procedures support nested and recursive calls, as described following. In addition, make sure your driver support is up-to-date, also described following.

Topics

Nested calls

Amazon Redshift stored procedures support nested and recursive calls. The maximum number of nesting levels allowed is 16. Nested calls can encapsulate business logic into smaller procedures, which can be shared by multiple callers.

If you call a nested procedure that has output parameters, the inner procedure must define INOUT arguments. In this case, the inner procedure is passed in a nonconstant variable. OUT arguments aren't allowed. This behavior occurs because a variable is needed to hold the output of the inner call.

The relationship between inner and outer procedures is logged in the `from_sp_call` column of SVL_STORED_PROC_CALL.

The following example shows passing variables to a nested procedure call through INOUT arguments.

```
CREATE OR REPLACE PROCEDURE inner_proc(INOUT a int, b int, INOUT c int) LANGUAGE
 plpgsql
AS $$
BEGIN
  a := b * a;
  c := b * c;
END;
$$;

CREATE OR REPLACE PROCEDURE outer_proc(multiplier int) LANGUAGE plpgsql
AS $$
DECLARE
  x int := 3;
  y int := 4;
BEGIN
```

```
  DROP TABLE IF EXISTS test_tbl;
  CREATE TEMP TABLE test_tbl(a int, b varchar(256));
  CALL inner_proc(x, multiplier, y);
  insert into test_tbl values (x, y::varchar);
END;
$$;

CALL outer_proc(5);

SELECT * from test_tbl;
 a  | b
----+----
 15 | 20
(1 row)
```

Driver support

We recommend that you upgrade your Java Database Connectivity (JDBC) and Open Database Connectivity (ODBC) drivers to the latest version that has support for Amazon Redshift stored procedures.

You might be able to use your existing driver if your client tool uses driver API operations that pass through the CALL statement to the server. Output parameters, if any, are returned as a result set of one row.

The latest versions of Amazon Redshift JDBC and ODBC drivers have metadata support for stored procedure discovery. They also have `CallableStatement` support for custom Java applications. For more information on drivers, see Connecting to an Amazon Redshift Cluster Using SQL Client Tools in the *Amazon Redshift Management Guide.*

The following examples show how to use different API operations of the JDBC driver for stored procedure calls.

```
void statement_example(Connection conn) throws SQLException {
  statement.execute("CALL sp_statement_example(1)");
}

void prepared_statement_example(Connection conn) throws SQLException {
  String sql = "CALL sp_prepared_statement_example(42, 84)";
  PreparedStatement pstmt = conn.prepareStatement(sql);
  pstmt.execute();
}
```

```
void callable_statement_example(Connection conn) throws SQLException {
  CallableStatement cstmt = conn.prepareCall("CALL sp_create_out_in(?,?)");
  cstmt.registerOutParameter(1, java.sql.Types.INTEGER);
  cstmt.setInt(2, 42);
  cstmt.executeQuery();
  Integer out_value = cstmt.getInt(1);
}
```

Examples

The following example calls the procedure name `test_spl`.

```
call test_sp1(3,'book');
INFO:  Table "tmp_tbl" does not exist and will be skipped
INFO:  min_val = 3, f2 = book
```

The following example calls the procedure name `test_spl2`.

```
call test_sp2(2,'2019');

         f2          | column2
---------------------+---------
 2019+2019+2019+2019 | 2
(1 row)
```

CANCEL

Cancels a database query that is currently running.

The CANCEL command requires the process ID or session ID of the running query and displays a confirmation message to verify that the query was canceled.

Required privileges

Following are required privileges for CANCEL:

- Superuser canceling their own query
- Superuser canceling a user's query
- Users with the CANCEL privilege canceling a user's query
- User canceling their own query

Syntax

```
CANCEL process_id [ 'message' ]
```

Parameters

process_id

To cancel a query running in an Amazon Redshift cluster, use the `pid` (Process ID) from STV_RECENTS that corresponds to the query that you want to cancel.

To cancel a query running in an Amazon Redshift Serverless workgroup, use the `session_id` from SYS_QUERY_HISTORY that corresponds to the query that you want to cancel.

'*message*'

An optional confirmation message that displays when the query cancellation completes. If you don't specify a message, Amazon Redshift displays the default message as verification. You must enclose the message in single quotation marks.

Usage notes

You can't cancel a query by specifying a *query ID*; you must specify the query's *process ID* (PID) or *Session ID*. You can only cancel queries currently being run by your user. Superusers can cancel all queries.

If queries in multiple sessions hold locks on the same table, you can use the PG_TERMINATE_BACKEND function to terminate one of the sessions. Doing this forces any currently running transactions in the terminated session to release all locks and roll back the transaction. To view currently held locks, query the STV_LOCKS system table.

Following certain internal events, Amazon Redshift might restart an active session and assign a new PID. If the PID has changed, you might receive the following error message.

```
Session <PID> does not exist. The session PID might have changed. Check the
 stl_restarted_sessions system table for details.
```

To find the new PID, query the STL_RESTARTED_SESSIONS system table and filter on the `oldpid` column.

```
select oldpid, newpid from stl_restarted_sessions where oldpid = 1234;
```

Examples

To cancel a currently running query in a Amazon Redshift cluster, first retrieve the process ID for the query that you want to cancel. To determine the process IDs for all currently running queries, type the following command:

```
select pid, starttime, duration,
trim(user_name) as user,
trim (query) as querytxt
from stv_recents
where status = 'Running';

pid |         starttime          | duration |   user   |    querytxt
-----+----------------------------+----------+----------+-----------------
802 | 2008-10-14 09:19:03.550885 |      132 | dwuser | select
venuename from venue where venuestate='FL', where venuecity not in
('Miami' , 'Orlando');
834 | 2008-10-14 08:33:49.473585 |  1250414 | dwuser | select *
from listing;
964 | 2008-10-14 08:30:43.290527 |   326179 | dwuser | select
sellerid from sales where qtysold in (8, 10);
```

Check the query text to determine which process id (PID) corresponds to the query that you want to cancel.

Type the following command to use PID 802 to cancel that query:

```
cancel 802;
```

The session where the query was running displays the following message:

```
ERROR:  Query (168) cancelled on user's request
```

where 168 is the query ID (not the process ID used to cancel the query).

Alternatively, you can specify a custom confirmation message to display instead of the default message. To specify a custom message, include your message in single quotation marks at the end of the CANCEL command:

```
cancel 802 'Long-running query';
```

The session where the query was running displays the following message:

```
ERROR:  Long-running query
```

CLOSE

(Optional) Closes all of the free resources that are associated with an open cursor. COMMIT, END, and ROLLBACK automatically close the cursor, so it isn't necessary to use the CLOSE command to explicitly close the cursor.

For more information, see DECLARE, FETCH.

Syntax

```
CLOSE cursor
```

Parameters

cursor

Name of the cursor to close.

CLOSE example

The following commands close the cursor and perform a commit, which ends the transaction:

```
close movie_cursor;
commit;
```

COMMENT

Creates or changes a comment about a database object.

Syntax

```
COMMENT ON
```

```
{
TABLE object_name |
COLUMN object_name.column_name |
CONSTRAINT constraint_name ON table_name |
DATABASE object_name |
VIEW object_name
}
IS 'text' | NULL
```

Parameters

object_name

Name of the database object being commented on. You can add a comment to the following objects:

- TABLE
- COLUMN (also takes a *column_name*).
- CONSTRAINT (also takes a *constraint_name* and *table_name*).
- DATABASE
- VIEW
- SCHEMA

IS '*text*' | NULL

The comment text that you want to add or replace for the specified object. The *text* string is data type TEXT. Enclose the comment in single quotation marks. Set the value to NULL to remove the comment text.

column_name

Name of the column being commented on. Parameter of COLUMN. Follows a table specified in `object_name`.

constraint_name

Name of the constraint that is being commented on. Parameter of CONSTRAINT.

table_name

Name of a table containing the constraint. Parameter of CONSTRAINT.

Usage notes

You must be a superuser or the owner of a database object to add or update a comment.

Comments on databases may only be applied to the current database. A warning message is displayed if you attempt to comment on a different database. The same warning is displayed for comments on databases that don't exist.

Comments on external tables, external columns, and columns of late binding views are not supported.

Examples

The following example adds a comment to the SALES table.

```
COMMENT ON TABLE sales IS 'This table stores tickets sales data';
```

The following example displays the comment on the SALES table.

```
select obj_description('public.sales'::regclass);

obj_description
-------------------------------------
This table stores tickets sales data
```

The following example removes a comment from the SALES table.

```
COMMENT ON TABLE sales IS NULL;
```

The following example adds a comment to the EVENTID column of the SALES table.

```
COMMENT ON COLUMN sales.eventid IS 'Foreign-key reference to the EVENT table.';
```

The following example displays a comment on the EVENTID column (column number 5) of the SALES table.

```
select col_description( 'public.sales'::regclass, 5::integer );

col_description
-----------------------------------------
```

```
Foreign-key reference to the EVENT table.
```

The following example adds a descriptive comment to the EVENT table.

```
comment on table event is 'Contains listings of individual events.';
```

To view comments, query the PG_DESCRIPTION system catalog. The following example returns the description for the EVENT table.

```
select * from pg_catalog.pg_description
where objoid =
(select oid from pg_class where relname = 'event'
and relnamespace =
(select oid from pg_catalog.pg_namespace where nspname = 'public') );

objoid | classoid | objsubid | description
-------+----------+----------+----------------------------------------
116658 |     1259 |        0 | Contains listings of individual events.
```

COMMIT

Commits the current transaction to the database. This command makes the database updates from the transaction permanent.

Syntax

```
COMMIT [ WORK | TRANSACTION ]
```

Parameters

WORK

Optional keyword. This keyword isn't supported within a stored procedure.

TRANSACTION

Optional keyword. WORK and TRANSACTION are synonyms. Neither is supported within a stored procedure.

For information about using COMMIT within a stored procedure, see Managing transactions.

Examples

Each of the following examples commits the current transaction to the database:

```
commit;
```

```
commit work;
```

```
commit transaction;
```

COPY

Client-side encryption for COPY and UNLOAD commands will no longer be open to new customers starting April 30, 2025. If you used client-side encryption with COPY and UNLOAD commands in the 12 months before April 30, 2025, you can continue to use client side encryption with COPY or UNLOAD commands until April 30, 2026. After April 30, 2026, you won't be able to use client-side encryption for COPY and UNLOAD. We recommend that you switch to using server-side encryption for COPY and UNLOAD as soon as possible. If you're already using server-side encryption for COPY and UNLOAD, there's no change and you can continue to use it without altering your queries. For more information on encryption for COPY and UNLOAD, see the ENCRYPTED parameter below.

Loads data into a table from data files or from an Amazon DynamoDB table. The files can be located in an Amazon Simple Storage Service (Amazon S3) bucket, an Amazon EMR cluster, or a remote host that is accessed using a Secure Shell (SSH) connection.

> **Note**
>
> Amazon Redshift Spectrum external tables are read-only. You can't COPY to an external table.

The COPY command appends the input data as additional rows to the table.

The maximum size of a single input row from any source is 4 MB.

Topics

Required permissions

To use the COPY command, you must have INSERT privilege for the Amazon Redshift table.

COPY syntax

```
COPY table-name
[ column-list ]
FROM data_source
authorization
[ [ FORMAT ] [ AS ] data_format ]
[ parameter [ argument ] [, ... ] ]
```

You can perform a COPY operation with as few as three parameters: a table name, a data source, and authorization to access the data.

Amazon Redshift extends the functionality of the COPY command to enable you to load data in several data formats from multiple data sources, control access to load data, manage data transformations, and manage the load operation.

The following sections present the required COPY command parameters, grouping the optional parameters by function. They also describe each parameter and explain how various options work together. You can go directly to a parameter description by using the alphabetical parameter list.

Required parameters

The COPY command requires three elements:

- Table Name
- Data Source
- Authorization

The simplest COPY command uses the following format.

```
COPY table-name
FROM data-source
authorization;
```

The following example creates a table named CATDEMO, and then loads the table with sample data from a data file in Amazon S3 named `category_pipe.txt`.

```
create table catdemo(catid smallint, catgroup varchar(10), catname varchar(10), catdesc
 varchar(50));
```

In the following example, the data source for the COPY command is a data file named `category_pipe.txt` in the `tickit` folder of an Amazon S3 bucket named `redshift-downloads`. The COPY command is authorized to access the Amazon S3 bucket through an AWS Identity and Access Management (IAM) role. If your cluster has an existing IAM role with permission to access Amazon S3 attached, you can substitute your role's Amazon Resource Name (ARN) in the following COPY command and run it.

```
copy catdemo
from 's3://redshift-downloads/tickit/category_pipe.txt'
iam_role 'arn:aws:iam::<aws-account-id>:role/<role-name>'
region 'us-east-1';
```

For complete instructions on how to use COPY commands to load sample data, including instructions for loading data from other AWS regions, see Load Sample Data from Amazon S3 in the Amazon Redshift Getting Started Guide.

table-name

The name of the target table for the COPY command. The table must already exist in the database. The table can be temporary or persistent. The COPY command appends the new input data to any existing rows in the table.

FROM *data-source*

The location of the source data to be loaded into the target table. A manifest file can be specified with some data sources.

The most commonly used data repository is an Amazon S3 bucket. You can also load from data files located in an Amazon EMR cluster, an Amazon EC2 instance, or a remote host that your cluster can access using an SSH connection, or you can load directly from a DynamoDB table.

- COPY from Amazon S3
- COPY from Amazon EMR
- COPY from remote host (SSH)
- COPY from Amazon DynamoDB

Authorization

A clause that indicates the method that your cluster uses for authentication and authorization to access other AWS resources. The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, Amazon DynamoDB, and Amazon EC2. You can provide that authorization by referencing an IAM role that is attached to your cluster or by providing the access key ID and secret access key for an IAM user.

- Authorization parameters
- Role-based access control
- Key-based access control

Optional parameters

You can optionally specify how COPY maps field data to columns in the target table, define source data attributes to enable the COPY command to correctly read and parse the source data, and manage which operations the COPY command performs during the load process.

- Column mapping options
- Data format parameters
- Data conversion parameters
- Data load operations

Column mapping

By default, COPY inserts field values into the target table's columns in the same order as the fields occur in the data files. If the default column order will not work, you can specify a column list or use JSONPath expressions to map source data fields to the target columns.

- Column List
- JSONPaths File

Data format parameters

You can load data from text files in fixed-width, character-delimited, comma-separated values (CSV), or JSON format, or from Avro files.

By default, the COPY command expects the source data to be in character-delimited UTF-8 text files. The default delimiter is a pipe character (|). If the source data is in another format, use the following parameters to specify the data format.

- FORMAT
- CSV
- DELIMITER
- FIXEDWIDTH
- SHAPEFILE
- AVRO
- JSON format for COPY
- ENCRYPTED
- BZIP2
- GZIP
- LZOP
- PARQUET
- ORC
- ZSTD

Data conversion parameters

As it loads the table, COPY attempts to implicitly convert the strings in the source data to the data type of the target column. If you need to specify a conversion that is different from the default behavior, or if the default conversion results in errors, you can manage data conversions by specifying the following parameters.

- ACCEPTANYDATE
- ACCEPTINVCHARS
- BLANKSASNULL
- DATEFORMAT
- EMPTYASNULL
- ENCODING
- ESCAPE
- EXPLICIT_IDS
- FILLRECORD
- IGNOREBLANKLINES
- IGNOREHEADER
- NULL AS
- REMOVEQUOTES
- ROUNDEC
- TIMEFORMAT
- TRIMBLANKS
- TRUNCATECOLUMNS

Data load operations

Manage the default behavior of the load operation for troubleshooting or to reduce load times by specifying the following parameters.

- COMPROWS
- COMPUPDATE
- IGNOREALLERRORS
- MAXERROR

- NOLOAD
- STATUPDATE

Usage notes and additional resources for the COPY command

For more information about how to use the COPY command, see the following topics:

- Usage notes
- Tutorial: Loading data from Amazon S3
- Amazon Redshift best practices for loading data
- Loading tables with the COPY command
  - Loading data from Amazon S3
  - Loading data from Amazon EMR
  - Loading data from remote hosts
  - Loading data from an Amazon DynamoDB table
- Troubleshooting data loads

COPY command examples

For more examples that show how to COPY from various sources, in disparate formats, and with different COPY options, see COPY examples.

COPY JOB

For information about using this command, see Create an S3 event integration to automatically copy files from Amazon S3 buckets.

Manages COPY commands that load data into a table. The COPY JOB command is an extension of the COPY command and automates data loading from Amazon S3 buckets. When you create a COPY job, Amazon Redshift detects when new Amazon S3 files are created in a specified path, and then loads them automatically without your intervention. The same parameters that are used in the original COPY command are used when loading the data. Amazon Redshift keeps track of the loaded files (based on filename) to verify that they are loaded only one time.

Note

For information about the COPY command, including usage, parameters, and permissions, see COPY.

Required permission

To use the COPY JOB command, you must have one of the following permissions in addition to all of the required permissions to use COPY:

- Superuser
- All of the following:
  - The relevant CREATE, ALTER, or DROP scoped permission for COPY JOBS in the database you want to COPY to.
  - USAGE permission for the schema you want to COPY to, or USAGE scoped permission for schemas in the database you want to COPY to.
  - INSERT permission for the table you want to COPY to, or INSERT scoped permission for tables in the schema or database you want to COPY to.

The IAM role specified with the COPY command must have permission to access the data to load. For more information, see IAM permissions for COPY, UNLOAD, and CREATE LIBRARY.

Syntax

Create a copy job. The parameters of the COPY command are saved with the copy job.

You can't run COPY JOB CREATE within the scope of a transaction block.

```
COPY copy-command JOB CREATE job-name
[AUTO ON | OFF]
```

Change the configuration of a copy job.

```
COPY JOB ALTER job-name
[AUTO ON | OFF]
```

Run a copy job. The stored COPY command parameters are used.

```
COPY JOB RUN job-name
```

List all copy jobs.

```
COPY JOB LIST
```

Show the details of a copy job.

```
COPY JOB SHOW job-name
```

Delete a copy job.

You can't run COPY JOB DROP within the scope of a transaction block.

```
COPY JOB DROP job-name
```

Parameters

copy-command

A COPY command that loads data from Amazon S3 to Amazon Redshift. The clause contains COPY parameters that define the Amazon S3 bucket, target table, IAM role, and other parameters used when loading data. All COPY command parameters for an Amazon S3 data load are supported except:

- The COPY JOB does not ingest preexisting files in the folder pointed to by the COPY command. Only files created after the COPY JOB creation timestamp are ingested.
- You cannot specify a COPY command with the MAXERROR or IGNOREALLERRORS options.
- You cannot specify a manifest file. COPY JOB requires a designated Amazon S3 location to monitor for newly created files.
- You cannot specify a COPY command with authorization types like Access and Secret keys. Only COPY commands that use the `IAM_ROLE` parameter for authorization are supported. For more information, see Authorization parameters.
- The COPY JOB doesn't support the default IAM role associated with the cluster. You must specify the `IAM_ROLE` in the COPY command.

For more information, see COPY from Amazon S3.

job-name

The name of the job used to reference the COPY job. The *job-name* can't contain a hyphen (-).

[AUTO ON | OFF]

Clause that indicates whether Amazon S3 data is automatically loaded into Amazon Redshift tables.

- When ON, Amazon Redshift monitors the source Amazon S3 path for newly created files, and if found, a COPY command is run with the COPY parameters in the job definition. This is the default.
- When OFF, Amazon Redshift does not run the COPY JOB automatically.

Usage notes

The options of the COPY command aren't validated until run time. For example, an invalid IAM_ROLE or an Amazon S3 data source results in runtime errors when the COPY JOB starts.

If the cluster is paused, COPY JOBS are not run.

To query COPY command files loaded and load errors, see STL_LOAD_COMMITS, STL_LOAD_ERRORS, STL_LOADERROR_DETAIL. For more information, see Verifying that the data loaded correctly.

Examples

The following example shows creating a COPY JOB to load data from an Amazon S3 bucket.

```
COPY public.target_table
FROM 's3://amzn-s3-demo-bucket/staging-folder'
IAM_ROLE 'arn:aws:iam::123456789012:role/MyLoadRoleName'
JOB CREATE my_copy_job_name
AUTO ON;
```

COPY parameter reference

COPY has many parameters that can be used in many situations. However, not all parameters are supported in each situation. For example, to load from ORC or PARQUET files there is a limited number of supported parameters. For more information, see COPY from columnar data formats.

Topics

Data sources

You can load data from text files in an Amazon S3 bucket, in an Amazon EMR cluster, or on a remote host that your cluster can access using an SSH connection. You can also load data directly from a DynamoDB table.

The maximum size of a single input row from any source is 4 MB.

To export data from a table to a set of files in an Amazon S3, use the UNLOAD command.

Topics

COPY from Amazon S3

To load data from files located in one or more S3 buckets, use the FROM clause to indicate how COPY locates the files in Amazon S3. You can provide the object path to the data files as part of the FROM clause, or you can provide the location of a manifest file that contains a list of Amazon S3 object paths. COPY from Amazon S3 uses an HTTPS connection. Ensure that the S3 IP ranges are added to your allow list. To learn more about the required S3 IP ranges, see Network isolation.

> **Important**
>
> If the Amazon S3 buckets that hold the data files don't reside in the same AWS Region as your cluster, you must use the REGION parameter to specify the Region in which the data is located.

Topics

- Syntax
- Examples
- Optional parameters
- Unsupported parameters

Syntax

```
FROM { 's3://objectpath' | 's3://manifest_file' }
authorization
| MANIFEST
| ENCRYPTED
| REGION [AS] 'aws-region'
| optional-parameters
```

Examples

The following example uses an object path to load data from Amazon S3.

```
copy customer
from 's3://amzn-s3-demo-bucket/customer'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The following example uses a manifest file to load data from Amazon S3.

```
copy customer
from 's3://amzn-s3-demo-bucket/cust.manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest;
```

Parameters

FROM

The source of the data to be loaded. For more information about the encoding of the Amazon S3 file, see Data conversion parameters.

's3://*copy_from_s3_objectpath*'

Specifies the path to the Amazon S3 objects that contain the data—for example, `'s3://amzn-s3-demo-bucket/custdata.txt'`. The *s3://copy_from_s3_objectpath* parameter can reference a single file or a set of objects or folders that have the same key prefix. For example, the name `custdata.txt` is a key prefix that refers to a number of physical files: `custdata.txt`,`custdata.txt.1`, `custdata.txt.2`, `custdata.txt.bak`,and so on. The key prefix can also reference a number of folders. For example, `'s3://amzn-s3-demo-bucket/custfolder'` refers to the folders `custfolder`, `custfolder_1`, `custfolder_2`, and so on. If a key prefix references multiple folders, all of the files in the folders are loaded. If a key prefix matches a file as well as a folder, such as `custfolder.log`, COPY attempts to load the file also. If a key prefix might result in COPY attempting to load unwanted files, use a manifest file. For more information, see copy_from_s3_manifest_file, following.

> **Important**
>
> If the S3 bucket that holds the data files doesn't reside in the same AWS Region as your cluster, you must use the REGION parameter to specify the Region in which the data is located.

For more information, see Loading data from Amazon S3.

's3://*copy_from_s3_manifest_file*'

Specifies the Amazon S3 object key for a manifest file that lists the data files to be loaded. The *'s3://*copy_from_s3_manifest_file' argument must explicitly reference a single file—for example, `'s3://amzn-s3-demo-bucket/manifest.txt'`. It can't reference a key prefix.

The manifest is a text file in JSON format that lists the URL of each file that is to be loaded from Amazon S3. The URL includes the bucket name and full object path for the file. The files that are specified in the manifest can be in different buckets, but all the buckets must be in the same AWS Region as the Amazon Redshift cluster. If a file is listed twice, the file is loaded twice. The following example shows the JSON for a manifest that loads three files.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket1/custdata.1","mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket1/custdata.2","mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket2/custdata.1","mandatory":false}
  ]
}
```

The double quotation mark characters are required, and must be simple quotation marks (0x22), not slanted or "smart" quotation marks. Each entry in the manifest can optionally include a `mandatory` flag. If `mandatory` is set to `true`, COPY terminates if it doesn't find the file for that entry; otherwise, COPY will continue. The default value for `mandatory` is `false`.

When loading from data files in ORC or Parquet format, a `meta` field is required, as shown in the following example.

```
{
   "entries":[
      {
         "url":"s3://amzn-s3-demo-bucket1/orc/2013-10-04-custdata",
         "mandatory":true,
         "meta":{
            "content_length":99
         }
      },
      {
         "url":"s3://amzn-s3-demo-bucket2/orc/2013-10-05-custdata",
         "mandatory":true,
         "meta":{
            "content_length":99
         }
      }
   ]
}
```

The manifest file must not be encrypted or compressed, even if the ENCRYPTED, GZIP, LZOP, BZIP2, or ZSTD options are specified. COPY returns an error if the specified manifest file isn't found or the manifest file isn't properly formed.

If a manifest file is used, the MANIFEST parameter must be specified with the COPY command. If the MANIFEST parameter isn't specified, COPY assumes that the file specified with FROM is a data file.

For more information, see Loading data from Amazon S3.

authorization

The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, Amazon DynamoDB, and Amazon EC2. You can provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster (role-based access control) or by providing the access credentials for a user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization parameters.

MANIFEST

Specifies that a manifest is used to identify the data files to be loaded from Amazon S3. If the MANIFEST parameter is used, COPY loads data from the files listed in the manifest referenced by *'s3://copy_from_s3_manifest_file'*. If the manifest file isn't found, or isn't properly formed, COPY fails. For more information, see Using a manifest to specify data files.

ENCRYPTED

A clause that specifies that the input files on Amazon S3 are encrypted using client-side encryption with customer managed keys. For more information, see Loading encrypted data files from Amazon S3. Don't specify ENCRYPTED if the input files are encrypted using Amazon S3 server-side encryption (SSE-KMS or SSE-S3). COPY reads server-side encrypted files automatically.

If you specify the ENCRYPTED parameter, you must also specify the MASTER_SYMMETRIC_KEY parameter or include the **`master_symmetric_key`** value in the the section called “Using CREDENTIALS” string.

If the encrypted files are in compressed format, add the GZIP, LZOP, BZIP2, or ZSTD parameter.

Manifest files and JSONPaths files must not be encrypted, even if the ENCRYPTED option is specified.

MASTER_SYMMETRIC_KEY '*root_key*'

The root symmetric key that was used to encrypt data files on Amazon S3. If MASTER_SYMMETRIC_KEY is specified, the ENCRYPTED parameter must also be specified.

MASTER_SYMMETRIC_KEY can't be used with the CREDENTIALS parameter. For more information, see Loading encrypted data files from Amazon S3.

If the encrypted files are in compressed format, add the GZIP, LZOP, BZIP2, or ZSTD parameter.

REGION [AS] '*aws-region*'

Specifies the AWS Region where the source data is located. REGION is required for COPY from an Amazon S3 bucket or an DynamoDB table when the AWS resource that contains the data isn't in the same Region as the Amazon Redshift cluster.

The value for *aws_region* must match a Region listed in the Amazon Redshift regions and endpoints table.

If the REGION parameter is specified, all resources, including a manifest file or multiple Amazon S3 buckets, must be located in the specified Region.

> **Note**
>
> Transferring data across Regions incurs additional charges against the Amazon S3 bucket or the DynamoDB table that contains the data. For more information about pricing, see **Data Transfer OUT From Amazon S3 To Another AWS Region** on the Amazon S3 Pricing page and **Data Transfer OUT** on the Amazon DynamoDB Pricing page.

By default, COPY assumes that the data is located in the same Region as the Amazon Redshift cluster.

Optional parameters

You can optionally specify the following parameters with COPY from Amazon S3:

- Column mapping options
- Data format parameters
- Data conversion parameters
- Data load operations

Unsupported parameters

You can't use the following parameters with COPY from Amazon S3:

- SSH
- READRATIO

COPY from Amazon EMR

You can use the COPY command to load data in parallel from an Amazon EMR cluster configured to write text files to the cluster's Hadoop Distributed File System (HDFS) in the form of fixed-width files, character-delimited files, CSV files, JSON-formatted files, or Avro files.

Topics

Syntax

```
FROM 'emr://emr_cluster_id/hdfs_filepath'
authorization
[ optional_parameters ]
```

Example

The following example loads data from an Amazon EMR cluster.

```
copy sales
from 'emr://j-SAMPLE2B500FC/myoutput/part-*'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

Parameters

FROM

The source of the data to be loaded.

'emr://*emr_cluster_id*/*hdfs_file_path*'

The unique identifier for the Amazon EMR cluster and the HDFS file path that references the data files for the COPY command. The HDFS data file names must not contain the wildcard characters asterisk (*) and question mark (?).

> **Note**
>
> The Amazon EMR cluster must continue running until the COPY operation completes. If any of the HDFS data files are changed or deleted before the COPY operation completes, you might have unexpected results, or the COPY operation might fail.

You can use the wildcard characters asterisk (*) and question mark (?) as part of the *hdfs_file_path* argument to specify multiple files to be loaded. For example, `'emr://j-SAMPLE2B500FC/myoutput/part*'` identifies the files `part-0000`, `part-0001`, and so on. If the file path doesn't contain wildcard characters, it is treated as a string literal. If you specify only a folder name, COPY attempts to load all files in the folder.

> **Important**
>
> If you use wildcard characters or use only the folder name, verify that no unwanted files will be loaded. For example, some processes might write a log file to the output folder.

For more information, see Loading data from Amazon EMR.

authorization

The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, Amazon DynamoDB, and Amazon EC2. You can provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster (role-based access control) or by providing the access credentials for a user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization parameters.

Supported parameters

You can optionally specify the following parameters with COPY from Amazon EMR:

Unsupported parameters

You can't use the following parameters with COPY from Amazon EMR:

- ENCRYPTED
- MANIFEST
- REGION
- READRATIO
- SSH

COPY from remote host (SSH)

You can use the COPY command to load data in parallel from one or more remote hosts, such Amazon Elastic Compute Cloud (Amazon EC2) instances or other computers. COPY connects to the remote hosts using Secure Shell (SSH) and runs commands on the remote hosts to generate text output. The remote host can be an EC2 Linux instance or another Unix or Linux computer configured to accept SSH connections. Amazon Redshift can connect to multiple hosts, and can open multiple SSH connections to each host. Amazon Redshift sends a unique command through each connection to generate text output to the host's standard output, which Amazon Redshift then reads as it does a text file.

Use the FROM clause to specify the Amazon S3 object key for the manifest file that provides the information COPY uses to open SSH connections and run the remote commands.

Topics

- Unsupported parameters

> **Important**
>
> If the S3 bucket that holds the manifest file doesn't reside in the same AWS Region as your cluster, you must use the REGION parameter to specify the Region in which the bucket is located.

Syntax

```
FROM 's3://'ssh_manifest_file' }
authorization
SSH
| optional-parameters
```

Examples

The following example uses a manifest file to load data from a remote host using SSH.

```
copy sales
from 's3://amzn-s3-demo-bucket/ssh_manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
ssh;
```

Parameters

FROM

The source of the data to be loaded.

's3://*copy_from_ssh_manifest_file*'

The COPY command can connect to multiple hosts using SSH, and can create multiple SSH connections to each host. COPY runs a command through each host connection, and then loads the output from the commands in parallel into the table. The *s3://copy_from_ssh_manifest_file* argument specifies the Amazon S3 object key for the manifest file that provides the information COPY uses to open SSH connections and run the remote commands.

The *s3://copy_from_ssh_manifest_file* argument must explicitly reference a single file; it can't be a key prefix. The following shows an example:

```
's3://amzn-s3-demo-bucket/ssh_manifest.txt'
```

The manifest file is a text file in JSON format that Amazon Redshift uses to connect to the host. The manifest file specifies the SSH host endpoints and the commands that will be run on the hosts to return data to Amazon Redshift. Optionally, you can include the host public key, the login user name, and a mandatory flag for each entry. The following example shows a manifest file that creates two SSH connections:

```
{
    "entries": [
     {"endpoint":"<ssh_endpoint_or_IP>",
           "command": "<remote_command>",
           "mandatory":true,
           "publickey": "<public_key>",
           "username": "<host_user_name>"},
     {"endpoint":"<ssh_endpoint_or_IP>",
           "command": "<remote_command>",
           "mandatory":true,
           "publickey": "<public_key>",
           "username": "<host_user_name>"}
     ]
}
```

The manifest file contains one `"entries"` construct for each SSH connection. You can have multiple connections to a single host or multiple connections to multiple hosts. The double quotation mark characters are required as shown, both for the field names and the values. The quotation mark characters must be simple quotation marks (0x22), not slanted or "smart" quotation marks. The only value that doesn't need double quotation mark characters is the Boolean value `true` or `false` for the `"mandatory"` field.

The following list describes the fields in the manifest file.

endpoint

The URL address or IP address of the host—for example, `"ec2-111-222-333.compute-1.amazonaws.com"`, or `"198.51.100.0"`.

command

The command to be run by the host to generate text output or binary output in gzip, lzop, bzip2, or zstd format. The command can be any command that the user *"host_user_name"* has permission to run. The command can be as simple as printing a file, or it can query a database or launch a script. The output (text file, gzip binary file, lzop binary file, or bzip2 binary file) must be in a form that the Amazon Redshift COPY command can ingest. For more information, see Preparing your input data.

publickey

(Optional) The public key of the host. If provided, Amazon Redshift will use the public key to identify the host. If the public key isn't provided, Amazon Redshift will not attempt host identification. For example, if the remote host's public key is `ssh-rsa AbcCbaxxx…Example root@amazon.com`, type the following text in the public key field: `"AbcCbaxxx…Example"`

mandatory

(Optional) A clause that indicates whether the COPY command should fail if the connection attempt fails. The default is `false`. If Amazon Redshift doesn't successfully make at least one connection, the COPY command fails.

username

(Optional) The user name that will be used to log on to the host system and run the remote command. The user login name must be the same as the login that was used to add the Amazon Redshift cluster's public key to the host's authorized keys file. The default username is `redshift`.

For more information about creating a manifest file, see Loading data process.

To COPY from a remote host, the SSH parameter must be specified with the COPY command. If the SSH parameter isn't specified, COPY assumes that the file specified with FROM is a data file and will fail.

If you use automatic compression, the COPY command performs two data read operations, which means it will run the remote command twice. The first read operation is to provide a data sample for compression analysis, then the second read operation actually loads the data. If executing the remote command twice might cause a problem, you should disable automatic compression. To disable automatic compression, run the COPY command with the COMPUPDATE parameter set to OFF. For more information, see Loading tables with automatic compression.

For detailed procedures for using COPY from SSH, see Loading data from remote hosts.

authorization

The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, Amazon DynamoDB, and Amazon EC2. You can provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster (role-based access control) or by providing the access credentials for a user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization parameters.

SSH

A clause that specifies that data is to be loaded from a remote host using the SSH protocol. If you specify SSH, you must also provide a manifest file using the s3://copy_from_ssh_manifest_file argument.

> **Note**
>
> If you are using SSH to copy from a host using a private IP address in a remote VPC, the VPC must have enhanced VPC routing enabled. For more information about Enhanced VPC routing, see Amazon Redshift Enhanced VPC Routing.

Optional parameters

You can optionally specify the following parameters with COPY from SSH:

- Column mapping options
- Data format parameters
- Data conversion parameters
- Data load operations

Unsupported parameters

You can't use the following parameters with COPY from SSH:

- ENCRYPTED
- MANIFEST
- READRATIO

COPY from Amazon DynamoDB

To load data from an existing DynamoDB table, use the FROM clause to specify the DynamoDB table name.

Topics

> **Important**
>
> If the DynamoDB table doesn't reside in the same region as your Amazon Redshift cluster, you must use the REGION parameter to specify the region in which the data is located.

Syntax

```
FROM 'dynamodb://table-name'
authorization
READRATIO ratio
| REGION [AS] 'aws_region'
| optional-parameters
```

Examples

The following example loads data from a DynamoDB table.

```
copy favoritemovies from 'dynamodb://ProductCatalog'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
readratio 50;
```

Parameters

FROM

The source of the data to be loaded.

'dynamodb://*table-name*'

The name of the DynamoDB table that contains the data, for example `'dynamodb://ProductCatalog'`. For details about how DynamoDB attributes are mapped to Amazon Redshift columns, see Loading data from an Amazon DynamoDB table.

A DynamoDB table name is unique to an AWS account, which is identified by the AWS access credentials.

authorization

The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, DynamoDB, and Amazon EC2. You can provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster (role-based access control) or by providing the access credentials for a user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization parameters.

READRATIO [AS] *ratio*

The percentage of the DynamoDB table's provisioned throughput to use for the data load. READRATIO is required for COPY from DynamoDB. It can't be used with COPY from Amazon S3. We highly recommend setting the ratio to a value less than the average unused provisioned throughput. Valid values are integers 1–200.

> **Important**
>
> Setting READRATIO to 100 or higher enables Amazon Redshift to consume the entirety of the DynamoDB table's provisioned throughput, which seriously degrades the performance of concurrent read operations against the same table during the COPY session. Write traffic is unaffected. Values higher than 100 are allowed to troubleshoot rare scenarios when Amazon Redshift fails to fulfill the provisioned throughput of the table. If you load data from DynamoDB to Amazon Redshift on an ongoing basis, consider organizing your DynamoDB tables as a time series to separate live traffic from the COPY operation.

Optional parameters

You can optionally specify the following parameters with COPY from Amazon DynamoDB:

- Column mapping options
- The following data conversion parameters are supported:
  - ACCEPTANYDATE
  - BLANKSASNULL
  - DATEFORMAT
  - EMPTYASNULL
  - ROUNDEC
  - TIMEFORMAT
  - TRIMBLANKS
  - TRUNCATECOLUMNS
- Data load operations

Unsupported parameters

You can't use the following parameters with COPY from DynamoDB:

- All data format parameters
- ESCAPE
- FILLRECORD
- IGNOREBLANKLINES
- IGNOREHEADER
- NULL
- REMOVEQUOTES
- ACCEPTINVCHARS
- MANIFEST
- ENCRYPTED

Authorization parameters

The COPY command needs authorization to access data in another AWS resource, including in Amazon S3, Amazon EMR, Amazon DynamoDB, and Amazon EC2. You can provide that authorization by referencing an AWS Identity and Access Management (IAM) role that is attached to your cluster (*role-based access control*). You can encrypt your load data on Amazon S3.

The following topics provide more details and examples of authentication options:

- IAM permissions for COPY, UNLOAD, and CREATE LIBRARY
- Role-based access control
- Key-based access control

Use one of the following to provide authorization for the COPY command:

- the section called “Using IAM_ROLE” parameter
- the section called “Using ACCESS_KEY_ID and SECRET_ACCESS_KEY” parameters
- the section called “Using CREDENTIALS” clause

Using the IAM_ROLE parameter

IAM_ROLE

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the COPY command runs.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. If you specify IAM_ROLE, you can't use ACCESS_KEY_ID and SECRET_ACCESS_KEY, SESSION_TOKEN, or CREDENTIALS.

The following shows the syntax for the IAM_ROLE parameter.

```
IAM_ROLE { default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' }
```

For more information, see Role-based access control.

Using the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters

ACCESS_KEY_ID, SECRET_ACCESS_KEY

This authorization method is not recommended.

> **Note**
>
> Instead of providing access credentials as plain text, we strongly recommend using role-based authentication by specifying the IAM_ROLE parameter. For more information, see [Role-based access control](#).

SESSION_TOKEN

The session token for use with temporary access credentials. When SESSION_TOKEN is specified, you must also use ACCESS_KEY_ID and SECRET_ACCESS_KEY to provide temporary access key credentials. If you specify SESSION_TOKEN you can't use IAM_ROLE or CREDENTIALS. For more information, see [Temporary security credentials](#) in the IAM User Guide.

> **Note**
>
> Instead of creating temporary security credentials, we strongly recommend using role-based authentication. When you authorize using an IAM role, Amazon Redshift automatically creates temporary user credentials for each session. For more information, see [Role-based access control](#).

The following shows the syntax for the SESSION_TOKEN parameter with the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters.

```
ACCESS_KEY_ID '<access-key-id>'
SECRET_ACCESS_KEY '<secret-access-key>'
SESSION_TOKEN '<temporary-token>';
```

If you specify SESSION_TOKEN you can't use CREDENTIALS or IAM_ROLE.

Using the CREDENTIALS parameter

CREDENTIALS

A clause that indicates the method your cluster will use when accessing other AWS resources that contain data files or manifest files. You can't use the CREDENTIALS parameter with IAM_ROLE or ACCESS_KEY_ID and SECRET_ACCESS_KEY.

The following shows the syntax for the CREDENTIALS parameter.

```
[WITH] CREDENTIALS [AS] 'credentials-args'
```

Note

For increased flexibility, we recommend using the IAM_ROLE parameter instead of the CREDENTIALS parameter.

Optionally, if the ENCRYPTED parameter is used, the *credentials-args* string also provides the encryption key.

The *credentials-args* string is case-sensitive and must not contain spaces.

The keywords WITH and AS are optional and are ignored.

You can specify either role-based access control or key-based access control. In either case, the IAM role or user must have the permissions required to access the specified AWS resources. For more information, see IAM permissions for COPY, UNLOAD, and CREATE LIBRARY.

Note

To safeguard your AWS credentials and protect sensitive data, we strongly recommend using role-based access control.

To specify role-based access control, provide the *credentials-args* string in the following format.

```
'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
```

To use temporary token credentials, you must provide the temporary access key ID, the temporary secret access key, and the temporary token. The *credentials-args* string is in the following format.

```
CREDENTIALS
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-
access-key>;token=<temporary-token>'
```

A COPY command using role-based access control with temporary credentials would resemble the following sample statement:

```
COPY customer FROM 's3://amzn-s3-demo-bucket/mydata'
CREDENTIALS
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key-id>;token=<temporary-token>'
```

For more information, see Temporary security credentials.

If the ENCRYPTED parameter is used, the *credentials-args* string is in the following format, where *<root-key>* is the value of the root key that was used to encrypt the files.

```
CREDENTIALS
'<credentials-args>;master_symmetric_key=<root-key>'
```

A COPY command using role-based access control with an encryption key would resemble the following sample statement:

```
COPY customer FROM 's3://amzn-s3-demo-bucket/mydata'
CREDENTIALS
'aws_iam_role=arn:aws:iam::<account-id>:role/<role-name>;master_symmetric_key=<root-key>'
```

Column mapping options

By default, COPY inserts values into the target table's columns in the same order as fields occur in the data files. If the default column order will not work, you can specify a column list or use JSONPath expressions to map source data fields to the target columns.

- Column List
- JSONPaths File

Column list

You can specify a comma-separated list of column names to load source data fields into specific target columns. The columns can be in any order in the COPY statement, but when loading from flat files, such as in an Amazon S3 bucket, their order must match the order of the source data.

When loading from an Amazon DynamoDB table, order doesn't matter. The COPY command matches attribute names in the items retrieved from the DynamoDB table to column names in the Amazon Redshift table. For more information, see Loading data from an Amazon DynamoDB table

The format for a column list is as follows.

```
COPY tablename (column1 [,column2, ...])
```

If a column in the target table is omitted from the column list, then COPY loads the target column's DEFAULT expression.

If the target column doesn't have a default, then COPY attempts to load NULL.

If COPY attempts to assign NULL to a column that is defined as NOT NULL, the COPY command fails.

If an IDENTITY column is included in the column list, then EXPLICIT_IDS must also be specified; if an IDENTITY column is omitted, then EXPLICIT_IDS can't be specified. If no column list is specified, the command behaves as if a complete, in-order column list was specified, with IDENTITY columns omitted if EXPLICIT_IDS was also not specified.

If a column is defined with GENERATED BY DEFAULT AS IDENTITY, then it can be copied. Values are generated or updated with values that you supply. The EXPLICIT_IDS option isn't required. COPY doesn't update the identity high watermark. For more information, see GENERATED BY DEFAULT AS IDENTITY.

JSONPaths file

When loading from data files in JSON or Avro format, COPY automatically maps the data elements in the JSON or Avro source data to the columns in the target table. It does so by matching field names in the Avro schema to column names in the target table or column list.

In some cases, your column names and field names don't match, or you need to map to deeper levels in the data hierarchy. In these cases, you can use a JSONPaths file to explicitly map JSON or Avro data elements to columns.

For more information, see JSONPaths file.

Data format parameters

By default, the COPY command expects the source data to be character-delimited UTF-8 text. The default delimiter is a pipe character (|). If the source data is in another format, use the following parameters to specify the data format:

- FORMAT
- CSV

- DELIMITER
- FIXEDWIDTH
- SHAPEFILE
- AVRO
- JSON format for COPY
- PARQUET
- ORC

In addition to the standard data formats, COPY supports the following columnar data formats for COPY from Amazon S3:

- ORC
- PARQUET

COPY from columnar format is supported with certain restriction. For more information, see COPY from columnar data formats.

Data format parameters

FORMAT [AS]

(Optional) Identifies data format keywords. The FORMAT arguments are described following.

CSV [QUOTE [AS] *'quote_character'*]

Enables use of CSV format in the input data. To automatically escape delimiters, newline characters, and carriage returns, enclose the field in the character specified by the QUOTE parameter. The default quotation mark character is a double quotation mark ("). When the quotation mark character is used within a field, escape the character with an additional quotation mark character. For example, if the quotation mark character is a double quotation mark, to insert the string `A "quoted" word` the input file should include the string `"A ""quoted"" word"`. When the CSV parameter is used, the default delimiter is a comma (,). You can specify a different delimiter by using the DELIMITER parameter.

When a field is enclosed in quotation marks, white space between the delimiters and the quotation mark characters is ignored. If the delimiter is a white space character, such as a tab, the delimiter isn't treated as white space.

CSV can't be used with FIXEDWIDTH, REMOVEQUOTES, or ESCAPE.

QUOTE [AS] *'quote_character'*

Optional. Specifies the character to be used as the quotation mark character when using the CSV parameter. The default is a double quotation mark ("). If you use the QUOTE parameter to define a quotation mark character other than double quotation mark, you don't need to escape double quotation marks within the field. The QUOTE parameter can be used only with the CSV parameter. The AS keyword is optional.

DELIMITER [AS] ['*delimiter_char*']

Specifies characters that are used to separate fields in the input file, such as a pipe character (`|`), a comma (`,`), a tab (`\t`), or multiple characters such as `|~|`. Non-printable characters are supported. Characters can also be represented in octal as their UTF-8 code units. For octal, use the format '\ddd', where 'd' is an octal digit (0–7). The default delimiter is a pipe character (`|`), unless the CSV parameter is used, in which case the default delimiter is a comma (`,`). The AS keyword is optional. DELIMITER can't be used with FIXEDWIDTH.

FIXEDWIDTH '*fixedwidth_spec*'

Loads the data from a file where each column width is a fixed length, rather than columns being separated by a delimiter. The *fixedwidth_spec* is a string that specifies a user-defined column label and column width. The column label can be either a text string or an integer, depending on what the user chooses. The column label has no relation to the column name. The order of the label/width pairs must match the order of the table columns exactly. FIXEDWIDTH can't be used with CSV or DELIMITER. In Amazon Redshift, the length of CHAR and VARCHAR columns is expressed in bytes, so be sure that the column width that you specify accommodates the binary length of multibyte characters when preparing the file to be loaded. For more information, see Character types.

The format for *fixedwidth_spec* is shown following:

```
'colLabel1:colWidth1,colLabel:colWidth2, ...'
```

SHAPEFILE [SIMPLIFY [AUTO] ['*tolerance*']]

Enables use of SHAPEFILE format in the input data. By default, the first column of the shapefile is either a `GEOMETRY` or `IDENTITY` column. All subsequent columns follow the order specified in the shapefile.

You can't use SHAPEFILE with FIXEDWIDTH, REMOVEQUOTES, or ESCAPE.

To use `GEOGRAPHY` objects with `COPY FROM SHAPEFILE`, first ingest into a `GEOMETRY` column, and then cast the objects to `GEOGRAPHY` objects. .

SIMPLIFY [*tolerance*]

(Optional) Simplifies all geometries during the ingestion process using the Ramer-Douglas-Peucker algorithm and the given tolerance.

SIMPLIFY AUTO [*tolerance*]

(Optional) Simplifies only geometries that are larger than the maximum geometry size. This simplification uses the Ramer-Douglas-Peucker algorithm and the automatically calculated tolerance if this doesn't exceed the specified tolerance. This algorithm calculates the size to store objects within the tolerance specified. The *tolerance* value is optional.

For examples of loading shapefiles, see Loading a shapefile into Amazon Redshift.

AVRO [AS] '*avro_option*'

Specifies that the source data is in Avro format.

Avro format is supported for COPY from these services and protocols:

- Amazon S3
- Amazon EMR
- Remote hosts (SSH)

Avro isn't supported for COPY from DynamoDB.

Avro is a data serialization protocol. An Avro source file includes a schema that defines the structure of the data. The Avro schema type must be `record`. COPY accepts Avro files created using the default uncompressed codec as well as the `deflate` and `snappy` compression codecs. For more information about Avro, go to Apache Avro.

Valid values for *avro_option* are as follows:

- `'auto'`
- `'auto ignorecase'`
- `'s3://jsonpaths_file'`

The default is `'auto'`.

COPY automatically maps the data elements in the Avro source data to the columns in the target table. It does so by matching field names in the Avro schema to column names in the target table. The matching is case-sensitive for `'auto'` and isn't case-sensitive for `'auto ignorecase'`.

Column names in Amazon Redshift tables are always lowercase, so when you use the `'auto'` option, matching field names must also be lowercase. If the field names aren't all lowercase, you can use the `'auto ignorecase'` option. With the default `'auto'` argument, COPY recognizes only the first level of fields, or *outer fields*, in the structure.

To explicitly map column names to Avro field names, you can use a JSONPaths file.

By default, COPY attempts to match all columns in the target table to Avro field names. To load a subset of the columns, you can optionally specify a column list. If a column in the target table is omitted from the column list, COPY loads the target column's DEFAULT expression. If the target column doesn't have a default, COPY attempts to load NULL. If a column is included in the column list and COPY doesn't find a matching field in the Avro data, COPY attempts to load NULL to the column.

If COPY attempts to assign NULL to a column that is defined as NOT NULL, the COPY command fails.

Avro Schema

An Avro source data file includes a schema that defines the structure of the data. COPY reads the schema that is part of the Avro source data file to map data elements to target table columns. The following example shows an Avro schema.

```
{
    "name": "person",
    "type": "record",
    "fields": [
        {"name": "id", "type": "int"},
        {"name": "guid", "type": "string"},
        {"name": "name", "type": "string"},
        {"name": "address", "type": "string"}]
}
```

The Avro schema is defined using JSON format. The top-level JSON object contains three name-value pairs with the names, or *keys*, `"name"`, `"type"`, and `"fields"`.

The `"fields"` key pairs with an array of objects that define the name and data type of each field in the data structure. By default, COPY automatically matches the field names to column names. Column names are always lowercase, so matching field names must also be lowercase, unless you specify the `‘auto ignorecase’` option. Any field names that don't match a column name are ignored. Order doesn't matter. In the previous example, COPY maps to the column names `id`, `guid`, `name`, and `address`.

With the default `'auto'` argument, COPY matches only the first-level objects to columns. To map to deeper levels in the schema, or if field names and column names don't match, use a JSONPaths file to define the mapping. For more information, see JSONPaths file.

If the value associated with a key is a complex Avro data type such as byte, array, record, map, or link, COPY loads the value as a string. Here, the string is the JSON representation of the data. COPY loads Avro enum data types as strings, where the content is the name of the type. For an example, see COPY from JSON format.

The maximum size of the Avro file header, which includes the schema and file metadata, is 1 MB.

The maximum size of a single Avro data block is 4 MB. This is distinct from the maximum row size. If the maximum size of a single Avro data block is exceeded, even if the resulting row size is less than the 4 MB row-size limit, the COPY command fails.

In calculating row size, Amazon Redshift internally counts pipe characters (|) twice. If your input data contains a very large number of pipe characters, it is possible for row size to exceed 4 MB even if the data block is less than 4 MB.

JSON [AS] '*json_option*'

The source data is in JSON format.

JSON format is supported for COPY from these services and protocols:

- Amazon S3
- COPY from Amazon EMR
- COPY from SSH

JSON isn't supported for COPY from DynamoDB.

Valid values for *json_option* are as follows :

- `'auto'`
- `'auto ignorecase'`
- `'s3://jsonpaths_file'`

- `'noshred'`

The default is `'auto'`. Amazon Redshift doesn't shred the attributes of JSON structures into multiple columns while loading a JSON document.

By default, COPY attempts to match all columns in the target table to JSON field name keys. To load a subset of the columns, you can optionally specify a column list. If the JSON field name keys aren't all lowercase, you can use the `'auto ignorecase'` option or a JSONPaths file to explicitly map column names to JSON field name keys.

If a column in the target table is omitted from the column list, then COPY loads the target column's DEFAULT expression. If the target column doesn't have a default, COPY attempts to load NULL. If a column is included in the column list and COPY doesn't find a matching field in the JSON data, COPY attempts to load NULL to the column.

If COPY attempts to assign NULL to a column that is defined as NOT NULL, the COPY command fails.

COPY maps the data elements in the JSON source data to the columns in the target table. It does so by matching *object keys*, or names, in the source name-value pairs to the names of columns in the target table.

Refer to the following details about each *json_option* value:

'auto'

With this option, matching is case-sensitive. Column names in Amazon Redshift tables are always lowercase, so when you use the `'auto'` option, matching JSON field names must also be lowercase.

'auto ignorecase'

With this option, the matching isn't case-sensitive. Column names in Amazon Redshift tables are always lowercase, so when you use the `'auto ignorecase'` option, the corresponding JSON field names can be lowercase, uppercase, or mixed-case.

's3://*jsonpaths_file*'

With this option, COPY uses the named JSONPaths file to map the data elements in the JSON source data to the columns in the target table. The *`s3://jsonpaths_file`* argument must be an Amazon S3 object key that explicitly references a single file. An example is `'s3://amzn-s3-demo-bucket/jsonpaths.txt`'. The argument can't be a key prefix. For more information about using a JSONPaths file, see the section called "JSONPaths file".

In some cases, the file specified by `jsonpaths_file` has the same prefix as the path specified by `copy_from_s3_objectpath` for the data files. If so, COPY reads the JSONPaths file as a data file and returns errors. For example, suppose that your data files use the object path `s3://amzn-s3-demo-bucket/my_data.json` and your JSONPaths file is `s3://amzn-s3-demo-bucket/my_data.jsonpaths`. In this case, COPY attempts to load `my_data.jsonpaths` as a data file.

'noshred'

With this option, Amazon Redshift doesn't shred the attributes of JSON structures into multiple columns while loading a JSON document.

JSON data file

The JSON data file contains a set of either objects or arrays. COPY loads each JSON object or array into one row in the target table. Each object or array corresponding to a row must be a stand-alone, root-level structure; that is, it must not be a member of another JSON structure.

A JSON *object* begins and ends with braces ({ }) and contains an unordered collection of name-value pairs. Each paired name and value are separated by a colon, and the pairs are separated by commas. By default, the *object key*, or name, in the name-value pairs must match the name of the corresponding column in the table. Column names in Amazon Redshift tables are always lowercase, so matching JSON field name keys must also be lowercase. If your column names and JSON keys don't match, use a the section called "JSONPaths file" to explicitly map columns to keys.

Order in a JSON object doesn't matter. Any names that don't match a column name are ignored. The following shows the structure of a simple JSON object.

```
{
  "column1": "value1",
  "column2": value2,
  "notacolumn" : "ignore this value"
}
```

A JSON *array* begins and ends with brackets ([ ]), and contains an ordered collection of values separated by commas. If your data files use arrays, you must specify a JSONPaths file to match the values to columns. The following shows the structure of a simple JSON array.

```
["value1", value2]
```

The JSON must be well-formed. For example, the objects or arrays can't be separated by commas or any other characters except white space. Strings must be enclosed in double quotation mark characters. Quote characters must be simple quotation marks (0x22), not slanted or "smart" quotation marks.

The maximum size of a single JSON object or array, including braces or brackets, is 4 MB. This is distinct from the maximum row size. If the maximum size of a single JSON object or array is exceeded, even if the resulting row size is less than the 4 MB row-size limit, the COPY command fails.

In calculating row size, Amazon Redshift internally counts pipe characters (|) twice. If your input data contains a very large number of pipe characters, it is possible for row size to exceed 4 MB even if the object size is less than 4 MB.

COPY loads `\n` as a newline character and loads `\t` as a tab character. To load a backslash, escape it with a backslash (`\\`).

COPY searches the specified JSON source for a well-formed, valid JSON object or array. If COPY encounters any non–white-space characters before locating a usable JSON structure, or between valid JSON objects or arrays, COPY returns an error for each instance. These errors count toward the MAXERROR error count. When the error count equals or exceeds MAXERROR, COPY fails.

For each error, Amazon Redshift records a row in the STL_LOAD_ERRORS system table. The LINE_NUMBER column records the last line of the JSON object that caused the error.

If IGNOREHEADER is specified, COPY ignores the specified number of lines in the JSON data. Newline characters in the JSON data are always counted for IGNOREHEADER calculations.

COPY loads empty strings as empty fields by default. If EMPTYASNULL is specified, COPY loads empty strings for CHAR and VARCHAR fields as NULL. Empty strings for other data types, such as INT, are always loaded with NULL.

The following options aren't supported with JSON:

- CSV
- DELIMITER
- ESCAPE

- FILLRECORD
- FIXEDWIDTH
- IGNOREBLANKLINES
- NULL AS
- READRATIO
- REMOVEQUOTES

For more information, see COPY from JSON format. For more information about JSON data structures, go to www.json.org.

JSONPaths file

If you are loading from JSON-formatted or Avro source data, by default COPY maps the first-level data elements in the source data to the columns in the target table. It does so by matching each name, or object key, in a name-value pair to the name of a column in the target table.

If your column names and object keys don't match, or to map to deeper levels in the data hierarchy, you can use a JSONPaths file to explicitly map JSON or Avro data elements to columns. The JSONPaths file maps JSON data elements to columns by matching the column order in the target table or column list.

The JSONPaths file must contain only a single JSON object (not an array). The JSON object is a name-value pair. The *object key*, which is the name in the name-value pair, must be `"jsonpaths"`. The *value* in the name-value pair is an array of *JSONPath expressions*. Each JSONPath expression references a single element in the JSON data hierarchy or Avro schema, similarly to how an XPath expression refers to elements in an XML document. For more information, see JSONPath expressions.

To use a JSONPaths file, add the JSON or AVRO keyword to the COPY command. Specify the S3 bucket name and object path of the JSONPaths file using the following format.

```
COPY tablename
FROM 'data_source'
CREDENTIALS 'credentials-args'
FORMAT AS { AVRO | JSON } 's3://jsonpaths_file';
```

The `s3://jsonpaths_file` value must be an Amazon S3 object key that explicitly references a single file, such as `'s3://amzn-s3-demo-bucket/jsonpaths.txt'`. It can't be a key prefix.

In some cases, if you're loading from Amazon S3 the file specified by `jsonpaths_file` has the same prefix as the path specified by `copy_from_s3_objectpath` for the data files. If so, COPY reads the JSONPaths file as a data file and returns errors. For example, suppose that your data files use the object path `s3://amzn-s3-demo-bucket/my_data.json` and your JSONPaths file is `s3://amzn-s3-demo-bucket/my_data.jsonpaths`. In this case, COPY attempts to load `my_data.jsonpaths` as a data file.

If the key name is any string other than `"jsonpaths"`, the COPY command doesn't return an error, but it ignores *jsonpaths_file* and uses the `'auto'` argument instead.

If any of the following occurs, the COPY command fails:

- The JSON is malformed.
- There is more than one JSON object.
- Any characters except white space exist outside the object.
- An array element is an empty string or isn't a string.

MAXERROR doesn't apply to the JSONPaths file.

The JSONPaths file must not be encrypted, even if the ENCRYPTED option is specified.

For more information, see COPY from JSON format.

JSONPath expressions

The JSONPaths file uses JSONPath expressions to map data fields to target columns. Each JSONPath expression corresponds to one column in the Amazon Redshift target table. The order of the JSONPath array elements must match the order of the columns in the target table or the column list, if a column list is used.

The double quotation mark characters are required as shown, both for the field names and the values. The quotation mark characters must be simple quotation marks (0x22), not slanted or "smart" quotation marks.

If an object element referenced by a JSONPath expression isn't found in the JSON data, COPY attempts to load a NULL value. If the referenced object is malformed, COPY returns a load error.

If an array element referenced by a JSONPath expression isn't found in the JSON or Avro data, COPY fails with the following error: `Invalid JSONPath format: Not an array or index` `out of range`. Remove any array elements from the JSONPaths that don't exist in the source data and verify that the arrays in the source data are well formed.

The JSONPath expressions can use either bracket notation or dot notation, but you can't mix notations. The following example shows JSONPath expressions using bracket notation.

```
{
    "jsonpaths": [
        "$['venuename']",
        "$['venuecity']",
        "$['venuestate']",
        "$['venueseats']"
    ]
}
```

The following example shows JSONPath expressions using dot notation.

```
{
    "jsonpaths": [
        "$.venuename",
        "$.venuecity",
        "$.venuestate",
        "$.venueseats"
    ]
}
```

In the context of Amazon Redshift COPY syntax, a JSONPath expression must specify the explicit path to a single name element in a JSON or Avro hierarchical data structure. Amazon Redshift doesn't support any JSONPath elements, such as wildcard characters or filter expressions, that might resolve to an ambiguous path or multiple name elements.

For more information, see COPY from JSON format.

Using JSONPaths with Avro Data

The following example shows an Avro schema with multiple levels.

```
{
    "name": "person",
    "type": "record",
    "fields": [
```

```
        {"name": "id", "type": "int"},
        {"name": "guid", "type": "string"},
        {"name": "isActive", "type": "boolean"},
        {"name": "age", "type": "int"},
        {"name": "name", "type": "string"},
        {"name": "address", "type": "string"},
        {"name": "latitude", "type": "double"},
        {"name": "longitude", "type": "double"},
        {
            "name": "tags",
            "type": {
                        "type" : "array",
                        "name" : "inner_tags",
                        "items" : "string"
                    }
        },
        {
            "name": "friends",
            "type": {
                        "type" : "array",
                        "name" : "inner_friends",
                        "items" : {
                                    "name" : "friends_record",
                                    "type" : "record",
                                    "fields" : [
                                                 {"name" : "id", "type" : "int"},
                                                 {"name" : "name", "type" : "string"}
                                               ]
                                  }
                    }
        },
        {"name": "randomArrayItem", "type": "string"}
    ]
}
```

The following example shows a JSONPaths file that uses AvroPath expressions to reference the previous schema.

```
{
    "jsonpaths": [
        "$.id",
        "$.guid",
        "$.address",
```

```
        "$.friends[0].id"
    ]
}
```

The JSONPaths example includes the following elements:

jsonpaths

The name of the JSON object that contains the AvroPath expressions.

[…]

Brackets enclose the JSON array that contains the path elements.

$

The dollar sign refers to the root element in the Avro schema, which is the `"fields"` array.

"$.id",

The target of the AvroPath expression. In this instance, the target is the element in the `"fields"` array with the name `"id"`. The expressions are separated by commas.

"$.friends[0].id"

Brackets indicate an array index. JSONPath expressions use zero-based indexing, so this expression references the first element in the `"friends"` array with the name `"id"`.

The Avro schema syntax requires using *inner fields* to define the structure of record and array data types. The inner fields are ignored by the AvroPath expressions. For example, the field `"friends"` defines an array named `"inner_friends"`, which in turn defines a record named `"friends_record"`. The AvroPath expression to reference the field `"id"` can ignore the extra fields to reference the target field directly. The following AvroPath expressions reference the two fields that belong to the `"friends"` array.

```
"$.friends[0].id"
"$.friends[0].name"
```

Columnar data format parameters

In addition to the standard data formats, COPY supports the following columnar data formats for COPY from Amazon S3. COPY from columnar format is supported with certain restrictions. For more information, see COPY from columnar data formats.

ORC

Loads the data from a file that uses Optimized Row Columnar (ORC) file format.

PARQUET

Loads the data from a file that uses Parquet file format.

File compression parameters

You can load from compressed data files by specifying the following parameters.

File compression parameters

BZIP2

A value that specifies that the input file or files are in compressed bzip2 format (.bz2 files). The COPY operation reads each compressed file and uncompresses the data as it loads.

GZIP

A value that specifies that the input file or files are in compressed gzip format (.gz files). The COPY operation reads each compressed file and uncompresses the data as it loads.

LZOP

A value that specifies that the input file or files are in compressed lzop format (.lzo files). The COPY operation reads each compressed file and uncompresses the data as it loads.

> **Note**
>
> COPY doesn't support files that are compressed using the lzop --*filter* option.

ZSTD

A value that specifies that the input file or files are in compressed Zstandard format (.zst files). The COPY operation reads each compressed file and uncompresses the data as it loads.

> **Note**
>
> ZSTD is supported only with COPY from Amazon S3.

Data conversion parameters

As it loads the table, COPY attempts to implicitly convert the strings in the source data to the data type of the target column. If you need to specify a conversion that is different from the default behavior, or if the default conversion results in errors, you can manage data conversions by specifying the following parameters. For more information on the syntax of these parameters, see COPY syntax.

- ACCEPTANYDATE
- ACCEPTINVCHARS
- BLANKSASNULL
- DATEFORMAT
- EMPTYASNULL
- ENCODING
- ESCAPE
- EXPLICIT_IDS
- FILLRECORD
- IGNOREBLANKLINES
- IGNOREHEADER
- NULL AS
- REMOVEQUOTES
- ROUNDEC
- TIMEFORMAT
- TRIMBLANKS
- TRUNCATECOLUMNS

Data conversion parameters

ACCEPTANYDATE

Allows any date format, including invalid formats such as `00/00/00 00:00:00`, to be loaded without generating an error. This parameter applies only to TIMESTAMP and DATE columns. Always use ACCEPTANYDATE with the DATEFORMAT parameter. If the date format for the data doesn't match the DATEFORMAT specification, Amazon Redshift inserts a NULL value into that field.

ACCEPTINVCHARS [AS] ['*replacement_char*']

Enables loading of data into VARCHAR columns even if the data contains invalid UTF-8 characters. When ACCEPTINVCHARS is specified, COPY replaces each invalid UTF-8 character with a string of equal length consisting of the character specified by *replacement_char*. For example, if the replacement character is '^', an invalid three-byte character will be replaced with '^^^'.

The replacement character can be any ASCII character except NULL. The default is a question mark (?). For information about invalid UTF-8 characters, see Multibyte character load errors.

COPY returns the number of rows that contained invalid UTF-8 characters, and it adds an entry to the STL_REPLACEMENTS system table for each affected row, up to a maximum of 100 rows for each node slice. Additional invalid UTF-8 characters are also replaced, but those replacement events aren't recorded.

If ACCEPTINVCHARS isn't specified, COPY returns an error whenever it encounters an invalid UTF-8 character.

ACCEPTINVCHARS is valid only for VARCHAR columns.

BLANKSASNULL

Loads blank fields, which consist of only white space characters, as NULL. This option applies only to CHAR and VARCHAR columns. Blank fields for other data types, such as INT, are always loaded with NULL. For example, a string that contains three space characters in succession (and no other characters) is loaded as a NULL. The default behavior, without this option, is to load the space characters as is.

DATEFORMAT [AS] {'*dateformat_string*' | 'auto' }

If no DATEFORMAT is specified, the default format is `'YYYY-MM-DD'`. For example, an alternative valid format is `'MM-DD-YYYY'`.

If the COPY command doesn't recognize the format of your date or time values, or if your date or time values use different formats, use the `'auto'` argument with the DATEFORMAT or TIMEFORMAT parameter. The `'auto'` argument recognizes several formats that aren't supported when using a DATEFORMAT and TIMEFORMAT string. The `'auto''` keyword is case-sensitive. For more information, see Using automatic recognition with DATEFORMAT and TIMEFORMAT.

The date format can include time information (hour, minutes, seconds), but this information is ignored. The AS keyword is optional. For more information, see DATEFORMAT and TIMEFORMAT strings.

EMPTYASNULL

Indicates that Amazon Redshift should load empty CHAR and VARCHAR fields as NULL. Empty fields for other data types, such as INT, are always loaded with NULL. Empty fields occur when data contains two delimiters in succession with no characters between the delimiters. EMPTYASNULL and NULL AS '' (empty string) produce the same behavior.

ENCODING [AS] *file_encoding*

Specifies the encoding type of the load data. The COPY command converts the data from the specified encoding into UTF-8 during loading.

Valid values for *file_encoding* are as follows:

- `UTF8`
- `UTF16`
- `UTF16LE`
- `UTF16BE`
- `ISO88591`

The default is `UTF8`.

Source file names must use UTF-8 encoding.

The following files must use UTF-8 encoding, even if a different encoding is specified for the load data:

- Manifest files
- JSONPaths files

The argument strings provided with the following parameters must use UTF-8:

- FIXEDWIDTH '*fixedwidth_spec*'
- ACCEPTINVCHARS '*replacement_char*'
- DATEFORMAT '*dateformat_string*'
- TIMEFORMAT '*timeformat_string*'

- NULL AS '*null_string*'

Fixed-width data files must use UTF-8 encoding. The field widths are based on the number of characters, not the number of bytes.

All load data must use the specified encoding. If COPY encounters a different encoding, it skips the file and returns an error.

If you specify `UTF16`, then your data must have a byte order mark (BOM). If you know whether your UTF-16 data is little-endian (LE) or big-endian (BE), you can use `UTF16LE` or `UTF16BE`, regardless of the presence of a BOM.

To use ISO-8859-1 encoding specify `ISO88591`. For more information, see [ISO/IEC 8859-1](ISO/IEC 8859-1) in *Wikipedia*.

ESCAPE

When this parameter is specified, the backslash character (\) in input data is treated as an escape character. The character that immediately follows the backslash character is loaded into the table as part of the current column value, even if it is a character that normally serves a special purpose. For example, you can use this parameter to escape the delimiter character, a quotation mark, an embedded newline character, or the escape character itself when any of these characters is a legitimate part of a column value.

If you specify the ESCAPE parameter in combination with the REMOVEQUOTES parameter, you can escape and retain quotation marks (`'` or `"`) that might otherwise be removed. The default null string, `\N`, works as is, but it can also be escaped in the input data as `\\N`. As long as you don't specify an alternative null string with the NULL AS parameter, `\N` and `\\N` produce the same results.

> **Note**
>
> The control character `0x00` (NUL) can't be escaped and should be removed from the input data or converted. This character is treated as an end of record (EOR) marker, causing the remainder of the record to be truncated.

You can't use the ESCAPE parameter for FIXEDWIDTH loads, and you can't specify the escape character itself; the escape character is always the backslash character. Also, you must ensure that the input data contains the escape character in the appropriate places.

Here are some examples of input data and the resulting loaded data when the ESCAPE parameter is specified. The result for row 4 assumes that the REMOVEQUOTES parameter is also specified. The input data consists of two pipe-delimited fields:

```
1|The quick brown fox\[newline]
jumped over the lazy dog.
2| A\\B\\C
3| A \| B \| C
4| 'A Midsummer Night\'s Dream'
```

The data loaded into column 2 looks like this:

```
The quick brown fox
jumped over the lazy dog.
A\B\C
A|B|C
A Midsummer Night's Dream
```

Note

Applying the escape character to the input data for a load is the responsibility of the user. One exception to this requirement is when you reload data that was previously unloaded with the ESCAPE parameter. In this case, the data will already contain the necessary escape characters.

The ESCAPE parameter doesn't interpret octal, hex, Unicode, or other escape sequence notation. For example, if your source data contains the octal line feed value (`\012`) and you try to load this data with the ESCAPE parameter, Amazon Redshift loads the value `012` into the table and doesn't interpret this value as a line feed that is being escaped.

In order to escape newline characters in data that originates from Microsoft Windows platforms, you might need to use two escape characters: one for the carriage return and one for the line feed. Alternatively, you can remove the carriage returns before loading the file (for example, by using the dos2unix utility).

EXPLICIT_IDS

Use EXPLICIT_IDS with tables that have IDENTITY columns if you want to override the autogenerated values with explicit values from the source data files for the tables. If the command includes a column list, that list must include the IDENTITY columns to use this parameter. The data format for EXPLICIT_IDS values must match the IDENTITY format specified by the CREATE TABLE definition.

When you run a COPY command against a table with the EXPLICIT_IDS option, Amazon Redshift does not check the uniqueness of IDENTITY columns in the table.

If a column is defined with GENERATED BY DEFAULT AS IDENTITY, then it can be copied. Values are generated or updated with values that you supply. The EXPLICIT_IDS option isn't required. COPY doesn't update the identity high watermark.

For an example of a COPY command using EXPLICIT_IDS, see Load VENUE with explicit values for an IDENTITY column.

FILLRECORD

Allows data files to be loaded when contiguous columns are missing at the end of some of the records. The missing columns are loaded as NULLs. For text and CSV formats, if the missing column is a VARCHAR column, zero-length strings are loaded instead of NULLs. To load NULLs to VARCHAR columns from text and CSV, specify the EMPTYASNULL keyword. NULL substitution only works if the column definition allows NULLs.

For example, if the table definition contains four nullable CHAR columns, and a record contains the values `apple, orange, banana, mango`, the COPY command could load and fill in a record that contains only the values `apple, orange`. The missing CHAR values would be loaded as NULL values.

IGNOREBLANKLINES

Ignores blank lines that only contain a line feed in a data file and does not try to load them.

IGNOREHEADER [AS] *number_rows*

Treats the specified *number_rows* as a file header and doesn't load them. Use IGNOREHEADER to skip file headers in all files in a parallel load.

NULL AS '*null_string*'

Loads fields that match *null_string* as NULL, where *null_string* can be any string. If your data includes a null terminator, also referred to as NUL (UTF-8 0000) or binary zero (0x000), COPY treats it as any other character. For example, a record containing '1' || NUL || '2' is copied as string of length 3 bytes. If a field contains only NUL, you can use NULL AS to replace the null terminator with NULL by specifying `'\0'` or `'\000'`—for example, `NULL AS '\0'` or `NULL AS '\000'`. If a field contains a string that ends with NUL and NULL AS is specified, the string is inserted with NUL at the end. Do not use '\n' (newline) for the *null_string* value. Amazon Redshift reserves '\n' for use as a line delimiter. The default *null_string* is `'\N`'.

> **Note**
>
> If you attempt to load nulls into a column defined as NOT NULL, the COPY command will fail.

REMOVEQUOTES

Removes surrounding quotation marks from strings in the incoming data. All characters within the quotation marks, including delimiters, are retained. If a string has a beginning single or double quotation mark but no corresponding ending mark, the COPY command fails to load that row and returns an error. The following table shows some simple examples of strings that contain quotation marks and the resulting loaded values.

Input String	Loaded Value with REMOVEQUOTES Option
"The delimiter is a pipe (|) character"	The delimiter is a pipe (|) character
'Black'	Black
"White"	White
Blue'	Blue'
'Blue	*Value not loaded: error condition*
"Blue	*Value not loaded: error condition*
' ' 'Black' ' '	' 'Black' '
' '	*<white space>*

ROUNDEC

Rounds up numeric values when the scale of the input value is greater than the scale of the column. By default, COPY truncates values when necessary to fit the scale of the column. For example, if a value of `20.259` is loaded into a DECIMAL(8,2) column, COPY truncates the value to `20.25` by default. If ROUNDEC is specified, COPY rounds the value to `20.26`. The INSERT command always rounds values when necessary to match the column's scale, so a COPY command with the ROUNDEC parameter behaves the same as an INSERT command.

TIMEFORMAT [AS] {'*timeformat_string*' | 'auto' | 'epochsecs' | 'epochmillisecs' }

Specifies the time format. If no TIMEFORMAT is specified, the default format is `YYYY-MM-DD HH:MI:SS` for TIMESTAMP columns or `YYYY-MM-DD HH:MI:SSOF` for TIMESTAMPTZ columns, where `OF` is the offset from Coordinated Universal Time (UTC). You can't include a time zone specifier in the *timeformat_string*. To load TIMESTAMPTZ data that is in a format different from the default format, specify 'auto'; for more information, see Using automatic recognition with DATEFORMAT and TIMEFORMAT. For more information about *timeformat_string*, see DATEFORMAT and TIMEFORMAT strings.

The `'auto'` argument recognizes several formats that aren't supported when using a DATEFORMAT and TIMEFORMAT string. If the COPY command doesn't recognize the format of your date or time values, or if your date and time values use formats different from each other, use the `'auto'` argument with the DATEFORMAT or TIMEFORMAT parameter. For more information, see Using automatic recognition with DATEFORMAT and TIMEFORMAT.

If your source data is represented as epoch time, that is the number of seconds or milliseconds since January 1, 1970, 00:00:00 UTC, specify `'epochsecs'` or `'epochmillisecs'`.

The `'auto'`, `'epochsecs'`, and `'epochmillisecs'` keywords are case-sensitive.

The AS keyword is optional.

TRIMBLANKS

Removes the trailing white space characters from a VARCHAR string. This parameter applies only to columns with a VARCHAR data type.

TRUNCATECOLUMNS

Truncates data in columns to the appropriate number of characters so that it fits the column specification. Applies only to columns with a VARCHAR or CHAR data type, and rows 4 MB or less in size.

Data load operations

Manage the default behavior of the load operation for troubleshooting or to reduce load times by specifying the following parameters.

- COMPROWS
- COMPUPDATE
- IGNOREALLERRORS
- MAXERROR
- NOLOAD
- STATUPDATE

Parameters

COMPROWS *numrows*

Specifies the number of rows to be used as the sample size for compression analysis. The analysis is run on rows from each data slice. For example, if you specify `COMPROWS 1000000` (1,000,000) and the system contains four total slices, no more than 250,000 rows for each slice are read and analyzed.

If COMPROWS isn't specified, the sample size defaults to 100,000 for each slice. Values of COMPROWS lower than the default of 100,000 rows for each slice are automatically upgraded to the default value. However, automatic compression will not take place if the amount of data being loaded is insufficient to produce a meaningful sample.

If the COMPROWS number is greater than the number of rows in the input file, the COPY command still proceeds and runs the compression analysis on all of the available rows. The accepted range for this argument is a number between 1000 and 2147483647 (2,147,483,647).

COMPUPDATE [PRESET | { ON | TRUE } | { OFF | FALSE }],

Controls whether compression encodings are automatically applied during a COPY.

When COMPUPDATE is PRESET, the COPY command chooses the compression encoding for each column if the target table is empty; even if the columns already have encodings other than RAW. Currently specified column encodings can be replaced. Encoding for each column is based on the column data type. No data is sampled. Amazon Redshift automatically assigns compression encoding as follows:

- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR or VARCHAR are assigned LZO compression.

When COMPUPDATE is omitted, the COPY command chooses the compression encoding for each column only if the target table is empty and you have not specified an encoding (other than RAW) for any of the columns. The encoding for each column is determined by Amazon Redshift. No data is sampled.

When COMPUPDATE is ON (or TRUE), or COMPUPDATE is specified without an option, the COPY command applies automatic compression if the table is empty; even if the table columns already have encodings other than RAW. Currently specified column encodings can be replaced. Encoding for each column is based on an analysis of sample data. For more information, see Loading tables with automatic compression.

When COMPUPDATE is OFF (or FALSE), automatic compression is disabled. Column encodings aren't changed.

For information about the system table to analyze compression, see STL_ANALYZE_COMPRESSION.

IGNOREALLERRORS

You can specify this option to ignore all errors that occur during the load operation.

You can't specify the IGNOREALLERRORS option if you specify the MAXERROR option. You can't specify the IGNOREALLERRORS option for columnar formats including ORC and Parquet.

MAXERROR [AS] *error_count*

If the load returns the *error_count* number of errors or greater, the load fails. If the load returns fewer errors, it continues and returns an INFO message that states the number of rows that could not be loaded. Use this parameter to allow loads to continue when certain rows fail to load into the table because of formatting errors or other inconsistencies in the data.

Set this value to `0` or `1` if you want the load to fail as soon as the first error occurs. The AS keyword is optional. The MAXERROR default value is `0` and the limit is `100000`.

The actual number of errors reported might be greater than the specified MAXERROR because of the parallel nature of Amazon Redshift. If any node in the Amazon Redshift cluster detects that MAXERROR has been exceeded, each node reports all of the errors it has encountered.

NOLOAD

Checks the validity of the data file without actually loading the data. Use the NOLOAD parameter to make sure that your data file loads without any errors before running the actual data load. Running COPY with the NOLOAD parameter is much faster than loading the data because it only parses the files.

STATUPDATE [{ ON | TRUE } | { OFF | FALSE }]

Governs automatic computation and refresh of optimizer statistics at the end of a successful COPY command. By default, if the STATUPDATE parameter isn't used, statistics are updated automatically if the table is initially empty.

Whenever ingesting data into a nonempty table significantly changes the size of the table, we recommend updating statistics either by running an ANALYZE command or by using the STATUPDATE ON argument.

With STATUPDATE ON (or TRUE), statistics are updated automatically regardless of whether the table is initially empty. If STATUPDATE is used, the current user must be either the table owner or a superuser. If STATUPDATE is not specified, only INSERT permission is required.

With STATUPDATE OFF (or FALSE), statistics are never updated.

For additional information, see Analyzing tables.

Alphabetical parameter list

The following list provides links to each COPY command parameter description, sorted alphabetically.

- ACCEPTANYDATE
- ACCEPTINVCHARS
- the section called “ACCESS_KEY_ID, SECRET_ACCESS_KEY”
- AVRO
- BLANKSASNULL
- BZIP2

- COMPROWS
- COMPUPDATE
- the section called “CREDENTIALS”
- CSV
- DATEFORMAT
- DELIMITER
- EMPTYASNULL
- ENCODING
- ENCRYPTED
- ESCAPE
- EXPLICIT_IDS
- FILLRECORD
- FIXEDWIDTH
- FORMAT
- FROM
- GZIP
- the section called “IAM_ROLE”
- IGNOREALLERRORS
- IGNOREBLANKLINES
- IGNOREHEADER
- JSON format for COPY
- LZOP
- MANIFEST
- MASTER_SYMMETRIC_KEY
- MAXERROR
- NOLOAD
- NULL AS
- READRATIO
- REGION
- REMOVEQUOTES

- ROUNDEC
- the section called "SESSION_TOKEN"
- SHAPEFILE
- SSH
- STATUPDATE
- TIMEFORMAT
- TRIMBLANKS
- TRUNCATECOLUMNS
- ZSTD

Usage notes

Topics

Permissions to access other AWS Resources

To move data between your cluster and another AWS resource, such as Amazon S3, Amazon DynamoDB, Amazon EMR, or Amazon EC2, your cluster must have permission to access the resource and perform the necessary actions. For example, to load data from Amazon S3, COPY must have LIST access to the bucket and GET access for the bucket objects. For information about minimum permissions, see IAM permissions for COPY, UNLOAD, and CREATE LIBRARY.

To get authorization to access the resource, your cluster must be authenticated. You can choose either of the following authentication methods:

- Role-based access control – For role-based access control, you specify an AWS Identity and Access Management (IAM) role that your cluster uses for authentication and authorization. To safeguard your AWS credentials and sensitive data, we strongly recommend using role-based authentication.
- Key-based access control – For key-based access control, you provide the AWS access credentials (access key ID and secret access key) for a user as plain text.

Role-based access control

With role-based access control, your cluster temporarily assumes an IAM role on your behalf. Then, based on the authorizations granted to the role, your cluster can access the required AWS resources.

Creating an IAM *role* is similar to granting permissions to a user, in that it is an AWS identity with permissions policies that determine what the identity can and can't do in AWS. However, instead of being uniquely associated with one user, a role can be assumed by any entity that needs it. Also, a role doesn’t have any credentials (a password or access keys) associated with it. Instead, if a role is associated with a cluster, access keys are created dynamically and provided to the cluster.

We recommend using role-based access control because it provides more secure, fine-grained control of access to AWS resources and sensitive user data, in addition to safeguarding your AWS credentials.

Role-based authentication delivers the following benefits:

- You can use AWS standard IAM tools to define an IAM role and associate the role with multiple clusters. When you modify the access policy for a role, the changes are applied automatically to all clusters that use the role.
- You can define fine-grained IAM policies that grant permissions for specific clusters and database users to access specific AWS resources and actions.
- Your cluster obtains temporary session credentials at run time and refreshes the credentials as needed until the operation completes. If you use key-based temporary credentials, the operation fails if the temporary credentials expire before it completes.
- Your access key ID and secret access key ID aren't stored or transmitted in your SQL code.

To use role-based access control, you must first create an IAM role using the Amazon Redshift service role type, and then attach the role to your cluster. The role must have, at a minimum, the permissions listed in IAM permissions for COPY, UNLOAD, and CREATE LIBRARY. For steps to create an IAM role and attach it to your cluster, see Authorizing Amazon Redshift to Access Other AWS Services On Your Behalf in the *Amazon Redshift Management Guide*.

You can add a role to a cluster or view the roles associated with a cluster by using the Amazon Redshift Management Console, CLI, or API. For more information, see Associating an IAM Role With a Cluster in the *Amazon Redshift Management Guide*.

When you create an IAM role, IAM returns an Amazon Resource Name (ARN) for the role. To specify an IAM role, provide the role ARN with either the the section called "Using IAM_ROLE" parameter or the the section called "Using CREDENTIALS" parameter.

For example, suppose the following role is attached to the cluster.

```
"IamRoleArn": "arn:aws:iam::0123456789012:role/MyRedshiftRole"
```

The following COPY command example uses the IAM_ROLE parameter with the ARN in the previous example for authentication and access to Amazon S3.

```
copy customer from 's3://amzn-s3-demo-bucket/mydata'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The following COPY command example uses the CREDENTIALS parameter to specify the IAM role.

```
copy customer from 's3://amzn-s3-demo-bucket/mydata'
credentials
'aws_iam_role=arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

In addition, a superuser can grant the ASSUMEROLE privilege to database users and groups to provide access to a role for COPY operations. For information, see GRANT.

Key-based access control

With key-based access control, you provide the access key ID and secret access key for an IAM user that is authorized to access the AWS resources that contain the data. You can use either the the section called "Using ACCESS_KEY_ID and SECRET_ACCESS_KEY" parameters together or the the section called "Using CREDENTIALS" parameter.

> **Note**
>
> We strongly recommend using an IAM role for authentication instead of supplying a plain-text access key ID and secret access key. If you choose key-based access control, never use your AWS account (root) credentials. Always create an IAM user and provide that user's access key ID and secret access key. For steps to create an IAM user, see Creating an IAM User in Your AWS Account.

To authenticate using ACCESS_KEY_ID and SECRET_ACCESS_KEY, replace *<access-key-id>* and *<secret-access-key>* with an authorized user's access key ID and full secret access key as shown following.

```
ACCESS_KEY_ID '<access-key-id>'
SECRET_ACCESS_KEY '<secret-access-key>';
```

To authenticate using the CREDENTIALS parameter, replace *<access-key-id>* and *<secret-access-key>* with an authorized user's access key ID and full secret access key as shown following.

```
CREDENTIALS
'aws_access_key_id=<access-key-id>;aws_secret_access_key=<secret-access-key>';
```

The IAM user must have, at a minimum, the permissions listed in IAM permissions for COPY, UNLOAD, and CREATE LIBRARY.

Temporary security credentials

If you are using key-based access control, you can further limit the access users have to your data by using temporary security credentials. Role-based authentication automatically uses temporary credentials.

> **Note**
>
> We strongly recommend using role-based access control instead of creating temporary credentials and providing access key ID and secret access key as plain text. Role-based access control automatically uses temporary credentials.

Temporary security credentials provide enhanced security because they have short lifespans and can't be reused after they expire. The access key ID and secret access key generated with the token can't be used without the token, and a user who has these temporary security credentials can access your resources only until the credentials expire.

To grant users temporary access to your resources, you call AWS Security Token Service (AWS STS) API operations. The AWS STS API operations return temporary security credentials consisting of a security token, an access key ID, and a secret access key. You issue the temporary security credentials to the users who need temporary access to your resources. These users can be existing IAM users, or they can be non-AWS users. For more information about creating temporary security credentials, see Using Temporary Security Credentials in the IAM User Guide.

You can use either the the section called “Using ACCESS_KEY_ID and SECRET_ACCESS_KEY” parameters together with the the section called “SESSION_TOKEN” parameter or the the section called “Using CREDENTIALS” parameter. You must also supply the access key ID and secret access key that were provided with the token.

To authenticate using ACCESS_KEY_ID, SECRET_ACCESS_KEY, and SESSION_TOKEN, replace *<temporary-access-key-id>*, *<temporary-secret-access-key>*, and *<temporary-token>* as shown following.

```
ACCESS_KEY_ID '<temporary-access-key-id>'
SECRET_ACCESS_KEY '<temporary-secret-access-key>'
SESSION_TOKEN '<temporary-token>';
```

To authenticate using CREDENTIALS, include `session_token=<temporary-token>` in the credentials string as shown following.

```
CREDENTIALS
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;session_token=<temporary-token>';
```

The following example shows a COPY command with temporary security credentials.

```
copy table-name
from 's3://objectpath'
access_key_id '<temporary-access-key-id>'
secret_access_key '<temporary-secret-access-key>'
session_token '<temporary-token>';
```

The following example loads the LISTING table with temporary credentials and file encryption.

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listings_pipe.txt'
access_key_id '<temporary-access-key-id>'
secret_access_key '<temporary-secret-access-key>'
session_token '<temporary-token>'
master_symmetric_key '<root-key>'
encrypted;
```

The following example loads the LISTING table using the CREDENTIALS parameter with temporary credentials and file encryption.

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listings_pipe.txt'
credentials
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;session_token=<temporary-token>;master_symmetric_key=<root-key>'
encrypted;
```

Important

The temporary security credentials must be valid for the entire duration of the COPY or UNLOAD operation. If the temporary security credentials expire during the operation, the command fails and the transaction is rolled back. For example, if temporary security credentials expire after 15 minutes and the COPY operation requires one hour, the COPY operation fails before it completes. If you use role-based access, the temporary security credentials are automatically refreshed until the operation completes.

IAM permissions for COPY, UNLOAD, and CREATE LIBRARY

The IAM role or user referenced by the CREDENTIALS parameter must have, at a minimum, the following permissions:

- For COPY from Amazon S3, permission to LIST the Amazon S3 bucket and GET the Amazon S3 objects that are being loaded, and the manifest file, if one is used.
- For COPY from Amazon S3, Amazon EMR, and remote hosts (SSH) with JSON-formatted data, permission to LIST and GET the JSONPaths file on Amazon S3, if one is used.

- For COPY from DynamoDB, permission to SCAN and DESCRIBE the DynamoDB table that is being loaded.
- For COPY from an Amazon EMR cluster, permission for the `ListInstances` action on the Amazon EMR cluster.
- For UNLOAD to Amazon S3, GET, LIST, and PUT permissions for the Amazon S3 bucket to which the data files are being unloaded.
- For CREATE LIBRARY from Amazon S3, permission to LIST the Amazon S3 bucket and GET the Amazon S3 objects being imported.

> **Note**
>
> If you receive the error message `S3ServiceException: Access Denied`, when running a COPY, UNLOAD, or CREATE LIBRARY command, your cluster doesn't have proper access permissions for Amazon S3.

You can manage IAM permissions by attaching an IAM policy to an IAM role that is attached to your cluster, to a user, or to the group to which your user belongs. For example, the `AmazonS3ReadOnlyAccess` managed policy grants LIST and GET permissions to Amazon S3 resources. For more information about IAM policies, see Managing IAM Policies in the *IAM User Guide*.

Using COPY with Amazon S3 access point aliases

COPY supports Amazon S3 access point aliases. For more information, see Using a bucket–style alias for your access point in the *Amazon Simple Storage Service User Guide*.

Loading multibyte data from Amazon S3

If your data includes non-ASCII multibyte characters (such as Chinese or Cyrillic characters), you must load the data to VARCHAR columns. The VARCHAR data type supports four-byte UTF-8 characters, but the CHAR data type only accepts single-byte ASCII characters. You can't load five-byte or longer characters into Amazon Redshift tables. For more information, see Multibyte characters.

Loading a column of the GEOMETRY or GEOGRAPHY data type

You can COPY to GEOMETRY or GEOGRAPHY columns from data in a character-delimited text file, such as a CSV file. The data must be in the hexadecimal form of the well-known binary format (either WKB or EWKB) or the well-known text format (either WKT or EWKT) and fit within the maximum size of a single input row to the COPY command. For more information, see COPY.

For information about how to load from a shapefile, see Loading a shapefile into Amazon Redshift.

For more information about the GEOMETRY or GEOGRAPHY data type, see Querying spatial data in Amazon Redshift.

Loading the HLLSKETCH data type

You can copy HLL sketches only in sparse or dense format supported by Amazon Redshift. To use the COPY command on HyperLogLog sketches, use the Base64 format for dense HyperLogLog sketches and the JSON format for sparse HyperLogLog sketches. For more information, see HyperLogLog functions.

The following example imports data from a CSV file into a table using CREATE TABLE and COPY. First, the example creates the table t1 using CREATE TABLE.

```
CREATE TABLE t1 (sketch hllsketch, a bigint);
```

Then it uses COPY to import data from a CSV file into the table t1.

```
COPY t1 FROM s3://amzn-s3-demo-bucket/unload/' IAM_ROLE
 'arn:aws:iam::0123456789012:role/MyRedshiftRole' NULL AS 'null' CSV;
```

Loading a column of the VARBYTE data type

You can load data from a file in CSV, Parquet, and ORC format. For CSV, the data is loaded from a file in hexadecimal representation of the VARBYTE data. You can't load VARBYTE data with the FIXEDWIDTH option. The ADDQUOTES or REMOVEQUOTES option of COPY is not supported. A VARBYTE column can't be used as a partition column.

Errors when reading multiple files

The COPY command is atomic and transactional. In other words, even when the COPY command reads data from multiple files, the entire process is treated as a single transaction. If COPY encounters an error reading a file, it automatically retries until the process times out (see statement_timeout) or if data can't be download from Amazon S3 for a prolonged period of time (between 15 and 30 minutes), ensuring that each file is loaded only once. If the COPY command fails, the entire transaction is canceled and all changes are rolled back. For more information about handling load errors, see Troubleshooting data loads.

After a COPY command is successfully initiated, it doesn't fail if the session terminates, for example when the client disconnects. However, if the COPY command is within a BEGIN … END transaction block that doesn't complete because the session terminates, the entire transaction, including the COPY, is rolled back. For more information about transactions, see BEGIN.

COPY from JSON format

The JSON data structure is made up of a set of objects or arrays. A JSON *object* begins and ends with braces, and contains an unordered collection of name-value pairs. Each name and value are separated by a colon, and the pairs are separated by commas. The name is a string in double quotation marks. The quotation mark characters must be simple quotation marks (0x22), not slanted or "smart" quotation marks.

A JSON *array* begins and ends with brackets, and contains an ordered collection of values separated by commas. A value can be a string in double quotation marks, a number, a Boolean true or false, null, a JSON object, or an array.

JSON objects and arrays can be nested, enabling a hierarchical data structure. The following example shows a JSON data structure with two valid objects.

```
{
    "id": 1006410,
    "title": "Amazon Redshift Database Developer Guide"
}
{
    "id": 100540,
    "name": "Amazon Simple Storage Service User Guide"
}
```

The following shows the same data as two JSON arrays.

```
[
    1006410,
    "Amazon Redshift Database Developer Guide"
```

```
]
[
    100540,
    "Amazon Simple Storage Service User Guide"
]
```

COPY options for JSON

You can specify the following options when using COPY with JSON format data:

- `'auto'` – COPY automatically loads fields from the JSON file.
- `'auto ignorecase'` – COPY automatically loads fields from the JSON file while ignoring the case of field names.
- `s3://jsonpaths_file` – COPY uses a JSONPaths file to parse the JSON source data. A *JSONPaths file* is a text file that contains a single JSON object with the name `"jsonpaths"` paired with an array of JSONPath expressions. If the name is any string other than `"jsonpaths"`, COPY uses the `'auto'` argument instead of using the JSONPaths file.

For examples that show how to load data using `'auto'`, `'auto ignorecase'`, or a JSONPaths file, and using either JSON objects or arrays, see Copy from JSON examples.

JSONPath option

In the Amazon Redshift COPY syntax, a JSONPath expression specifies the explicit path to a single name element in a JSON hierarchical data structure, using either bracket notation or dot notation. Amazon Redshift doesn't support any JSONPath elements, such as wildcard characters or filter expressions, that might resolve to an ambiguous path or multiple name elements. As a result, Amazon Redshift can't parse complex, multi-level data structures.

The following is an example of a JSONPaths file with JSONPath expressions using bracket notation. The dollar sign ($) represents the root-level structure.

```
{
    "jsonpaths": [
       "$['id']",
       "$['store']['book']['title']",
 "$['location'][0]"
    ]
}
```

In the previous example, `$['location'][0]` references the first element in an array. JSON uses zero-based array indexing. Array indexes must be positive integers (greater than or equal to zero).

The following example shows the previous JSONPaths file using dot notation.

```
{
    "jsonpaths": [
       "$.id",
       "$.store.book.title",
 "$.location[0]"
    ]
}
```

You can't mix bracket notation and dot notation in the `jsonpaths` array. Brackets can be used in both bracket notation and dot notation to reference an array element.

When using dot notation, the JSONPath expressions can't contain the following characters:

- Single straight quotation mark (')
- Period, or dot (.)
- Brackets ([ ]) unless used to reference an array element

If the value in the name-value pair referenced by a JSONPath expression is an object or an array, the entire object or array is loaded as a string, including the braces or brackets. For example, suppose that your JSON data contains the following object.

```
{
    "id": 0,
    "guid": "84512477-fa49-456b-b407-581d0d851c3c",
    "isActive": true,
    "tags": [
        "nisi",
        "culpa",
        "ad",
        "amet",
        "voluptate",
        "reprehenderit",
        "veniam"
    ],
    "friends": [
```

```
        {
            "id": 0,
            "name": "Martha Rivera"
        },
        {
            "id": 1,
            "name": "Renaldo"
        }
    ]
}
```

The JSONPath expression `$['tags']` then returns the following value.

```
"["nisi","culpa","ad","amet","voluptate","reprehenderit","veniam"]"
```

The JSONPath expression `$['friends'][1]` then returns the following value.

```
"{"id": 1,"name": "Renaldo"}"
```

Each JSONPath expression in the `jsonpaths` array corresponds to one column in the Amazon Redshift target table. The order of the `jsonpaths` array elements must match the order of the columns in the target table or the column list, if a column list is used.

For examples that show how to load data using either the `'auto'` argument or a JSONPaths file, and using either JSON objects or arrays, see Copy from JSON examples.

For information on how to copy multiple JSON files, see Using a manifest to specify data files.

Escape characters in JSON

COPY loads `\n` as a newline character and loads `\t` as a tab character. To load a backslash, escape it with a backslash (`\\`).

For example, suppose you have the following JSON in a file named `escape.json` in the bucket `s3://amzn-s3-demo-bucket/json/`.

```
{
  "backslash": "This is a backslash: \\",
  "newline": "This sentence\n is on two lines.",
  "tab": "This sentence \t contains a tab."
```

```
}
```

Run the following commands to create the ESCAPES table and load the JSON.

```
create table escapes (backslash varchar(25), newline varchar(35), tab varchar(35));

copy escapes from 's3://amzn-s3-demo-bucket/json/escape.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as json 'auto';
```

Query the ESCAPES table to view the results.

```
select * from escapes;

       backslash        |      newline      |               tab
------------------------+-------------------+----------------------------------
 This is a backslash: \ | This sentence     | This sentence    contains a tab.
                        :  is on two lines.
(1 row)
```

Loss of numeric precision

You might lose precision when loading numbers from data files in JSON format to a column that is defined as a numeric data type. Some floating point values aren't represented exactly in computer systems. As a result, data you copy from a JSON file might not be rounded as you expect. To avoid a loss of precision, we recommend using one of the following alternatives:

- Represent the number as a string by enclosing the value in double quotation characters.
- Use ROUNDEC to round the number instead of truncating.
- Instead of using JSON or Avro files, use CSV, character-delimited, or fixed-width text files.

COPY from columnar data formats

COPY can load data from Amazon S3 in the following columnar formats:

- ORC
- Parquet

For examples of using COPY from columnar data formats, see COPY examples.

COPY supports columnar formatted data with the following considerations:

- The Amazon S3 bucket must be in the same AWS Region as the Amazon Redshift database.
- To access your Amazon S3 data through a VPC endpoint, set up access using IAM policies and IAM roles as described in Using Amazon Redshift Spectrum with Enhanced VPC Routing in the *Amazon Redshift Management Guide*.
- COPY doesn't automatically apply compression encodings.
- Only the following COPY parameters are supported:
  - ACCEPTINVCHARS when copying from an ORC or Parquet file.
  - FILLRECORD
  - FROM
  - IAM_ROLE
  - CREDENTIALS
  - STATUPDATE
  - MANIFEST
  - EXPLICIT_IDS
- If COPY encounters an error while loading, the command fails. ACCEPTANYDATE and MAXERROR aren't supported for columnar data types.
- Error messages are sent to the SQL client. Some errors are logged in STL_LOAD_ERRORS and STL_ERROR.
- COPY inserts values into the target table's columns in the same order as the columns occur in the columnar data files. The number of columns in the target table and the number of columns in the data file must match.
- If the file you specify for the COPY operation includes one of the following extensions, we decompress the data without the need for adding any parameters:
  - `.gz`
  - `.snappy`
  - `.bz2`
- COPY from the Parquet and ORC file formats uses Redshift Spectrum and the bucket access. To use COPY for these formats, be sure there are no IAM policies blocking the use of Amazon S3 presigned URLs. The presigned URLs generated by Amazon Redshift are valid for 1 hour so that Amazon Redshift has enough time to load all the files from the Amazon S3 bucket. A unique presigned URL is generated for each file scanned by COPY from columnar data formats.

For bucket policies that include an `s3:signatureAge` action, make sure to set the value to at least 3,600,000 milliseconds. For more information, see Using Amazon Redshift Spectrum with enhanced VPC routing.

- The REGION parameter is not supported with COPY from columnar data formats. Even if your Amazon S3 bucket and your database are in the same AWS Region, you can encounter an error, such as, REGION argument is not supported for PARQUET based COPY.

DATEFORMAT and TIMEFORMAT strings

The COPY command uses the DATEFORMAT and TIMEFORMAT options to parse date and time values in your source data. DATEFORMAT and TIMEFORMAT are formatted strings that must match the format of your source data's date and time values. For example, a COPY command loading source data with the date value `Jan-01-1999` must include the following DATEFORMAT string:

```
COPY ...
            DATEFORMAT AS 'MON-DD-YYYY'
```

For more information on managing COPY data conversions, see Data conversion parameters.

DATEFORMAT and TIMEFORMAT strings can contain datetime separators (such as '`-`', '`/`', or '`:`'), as well the datepart and timepart formats in the following table.

> **Note**
>
> If you can't match the format of your date or time values with the following dateparts and timeparts, or if you have date and time values that use formats different from each other, use the `'auto'` argument with the DATEFORMAT or TIMEFORMAT parameter. The `'auto'` argument recognizes several formats that aren't supported when using a DATEFORMAT or TIMEFORMAT string. For more information, see Using automatic recognition with DATEFORMAT and TIMEFORMAT.

Datepart or timepart	Meaning
YY	Year without century
YYYY	Year with century

Datepart or timepart	Meaning
MM	Month as a number
MON	Month as a name (abbreviated name or full name)
DD	Day of month as a number
HH or HH24	Hour (24-hour clock) **Note** In DATETIME format strings for SQL functions, HH is the same as HH12. However, in DATEFORMAT and TIMEFORMAT strings for COPY, HH is the same as HH24.
HH12	Hour (12-hour clock)
MI	Minutes
SS	Seconds
AM or PM	Meridian indicator (for 12-hour clock)

The default date format is YYYY-MM-DD. The default timestamp without time zone (TIMESTAMP) format is YYYY-MM-DD HH:MI:SS. The default timestamp with time zone (TIMESTAMPTZ) format is YYYY-MM-DD HH:MI:SSOF, where OF is the offset from UTC (for example, -8:00. You can't include a time zone specifier (TZ, tz, or OF) in the timeformat_string. The seconds (SS) field also supports fractional seconds up to a microsecond level of detail. To load TIMESTAMPTZ data that is in a format different from the default format, specify 'auto'.

Following are some sample dates or times you can encounter in your source data, and the corresponding DATEFORMAT or TIMEFORMAT strings for them.

Example of source data date or time	DATEFORMAT or TIMEFORMAT Syntax
03/31/2003	DATEFORMAT AS 'MM/DD/YYYY'
March 31, 2003	DATEFORMAT AS 'MON DD, YYYY'
03.31.2003 18:45:05 03.31.2003 18:45:05.123456	TIMEFORMAT AS 'MM.DD.YYYY HH:MI:SS'

Example

For an example of using TIMEFORMAT, see Load a timestamp or datestamp.

Using automatic recognition with DATEFORMAT and TIMEFORMAT

If you specify `'auto'` as the argument for the DATEFORMAT or TIMEFORMAT parameter, Amazon Redshift will automatically recognize and convert the date format or time format in your source data. The following shows an example.

```
copy favoritemovies from 'dynamodb://ProductCatalog'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
dateformat 'auto';
```

When used with the `'auto'` argument for DATEFORMAT and TIMEFORMAT, COPY recognizes and converts the date and time formats listed in the table in DATEFORMAT and TIMEFORMAT strings. In addition, the `'auto'` argument recognizes the following formats that aren't supported when using a DATEFORMAT and TIMEFORMAT string.

Format	Example of Valid Input String
ISO 8601	2019-02-11T05:09:12.195Z
Julian	J2451187
BC	Jan-08-95 BC

Format	Example of Valid Input String
YYYYMMDD HHMISS	19960108 040809
YYMMDD HHMISS	960108 040809
YYYY.DDD	1996.008
YYYY-MM-DD HH:MI:SS.SSS	1996-01-08 04:05:06.789
DD Mon HH:MI:SS YYYY TZ	17 Dec 07:37:16 1997 PST
MM/DD/YYYY HH:MI:SS.SS TZ	12/17/1997 07:37:16.00 PST
YYYY-MM-DD HH:MI:SS+/-TZ	1997-12-17 07:37:16-08
DD.MM.YYYY HH:MI:SS TZ	12.17.1997 07:37:16.00 PST

Automatic recognition doesn't support epochsecs and epochmillisecs.

To test whether a date or timestamp value will be automatically converted, use a CAST function to attempt to convert the string to a date or timestamp value. For example, the following commands test the timestamp value `'J2345678 04:05:06.789'`:

```
create table formattest (test char(21));
insert into formattest values('J2345678 04:05:06.789');
select test, cast(test as timestamp) as timestamp, cast(test as date) as date from
 formattest;

        test          |      timestamp      | date
----------------------+---------------------+------------
J2345678 04:05:06.789   1710-02-23 04:05:06 1710-02-23
```

If the source data for a DATE column includes time information, the time component is truncated. If the source data for a TIMESTAMP column omits time information, 00:00:00 is used for the time component.

COPY examples

> **Note**
>
> These examples contain line breaks for readability. Do not include line breaks or spaces in your *credentials-args* string.

Topics

Load FAVORITEMOVIES from an DynamoDB table

The AWS SDKs include a simple example of creating a DynamoDB table called *Movies*. (For this example, see Getting Started with DynamoDB.) The following example loads the Amazon Redshift MOVIES table with data from the DynamoDB table. The Amazon Redshift table must already exist in the database.

```
copy favoritemovies from 'dynamodb://Movies'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
readratio 50;
```

Load LISTING from an Amazon S3 bucket

The following example loads LISTING from an Amazon S3 bucket. The COPY command loads all of the files in the `/data/listing/` folder.

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listing/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

Load LISTING from an Amazon EMR cluster

The following example loads the SALES table with tab-delimited data from lzop-compressed files in an Amazon EMR cluster. COPY loads every file in the `myoutput/` folder that begins with `part-`.

```
copy sales
from 'emr://j-SAMPLE2B500FC/myoutput/part-*'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '\t' lzop;
```

The following example loads the SALES table with JSON formatted data in an Amazon EMR cluster. COPY loads every file in the `myoutput/json/` folder.

```
copy sales
from 'emr://j-SAMPLE2B500FC/myoutput/json/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
JSON 's3://amzn-s3-demo-bucket/jsonpaths.txt';
```

Using a manifest to specify data files

You can use a manifest to ensure that your COPY command loads all of the required files, and only the required files, from Amazon S3. You can also use a manifest when you need to load multiple files from different buckets or files that don't share the same prefix.

For example, suppose that you need to load the following three files: `custdata1.txt`, `custdata2.txt`, and `custdata3.txt`. You could use the following command to load all of the files in `amzn-s3-demo-bucket` that begin with `custdata` by specifying a prefix:

```
copy category
from 's3://amzn-s3-demo-bucket/custdata'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

If only two of the files exist because of an error, COPY loads only those two files and finishes successfully, resulting in an incomplete data load. If the bucket also contains an unwanted file that happens to use the same prefix, such as a file named `custdata.backup` for example, COPY loads that file as well, resulting in unwanted data being loaded.

To ensure that all of the required files are loaded and to prevent unwanted files from being loaded, you can use a manifest file. The manifest is a JSON-formatted text file that lists the files to be processed by the COPY command. For example, the following manifest loads the three files in the previous example.

```
{
   "entries":[
      {
         "url":"s3://amzn-s3-demo-bucket/custdata.1",
         "mandatory":true
      },
      {
         "url":"s3://amzn-s3-demo-bucket/custdata.2",
         "mandatory":true
      },
      {
         "url":"s3://amzn-s3-demo-bucket/custdata.3",
         "mandatory":true
      }
   ]
}
```

The optional `mandatory` flag indicates whether COPY should terminate if the file doesn't exist. The default is `false`. Regardless of any mandatory settings, COPY terminates if no files are found. In this example, COPY returns an error if any of the files isn't found. Unwanted files that might have been picked up if you specified only a key prefix, such as `custdata.backup`, are ignored, because they aren't on the manifest.

When loading from data files in ORC or Parquet format, a `meta` field is required, as shown in the following example.

```
{
   "entries":[
      {
         "url":"s3://amzn-s3-demo-bucket1/orc/2013-10-04-custdata",
         "mandatory":true,
         "meta":{
            "content_length":99
         }
      },
      {
         "url":"s3://amzn-s3-demo-bucket2/orc/2013-10-05-custdata",
         "mandatory":true,
         "meta":{
            "content_length":99
         }
      }
   ]
}
```

The following example uses a manifest named `cust.manifest`.

```
copy customer
from 's3://amzn-s3-demo-bucket/cust.manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as orc
manifest;
```

You can use a manifest to load files from different buckets or files that don't share the same prefix. The following example shows the JSON to load data with files whose names begin with a date stamp.

```
{
```

```
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/2013-10-04-custdata.txt","mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket/2013-10-05-custdata.txt","mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket/2013-10-06-custdata.txt","mandatory":true},
    {"url":"s3://amzn-s3-demo-bucket/2013-10-07-custdata.txt","mandatory":true}
  ]
}
```

The manifest can list files that are in different buckets, as long as the buckets are in the same AWS Region as the cluster.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket1/custdata1.txt","mandatory":false},
    {"url":"s3://amzn-s3-demo-bucket2/custdata1.txt","mandatory":false},
    {"url":"s3://amzn-s3-demo-bucket2/custdata2.txt","mandatory":false}
  ]
}
```

Load LISTING from a pipe-delimited file (default delimiter)

The following example is a very simple case in which no options are specified and the input file contains the default delimiter, a pipe character ('|').

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listings_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

Load LISTING using columnar data in Parquet format

The following example loads data from a folder on Amazon S3 named parquet.

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listings/parquet/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as parquet;
```

Load LISTING using columnar data in ORC format

The following example loads data from a folder on Amazon S3 named `orc`.

```
copy listing
from 's3://amzn-s3-demo-bucket/data/listings/orc/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as orc;
```

Load EVENT with options

The following example loads pipe-delimited data into the EVENT table and applies the following rules:

- If pairs of quotation marks are used to surround any character strings, they are removed.
- Both empty strings and strings that contain blanks are loaded as NULL values.
- The load fails if more than 5 errors are returned.
- Timestamp values must comply with the specified format; for example, a valid timestamp is `2008-09-26 05:43:12`.

```
copy event
from 's3://amzn-s3-demo-bucket/data/allevents_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
removequotes
emptyasnull
blanksasnull
maxerror 5
delimiter '|'
timeformat 'YYYY-MM-DD HH:MI:SS';
```

Load VENUE from a fixed-width data file

```
copy venue
from 's3://amzn-s3-demo-bucket/data/venue_fw.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
fixedwidth 'venueid:3,venuename:25,venuecity:12,venuestate:2,venueseats:6';
```

The preceding example assumes a data file formatted in the same way as the sample data shown. In the sample following, spaces act as placeholders so that all of the columns are the same width as noted in the specification:

```
1  Toyota Park              Bridgeview  IL0
```

```
2   Columbus Crew Stadium    Columbus    OH0
3   RFK Stadium              Washington  DC0
4   CommunityAmerica BallparkKansas City KS0
5   Gillette Stadium         Foxborough  MA68756
```

Load CATEGORY from a CSV file

Suppose you want to load the CATEGORY with the values shown in the following table.

catid	catgroup	catname	catdesc
12	Shows	Musicals	Musical theatre
13	Shows	Plays	All "non-musical" theatre
14	Shows	Opera	All opera, light, and "rock" opera
15	Concerts	Classical	All symphony, concerto, and choir concerts

The following example shows the contents of a text file with the field values separated by commas.

```
12,Shows,Musicals,Musical theatre
13,Shows,Plays,All "non-musical" theatre
14,Shows,Opera,All opera, light, and "rock" opera
15,Concerts,Classical,All symphony, concerto, and choir concerts
```

If you load the file using the DELIMITER parameter to specify comma-delimited input, the COPY command fails because some input fields contain commas. You can avoid that problem by using the CSV parameter and enclosing the fields that contain commas in quotation mark characters. If the quotation mark character appears within a quoted string, you need to escape it by doubling the quotation mark character. The default quotation mark character is a double quotation mark, so you need to escape each double quotation mark with an additional double quotation mark. Your new input file looks something like this.

```
12,Shows,Musicals,Musical theatre
13,Shows,Plays,"All ""non-musical"" theatre"
14,Shows,Opera,"All opera, light, and ""rock"" opera"
15,Concerts,Classical,"All symphony, concerto, and choir concerts"
```

Assuming the file name is `category_csv.txt`, you can load the file by using the following COPY command:

```
copy category
from 's3://amzn-s3-demo-bucket/data/category_csv.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
csv;
```

Alternatively, to avoid the need to escape the double quotation marks in your input, you can specify a different quotation mark character by using the QUOTE AS parameter. For example, the following version of `category_csv.txt` uses '%' as the quotation mark character.

```
12,Shows,Musicals,Musical theatre
13,Shows,Plays,%All "non-musical" theatre%
14,Shows,Opera,%All opera, light, and "rock" opera%
15,Concerts,Classical,%All symphony, concerto, and choir concerts%
```

The following COPY command uses QUOTE AS to load `category_csv.txt`:

```
copy category
from 's3://amzn-s3-demo-bucket/data/category_csv.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
csv quote as '%';
```

Load VENUE with explicit values for an IDENTITY column

The following example assumes that when the VENUE table was created that at least one column (such as the `venueid` column) was specified to be an IDENTITY column. This command overrides the default IDENTITY behavior of autogenerating values for an IDENTITY column and instead loads the explicit values from the venue.txt file. Amazon Redshift does not check if duplicate IDENTITY values are loaded into the table when using the EXLICIT_IDS option.

```
copy venue
from 's3://amzn-s3-demo-bucket/data/venue.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
explicit_ids;
```

Load TIME from a pipe-delimited GZIP file

The following example loads the TIME table from a pipe-delimited GZIP file:

```
copy time
from 's3://amzn-s3-demo-bucket/data/timerows.gz'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
gzip
delimiter '|';
```

Load a timestamp or datestamp

The following example loads data with a formatted timestamp.

> **Note**
>
> The TIMEFORMAT of `HH:MI:SS` can also support fractional seconds beyond the `SS` to a microsecond level of detail. The file `time.txt` used in this example contains one row, `2009-01-12 14:15:57.119568`.

```
copy timestamp1
from 's3://amzn-s3-demo-bucket/data/time.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
timeformat 'YYYY-MM-DD HH:MI:SS';
```

The result of this copy is as follows:

```
select * from timestamp1;
c1
----------------------------
2009-01-12 14:15:57.119568
(1 row)
```

Load data from a file with default values

The following example uses a variation of the VENUE table in the TICKIT database. Consider a VENUE_NEW table defined with the following statement:

```
create table venue_new(
venueid smallint not null,
venuename varchar(100) not null,
venuecity varchar(30),
```

```
venuestate char(2),
venueseats integer not null default '1000');
```

Consider a venue_noseats.txt data file that contains no values for the VENUESEATS column, as shown in the following example:

```
1|Toyota Park|Bridgeview|IL|
2|Columbus Crew Stadium|Columbus|OH|
3|RFK Stadium|Washington|DC|
4|CommunityAmerica Ballpark|Kansas City|KS|
5|Gillette Stadium|Foxborough|MA|
6|New York Giants Stadium|East Rutherford|NJ|
7|BMO Field|Toronto|ON|
8|The Home Depot Center|Carson|CA|
9|Dick's Sporting Goods Park|Commerce City|CO|
10|Pizza Hut Park|Frisco|TX|
```

The following COPY statement will successfully load the table from the file and apply the DEFAULT value ('1000') to the omitted column:

```
copy venue_new(venueid, venuename, venuecity, venuestate)
from 's3://amzn-s3-demo-bucket/data/venue_noseats.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|';
```

Now view the loaded table:

```
select * from venue_new order by venueid;
venueid |         venuename          |    venuecity    | venuestate | venueseats
---------+----------------------------+-----------------+------------+------------
1 | Toyota Park                | Bridgeview      | IL         |       1000
2 | Columbus Crew Stadium      | Columbus        | OH         |       1000
3 | RFK Stadium                | Washington      | DC         |       1000
4 | CommunityAmerica Ballpark  | Kansas City     | KS         |       1000
5 | Gillette Stadium           | Foxborough      | MA         |       1000
6 | New York Giants Stadium    | East Rutherford | NJ         |       1000
7 | BMO Field                  | Toronto         | ON         |       1000
8 | The Home Depot Center      | Carson          | CA         |       1000
9 | Dick's Sporting Goods Park | Commerce City   | CO         |       1000
10 | Pizza Hut Park             | Frisco          | TX         |       1000
(10 rows)
```

For the following example, in addition to assuming that no VENUESEATS data is included in the file, also assume that no VENUENAME data is included:

```
1||Bridgeview|IL|
2||Columbus|OH|
3||Washington|DC|
4||Kansas City|KS|
5||Foxborough|MA|
6||East Rutherford|NJ|
7||Toronto|ON|
8||Carson|CA|
9||Commerce City|CO|
10||Frisco|TX|
```

Using the same table definition, the following COPY statement fails because no DEFAULT value was specified for VENUENAME, and VENUENAME is a NOT NULL column:

```
copy venue(venueid, venuecity, venuestate)
from 's3://amzn-s3-demo-bucket/data/venue_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|';
```

Now consider a variation of the VENUE table that uses an IDENTITY column:

```
create table venue_identity(
venueid int identity(1,1),
venuename varchar(100) not null,
venuecity varchar(30),
venuestate char(2),
venueseats integer not null default '1000');
```

As with the previous example, assume that the VENUESEATS column has no corresponding values in the source file. The following COPY statement successfully loads the table, including the predefined IDENTITY data values instead of autogenerating those values:

```
copy venue(venueid, venuename, venuecity, venuestate)
from 's3://amzn-s3-demo-bucket/data/venue_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|' explicit_ids;
```

This statement fails because it doesn't include the IDENTITY column (VENUEID is missing from the column list) yet includes an EXPLICIT_IDS parameter:

```
copy venue(venuename, venuecity, venuestate)
from 's3://amzn-s3-demo-bucket/data/venue_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|' explicit_ids;
```

This statement fails because it doesn't include an EXPLICIT_IDS parameter:

```
copy venue(venueid, venuename, venuecity, venuestate)
from 's3://amzn-s3-demo-bucket/data/venue_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|';
```

COPY data with the ESCAPE option

The following example shows how to load characters that match the delimiter character (in this case, the pipe character). In the input file, make sure that all of the pipe characters (|) that you want to load are escaped with the backslash character (\). Then load the file with the ESCAPE parameter.

```
$ more redshiftinfo.txt
1|public\|event\|dwuser
2|public\|sales\|dwuser

create table redshiftinfo(infoid int,tableinfo varchar(50));

copy redshiftinfo from 's3://amzn-s3-demo-bucket/data/redshiftinfo.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|' escape;

select * from redshiftinfo order by 1;
infoid |       tableinfo
-------+--------------------
1      | public|event|dwuser
2      | public|sales|dwuser
(2 rows)
```

Without the ESCAPE parameter, this COPY command fails with an `Extra column(s) found` error.

> **Important**
>
> If you load your data using a COPY with the ESCAPE parameter, you must also specify the ESCAPE parameter with your UNLOAD command to generate the reciprocal output file. Similarly, if you UNLOAD using the ESCAPE parameter, you need to use ESCAPE when you COPY the same data.

Copy from JSON examples

In the following examples, you load the CATEGORY table with the following data.

CATID	CATGROUP	CATNAME	CATDESC
1	Sports	MLB	Major League Baseball
2	Sports	NHL	National Hockey League
3	Sports	NFL	National Football League
4	Sports	NBA	National Basketball Association
5	Concerts	Classical	All symphony, concerto, and choir concerts

Topics

Load from JSON data using the 'auto' option

To load from JSON data using the `'auto'` option, the JSON data must consist of a set of objects. The key names must match the column names, but the order doesn't matter. The following shows the contents of a file named `category_object_auto.json`.

```
{
    "catdesc": "Major League Baseball",
    "catid": 1,
    "catgroup": "Sports",
    "catname": "MLB"
}
{
    "catgroup": "Sports",
    "catid": 2,
    "catname": "NHL",
    "catdesc": "National Hockey League"
}
{
    "catid": 3,
    "catname": "NFL",
    "catgroup": "Sports",
    "catdesc": "National Football League"
}
{
    "bogus": "Bogus Sports LLC",
    "catid": 4,
    "catgroup": "Sports",
    "catname": "NBA",
    "catdesc": "National Basketball Association"
}
{
    "catid": 5,
    "catgroup": "Shows",
    "catname": "Musicals",
    "catdesc": "All symphony, concerto, and choir concerts"
}
```

To load from the JSON data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_object_auto.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 'auto';
```

Load from JSON data using the 'auto ignorecase' option

To load from JSON data using the `'auto ignorecase'` option, the JSON data must consist of a set of objects. The case of the key names doesn't have to match the column names and the order doesn't matter. The following shows the contents of a file named `category_object_auto-ignorecase.json`.

```
{
    "CatDesc": "Major League Baseball",
    "CatID": 1,
    "CatGroup": "Sports",
    "CatName": "MLB"
}
{
    "CatGroup": "Sports",
    "CatID": 2,
    "CatName": "NHL",
    "CatDesc": "National Hockey League"
}
{
    "CatID": 3,
    "CatName": "NFL",
    "CatGroup": "Sports",
    "CatDesc": "National Football League"
}
{
    "bogus": "Bogus Sports LLC",
    "CatID": 4,
    "CatGroup": "Sports",
    "CatName": "NBA",
    "CatDesc": "National Basketball Association"
}
{
    "CatID": 5,
    "CatGroup": "Shows",
    "CatName": "Musicals",
    "CatDesc": "All symphony, concerto, and choir concerts"
}
```

To load from the JSON data file in the previous example, run the following COPY command.

```
copy category
```

```
from 's3://amzn-s3-demo-bucket/category_object_auto ignorecase.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 'auto ignorecase';
```

Load from JSON data using a JSONPaths file

If the JSON data objects don't correspond directly to column names, you can use a JSONPaths file to map the JSON elements to columns. The order doesn't matter in the JSON source data, but the order of the JSONPaths file expressions must match the column order. Suppose that you have the following data file, named `category_object_paths.json`.

```
{
    "one": 1,
    "two": "Sports",
    "three": "MLB",
    "four": "Major League Baseball"
}
{
    "three": "NHL",
    "four": "National Hockey League",
    "one": 2,
    "two": "Sports"
}
{
    "two": "Sports",
    "three": "NFL",
    "one": 3,
    "four": "National Football League"
}
{
    "one": 4,
    "two": "Sports",
    "three": "NBA",
    "four": "National Basketball Association"
}
{
    "one": 6,
    "two": "Shows",
    "three": "Musicals",
    "four": "All symphony, concerto, and choir concerts"
}
```

The following JSONPaths file, named `category_jsonpath.json`, maps the source data to the table columns.

```
{
    "jsonpaths": [
        "$['one']",
        "$['two']",
        "$['three']",
        "$['four']"
    ]
}
```

To load from the JSON data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_object_paths.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 's3://amzn-s3-demo-bucket/category_jsonpath.json';
```

Load from JSON arrays using a JSONPaths file

To load from JSON data that consists of a set of arrays, you must use a JSONPaths file to map the array elements to columns. Suppose that you have the following data file, named `category_array_data.json`.

```
[1,"Sports","MLB","Major League Baseball"]
[2,"Sports","NHL","National Hockey League"]
[3,"Sports","NFL","National Football League"]
[4,"Sports","NBA","National Basketball Association"]
[5,"Concerts","Classical","All symphony, concerto, and choir concerts"]
```

The following JSONPaths file, named `category_array_jsonpath.json`, maps the source data to the table columns.

```
{
    "jsonpaths": [
        "$[0]",
        "$[1]",
        "$[2]",
        "$[3]"
    ]
```

```
}
```

To load from the JSON data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_array_data.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 's3://amzn-s3-demo-bucket/category_array_jsonpath.json';
```

Copy from Avro examples

In the following examples, you load the CATEGORY table with the following data.

CATID	CATGROUP	CATNAME	CATDESC
1	Sports	MLB	Major League Baseball
2	Sports	NHL	National Hockey League
3	Sports	NFL	National Football League
4	Sports	NBA	National Basketball Association
5	Concerts	Classical	All symphony, concerto, and choir concerts

Topics

- Load from Avro data using the 'auto' option
- Load from Avro data using the 'auto ignorecase' option
- Load from Avro data using a JSONPaths file

Load from Avro data using the 'auto' option

To load from Avro data using the `'auto'` argument, field names in the Avro schema must match the column names. When using the `'auto'` argument, order doesn't matter. The following shows the schema for a file named `category_auto.avro`.

```
{
    "name": "category",
```

```
    "type": "record",
    "fields": [
        {"name": "catid", "type": "int"},
        {"name": "catdesc", "type": "string"},
        {"name": "catname", "type": "string"},
        {"name": "catgroup", "type": "string"},
}
```

The data in an Avro file is in binary format, so it isn't human-readable. The following shows a JSON representation of the data in the `category_auto.avro` file.

```
{
   "catid": 1,
   "catdesc": "Major League Baseball",
   "catname": "MLB",
   "catgroup": "Sports"
}
{
   "catid": 2,
   "catdesc": "National Hockey League",
   "catname": "NHL",
   "catgroup": "Sports"
}
{
   "catid": 3,
   "catdesc": "National Basketball Association",
   "catname": "NBA",
   "catgroup": "Sports"
}
{
   "catid": 4,
   "catdesc": "All symphony, concerto, and choir concerts",
   "catname": "Classical",
   "catgroup": "Concerts"
}
```

To load from the Avro data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_auto.avro'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as avro 'auto';
```

Load from Avro data using the 'auto ignorecase' option

To load from Avro data using the `'auto ignorecase'` argument, the case of the field names in the Avro schema does not have to match the case of column names. When using the `'auto ignorecase'` argument, order doesn't matter. The following shows the schema for a file named `category_auto-ignorecase.avro`.

```
{
    "name": "category",
    "type": "record",
    "fields": [
        {"name": "CatID", "type": "int"},
        {"name": "CatDesc", "type": "string"},
        {"name": "CatName", "type": "string"},
        {"name": "CatGroup", "type": "string"},
}
```

The data in an Avro file is in binary format, so it isn't human-readable. The following shows a JSON representation of the data in the `category_auto-ignorecase.avro` file.

```
{
   "CatID": 1,
   "CatDesc": "Major League Baseball",
   "CatName": "MLB",
   "CatGroup": "Sports"
}
{
   "CatID": 2,
   "CatDesc": "National Hockey League",
   "CatName": "NHL",
   "CatGroup": "Sports"
}
{
   "CatID": 3,
   "CatDesc": "National Basketball Association",
   "CatName": "NBA",
   "CatGroup": "Sports"
}
{
   "CatID": 4,
   "CatDesc": "All symphony, concerto, and choir concerts",
   "CatName": "Classical",
```

```
   "CatGroup": "Concerts"
}
```

To load from the Avro data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_auto-ignorecase.avro'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as avro 'auto ignorecase';
```

Load from Avro data using a JSONPaths file

If the field names in the Avro schema don't correspond directly to column names, you can use a JSONPaths file to map the schema elements to columns. The order of the JSONPaths file expressions must match the column order.

Suppose that you have a data file named `category_paths.avro` that contains the same data as in the previous example, but with the following schema.

```
{
    "name": "category",
    "type": "record",
    "fields": [
        {"name": "id", "type": "int"},
        {"name": "desc", "type": "string"},
        {"name": "name", "type": "string"},
        {"name": "group", "type": "string"},
        {"name": "region", "type": "string"}
     ]
}
```

The following JSONPaths file, named `category_path.avropath`, maps the source data to the table columns.

```
{
    "jsonpaths": [
        "$['id']",
        "$['group']",
        "$['name']",
        "$['desc']"
    ]
```

```
}
```

To load from the Avro data file in the previous example, run the following COPY command.

```
copy category
from 's3://amzn-s3-demo-bucket/category_object_paths.avro'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format avro 's3://amzn-s3-demo-bucket/category_path.avropath ';
```

Preparing files for COPY with the ESCAPE option

The following example describes how you might prepare data to "escape" newline characters before importing the data into an Amazon Redshift table using the COPY command with the ESCAPE parameter. Without preparing the data to delimit the newline characters, Amazon Redshift returns load errors when you run the COPY command, because the newline character is normally used as a record separator.

For example, consider a file or a column in an external table that you want to copy into an Amazon Redshift table. If the file or column contains XML-formatted content or similar data, you need to make sure that all of the newline characters (\n) that are part of the content are escaped with the backslash character (\).

A file or table containing embedded newlines characters provides a relatively easy pattern to match. Each embedded newline character most likely always follows a > character with potentially some white space characters (`' '` or tab) in between, as you can see in the following example of a text file named `nlTest1.txt`.

```
$ cat nlTest1.txt
<xml start>
<newline characters provide>
<line breaks at the end of each>
<line in content>
</xml>|1000
<xml>
</xml>|2000
```

With the following example, you can run a text-processing utility to pre-process the source file and insert escape characters where needed. (The | character is intended to be used as delimiter to separate column data when copied into an Amazon Redshift table.)

```
$ sed -e ':a;N;$!ba;s/>[[:space:]]*\n/>\\\n/g' nlTest1.txt > nlTest2.txt
```

Similarly, you can use Perl to perform a similar operation:

```
cat nlTest1.txt | perl -p -e 's/>\s*\n/>\\\n/g' > nlTest2.txt
```

To accommodate loading the data from the `nlTest2.txt` file into Amazon Redshift, we created a two-column table in Amazon Redshift. The first column c1, is a character column that holds XML-formatted content from the `nlTest2.txt` file. The second column c2 holds integer values loaded from the same file.

After running the `sed` command, you can correctly load data from the `nlTest2.txt` file into an Amazon Redshift table using the ESCAPE parameter.

Note

When you include the ESCAPE parameter with the COPY command, it escapes a number of special characters that include the backslash character (including newline).

```
copy t2 from 's3://amzn-s3-demo-bucket/data/nlTest2.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
escape
delimiter as '|';

select * from t2 order by 2;

c1             |  c2
-------------+------
<xml start>
<newline characters provide>
<line breaks at the end of each>
<line in content>
</xml>
| 1000
<xml>
</xml>       | 2000
(2 rows)
```

You can prepare data files exported from external databases in a similar way. For example, with an Oracle database, you can use the REPLACE function on each affected column in a table that you want to copy into Amazon Redshift.

```
SELECT c1, REPLACE(c2, \n',\\n' ) as c2 from my_table_with_xml
```

In addition, many database export and extract, transform, load (ETL) tools that routinely process large amounts of data provide options to specify escape and delimiter characters.

Loading a shapefile into Amazon Redshift

The following examples demonstrate how to load an Esri shapefile using COPY. For more information about loading shapefiles, see Loading a shapefile into Amazon Redshift.

Loading a shapefile

The following steps show how to ingest OpenStreetMap data from Amazon S3 using the COPY command. This example assumes that the Norway shapefile archive from the download site of Geofabrik has been uploaded to a private Amazon S3 bucket in your AWS Region. The `.shp`, `.shx`, and `.dbf` files must share the same Amazon S3 prefix and file name.

Ingesting data without simplification

The following commands create tables and ingest data that can fit in the maximum geometry size without any simplification. Open the `gis_osm_natural_free_1.shp` in your preferred GIS software and inspect the columns in this layer. By default, either IDENTITY or GEOMETRY columns are first. When a GEOMETRY column is first, you can create the table as shown following.

```
CREATE TABLE norway_natural (
   wkb_geometry GEOMETRY,
   osm_id BIGINT,
   code INT,
   fclass VARCHAR,
   name VARCHAR);
```

Or, when an IDENTITY column is first, you can create the table as shown following.

```
CREATE TABLE norway_natural_with_id (
   fid INT IDENTITY(1,1),
   wkb_geometry GEOMETRY,
```

```
    osm_id BIGINT,
    code INT,
    fclass VARCHAR,
    name VARCHAR);
```

Now you can ingest the data using COPY.

```
COPY norway_natural FROM 's3://bucket_name/shapefiles/norway/
gis_osm_natural_free_1.shp'
FORMAT SHAPEFILE
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';
INFO: Load into table 'norway_natural' completed, 83891 record(s) loaded successfully
```

Or you can ingest the data as shown following.

```
COPY norway_natural_with_id FROM 's3://bucket_name/shapefiles/norway/
gis_osm_natural_free_1.shp'
FORMAT SHAPEFILE
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';
INFO: Load into table 'norway_natural_with_id' completed, 83891 record(s) loaded
 successfully.
```

Ingesting data with simplification

The following commands create a table and try to ingest data that can't fit in the maximum geometry size without any simplification. Inspect the `gis_osm_water_a_free_1.shp` shapefile and create the appropriate table as shown following.

```
CREATE TABLE norway_water (
    wkb_geometry GEOMETRY,
    osm_id BIGINT,
    code INT,
    fclass VARCHAR,
    name VARCHAR);
```

When the COPY command runs, it results in an error.

```
COPY norway_water FROM 's3://bucket_name/shapefiles/norway/gis_osm_water_a_free_1.shp'
FORMAT SHAPEFILE
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';
```

```
ERROR:  Load into table 'norway_water' failed.  Check 'stl_load_errors' system table
 for details.
```

Querying STL_LOAD_ERRORS shows that the geometry is too large.

```
SELECT line_number, btrim(colname), btrim(err_reason) FROM stl_load_errors WHERE query
 = pg_last_copy_id();
 line_number |    btrim     |                                 btrim
-------------+--------------
+-----------------------------------------------------------------------
     1184705 | wkb_geometry | Geometry size: 1513736 is larger than maximum supported
 size: 1048447
```

To overcome this, the SIMPLIFY AUTO parameter is added to the COPY command to simplify geometries.

```
COPY norway_water FROM 's3://bucket_name/shapefiles/norway/gis_osm_water_a_free_1.shp'
FORMAT SHAPEFILE
SIMPLIFY AUTO
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';

INFO:  Load into table 'norway_water' completed, 1989196 record(s) loaded successfully.
```

To view the rows and geometries that were simplified, query SVL_SPATIAL_SIMPLIFY.

```
SELECT * FROM svl_spatial_simplify WHERE query = pg_last_copy_id();
 query | line_number | maximum_tolerance | initial_size | simplified | final_size |
 final_tolerance
-------+-------------+-------------------+--------------+------------+------------
+----------------------
    20 |     1184704 |                -1 |      1513736 | t          |    1008808 |
 1.276386653895e-05
    20 |     1664115 |                -1 |      1233456 | t          |    1023584 |
 6.11707814796635e-06
```

Using SIMPLIFY AUTO *max_tolerance* with the tolerance lower than the automatically calculated ones probably results in an ingestion error. In this case, use MAXERROR to ignore errors.

```
COPY norway_water FROM 's3://bucket_name/shapefiles/norway/gis_osm_water_a_free_1.shp'
FORMAT SHAPEFILE
```

```
SIMPLIFY AUTO 1.1E-05
MAXERROR 2
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';

INFO:  Load into table 'norway_water' completed, 1989195 record(s) loaded successfully.
INFO:  Load into table 'norway_water' completed, 1 record(s) could not be loaded.
 Check 'stl_load_errors' system table for details.
```

Query SVL_SPATIAL_SIMPLIFY again to identify the record that COPY didn't manage to load.

```
SELECT * FROM svl_spatial_simplify WHERE query = pg_last_copy_id();
 query | line_number | maximum_tolerance | initial_size | simplified | final_size |
 final_tolerance
-------+-------------+-------------------+--------------+------------+------------
+-----------------
    29 |     1184704 |           1.1e-05 |      1513736 | f          |          0 |
           0
    29 |     1664115 |           1.1e-05 |      1233456 | t          |     794432 |
     1.1e-05
```

In this example, the first record didn't manage to fit, so the simplified column is showing false. The second record was loaded within the given tolerance. However, the final size is larger than using the automatically calculated tolerance without specifying the maximum tolerance.

Loading from a compressed shapefile

Amazon Redshift COPY supports ingesting data from a compressed shapefile. All shapefile components must have the same Amazon S3 prefix and the same compression suffix. As an example, suppose that you want to load the data from the previous example. In this case, the files gis_osm_water_a_free_1.shp.gz, gis_osm_water_a_free_1.dbf.gz, and gis_osm_water_a_free_1.shx.gz must share the same Amazon S3 directory. The COPY command requires the GZIP option, and the FROM clause must specify the correct compressed file, as shown following.

```
COPY norway_natural FROM 's3://bucket_name/shapefiles/norway/compressed/
gis_osm_natural_free_1.shp.gz'
FORMAT SHAPEFILE
GZIP
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';
INFO:  Load into table 'norway_natural' completed, 83891 record(s) loaded successfully.
```

Loading data into a table with a different column order

If you have a table that doesn't have GEOMETRY as the first column, you can use column mapping to map columns to the target table. For example, create a table with osm_id specified as a first column.

```
CREATE TABLE norway_natural_order (
   osm_id BIGINT,
   wkb_geometry GEOMETRY,
   code INT,
   fclass VARCHAR,
   name VARCHAR);
```

Then ingest a shapefile using column mapping.

```
COPY norway_natural_order(wkb_geometry, osm_id, code, fclass, name)
FROM 's3://bucket_name/shapefiles/norway/gis_osm_natural_free_1.shp'
FORMAT SHAPEFILE
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/MyRoleName';
INFO:  Load into table 'norway_natural_order' completed, 83891 record(s) loaded
 successfully.
```

Loading data into a table with a geography column

If you have a table that has a GEOGRAPHY column, you first ingest into a GEOMETRY column and then cast the objects to GEOGRAPHY objects. For example, after you copy your shapefile into a GEOMETRY column, alter the table to add a column of the GEOGRAPHY data type.

```
ALTER TABLE norway_natural ADD COLUMN wkb_geography GEOGRAPHY;
```

Then convert geometries to geographies.

```
UPDATE norway_natural SET wkb_geography = wkb_geometry::geography;
```

Optionally, you can drop the GEOMETRY column.

```
ALTER TABLE norway_natural DROP COLUMN wkb_geometry;
```

COPY command with the NOLOAD option

To validate data files before you actually load the data, use the NOLOAD option with the COPY command. Amazon Redshift parses the input file and displays any errors that occur. The following example uses the NOLOAD option and no rows are actually loaded into the table.

```
COPY public.zipcode1
FROM 's3://amzn-s3-demo-bucket/mydata/zipcode.csv'
DELIMITER ';'
IGNOREHEADER 1 REGION 'us-east-1'
NOLOAD
CREDENTIALS 'aws_iam_role=arn:aws:iam::123456789012:role/myRedshiftRole';

Warnings:
Load into table 'zipcode1' completed, 0 record(s) loaded successfully.
```

COPY command with a multibyte delimiter and the ENCODING option

The following example loads LATIN1 from an Amazon S3 file that contains multibyte data. The COPY command specifies the delimiter in octal form `\302\246\303\254` to separate the fields in the input file which is encoded as ISO-8859-1. To specify the same delimiter in UTF-8, specify `DELIMITER '¦ì'`.

```
COPY latin1
FROM 's3://amzn-s3-demo-bucket/multibyte/myfile'
IAM_ROLE 'arn:aws:iam::123456789012:role/myRedshiftRole'
DELIMITER '\302\246\303\254'
ENCODING ISO88591
```

CREATE DATABASE

Creates a new database.

To create a database, you must be a superuser or have the CREATEDB privilege. To create a database associated with a zero-ETL integration, you must be a superuser or have both CREATEDB and CREATEUSER privileges.

You can't run CREATE DATABASE within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

Syntax

```
CREATE DATABASE database_name
[ { [
      FROM INTEGRATION '<integration_id>'[ DATABASE '<source_database>' ]
      [ SET ]
      [ ACCEPTINVCHARS [=] { TRUE | FALSE }]
      [ QUERY_ALL_STATES [=] { TRUE | FALSE }]
      [ REFRESH_INTERVAL <interval> ]
      [ TRUNCATECOLUMNS [=] { TRUE | FALSE } ]
      [ HISTORY_MODE [=] {TRUE | FALSE} ]
    ]
    [ WITH ]
    [ OWNER [=] db_owner ]
    [ CONNECTION LIMIT { limit | UNLIMITED } ]
    [ COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI } ]
    [ ISOLATION LEVEL { SERIALIZABLE | SNAPSHOT } ]
  }
  | { FROM { { ARN '<arn>' } { WITH DATA CATALOG SCHEMA '<schema>' | WITH NO DATA
 CATALOG SCHEMA } } }
  | { IAM_ROLE  {default | 'SESSION' | 'arn:aws:iam::<account-id>:role/<role-name>' } }
  | { [ WITH PERMISSIONS ] FROM DATASHARE datashare_name OF [ ACCOUNT account_id ]
 NAMESPACE namespace_guid }
]
```

Parameters

database_name

Name of the new database. For more information about valid names, see Names and identifiers.

FROM INTEGRATION '<integration_id>' [DATABASE '<source_database>']

Specifies whether to create the database using a zero-ETL integration identifier. You can retrieve the `integration_id` from SVV_INTEGRATION system view. For Aurora PostgreSQL zero-ETL integrations, you also need to specify `source_database` name, which can also be retrieved from SVV_INTEGRATION.

For an example, see Create databases to receive results of zero-ETL integrations. For more information about creating databases with zero-ETL integrations, see Creating destination databases in Amazon Redshift in the *Amazon Redshift Management Guide*.

SET

Optional keyword.

ACCEPTINVCHARS [=] { TRUE | FALSE }

The ACCEPTINVCHARS clause sets whether zero-ETL integration tables continue with ingestion when invalid characters are detected for the VARCHAR data type. When invalid characters are encountered, the invalid character is replaced with a default `?` character.

QUERY_ALL_STATES [=] { TRUE | FALSE }

The QUERY_ALL_STATES clause sets whether zero-ETL integration tables can be queried in all states (`Synced`, `Failed`, `ResyncRequired`, and `ResyncInitiated`). By default, a zero-ETL integration table can only be queried in `Synced` state.

REFRESH_INTERVAL <interval>

The REFRESH_INTERVAL clause sets the approximate time interval, in seconds, to refresh data from the zero-ETL source to the target database. The value can be set 0–432,000 seconds (5 days) for zero-ETL integrations whose source type is Aurora MySQL, Aurora PostgreSQL, or RDS for MySQL. For Amazon DynamoDB zero-ETL integrations, the value can be set 900–432,000 seconds (15 minutes –5 days). The default `interval` is zero (0) seconds for zero-ETL integrations whose source type is Aurora MySQL, Aurora PostgreSQL, or RDS for MySQL. For Amazon DynamoDB zero-ETL integrations, the default `interval` is 900 seconds (15 minutes).

TRUNCATECOLUMNS [=] { TRUE | FALSE }

The TRUNCATECOLUMNS clause sets whether zero-ETL integration tables continue with ingestion when the values for the VARCHAR column or SUPER column attributes are beyond the limit. When `TRUE`, the values are truncated to fit into the column and the values of overflowing JSON attributes are truncated to fit into the SUPER column.

HISTORY_MODE [=] {TRUE | FALSE}

A clause that specifies whether Amazon Redshift will set history mode for all new tables in the specified database. This option is only applicable for databases created for zero-ETL integration.

The HISTORY_MODE clause can be set to `TRUE` or `FALSE`. The default is `FALSE`. For information about HISTORY_MODE, see History mode in the *Amazon Redshift Management Guide*.

WITH

Optional keyword.

OWNER [=] db_owner

Specifies username of database owner.

CONNECTION LIMIT { *limit* | UNLIMITED }

The maximum number of database connections users are permitted to have open concurrently. The limit isn't enforced for superusers. Use the UNLIMITED keyword to permit the maximum number of concurrent connections. A limit on the number of connections for each user might also apply. For more information, see CREATE USER. The default is UNLIMITED. To view current connections, query the STV_SESSIONS system view.

> **Note**
>
> If both user and database connection limits apply, an unused connection slot must be available that is within both limits when a user attempts to connect.

COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI }

A clause that specifies whether string search or comparison is case sensitive or case insensitive. The default is case sensitive.

COLLATE is not supported when you create a database from a datashare.

CASE_SENSITIVE and CS are interchangeable and yield the same results. Similarly, CASE_INSENSITIVE and CI are interchangeable and yield the same results.

ISOLATION LEVEL { SERIALIZABLE | SNAPSHOT }

A clause that specifies the isolation level used when queries run against a database.

- SERIALIZABLE isolation – Provides full serializability for concurrent transactions. For more information, see Serializable isolation.
- SNAPSHOT isolation – Provides an isolation level with protection against update and delete conflicts. This is the default for a database created in a provisioned cluster or serverless namespace.

You can view which concurrency model your database is running as follows:

- Query the STV_DB_ISOLATION_LEVEL catalog view. For more information, see STV_DB_ISOLATION_LEVEL.

```
SELECT * FROM stv_db_isolation_level;
```

- Query the PG_DATABASE_INFO view.

```
SELECT datname, datconfig FROM pg_database_info;
```

  The isolation level per database appears next to the key `concurrency_model`. A value of 1 denotes SNAPSHOT. A value of 2 denotes SERIALIZABLE.

In Amazon Redshift databases, both SERIALIZABLE and SNAPSHOT isolation are types of serializable isolation levels. That is, dirty reads, non-repeatable reads, and phantom reads are prevented according to the SQL standard. Both isolation levels guarantee that a transaction operates on a snapshot of data as it exists when the transaction begins, and that no other transaction can change that snapshot. However, SNAPSHOT isolation doesn't provide full serializability, because it doesn't prevent write skew inserts and updates on different table rows.

The following scenario illustrates write skew updates using the SNAPSHOT isolation level. A table named `Numbers` contains a column named `digits` that contains `0` and `1` values. Each user's UPDATE statement doesn't overlap the other user. However, the `0` and `1` values are swapped. The SQL they run follows this timeline with these results:

Time	User 1 action	User 2 action
1	BEGIN;	
2		BEGIN;
3	SELECT * FROM Number `digits`	

Time	User 1 action	User 2 action
	`` - ----- 0 1 ```	
4		SELECT * FROM Numbers; ``` digits ------ 0 1 ```
5	UPDATE Number SET digits=0 WHERE digits=1	
6	SELECT * FROM Number ``` digits - ----- 0 0 ```	
7	COMMIT	
8		Update Numbers SET digits=1 WHERE digits=0;

Time	User 1 action	User 2 action
9		SELECT * FROM Numbers; `digits` `------` `1` `1`
10		COMMIT;
11	SELECT * FROM Number `digits` `-` `-----` `1` `0`	
12		SELECT * FROM Numbers; `digits` `------` `1` `0`

If the same scenario is run using serializable isolation, then Amazon Redshift terminates user 2 due to a serializable violation and returns error `1023`. For more information, see How to fix serializable isolation errors. In this case, only user 1 can commit successfully. Not all workloads require serializable isolation as a requirement, in which case snapshot isolation suffices as the target isolation level for your database.

FROM ARN '<ARN>'

The AWS Glue database ARN to use to create the database.

{ WITH DATA CATALOG SCHEMA '<schema>' | WITH NO DATA CATALOG SCHEMA }

> **Note**
>
> This parameter is only applicable if your CREATE DATABASE command also uses the FROM ARN parameter.

Specifies whether to create the database using a schema to help access objects in the AWS Glue Data Catalog.

IAM_ROLE { default | 'SESSION' | 'arn:aws:iam::*<AWS account-id>*:role/*<role-name>*' }

> **Note**
>
> This parameter is only applicable if your CREATE DATABASE command also uses the FROM ARN parameter.

If you specify an IAM role that is associated with the cluster when running the CREATE DATABASE command, Amazon Redshift will use the role's credentials when you run queries on the database.

Specifying the `default` keyword means to use the IAM role that's set as the default and associated with the cluster.

Use `'SESSION'` if you connect to your Amazon Redshift cluster using a federated identity and access the tables from the external schema created using this command. For an example of using a federated identity, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift Spectrum external tables, which explains how to configure federated identity.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. As a minimum, the IAM role must have permission to perform a LIST operation on the Amazon S3 bucket to be accessed and a GET operation on the Amazon S3 objects the bucket contains. To learn more about using IAM_ROLE when creating a database using AWS Glue Data Catalog for datashares, see [Working with Lake Formation-managed datashares as a consumer](#).

The following shows the syntax for the IAM_ROLE parameter string for a single ARN.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-name>'
```

You can chain roles so that your cluster can assume another IAM role, possibly belonging to another account. You can chain up to 10 roles. For more information, see [Chaining IAM roles in Amazon Redshift Spectrum](#).

To this IAM role, attach an IAM permissions policy similar to the following.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AccessSecret",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetResourcePolicy",
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret",
                "secretsmanager:ListSecretVersionIds"
            ],
            "Resource": "arn:aws:secretsmanager:us-west-2:123456789012:secret:my-rds-secret-VNenFy"
        },
        {
            "Sid": "VisualEditor1",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetRandomPassword",
                "secretsmanager:ListSecrets"
            ],
            "Resource": "*"
        }
    ]
}
```

For the steps to create an IAM role to use with federated query, see Creating a secret and an IAM role to use federated queries.

> **Note**
>
> Don't include spaces in the list of chained roles.

The following shows the syntax for chaining three roles.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-1-name>,arn:aws:iam::<aws-
account-id>:role/<role-2-name>,arn:aws:iam::<aws-account-id>:role/<role-3-name>'
```

Syntax for using CREATE DATABASE with a datashare

The following syntax describes the CREATE DATABASE command used to create databases from a datashare for sharing data within the same AWS account.

```
CREATE DATABASE database_name
[ [ WITH PERMISSIONS ] FROM DATASHARE datashare_name OF [ ACCOUNT account_id ]
 NAMESPACE namespace_guid
```

The following syntax describes the CREATE DATABASE command used to create databases from a datashare for sharing data across AWS accounts.

```
CREATE DATABASE database_name
[ [ WITH PERMISSIONS ] FROM DATASHARE datashare_name OF ACCOUNT account_id
 NAMESPACE namespace_guid
```

Parameters for using CREATE DATABASE with a datashare

FROM DATASHARE

A keyword that indicates where the datashare is located.

datashare_name

The name of the datashare that the consumer database is created on.

WITH PERMISSIONS

Specifies that the database created from the datashare requires object-level permissions to access individual database objects. Without this clause, users or roles granted the USAGE permission on the database will automatically have access to all database objects in the database.

NAMESPACE *namespace_guid*

A value that specifies the producer namespace that the datashare belongs to.

ACCOUNT *account_id*

A value that specifies the producer account that the datashare belongs to.

Usage notes for CREATE DATABASE for data sharing

As a database superuser, when you use CREATE DATABASE to create databases from datashares within the AWS account, specify the NAMESPACE option. The ACCOUNT option is optional. When you use CREATE DATABASE to create databases from datashares across AWS accounts, specify both the ACCOUNT and NAMESPACE from the producer.

You can create only one consumer database for one datashare on a consumer cluster. You can't create multiple consumer databases referring to the same datashare.

CREATE DATABASE from AWS Glue Data Catalog

To create a database using an AWS Glue database ARN, specify the ARN in your CREATE DATABASE command.

```
CREATE DATABASE sampledb FROM ARN <glue-database-arn> WITH NO DATA CATALOG SCHEMA;
```

Optionally, you can also supply a value into the IAM_ROLE parameter. For more information about the parameter and accepted values, see Parameters.

The following are examples that demonstrate how to create a database from an ARN using an IAM role.

```
CREATE DATABASE sampledb FROM ARN <glue-database-arn> WITH NO DATA CATALOG SCHEMA
 IAM_ROLE <iam-role-arn>
```

```
CREATE DATABASE sampledb FROM ARN <glue-database-arn> WITH NO DATA CATALOG SCHEMA
 IAM_ROLE default;
```

You can also create a database using a DATA CATALOG SCHEMA.

```
CREATE DATABASE sampledb FROM ARN <glue-database-arn> WITH DATA CATALOG SCHEMA
 <sample_schema> IAM_ROLE default;
```

Create databases to receive results of zero-ETL integrations

To create a database using a zero-ETL integration identity, specify the `integration_id` in your CREATE DATABASE command.

```
CREATE DATABASE destination_db_name FROM INTEGRATION 'integration_id';
```

For example, first, retrieve the integration ids from SVV_INTEGRATION;

```
SELECT integration_id FROM SVV_INTEGRATION;
```

Then use one of the integration ids retrieved to create the database that receives zero-ETL integrations.

```
CREATE DATABASE sampledb FROM INTEGRATION 'a1b2c3d4-5678-90ab-cdef-EXAMPLE11111';
```

When the zero-ETL integrations source database is needed, then, for example, specify.

```
CREATE DATABASE sampledb FROM INTEGRATION 'a1b2c3d4-5678-90ab-cdef-EXAMPLE11111'
 DATABASE sourcedb;
```

You can also set a refresh interval for the database. For example, to set the refresh interval to 7,200 seconds for data from a zero-ETL integration source:

```
CREATE DATABASE myacct_mysql FROM INTEGRATION 'a1b2c3d4-5678-90ab-cdef-EXAMPLE11111'
 SET REFRESH_INTERVAL 7200;
```

Query the SVV_INTEGRATION catalog view for information about a zero-ETL integration, such as, integration_id, target_database, source, refresh_interval, and more.

```
SELECT * FROM svv_integration;
```

The following example creates a database from an integration with history mode on.

```
CREATE DATABASE sample_integration_db FROM INTEGRATION 'a1b2c3d4-5678-90ab-cdef-
EXAMPLE11111' SET HISTORY_MODE = true;
```

CREATE DATABASE limits

Amazon Redshift enforces these limits for databases:

- Maximum of 60 user-defined databases per cluster.
- Maximum of 127 bytes for a database name.
- A database name can't be a reserved word.

Database collation

Collation is a set of rules that defines how database engine compares and sorts the character type data in SQL. Case-insensitive collation is the most commonly used collation. Amazon Redshift uses case-insensitive collation to facilitate migration from other data warehouse systems. With the native support of case-insensitive collation, Amazon Redshift continues to use important tuning or optimization methods, such as distribution keys, sort keys, or range restricted scan.

The COLLATE clause specifies the default collation for all CHAR and VARCHAR columns in the database. If CASE_INSENSITIVE is specified, all CHAR or VARCHAR columns use case-insensitive collation. For information about collation, see Collation sequences.

Data inserted or ingested in case-insensitive columns will keep its original case. But all comparison-based string operations including sorting and grouping are case-insensitive. Pattern matching operations such as LIKE predicates, similar to, and regular expression functions are also case-insensitive.

The following SQL operations support applicable collation semantics:

- Comparison operators: =, <>, <, <=, >, >=.
- LIKE operator
- ORDER BY clauses
- GROUP BY clauses
- Aggregate functions that use string comparison, such as MIN and MAX and LISTAGG
- Window functions, such as PARTITION BY clauses and ORDER BY clauses

- Scalar functions greatest() and least(), STRPOS(), REGEXP_COUNT(), REGEXP_REPLACE(), REGEXP_INSTR(), REGEXP_SUBSTR()
- Distinct clause
- UNION, INTERSECT and EXCEPT
- IN LIST

For external queries, including Amazon Redshift Spectrum and Aurora PostgreSQL federated queries, collation of VARCHAR or CHAR column is the same as the current database-level collation.

The following example queries a Amazon Redshift Spectrum table:

```
SELECT ci_varchar FROM spectrum.test_collation
WHERE ci_varchar = 'AMAZON';

ci_varchar
----------
amazon
Amazon
AMAZON
AmaZon
(4 rows)
```

For information on how to create tables using database collation, see CREATE TABLE.

For information on the COLLATE function, see COLLATE function.

Database collation limitations

The following are limitations when working with database collation in Amazon Redshift:

- All system tables or views, including PG catalog tables and Amazon Redshift system tables are case-sensitive.
- When consumer database and producer database have different database-level collations, Amazon Redshift doesn't support cross-database and cross-cluster queries.
- Amazon Redshift doesn't support case-insensitive collation in leader node-only query.

  The following example shows an unsupported case-insensitive query and the error that Amazon Redshift sends:

  ```
  SELECT collate(usename, 'case_insensitive') FROM pg_user;
  ```

```
ERROR:  Case insensitive collation is not supported in leader node only query.
```

- Amazon Redshift doesn't support interaction between case-sensitive and case-insensitive columns, such as comparison, function, join, or set operations.

  The following examples show errors when case-sensitive and case-insensitive columns interact:

```
CREATE TABLE test
  (ci_col varchar(10) COLLATE case_insensitive,
   cs_col varchar(10) COLLATE case_sensitive,
   cint int,
   cbigint bigint);
```

```
SELECT ci_col = cs_col FROM test;
ERROR:  Query with different collations is not supported yet.
```

```
SELECT concat(ci_col, cs_col) FROM test;
ERROR:  Query with different collations is not supported yet.
```

```
SELECT ci_col FROM test UNION SELECT cs_col FROM test;
ERROR:  Query with different collations is not supported yet.
```

```
SELECT * FROM test a, test b WHERE a.ci_col = b.cs_col;
ERROR:  Query with different collations is not supported yet.
```

```
Select Coalesce(ci_col, cs_col) from test;
ERROR:  Query with different collations is not supported yet.
```

```
Select case when cint > 0 then ci_col else cs_col end from test;
ERROR:  Query with different collations is not supported yet.
```

- Amazon Redshift doesn't support collation for SUPER data type. Creating SUPER columns in case-insensitive databases and interactions between SUPER and case-insensitive columns aren't supported.

  The following example creates a table with the SUPER as the data type in the case-insensitive database:

```
CREATE TABLE super_table (a super);
ERROR: SUPER column is not supported in case insensitive database.
```

The following example queries data with a case-insensitive string comparing with the SUPER data:

```
CREATE TABLE test_super_collation
(s super, c varchar(10) COLLATE case_insensitive, i int);
```

```
SELECT s = c FROM test_super_collation;
ERROR:  Coercing from case insensitive string to SUPER is not supported.
```

To make these queries work, use the COLLATE function to convert collation of one column to match the other. For more information, see COLLATE function.

Examples

Creating a database

The following example creates a database named TICKIT and gives ownership to the user DWUSER.

```
create database tickit
with owner dwuser;
```

To view details about databases, query the PG_DATABASE_INFO catalog table.

```
select datname, datdba, datconnlimit
from pg_database_info
where datdba > 1;

 datname     | datdba | datconnlimit
-------------+--------+-------------
 admin       |    100 | UNLIMITED
 reports     |    100 | 100
 tickit      |    100 | 100
```

The following example creates a database named **sampledb** with SNAPSHOT isolation level.

```
CREATE DATABASE sampledb ISOLATION LEVEL SNAPSHOT;
```

The following example creates the database sales_db from the datashare salesshare.

```
CREATE DATABASE sales_db FROM DATASHARE salesshare OF NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

Database collation examples

Creating a case-insensitive database

The following example creates the `sampledb` database, creates the T1 table, and inserts data into the T1 table.

```
create database sampledb collate case_insensitive;
```

Connect to the new database that you just created using your SQL client. When using Amazon Redshift query editor v2, choose the `sampledb` in the **Editor**. When using RSQL, use a command like the following.

```
\connect sampledb;
```

```
CREATE TABLE T1 (
  col1 Varchar(20) distkey sortkey
);
```

```
INSERT INTO T1 VALUES ('bob'), ('john'), ('Mary'), ('JOHN'), ('Bob');
```

Then the query finds results with `John`.

```
SELECT * FROM T1 WHERE col1 = 'John';

 col1
 ------
 john
 JOHN
(2 row)
```

Ordering in a case-insensitive order

The following example shows the case-insensitive ordering with table T1. The ordering of *Bob* and *bob* or *John* and *john* is nondeterministic because they are equal in case-insensitive column.

```
SELECT * FROM T1 ORDER BY 1;

 col1
 ------
 bob
 Bob
 JOHN
 john
 Mary
(5 rows)
```

Similarly, the following example shows case-insensitive ordering with the GROUP BY clause. *Bob* and *bob* are equal and belong to the same group. It is nondeterministic which one shows up in the result.

```
SELECT col1, count(*) FROM T1 GROUP BY 1;

 col1 | count
 -----+------
 Mary |  1
 bob  |  2
 JOHN |  2
(3 rows)
```

Querying with a window function on case-insensitive columns

The following example queries a window function on a case-insensitive column.

```
SELECT col1, rank() over (ORDER BY col1) FROM T1;

 col1 | rank
 -----+------
 bob  |   1
 Bob  |   1
 john |   3
 JOHN |   3
 Mary |   5
```

```
(5 rows)
```

Querying with the DISTINCT keyword

The following example queries the T1 table with the DISTINCT keyword.

```
SELECT DISTINCT col1 FROM T1;

 col1
 ------
 bob
 Mary
 john
(3 rows)
```

Querying with the UNION clause

The following example shows the results from the UNION of the tables T1 and T2.

```
CREATE TABLE T2 AS SELECT * FROM T1;
```

```
SELECT col1 FROM T1 UNION SELECT col1 FROM T2;

 col1
 ------
 john
 bob
 Mary
(3 rows)
```

CREATE DATASHARE

Creates a new datashare in the current database. The owner of this datashare is the issuer of the CREATE DATASHARE command.

Amazon Redshift associates each datashare with a single Amazon Redshift database. You can only add objects from the associated database to a datashare. You can create multiple datashares on the same Amazon Redshift database.

For information about datashares, see Data sharing in Amazon Redshift.

To view information about the datashares, use SHOW DATASHARES.

Required privileges

Following are required privileges for CREATE DATASHARE:

- Superuser
- Users with the CREATE DATASHARE privilege
- Database owner

Syntax

```
CREATE DATASHARE datashare_name
[[SET] PUBLICACCESSIBLE [=] TRUE | FALSE ];
```

Parameters

datashare_name

The name of the datashare. The datashare name must be unique in the cluster namespace.

[[SET] PUBLICACCESSIBLE]

A clause that specifies whether the datashare can be shared to clusters that are publicly accessible.

The default value for `SET PUBLICACCESSIBLE` is `FALSE`.

Usage notes

By default, the owner of the datashare only owns the share but not objects within the share.

Only superusers and the database owner can use CREATE DATASHARE and delegate ALTER privileges to other users or groups.

Examples

The following example creates the datashare `salesshare`.

```
CREATE DATASHARE salesshare;
```

The following example creates the datashare `demoshare` that AWS Data Exchange manages.

```
CREATE DATASHARE demoshare SET PUBLICACCESSIBLE TRUE, MANAGEDBY ADX;
```

CREATE EXTERNAL FUNCTION

Creates a scalar user-defined function (UDF) based on AWS Lambda for Amazon Redshift. For more information about Lambda user-defined functions, see Scalar Lambda UDFs.

Required privileges

Following are required privileges for CREATE EXTERNAL FUNCTION:

- Superuser
- Users with the CREATE [OR REPLACE] EXTERNAL FUNCTION privilege

Syntax

```
CREATE [ OR REPLACE ] EXTERNAL FUNCTION external_fn_name ( [data_type] [, ...] )
RETURNS data_type
{ VOLATILE | STABLE }
LAMBDA 'lambda_fn_name'
IAM_ROLE { default | ‘arn:aws:iam::<AWS account-id>:role/<role-name>’
RETRY_TIMEOUT milliseconds
MAX_BATCH_ROWS count
MAX_BATCH_SIZE size [ KB | MB ];
```

Parameters

OR REPLACE

A clause that specifies that if a function with the same name and input argument data types, or *signature*, as this one already exists, the existing function is replaced. You can only replace a function with a new function that defines an identical set of data types. You must be a superuser to replace a function.

If you define a function with the same name as an existing function but a different signature, you create a new function. In other words, the function name is overloaded. For more information, see Overloading function names.

external_fn_name

The name of the external function. If you specify a schema name (such as myschema.myfunction), the function is created using the specified schema. Otherwise, the function is created in the current schema. For more information about valid names, see Names and identifiers.

We recommend that you prefix all UDF names with `f_`. Amazon Redshift reserves the `f_` prefix for UDF names. By using the `f_` prefix, you help ensure that your UDF name won't conflict with any built-in SQL function names for Amazon Redshift now or in the future. For more information, see Preventing UDF naming conflicts.

data_type

The data type for the input arguments. For more information, see Scalar Python UDFs and Scalar Lambda UDFs.

RETURNS *data_type*

The data type of the value returned by the function. The RETURNS data type can be any standard Amazon Redshift data type. For more information, see Scalar Python UDFs and Scalar Lambda UDFs.

VOLATILE | STABLE

Informs the query optimizer about the volatility of the function.

To get the best optimization, label your function with the strictest volatility category that is valid for it. In order of strictness, beginning with the least strict, the volatility categories are as follows:

- VOLATILE
- STABLE

VOLATILE

Given the same arguments, the function can return different results on successive calls, even for the rows in a single statement. The query optimizer cannot make assumptions about the behavior of a volatile function. A query that uses a volatile function must reevaluate the function for every input.

STABLE

Given the same arguments, the function is guaranteed to return the same results on successive calls processed within a single statement. The function can return different results when called in different statements. This category makes it so the optimizer can reduce the number of times the function is called within a single statement.

Note that if the chosen strictness is not valid for the function, there is a risk that the optimizer might skip some calls based on this strictness. This can result in an incorrect result set.

The IMMUTABLE clause isn't currently supported for Lambda UDFs.

LAMBDA *'lambda_fn_name'*

The name of the function that Amazon Redshift calls.

For steps to create an AWS Lambda function, see Create a Lambda function with the console in the *AWS Lambda Developer Guide*.

For information regarding permissions required for the Lambda function, see AWS Lambda permissions in the *AWS Lambda Developer Guide*.

IAM_ROLE { default | ‘arn:aws:iam::*<AWS account-id>*:role/*<role-name>*’

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE EXTERNAL FUNCTION command runs.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. The CREATE EXTERNAL FUNCTION command is authorized to invoke Lambda functions through this IAM role. If your cluster has an existing IAM role with permissions to invoke Lambda functions attached, you can substitute your role's ARN. For more information, see Configuring the authorization parameter for Lambda UDFs.

The following shows the syntax for the IAM_ROLE parameter.

```
IAM_ROLE 'arn:aws:iam::aws-account-id:role/role-name'
```

RETRY_TIMEOUT *milliseconds*

The amount of total time in milliseconds that Amazon Redshift uses for the delays in retry backoffs.

Instead of retrying immediately for any failed queries, Amazon Redshift performs backoffs and waits for a certain amount of time between retries. Then Amazon Redshift retries the request to rerun the failed query until the sum of all the delays is equal to or exceeds the RETRY_TIMEOUT value that you specified. The default value is 20,000 milliseconds.

When a Lambda function is invoked, Amazon Redshift retries for queries that receive errors such as `TooManyRequestsException`, `EC2ThrottledException`, and `ServiceException`.

You can set the RETRY_TIMEOUT parameter to 0 milliseconds to prevent any retries for a Lambda UDF.

MAX_BATCH_ROWS *count*

The maximum number of rows that Amazon Redshift sends in a single batch request for a single lambda invocation.

This parameter's minimum value is 1. The maximum value is INT_MAX, or 2,147,483,647.

This parameter is optional. The default value is INT_MAX, or 2,147,483,647.

MAX_BATCH_SIZE *size* [KB **|** MB]

The maximum size of the data payload that Amazon Redshift sends in a single batch request for a single lambda invocation.

This parameter's minimum value is 1 KB. The maximum value is 5 MB.

This parameter's default value is 5 MB.

KB and MB are optional. If you don't set the unit of measurement, Amazon Redshift defaults to using KB.

Usage notes

Consider the following when you create Lambda UDFs:

- The order of Lambda function calls on the input arguments isn't fixed or guaranteed. It might vary between instances of running queries, depending on the cluster configuration.
- The functions are not guaranteed to be applied to each input argument once and only once. The interaction between Amazon Redshift and AWS Lambda might lead to repetitive calls with the same inputs.

Examples

Following are examples of using scalar Lambda user-defined functions (UDFs).

Scalar Lambda UDF example using a Node.js Lambda function

The following example creates an external function called `exfunc_sum` that takes two integers as input arguments. This function returns the sum as an integer output. The name of the Lambda function to be called is `lambda_sum`. The language used for this Lambda function is Node.js 12.x. Make sure to specify the IAM role. The example uses `'arn:aws:iam::123456789012:user/johndoe'` as the IAM role.

```
CREATE EXTERNAL FUNCTION exfunc_sum(INT,INT)
RETURNS INT
VOLATILE
LAMBDA 'lambda_sum'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-Exfunc-Test';
```

The Lambda function takes in the request payload and iterates over each row. All the values in a single row are added to calculate the sum for that row, which is saved in the response array. The number of rows in the results array is similar to the number of rows received in the request payload.

The JSON response payload must have the result data in the 'results' field for it to be recognized by the external function. The arguments field in the request sent to the Lambda function contains the data payload. There can be multiple rows in the data payload in case of a batch request. The following Lambda function iterates over all the rows in the request data payload. It also individually iterates over all the values within a single row.

```
exports.handler = async (event) => {
    // The 'arguments' field in the request sent to the Lambda function contains the
 data payload.
    var t1 = event['arguments'];

    // 'len(t1)' represents the number of rows in the request payload.
    // The number of results in the response payload should be the same as the number
 of rows received.
    const resp = new Array(t1.length);

    // Iterating over all the rows in the request payload.
    for (const [i, x] of t1.entries())
```

```
    {
        var sum = 0;
        // Iterating over all the values in a single row.
        for (const y of x) {
            sum = sum + y;
        }
        resp[i] = sum;
    }
    // The 'results' field should contain the results of the lambda call.
    const response = {
        results: resp
    };
    return JSON.stringify(response);
};
```

The following example calls the external function with literal values.

```
select exfunc_sum(1,2);
exfunc_sum
------------
 3
(1 row)
```

The following example creates a table called t_sum with two columns, c1 and c2, of the integer data type and inserts two rows of data. Then the external function is called by passing the column names of this table. The two table rows are sent in a batch request in request payload as a single Lambda invocation.

```
CREATE TABLE t_sum(c1 int, c2 int);
INSERT INTO t_sum VALUES (4,5), (6,7);
SELECT exfunc_sum(c1,c2) FROM t_sum;
 exfunc_sum
---------------
 9
 13
(2 rows)
```

Scalar Lambda UDF example using the RETRY_TIMEOUT attribute

In the following section, you can find an example of how to use the RETRY_TIMEOUT attribute in Lambda UDFs.

AWS Lambda functions have concurrency limits that you can set for each function. For more information on concurrency limits, see [Managing concurrency for a Lambda function]() in the *AWS Lambda Developer Guide* and the post [Managing AWS Lambda Function Concurrency]() on the AWS Compute Blog.

When the number of requests being served by a Lambda UDF exceeds the concurrency limits, the new requests receive the `TooManyRequestsException` error. The Lambda UDF retries on this error until the sum of all the delays between the requests sent to the Lambda function is equal to or exceeds the RETRY_TIMEOUT value that you set. The default RETRY_TIMEOUT value is 20,000 milliseconds.

The following example uses a Lambda function named `exfunc_sleep_3`. This function takes in the request payload, iterates over each row, and converts the input to uppercase. It then sleeps for 3 seconds and returns the result. The language used for this Lambda function is Python 3.8.

The number of rows in the results array is similar to the number of rows received in the request payload. The JSON response payload must have the result data in the `results` field for it to be recognized by the external function. The `arguments` field in the request sent to the Lambda function contains the data payload. In the case of a batch request, multiple rows can appear in the data payload.

The concurrency limit for this function is specifically set to 1 in reserved concurrency to demonstrate the use of the RETRY_TIMEOUT attribute. When the attribute is set to 1, the Lambda function can only serve one request at a time.

```
import json
import time
def lambda_handler(event, context):
    t1 = event['arguments']
    # 'len(t1)' represents the number of rows in the request payload.
    # The number of results in the response payload should be the same as the number of
 rows received.
    resp = [None]*len(t1)

    # Iterating over all rows in the request payload.
    for i, x in enumerate(t1):
        # Iterating over all the values in a single row.
        for j, y in enumerate(x):
            resp[i] = y.upper()

    time.sleep(3)
```

```
    ret = dict()
    ret['results'] = resp
    ret_json = json.dumps(ret)
    return ret_json
```

Following, two additional examples illustrate the RETRY_TIMEOUT attribute. They each invoke a single Lambda UDF. While invoking the Lambda UDF, each example runs the same SQL query to invoke the Lambda UDF from two concurrent database sessions at the same time. When first query that invokes the Lambda UDF is being served by the UDF, the second query receives the `TooManyRequestsException` error. This result occurs because you specifically set the reserved concurrency in the UDF to 1. For information on how to set reserved concurrency for Lambda functions, see Configuring reserved concurrency.

The first example, following, sets the RETRY_TIMEOUT attribute for the Lambda UDF to 0 milliseconds. If the Lambda request receives any exceptions from the Lambda function, Amazon Redshift doesn't make any retries. This result occurs because the RETRY_TIMEOUT attribute is set to 0.

```
CREATE OR REPLACE EXTERNAL FUNCTION exfunc_upper(varchar)
RETURNS varchar
VOLATILE
LAMBDA 'exfunc_sleep_3'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-Exfunc-Test'
RETRY_TIMEOUT 0;
```

With the RETRY_TIMEOUT set to 0, you can run the following two queries from separate database sessions to see different results.

The first SQL query that uses the Lambda UDF runs successfully.

```
select exfunc_upper('Varchar');
 exfunc_upper
 --------------
 VARCHAR
(1 row)
```

The second query, which is run from a separate database session at the same time, receives the `TooManyRequestsException` error.

```
select exfunc_upper('Varchar');
```

```
ERROR:  Rate Exceeded.; Exception: TooManyRequestsException; ShouldRetry: 1
DETAIL:
-----------------------------------------------
error:  Rate Exceeded.; Exception: TooManyRequestsException; ShouldRetry: 1
code:      32103
context:query:     0
location:  exfunc_client.cpp:102
process:   padbmaster [pid=26384]
-----------------------------------------------
```

The second example, following, sets the RETRY_TIMEOUT attribute for the Lambda UDF to 3,000 milliseconds. Even if the second query is run concurrently, the Lambda UDF retries until the total delays is 3,000 milliseconds. Thus, both queries run successfully.

```
CREATE OR REPLACE EXTERNAL FUNCTION exfunc_upper(varchar)
RETURNS varchar
VOLATILE
LAMBDA 'exfunc_sleep_3'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-Exfunc-Test'
RETRY_TIMEOUT 3000;
```

With the RETRY_TIMEOUT set to 3,000 milliseconds, you can run the following two queries from separate database sessions to see the same results.

The first SQL query that runs the Lambda UDF runs successfully.

```
select exfunc_upper('Varchar');
 exfunc_upper
 --------------
 VARCHAR
(1 row)
```

The second query runs concurrently, and the Lambda UDF retries until the total delay is 3,000 milliseconds.

```
select exfunc_upper('Varchar');
 exfunc_upper
--------------
 VARCHAR
(1 row)
```

Scalar Lambda UDF example using a Python Lambda function

The following example creates an external function that is named `exfunc_multiplication` and that multiplies numbers and returns an integer. This example incorporates the success and `error_msg` fields in the Lambda response. The success field is set to false when there is an integer overflow in the multiplication result, and the `error_msg` message is set to `Integer multiplication overflow`. The `exfunc_multiplication` function takes three integers as input arguments and returns the sum as an integer output.

The name of the Lambda function that is called is `lambda_multiplication`. The language used for this Lambda function is Python 3.8. Make sure to specify the IAM role.

```
CREATE EXTERNAL FUNCTION exfunc_multiplication(int, int, int)
RETURNS INT
VOLATILE
LAMBDA 'lambda_multiplication'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-Exfunc-Test';
```

The Lambda function takes in the request payload and iterates over each row. All the values in a single row are multiplied to calculate the result for that row, which is saved in the response list. This example uses a Boolean success value that is set to true by default. If the multiplication result for a row has an integer overflow, then the success value is set to false. Then the iteration loop breaks.

While creating the response payload, if the success value is false, the following Lambda function adds the `error_msg` field in the payload. It also sets the error message to `Integer multiplication overflow`. If the success value is true, then the result data is added in the results field. The number of rows in the results array, if any, is similar to the number of rows received in the request payload.

The arguments field in the request sent to the Lambda function contains the data payload. There can be multiple rows in the data payload in case of a batch request. The following Lambda function iterates over all the rows in the request data payload and individually iterates over all the values within a single row.

```
import json
def lambda_handler(event, context):
    t1 = event['arguments']
    # 'len(t1)' represents the number of rows in the request payload.
```

```
    # The number of results in the response payload should be the same as the number of
 rows received.
    resp = [None]*len(t1)

    # By default success is set to 'True'.
    success = True
    # Iterating over all rows in the request payload.
    for i, x in enumerate(t1):
        mul = 1
        # Iterating over all the values in a single row.
        for j, y in enumerate(x):
            mul = mul*y

        # Check integer overflow.
        if (mul >= 9223372036854775807 or mul <= -9223372036854775808):
            success = False
            break
        else:
            resp[i] = mul
    ret = dict()
    ret['success'] = success
    if not success:
        ret['error_msg'] = "Integer multiplication overflow"
    else:
        ret['results'] = resp
    ret_json = json.dumps(ret)

    return ret_json
```

The following example calls the external function with literal values.

```
SELECT exfunc_multiplication(8, 9, 2);
  exfunc_multiplication
---------------------------
          144
(1 row)
```

The following example creates a table named t_multi with three columns, c1, c2, and c3, of the integer data type. The external function is called by passing the column names of this table. The data is inserted in such a way to cause integer overflow to show how the error is propagated.

```
CREATE TABLE t_multi (c1 int, c2 int, c3 int);
```

```
INSERT INTO t_multi VALUES (2147483647, 2147483647, 4);
SELECT exfunc_multiplication(c1, c2, c3) FROM t_multi;
DETAIL:
  -----------------------------------------------
  error:  Integer multiplication overflow
  code:      32004context:
  context:
  query:     38
  location:  exfunc_data.cpp:276
  process:   query2_16_38 [pid=30494]
  -----------------------------------------------
```

CREATE EXTERNAL MODEL

Topics

- Prerequisites for CREATE EXTERNAL MODEL
- Required privileges
- Cost control
- CREATE EXTERNAL MODEL syntax
- CREATE EXTERNAL MODEL parameters and settings
- CREATE EXTERNAL MODEL inference function parameters

Prerequisites for CREATE EXTERNAL MODEL

Before you use the CREATE EXTERNAL MODEL statement, complete the prerequisites in Cluster setup for using Amazon Redshift ML. The following is a high-level summary of the prerequisites.

- Create an Amazon Redshift cluster with the AWS Management Console or the AWS Command Line Interface (AWS CLI).
- Attach the AWS Identity and Access Management (IAM) policy while creating the cluster.
- To allow Amazon Redshift and Amazon Bedrock to assume the role to interact with other services, add the appropriate trust policy to the IAM role.
- Enable access to the specific LLMs that you want to use from the Amazon Bedrock console.
- (Optional) If you encounter throttling exceptions coming from Amazon Bedrock such as `Too many requests, please wait before trying again`, even with small amounts of data, check the quotas under **Service Quotas** in your Amazon Bedrock account. Check that the applied

account-level quota is at least the same as the AWS default quota value for the **InvokeModel** requests for the model you are using.

For details for the IAM role, trust policy, and other prerequisites, see Cluster setup for using Amazon Redshift ML.

Required privileges

Following are required privileges for CREATE EXTERNAL MODEL:

- Superuser
- Users with the CREATE MODEL privilege
- Roles with the GRANT CREATE MODEL privilege

Cost control

Amazon Redshift ML uses existing cluster resources to create prediction models, so you don't have to pay additional costs. However, AWS charges for using Amazon Bedrock based on the model you select. For more information, see Costs for using Amazon Redshift ML.

CREATE EXTERNAL MODEL syntax

The following is the full syntax of the CREATE EXTERNAL MODEL statement.

```
CREATE EXTERNAL MODEL model_name
FUNCTION function_name
IAM_ROLE {default/'arn:aws:iam::<account-id>:role/<role-name>'}
MODEL_TYPE BEDROCK
SETTINGS (
   MODEL_ID model_id
   [, PROMPT 'prompt prefix']
   [, SUFFIX 'prompt suffix']
   [, REQUEST_TYPE {RAW|UNIFIED}]
   [, RESPONSE_TYPE {VARCHAR|SUPER}]
);
```

The `CREATE EXTERNAL MODEL` command creates an inference function that you use to generate content.

The following is the syntax of an inference function that `CREATE EXTERNAL MODEL` creates using a `REQUEST_TYPE` of `RAW`:

```
SELECT inference_function_name(request_super)
[FROM table];
```

The following is the syntax of an inference function that `CREATE EXTERNAL MODEL` creates using a `REQUEST_TYPE` of `UNIFIED`:

```
SELECT inference_function_name(input_text, [, inference_config [,
 additional_model_request_fields]])
[FROM table];
```

For information about how to use the inference function, see Using an external model for Amazon Redshift ML integration with Amazon Bedrock.

CREATE EXTERNAL MODEL parameters and settings

This section describes the parameters and settings for the `CREATE EXTERNAL MODEL` command.

Topics

- CREATE EXTERNAL MODEL parameters
- CREATE EXTERNAL MODEL settings

CREATE EXTERNAL MODEL parameters

model_name

The name for the external model. The model name in a schema must be unique.

FUNCTION *function_name (data_type [,...])*

The name for the inference function that `CREATE EXTERNAL MODEL` creates. You use the inference function to send requests to Amazon Bedrock and retrieve ML-generated text.

IAM_ROLE *{ default | 'arn:aws:iam::<account-id>:role/<role-name>' }*

The IAM role that Amazon Redshift uses to access Amazon Bedrock. For information about the IAM role, see Creating or updating an IAM role for Amazon Redshift ML integration with Amazon Bedrock.

MODEL_TYPE BEDROCK

Specifies the model type. The only valid value is `BEDROCK`.

SETTINGS (MODEL_ID model_id [,...])

Specifies the external model settings. See the section following for details.

CREATE EXTERNAL MODEL settings

MODEL_ID model_id

The identifier for the external model, for example, `anthropic.claude-v2`. For information about Amazon Bedrock model IDs, see [Amazon Bedrock model IDs](#).

PROMPT 'prompt prefix'

Specifies a static prompt that Amazon Redshift adds to the beginning of every inference request. Only supported with a `REQUEST_TYPE` of `UNIFIED`.

SUFFIX 'prompt suffix'

Specifies a static prompt that Amazon Redshift adds to the end of every inference request. Only supported with a `REQUEST_TYPE` of `UNIFIED`.

REQUEST_TYPE { RAW | UNIFIED }

Specifies the format of the request sent to Amazon Bedrock. Valid values include the following:

- **RAW**: The inference function takes the input as a single super value, and always returns a super value. The format of the super value is specific to to the Amazon Bedrock model selected. A super is a prediction model that combines multiple algorithms to produce a single, improved prediction.
- **UNIFIED**: The inference function uses the unified API. All models have a unified and consistent interface with Amazon Bedrock. This works for all models that support messages. This value is the default.

  For more information, see the [Converse API documentation](#) in the *Amazon Bedrock API documentation*.

RESPONSE_TYPE { VARCHAR | SUPER }

Specifies the format of the response. If the `REQUEST_TYPE` is `RAW`, the `RESPONSE_TYPE` is requred and the only valid value is `SUPER`. For all other `REQUEST TYPE` values, the default value is `VARCHAR`, and `RESPONSE_TYPE` is optional. Valid values include the following:

- **VARCHAR**: Amazon Redshift only returns the text response generated by the model.
- **SUPER**: Amazon Redshift returns the whole response JSON generated by the model as a super. This includes the text response, and information such as the stop reason, and the model input and output token usage. A super is a prediction model that combines multiple algorithms to produce a single, improved prediction.

CREATE EXTERNAL MODEL inference function parameters

This section describes valid parameters for the inference function that the `CREATE EXTERNAL MODEL` command creates.

CREATE EXTERNAL MODEL inference function parameters for `REQUEST_TYPE` of `RAW`

An inference function created with a `REQUEST_TYPE` of `RAW` has one super input argument and always returns a super data type. The syntax of the input super follows the syntax of the request of the specific model selected from Amazon Bedrock.

CREATE EXTERNAL MODEL inference function parameters for `REQUEST_TYPE` of `UNIFIED`

input_text

The text that Amazon Redshift sends to Amazon Bedrock.

inference_config

A super value that contains optional parameters that Amazon Redshift sends to Amazon Bedrock. These can include the following:

- maxTokens
- stopSequences
- temperature
- topP

These parameters are all optional and are all case-sensitive. For information about these parameters, see InferenceConfiguration in the *Amazon Bedrock API Reference*.

CREATE EXTERNAL SCHEMA

Creates a new external schema in the current database. You can use this external schema to connect to Amazon RDS for PostgreSQL or Amazon Aurora PostgreSQL-Compatible Edition databases. You can also create an external schema that references a database in an external data catalog such as AWS Glue, Athena, or a database in an Apache Hive metastore, such as Amazon EMR.

The owner of this schema is the issuer of the CREATE EXTERNAL SCHEMA command. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner. To grant access to the schema to other users or user groups, use the GRANT command.

You can't use the GRANT or REVOKE commands for permissions on an external table. Instead, grant or revoke the permissions on the external schema.

Note

If you currently have Redshift Spectrum external tables in the Amazon Athena data catalog, you can migrate your Athena data catalog to an AWS Glue Data Catalog. To use the AWS Glue Data Catalog with Redshift Spectrum, you might need to change your AWS Identity and Access Management (IAM) policies. For more information, see Upgrading to the AWS Glue Data Catalog in the *Athena User Guide*.

To view details for external schemas, query the SVV_EXTERNAL_SCHEMAS system view.

Syntax

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference data using an external data catalog. For more information, see Amazon Redshift Spectrum.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] local_schema_name
FROM [ [ DATA CATALOG ] | HIVE METASTORE | POSTGRES | MYSQL | KINESIS | MSK | REDSHIFT
 | KAFKA ]
[ DATABASE 'database_name' ]
[ SCHEMA 'schema_name' ]
[ REGION 'aws-region' ]
[ IAM_ROLE [ default | 'SESSION' | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ] ]
[ AUTHENTICATION [ none | iam | mtls] ]
[ AUTHENTICATION_ARN 'acm-certificate-arn' | SECRET_ARN 'ssm-secret- arn' ]
[ URI ['hive_metastore_uri' [ PORT port_number ] | 'hostname' [ PORT port_number ] |
 'Kafka bootstrap URL'] ]
[ CLUSTER_ARN 'arn:aws:kafka:<region>:<AWS account-id>:cluster/msk/<cluster uuid>' ]
[ CATALOG_ROLE [ 'SESSION' | 'catalog-role-arn-string' ] ]
[ CREATE EXTERNAL DATABASE IF NOT EXISTS ]
```

```
[ CATALOG_ID 'Amazon Web Services account ID containing Glue or Lake Formation
 database' ]
```

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference data using a federated query to RDS POSTGRES or Aurora PostgreSQL. You can also create an external schema that references streaming sources, such as Kinesis Data Streams. For more information, see Querying data with federated queries in Amazon Redshift.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] local_schema_name
FROM POSTGRES
DATABASE 'federated_database_name' [SCHEMA 'schema_name']
URI 'hostname' [ PORT port_number ]
IAM_ROLE [ default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ]
SECRET_ARN 'ssm-secret-arn'
```

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference data using a federated query to RDS MySQL or Aurora MySQL. For more information, see Querying data with federated queries in Amazon Redshift.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] local_schema_name
FROM MYSQL
DATABASE 'federated_database_name'
URI 'hostname' [ PORT port_number ]
IAM_ROLE [ default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ]
SECRET_ARN 'ssm-secret-arn'
```

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference data in a Kinesis stream. For more information, see Streaming ingestion to a materialized view.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] schema_name
FROM KINESIS
IAM_ROLE [ default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ]
```

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference the Amazon Managed Streaming for Apache Kafka or Confluent Cloud cluster and its topics to ingest from. To connect, you provide the broker URI. For more information, see Streaming ingestion to a materialized view.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] schema_name
```

```
FROM KAFKA
[ IAM_ROLE [ default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' ] ]
URI 'Kafka bootstrap URI'
AUTHENTICATION [ none | iam | mtls ]
[ AUTHENTICATION_ARN 'acm-certificate-arn' | SECRET_ARN 'ssm-secret- arn' ];
```

The following syntax describes the CREATE EXTERNAL SCHEMA command used to reference data using a cross-database query.

```
CREATE EXTERNAL SCHEMA local_schema_name
FROM  REDSHIFT
DATABASE 'redshift_database_name' SCHEMA 'redshift_schema_name'
```

Parameters

IF NOT EXISTS

A clause that indicates that if the specified schema already exists, the command should make no changes and return a message that the schema exists, rather than terminating with an error. This clause is useful when scripting, so the script doesn't fail if CREATE EXTERNAL SCHEMA tries to create a schema that already exists.

local_schema_name

The name of the new external schema. For more information about valid names, see Names and identifiers.

FROM [DATA CATALOG] | HIVE METASTORE | POSTGRES | MYSQL | KINESIS | MSK | REDSHIFT

A keyword that indicates where the external database is located.

DATA CATALOG indicates that the external database is defined in the Athena data catalog or the AWS Glue Data Catalog.

If the external database is defined in an external Data Catalog in a different AWS Region, the REGION parameter is required. DATA CATALOG is the default.

HIVE METASTORE indicates that the external database is defined in an Apache Hive metastore. If HIVE METASTORE, is specified, URI is required.

POSTGRES indicates that the external database is defined in RDS PostgreSQL or Aurora PostgreSQL.

MYSQL indicates that the external database is defined in RDS MySQL or Aurora MySQL.

KINESIS indicates that the data source is a stream from Kinesis Data Streams.

MSK indicates that the data source is an Amazon MSK provisioned or serverless cluster.

KAFKA indicates that the data source is a Kafka cluster. You can use this keyword for both Amazon MSK and Confluent Cloud.

FROM REDSHIFT

A keyword that indicates that the database is located in Amazon Redshift.

DATABASE '*redshift_database_name*' SCHEMA '*redshift_schema_name*'

The name of the Amazon Redshift database.

The *redshift_schema_name* indicates the schema in Amazon Redshift. The default *redshift_schema_name* is `public`.

DATABASE '*federated_database_name*'

A keyword that indicates the name of the external database in a supported PostgreSQL or MySQL database engine.

[SCHEMA '*schema_name*']

The *schema_name* indicates the schema in a supported PostgreSQL database engine. The default *schema_name* is `public`.

You can't specify a SCHEMA when you set up a federated query to a supported MySQL database engine.

REGION '*aws-region*'

If the external database is defined in an Athena data catalog or the AWS Glue Data Catalog, the AWS Region in which the database is located. This parameter is required if the database is defined in an external Data Catalog.

URI ['hive_metastore_uri' [PORT port_number] **|** 'hostname' [PORT port_number] **|** 'Kafka bootstrap URI']

The hostname URI and port_number of a supported PostgreSQL or MySQL database engine. The *hostname* is the head node of the replica set. The endpoint must be reachable (routable) from the Amazon Redshift cluster. The default PostgreSQL port_number is 5432. The default MySQL port_number is 3306.

Note

The supported PostgreSQL or MySQL database engine must be in the same VPC as your Amazon Redshift cluster with a security group linking Amazon Redshift and RDS url-rsPostgreSQL or Aurora PostgreSQL. Additionally, you can use enhanced VPC routing to configure a cross-VPC use case. For more information, see Redshift-managed VPC endpoints.

Specifying a hive metastore URI

If the database is in a Hive metastore, specify the URI and optionally the port number for the metastore. The default port number is 9083.

A URI doesn't contain a protocol specification ("http://"). An example valid URI: `uri '172.10.10.10'`.

Specifying a broker URI for streaming ingestion

Including the bootstrap-broker URI provides the ability to connect to an Amazon MSK or Confluent Cloud cluster and receive streamed data. For more information and to see an example, see Getting started with streaming ingestion from Amazon Managed Streaming for Apache Kafka.

IAM_ROLE [default | 'SESSION' | 'arn:aws:iam::*<AWS account-id>*:role/*<role-name>*']

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE EXTERNAL SCHEMA command runs.

Use `'SESSION'` if you connect to your Amazon Redshift cluster using a federated identity and access the tables from the external schema created using this command. For more information, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift Spectrum external tables, which explains how to configure federated identity. Note that this configuration, using `'SESSION'` in place of the ARN, can be used only if the schema is created using `DATA CATALOG`.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. As a minimum, the IAM role must have permission to perform a LIST operation on the Amazon S3 bucket to be accessed and a GET operation on the Amazon S3 objects the bucket contains.

The following shows the syntax for the IAM_ROLE parameter string for a single ARN.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-name>'
```

You can chain roles so that your cluster can assume another IAM role, possibly belonging to another account. You can chain up to 10 roles. For an example of chaining roles, see Chaining IAM roles in Amazon Redshift Spectrum.

To this IAM role, attach an IAM permissions policy similar to the following.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AccessSecret",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetResourcePolicy",
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret",
                "secretsmanager:ListSecretVersionIds"
            ],
            "Resource": "arn:aws:secretsmanager:us-
west-2:123456789012:secret:my-rds-secret-VNenFy"
        },
        {
            "Sid": "VisualEditor1",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetRandomPassword",
                "secretsmanager:ListSecrets"
            ],
            "Resource": "*"
        }
    ]
}
```

For the steps to create an IAM role to use with federated query, see Creating a secret and an IAM role to use federated queries.

> **Note**
>
> Don't include spaces in the list of chained roles.

The following shows the syntax for chaining three roles.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-1-name>,arn:aws:iam::<aws-account-id>:role/<role-2-name>,arn:aws:iam::<aws-account-id>:role/<role-3-name>'
```

SECRET_ARN '*ssm-secret-arn*'

The Amazon Resource Name (ARN) of a supported PostgreSQL or MySQL database engine secret created using AWS Secrets Manager. For information about how to create and retrieve an ARN for a secret, see Manage secrets with AWS Secrets Manager in the *AWS Secrets Manager User Guide*, and Retrieving the Amazon Resource Name (ARN) of the secret in Amazon Redshift..

CATALOG_ROLE ['SESSION' | *catalog-role-arn-string*]

Use `'SESSION'` to connect to your Amazon Redshift cluster using a federated identity for authentication and authorization to the data catalog. For more information about completing the steps for federated identity, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift Spectrum external tables. Note that the `'SESSION'` role can be used only if the schema is created in DATA CATALOG.

Use the Amazon Resource Name ARN for an IAM role that your cluster uses for authentication and authorization for the data catalog.

If CATALOG_ROLE isn't specified, Amazon Redshift uses the specified IAM_ROLE. The catalog role must have permission to access the Data Catalog in AWS Glue or Athena. For more information, see IAM policies for Amazon Redshift Spectrum.

The following shows the syntax for the CATALOG_ROLE parameter string for a single ARN.

```
CATALOG_ROLE 'arn:aws:iam::<aws-account-id>:role/<catalog-role>'
```

You can chain roles so that your cluster can assume another IAM role, possibly belonging to another account. You can chain up to 10 roles. For more information, see Chaining IAM roles in Amazon Redshift Spectrum.

> **Note**
>
> The list of chained roles must not include spaces.

The following shows the syntax for chaining three roles.

```
CATALOG_ROLE 'arn:aws:iam::<aws-account-id>:role/<catalog-role-1-
name>,arn:aws:iam::<aws-account-id>:role/<catalog-role-2-name>,arn:aws:iam::<aws-
account-id>:role/<catalog-role-3-name>'
```

CREATE EXTERNAL DATABASE IF NOT EXISTS

A clause that creates an external database with the name specified by the DATABASE argument, if the specified external database doesn't exist. If the specified external database exists, the command makes no changes. In this case, the command returns a message that the external database exists, rather than terminating with an error.

> **Note**
>
> You can't use CREATE EXTERNAL DATABASE IF NOT EXISTS with HIVE METASTORE. To use CREATE EXTERNAL DATABASE IF NOT EXISTS with a Data Catalog enabled for AWS Lake Formation, you need `CREATE_DATABASE` permission on the Data Catalog.

CATALOG_ID '*Amazon Web Services account ID containing Glue or Lake Formation database*'

The account id where the data catalog database is stored.

`CATALOG_ID` can be specified only if you plan to connect to your Amazon Redshift cluster or to Amazon Redshift Serverless using a federated identity for authentication and authorization to the data catalog by setting either of the following:

- `CATALOG_ROLE` to `'SESSION'`
- `IAM_ROLE` to `'SESSION'` and `'CATALOG_ROLE'` set to its default

For more information about completing the steps for federated identity, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift Spectrum external tables.

AUTHENTICATION

The authentication type defined for streaming ingestion. Streaming ingestion with authentication types works with Amazon Managed Streaming for Apache Kafka. The `AUTHENTICATION` types are the following:

- **none** – Specifies that there is no authentication required. This corresponds to Unauthenticated access on MSK or plaintext with TLS on Apache Kafka.
- **iam** – Specifies IAM authentication. When you choose this, make sure that the IAM role has permissions for IAM authentication. For more information about defining the external schema, see Getting started with streaming ingestion from Apache Kafka sources.
- **mtls** – Specifies that mutual transport layer security provides secure communication by facilitating authentication between a client and server. In this case, the client is Redshift and the server is Amazon MSK. For more information about configuring streaming ingestion with mTLS, see Authentication with mTLS for Redshift streaming ingestion from Apache Kafka sources.

AUTHENTICATION_ARN

The ARN of the AWS Certificate Manager certificate used by Amazon Redshift for mtls authentication with Amazon MSK. The ARN is available in the ACM console when you choose the issued certificate.

CLUSTER_ARN

For streaming ingestion, the CLUSTER_ARN is the cluster identifier for the Amazon Managed Streaming for Apache Kafka cluster you're streaming from. When using CLUSTER_ARN, it requires an IAM role policy that includes the `kafka:GetBootstrapBrokers` permission. This option is provided for backward compatibility. Currently, we recommend using the bootstrap-broker URI option to connect to Amazon Managed Streaming for Apache Kafka clusters. For more information, see Streaming ingestion.

Usage notes

For limits when using the Athena data catalog, see Athena Limits in the AWS General Reference.

For limits when using the AWS Glue Data Catalog, see AWS Glue Limits in the AWS General Reference.

These limits don't apply to a Hive metastore.

There is a maximum of 9,900 schemas per database. For more information, see Quotas and limits in the *Amazon Redshift Management Guide*.

To unregister the schema, use the DROP SCHEMA command.

To view details for external schemas, query the following system views:

- SVV_EXTERNAL_SCHEMAS
- SVV_EXTERNAL_TABLES
- SVV_EXTERNAL_COLUMNS

Examples

The following example creates an external schema using a database in a data catalog named `sampledb` in the US West (Oregon) Region. Use this example with an Athena or AWS Glue data catalog.

```
create external schema spectrum_schema
from data catalog
database 'sampledb'
region 'us-west-2'
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole';
```

The following example creates an external schema and creates a new external database named `spectrum_db`.

```
create external schema spectrum_schema
from data catalog
database 'spectrum_db'
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole'
create external database if not exists;
```

The following example creates an external schema using a Hive metastore database named `hive_db`.

```
create external schema hive_schema
from hive metastore
```

```
database 'hive_db'
uri '172.10.10.10' port 99
iam_role 'arn:aws:iam::123456789012:role/MySpectrumRole';
```

The following example chains roles to use the role `myS3Role` for accessing Amazon S3 and uses `myAthenaRole` for data catalog access. For more information, see [Chaining IAM roles in Amazon Redshift Spectrum](#).

```
create external schema spectrum_schema
from data catalog
database 'spectrum_db'
iam_role 'arn:aws:iam::123456789012:role/myRedshiftRole,arn:aws:iam::123456789012:role/
myS3Role'
catalog_role 'arn:aws:iam::123456789012:role/myAthenaRole'
create external database if not exists;
```

The following example creates an external schema that references an Aurora PostgreSQL database.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] myRedshiftSchema
FROM POSTGRES
DATABASE 'my_aurora_db' SCHEMA 'my_aurora_schema'
URI 'endpoint to aurora hostname' PORT 5432
IAM_ROLE 'arn:aws:iam::123456789012:role/MyAuroraRole'
SECRET_ARN 'arn:aws:secretsmanager:us-east-2:123456789012:secret:development/
MyTestDatabase-AbCdEf'
```

The following example creates an external schema to refer to the sales_db imported on the consumer cluster.

```
CREATE EXTERNAL SCHEMA sales_schema FROM REDSHIFT DATABASE 'sales_db' SCHEMA 'public';
```

The following example creates an external schema that references an Aurora MySQL database.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] myRedshiftSchema
FROM MYSQL
DATABASE 'my_aurora_db'
URI 'endpoint to aurora hostname'
IAM_ROLE 'arn:aws:iam::123456789012:role/MyAuroraRole'
SECRET_ARN 'arn:aws:secretsmanager:us-east-2:123456789012:secret:development/
MyTestDatabase-AbCdEf'
```

CREATE EXTERNAL TABLE

Creates a new external table in the specified schema. All external tables must be created in an external schema. Search path isn't supported for external schemas and external tables. For more information, see CREATE EXTERNAL SCHEMA.

In addition to external tables created using the CREATE EXTERNAL TABLE command, Amazon Redshift can reference external tables defined in an AWS Glue or AWS Lake Formation catalog or an Apache Hive metastore. Use the CREATE EXTERNAL SCHEMA command to register an external database defined in the external catalog and make the external tables available for use in Amazon Redshift. If the external table exists in an AWS Glue or AWS Lake Formation catalog or Hive metastore, you don't need to create the table using CREATE EXTERNAL TABLE. To view external tables, query the SVV_EXTERNAL_TABLES system view.

By running the CREATE EXTERNAL TABLE AS command, you can create an external table based on the column definition from a query and write the results of that query into Amazon S3. The results are in Apache Parquet or delimited text format. If the external table has a partition key or keys, Amazon Redshift partitions new files according to those partition keys and registers new partitions into the external catalog automatically. For more information about CREATE EXTERNAL TABLE AS, see Usage notes.

You can query an external table using the same SELECT syntax you use with other Amazon Redshift tables. You can also use the INSERT syntax to write new files into the location of external table on Amazon S3. For more information, see INSERT (external table).

To create a view with an external table, include the WITH NO SCHEMA BINDING clause in the CREATE VIEW statement.

You can't run CREATE EXTERNAL TABLE inside a transaction (BEGIN … END). For more information about transactions, see Serializable isolation.

Required privileges

To create external tables, you must be the owner of the external schema or a superuser. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner. Access to external tables is controlled by access to the external schema. You can't GRANT or REVOKE permissions on an external table. Instead, grant or revoke USAGE on the external schema.

The Usage notes have additional information about specific permissions for external tables.

Syntax

```
CREATE EXTERNAL TABLE
external_schema.table_name
(column_name data_type [, …] )
[ PARTITIONED BY (col_name data_type [, … ] )]
[ { ROW FORMAT DELIMITED row_format |
  ROW FORMAT SERDE 'serde_name'
  [ WITH SERDEPROPERTIES ( 'property_name' = 'property_value' [, ...] ) ] } ]
STORED AS file_format
LOCATION { 's3://bucket/folder/' | 's3://bucket/manifest_file' }
[ TABLE PROPERTIES ( 'property_name'='property_value' [, ...] ) ]
```

The following is the syntax for CREATE EXTERNAL TABLE AS.

```
CREATE EXTERNAL TABLE
external_schema.table_name
[ PARTITIONED BY (col_name [, … ] ) ]
[ ROW FORMAT DELIMITED row_format ]
STORED AS file_format
LOCATION { 's3://bucket/folder/' }
[ TABLE PROPERTIES ( 'property_name'='property_value' [, ...] ) ]
 AS
 { select_statement }
```

Parameters

external_schema.table_name

The name of the table to be created, qualified by an external schema name. External tables must be created in an external schema. For more information, see CREATE EXTERNAL SCHEMA.

The maximum length for the table name is 127 bytes; longer names are truncated to 127 bytes. You can use UTF-8 multibyte characters up to a maximum of four bytes. Amazon Redshift enforces a limit of 9,900 tables per cluster, including user-defined temporary tables and temporary tables created by Amazon Redshift during query processing or system maintenance. Optionally, you can qualify the table name with the database name. In the following example, the database name is `spectrum_db`, the external schema name is `spectrum_schema`, and the table name is `test`.

```
create external table spectrum_db.spectrum_schema.test (c1 int)
stored as parquet
location 's3://amzn-s3-demo-bucket/myfolder/';
```

If the database or schema specified doesn't exist, the table isn't created, and the statement returns an error. You can't create tables or views in the system databases `template0`, `template1`, `padb_harvest`, or `sys:internal`.

The table name must be a unique name for the specified schema.

For more information about valid names, see Names and identifiers.

(*column_name data_type*)

The name and data type of each column being created.

The maximum length for the column name is 127 bytes; longer names are truncated to 127 bytes. You can use UTF-8 multibyte characters up to a maximum of four bytes. You can't specify column names `"$path"` or `"$size"`. For more information about valid names, see Names and identifiers.

By default, Amazon Redshift creates external tables with the pseudocolumns `$path` and `$size`. You can disable creation of pseudocolumns for a session by setting the `spectrum_enable_pseudo_columns` configuration parameter to `false`. For more information, see Pseudocolumns .

If pseudocolumns are enabled, the maximum number of columns you can define in a single table is 1,598. If pseudocolumns aren't enabled, the maximum number of columns you can define in a single table is 1,600.

If you are creating a "wide table," make sure that your list of columns doesn't exceed row-width boundaries for intermediate results during loads and query processing. For more information, see Usage notes.

For a CREATE EXTERNAL TABLE AS command, a column list is not required, because columns are derived from the query.

data_type

The following Data types are supported:

- SMALLINT (INT2)
- INTEGER (INT, INT4)

- BIGINT (INT8)
- DECIMAL (NUMERIC)
- REAL (FLOAT4)
- DOUBLE PRECISION (FLOAT8)
- BOOLEAN (BOOL)
- CHAR (CHARACTER)
- VARCHAR (CHARACTER VARYING)
- VARBYTE (CHARACTER VARYING) – can be used with Parquet and ORC data files, and only with non-partitioned tables.
- DATE – can be used only with text, Parquet, or ORC data files, or as a partition column.
- TIMESTAMP

For DATE, you can use the formats as described following. For month values represented using digits, the following formats are supported:

- `mm-dd-yyyy` For example, `05-01-2017`. This is the default.
- `yyyy-mm-dd`, where the year is represented by more than 2 digits. For example, `2017-05-01`.

For month values represented using the three letter abbreviation, the following formats are supported:

- `mmm-dd-yyyy` For example, `may-01-2017`. This is the default.
- `dd-mmm-yyyy`, where the year is represented by more than 2 digits. For example, `01-may-2017`.
- `yyyy-mmm-dd`, where the year is represented by more than 2 digits. For example, `2017-may-01`.

For year values that are consistently less than 100, the year is calculated in the following manner:

- If year is less than 70, the year is calculated as the year plus 2000. For example, the date 05-01-17 in the `mm-dd-yyyy` format is converted into `05-01-2017`.
- If year is less than 100 and greater than 69, the year is calculated as the year plus 1900. For example the date 05-01-89 in the `mm-dd-yyyy` format is converted into `05-01-1989`.
- For year values represented by two digits, add leading zeroes to represent the year in 4 digits.

Timestamp values in text files must be in the format `yyyy-mm-dd HH:mm:ss.SSSSSS`, as the following timestamp value shows: `2017-05-01 11:30:59.000000`.

The length of a VARCHAR column is defined in bytes, not characters. For example, a VARCHAR(12) column can contain 12 single-byte characters or 6 two-byte characters. When you query an external table, results are truncated to fit the defined column size without returning an error. For more information, see Storage and ranges.

For best performance, we recommend specifying the smallest column size that fits your data. To find the maximum size in bytes for values in a column, use the OCTET_LENGTH function. The following example returns the maximum size of values in the email column.

```
select max(octet_length(email)) from users;

max
---
 62
```

PARTITIONED BY (*col_name data_type* [, …])

A clause that defines a partitioned table with one or more partition columns. A separate data directory is used for each specified combination, which can improve query performance in some circumstances. Partitioned columns don't exist within the table data itself. If you use a value for *col_name* that is the same as a table column, you get an error.

After creating a partitioned table, alter the table using an ALTER TABLE … ADD PARTITION statement to register new partitions to the external catalog. When you add a partition, you define the location of the subfolder on Amazon S3 that contains the partition data.

For example, if the table `spectrum.lineitem_part` is defined with `PARTITIONED BY (l_shipdate date)`, run the following ALTER TABLE command to add a partition.

```
ALTER TABLE spectrum.lineitem_part ADD PARTITION (l_shipdate='1992-01-29')
LOCATION 's3://spectrum-public/lineitem_partition/l_shipdate=1992-01-29';
```

If you are using CREATE EXTERNAL TABLE AS, you don't need to run ALTER TABLE...ADD PARTITION. Amazon Redshift automatically registers new partitions in the external catalog. Amazon Redshift also automatically writes corresponding data to partitions in Amazon S3 based on the partition key or keys defined in the table.

To view partitions, query the SVV_EXTERNAL_PARTITIONS system view.

> **Note**
>
> For a CREATE EXTERNAL TABLE AS command, you don't need to specify the data type of the partition column because this column is derived from the query.

ROW FORMAT DELIMITED *rowformat*

A clause that specifies the format of the underlying data. Possible values for *rowformat* are as follows:

- LINES TERMINATED BY '*delimiter*'
- FIELDS TERMINATED BY '*delimiter*'

Specify a single ASCII character for '*delimiter*'. You can specify non-printing ASCII characters using octal, in the format `'\ddd'` where *d* is an octal digit (0–7) up to '\177'. The following example specifies the BEL (bell) character using octal.

```
ROW FORMAT DELIMITED FIELDS TERMINATED BY '\007'
```

If ROW FORMAT is omitted, the default format is DELIMITED FIELDS TERMINATED BY '\A' (start of heading) and LINES TERMINATED BY '\n' (newline).

ROW FORMAT SERDE '*serde_name*' , [WITH SERDEPROPERTIES ('*property_name*' = '*property_value*' [, ...])]

A clause that specifies the SERDE format for the underlying data.

'*serde_name*'

The name of the SerDe. You can specify the following formats:

- org.apache.hadoop.hive.serde2.RegexSerDe
- com.amazonaws.glue.serde.GrokSerDe
- org.apache.hadoop.hive.serde2.OpenCSVSerde

  This parameter supports the following SerDe property for OpenCSVSerde:

  ```
  'wholeFile' = 'true'
  ```

  Set the `wholeFile` property to `true` to properly parse new line characters (\n) within quoted strings for OpenCSV requests.

- org.openx.data.jsonserde.JsonSerDe
  - The JSON SERDE also supports Ion files.
  - The JSON must be well-formed.
  - Timestamps in Ion and JSON must use ISO8601 format.
  - This parameter supports the following SerDe property for JsonSerDe:

    ```
    'strip.outer.array'='true'
    ```

    Processes Ion/JSON files containing one very large array enclosed in outer brackets ([…]) as if it contains multiple JSON records within the array.
- com.amazon.ionhiveserde.IonHiveSerDe

  The Amazon ION format provides text and binary formats, in addition to data types. For an external table that references data in ION format, you map each column in the external table to the corresponding element in the ION format data. For more information, see Amazon Ion. You also need to specify the input and output formats.

WITH SERDEPROPERTIES ('*property_name*' = '*property_value*' [, ...])]

Optionally, specify property names and values, separated by commas.

If ROW FORMAT is omitted, the default format is DELIMITED FIELDS TERMINATED BY '\A' (start of heading) and LINES TERMINATED BY '\n' (newline).

STORED AS *file_format*

The file format for data files.

Valid formats are as follows:

- PARQUET
- RCFILE (for data using ColumnarSerDe only, not LazyBinaryColumnarSerDe)
- SEQUENCEFILE
- TEXTFILE (for text files, including JSON files).
- ORC
- AVRO
- INPUTFORMAT '*input_format_classname*' OUTPUTFORMAT '*output_format_classname*'

The CREATE EXTERNAL TABLE AS command only supports two file formats, TEXTFILE and PARQUET.

For INPUTFORMAT and OUTPUTFORMAT, specify a class name, as the following example shows.

```
'org.apache.hadoop.mapred.TextInputFormat'
```

LOCATION { 's3://*bucket/folder/*' | 's3://*bucket/manifest_file*'}

The path to the Amazon S3 bucket or folder that contains the data files or a manifest file that contains a list of Amazon S3 object paths. The buckets must be in the same AWS Region as the Amazon Redshift cluster. For a list of supported AWS Regions, see Amazon Redshift Spectrum limitations.

If the path specifies a bucket or folder, for example `'s3://amzn-s3-demo-bucket/custdata/'`, Redshift Spectrum scans the files in the specified bucket or folder and any subfolders. Redshift Spectrum ignores hidden files and files that begin with a period or underscore.

If the path specifies a manifest file, the `'s3://bucket/manifest_file'` argument must explicitly reference a single file—for example, `'s3://amzn-s3-demo-bucket/manifest.txt'`. It can't reference a key prefix.

The manifest is a text file in JSON format that lists the URL of each file that is to be loaded from Amazon S3 and the size of the file, in bytes. The URL includes the bucket name and full object path for the file. The files that are specified in the manifest can be in different buckets, but all the buckets must be in the same AWS Region as the Amazon Redshift cluster. If a file is listed twice, the file is loaded twice. The following example shows the JSON for a manifest that loads three files.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket1/custdata.1", "meta": { "content_length":
 5956875 } },
    {"url":"s3://amzn-s3-demo-bucket1/custdata.2", "meta": { "content_length":
 5997091 } },
    {"url":"s3://amzn-s3-demo-bucket2/custdata.1", "meta": { "content_length":
 5978675 } }
  ]
}
```

You can make the inclusion of a particular file mandatory. To do this, include a `mandatory` option at the file level in the manifest. When you query an external table with a mandatory file that is missing, the SELECT statement fails. Ensure that all files included in the definition of the external table are present. If they aren't all present, an error appears showing the first mandatory file that isn't found. The following example shows the JSON for a manifest with the `mandatory` option set to `true`.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket1/custdata.1", "mandatory":true, "meta":
 { "content_length": 5956875 } },
    {"url":"s3://amzn-s3-demo-bucket1/custdata.2", "mandatory":false, "meta":
 { "content_length": 5997091 } },
    {"url":"s3://amzn-s3-demo-bucket2/custdata.1", "meta": { "content_length":
 5978675 } }
  ]
}
```

To reference files created using UNLOAD, you can use the manifest created using UNLOAD with the MANIFEST parameter. The manifest file is compatible with a manifest file for COPY from Amazon S3, but uses different keys. Keys that aren't used are ignored.

TABLE PROPERTIES ('*property_name*'='*property_value*' [, ...])

A clause that sets the table definition for table properties.

> **Note**
>
> Table properties are case-sensitive.

'compression_type'='*value*'

A property that sets the type of compression to use if the file name doesn't contain an extension. If you set this property and there is a file extension, the extension is ignored and the value set by the property is used. Valid values for compression type are as follows:

- bzip2
- gzip
- none

- snappy

'data_cleansing_enabled'='true / false’

This property sets whether data handling is on for the table. When 'data_cleansing_enabled' is set to true, data handling is on for the table. When 'data_cleansing_enabled' is set to false, data handling is off for the table. Following is a list of the table–level data handling properties controlled by this property:

- column_count_mismatch_handling
- invalid_char_handling
- numeric_overflow_handling
- replacement_char
- surplus_char_handling

For examples, see Data handling examples.

'invalid_char_handling'='*value*'

Specifies the action to perform when query results contain invalid UTF-8 character values. You can specify the following actions:

DISABLED

Doesn't perform invalid character handling.

FAIL

Cancels queries that return data containing invalid UTF-8 values.

SET_TO_NULL

Replaces invalid UTF-8 values with null.

DROP_ROW

Replaces each value in the row with null.

REPLACE

Replaces the invalid character with the replacement character you specify using `replacement_char`.

'replacement_char'='*character*’

Specifies the replacement character to use when you set `invalid_char_handling` to REPLACE.

'numeric_overflow_handling'='value'

Specifies the action to perform when ORC data contains an integer (for example, BIGINT or int64) that is larger than the column definition (for example, SMALLINT or int16). You can specify the following actions:

DISABLED

Invalid character handling is turned off.

FAIL

Cancel the query when the data includes invalid characters.

SET_TO_NULL

Set invalid characters to null.

DROP_ROW

Set each value in the row to null.

'surplus_bytes_handling'='*value*'

Specifies how to handle data being loaded that exceeds the length of the data type defined for columns containing VARBYTE data. By default, Redshift Spectrum sets the value to null for data that exceeds the width of the column.

You can specify the following actions to perform when the query returns data that exceeds the length of the data type:

SET_TO_NULL

Replaces data that exceeds the column width with null.

DISABLED

Doesn't perform surplus byte handling.

FAIL

Cancels queries that return data exceeding the column width.

DROP_ROW

Drop all rows that contain data exceeding column width.

TRUNCATE

Removes the characters that exceed the maximum number of characters defined for the column.

'surplus_char_handling'='*value*'

Specifies how to handle data being loaded that exceeds the length of the data type defined for columns containing VARCHAR, CHAR, or string data. By default, Redshift Spectrum sets the value to null for data that exceeds the width of the column.

You can specify the following actions to perform when the query returns data that exceeds the column width:

SET_TO_NULL

Replaces data that exceeds the column width with null.

DISABLED

Doesn't perform surplus character handling.

FAIL

Cancels queries that return data exceeding the column width.

DROP_ROW

Replaces each value in the row with null.

TRUNCATE

Removes the characters that exceed the maximum number of characters defined for the column.

'column_count_mismatch_handling'='value’

Identifies if the file contains less or more values for a row than the number of columns specified in the external table definition. This property is only available for an uncompressed text file format. You can specify the following actions:

DISABLED

Column count mismatch handling is turned off.

FAIL

Fail the query if the column count mismatch is detected.

SET_TO_NULL

Fill missing values with NULL and ignore the additional values in each row.

DROP_ROW

Drop all rows that contain column count mismatch error from the scan.

'numRows'='*row_count*'

A property that sets the numRows value for the table definition. To explicitly update an external table's statistics, set the numRows property to indicate the size of the table. Amazon Redshift doesn't analyze external tables to generate the table statistics that the query optimizer uses to generate a query plan. If table statistics aren't set for an external table, Amazon Redshift generates a query execution plan based on an assumption that external tables are the larger tables and local tables are the smaller tables.

'skip.header.line.count'='*line_count*'

A property that sets number of rows to skip at the beginning of each source file.

'serialization.null.format'=' '

A property that specifies Spectrum should return a `NULL` value when there is an exact match with the text supplied in a field.

'orc.schema.resolution'='mapping_type'

A property that sets the column mapping type for tables that use ORC data format. This property is ignored for other data formats.

Valid values for column mapping type are as follows:

- name
- position

If the *orc.schema.resolution* property is omitted, columns are mapped by name by default. If *orc.schema.resolution* is set to any value other than *'name'* or *'position'*, columns are mapped by position. For more information about column mapping, see [Mapping external table columns to ORC columns](#).

> **Note**
>
> The COPY command maps to ORC data files only by position. The *orc.schema.resolution* table property has no effect on COPY command behavior.

'write.parallel'='on / off'

A property that sets whether CREATE EXTERNAL TABLE AS should write data in parallel. By default, CREATE EXTERNAL TABLE AS writes data in parallel to multiple files, according to the number of slices in the cluster. The default option is on. When 'write.parallel' is set to off, CREATE EXTERNAL TABLE AS writes to one or more data files serially onto Amazon S3. This table property also applies to any subsequent INSERT statement into the same external table.

‘write.maxfilesize.mb’=‘size’

A property that sets the maximum size (in MB) of each file written to Amazon S3 by CREATE EXTERNAL TABLE AS. The size must be a valid integer between 5 and 6200. The default maximum file size is 6,200 MB. This table property also applies to any subsequent INSERT statement into the same external table.

‘write.kms.key.id’=‘*value*’

You can specify an AWS Key Management Service key to enable Server–Side Encryption (SSE) for Amazon S3 objects, where *value* is one of the following:

- `auto` to use the default AWS KMS key stored in the Amazon S3 bucket.
- *kms-key* that you specify to encrypt data.

select_statement

A statement that inserts one or more rows into the external table by defining any query. All rows that the query produces are written to Amazon S3 in either text or Parquet format based on the table definition.

Examples

A collection of examples is available at [Examples](#).

Usage notes

This topic contains usage notes for CREATE EXTERNAL TABLE. You can't view details for Amazon Redshift Spectrum tables using the same resources that you use for standard Amazon Redshift tables, such as PG_TABLE_DEF, STV_TBL_PERM, PG_CLASS, or information_schema. If your business intelligence or analytics tool doesn't recognize Redshift Spectrum external tables, configure your application to query SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS.

CREATE EXTERNAL TABLE AS

In some cases, you might run the CREATE EXTERNAL TABLE AS command on an AWS Glue Data Catalog, AWS Lake Formation external catalog, or Apache Hive metastore. In such cases, you use an AWS Identity and Access Management (IAM) role to create the external schema. This IAM role must have both read and write permissions on Amazon S3.

If you use a Lake Formation catalog, the IAM role must have the permission to create table in the catalog. In this case, it must also have the data lake location permission on the target Amazon S3 path. This IAM role becomes the owner of the new AWS Lake Formation table.

To ensure that file names are unique, Amazon Redshift uses the following format for the name of each file uploaded to Amazon S3 by default.

<date>_<time>_<microseconds>_<query_id>_<slice-number>_part_<part-number>.<format>.

An example is `20200303_004509_810669_1007_0001_part_00.parquet`.

Consider the following when running the CREATE EXTERNAL TABLE AS command:

- The Amazon S3 location must be empty.
- Amazon Redshift only supports PARQUET and TEXTFILE formats when using the STORED AS clause.
- You don't need to define a column definition list. Column names and column data types of the new external table are derived directly from the SELECT query.
- You don't need to define the data type of the partition column in the PARTITIONED BY clause. If you specify a partition key, the name of this column must exist in the SELECT query result. When having multiple partition columns, their order in the SELECT query doesn't matter. Amazon Redshift uses their order defined in the PARTITIONED BY clause to create the external table.
- Amazon Redshift automatically partitions output files into partition folders based on the partition key values. By default, Amazon Redshift removes partition columns from the output files.
- The LINES TERMINATED BY 'delimiter' clause isn't supported.
- The ROW FORMAT SERDE 'serde_name' clause isn't supported.
- The use of manifest files isn't supported. Thus, you can't define the LOCATION clause to a manifest file on Amazon S3.

- Amazon Redshift automatically updates the 'numRows' table property at the end of the command.
- The 'compression_type' table property only accepts 'none' or 'snappy' for the PARQUET file format.
- Amazon Redshift doesn't allow the LIMIT clause in the outer SELECT query. Instead, you can use a nested LIMIT clause.
- You can use STL_UNLOAD_LOG to track the files that are written to Amazon S3 by each CREATE EXTERNAL TABLE AS operation.

Permissions to create and query external tables

To create external tables, make sure that you're the owner of the external schema or a superuser. To transfer ownership of an external schema, use ALTER SCHEMA. The following example changes the owner of the `spectrum_schema` schema to `newowner`.

```
alter schema spectrum_schema owner to newowner;
```

To run a Redshift Spectrum query, you need the following permissions:

- Usage permission on the schema
- Permission to create temporary tables in the current database

The following example grants usage permission on the schema `spectrum_schema` to the `spectrumusers` user group.

```
grant usage on schema spectrum_schema to group spectrumusers;
```

The following example grants temporary permission on the database `spectrumdb` to the `spectrumusers` user group.

```
grant temp on database spectrumdb to group spectrumusers;
```

Pseudocolumns

By default, Amazon Redshift creates external tables with the pseudocolumns *$path* and *$size*. Select these columns to view the path to the data files on Amazon S3 and the size of the data files for each row returned by a query. The *$path* and *$size* column names must be delimited with double quotation marks. A *SELECT ** clause doesn't return the pseudocolumns . You must explicitly include the *$path* and *$size* column names in your query, as the following example shows.

```
select "$path", "$size"
from spectrum.sales_part
where saledate = '2008-12-01';
```

You can disable creation of pseudocolumns for a session by setting the *spectrum_enable_pseudo_columns* configuration parameter to *false*.

> **Important**
>
> Selecting *$size* or *$path* incurs charges because Redshift Spectrum scans the data files in Amazon S3 to determine the size of the result set. For more information, see Amazon Redshift Pricing.

Setting data handling options

You can set table parameters to specify input handling for data being queried in external tables, including:

- Surplus characters in columns containing VARCHAR, CHAR, and string data. For more information, see the external table property `surplus_char_handling`.
- Invalid characters in columns containing VARCHAR, CHAR, and string data. For more information, see the external table property `invalid_char_handling`.
- Replacement character to use when you specify REPLACE for the external table property `invalid_char_handling`.
- Cast overflow handling in columns containing integer and decimal data. For more information, see the external table property `numeric_overflow_handling`.
- Surplus_bytes_handling to specify input handling for surplus bytes in columns containing varbyte data. For more information, see the external table property `surplus_bytes_handling`.

Examples

The following example creates a table named SALES in the Amazon Redshift external schema named `spectrum`. The data is in tab-delimited text files. The TABLE PROPERTIES clause sets the numRows property to 170,000 rows.

Depending on the identity you use to run CREATE EXTERNAL TABLE, there may be IAM permissions that you have to configure. As a best practice, we recommend attaching permissions policies to an IAM role and then assigning it to users and groups as needed. For more information, see Identity and access management in Amazon Redshift.

```
create external table spectrum.sales(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
saledate date,
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
row format delimited
fields terminated by '\t'
stored as textfile
location 's3://redshift-downloads/tickit/spectrum/sales/'
table properties ('numRows'='170000');
```

The following example creates a table that uses the JsonSerDe to reference data in JSON format.

```
create external table spectrum.cloudtrail_json (
event_version int,
event_id bigint,
event_time timestamp,
event_type varchar(10),
awsregion varchar(20),
event_name varchar(max),
event_source varchar(max),
requesttime timestamp,
useragent varchar(max),
recipientaccountid bigint)
row format serde 'org.openx.data.jsonserde.JsonSerDe'
```

```
with serdeproperties (
'dots.in.keys' = 'true',
'mapping.requesttime' = 'requesttimestamp'
) location 's3://amzn-s3-demo-bucket/json/cloudtrail';
```

The following CREATE EXTERNAL TABLE AS example creates a nonpartitioned external table. Then it writes the result of the SELECT query as Apache Parquet to the target Amazon S3 location.

```
CREATE EXTERNAL TABLE spectrum.lineitem
STORED AS parquet
LOCATION 'S3://amzn-s3-demo-bucket/cetas/lineitem/'
AS SELECT * FROM local_lineitem;
```

The following example creates a partitioned external table and includes the partition columns in the SELECT query.

```
CREATE EXTERNAL TABLE spectrum.partitioned_lineitem
PARTITIONED BY (l_shipdate, l_shipmode)
STORED AS parquet
LOCATION 'S3://amzn-s3-demo-bucket/cetas/partitioned_lineitem/'
AS SELECT l_orderkey, l_shipmode, l_shipdate, l_partkey FROM local_table;
```

For a list of existing databases in the external data catalog, query the SVV_EXTERNAL_DATABASES system view.

```
select eskind,databasename,esoptions from svv_external_databases order by databasename;
```

```
eskind | databasename | esoptions
-------+--------------
+----------------------------------------------------------------------------------
     1 | default      | {"REGION":"us-
west-2","IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
     1 | sampledb     | {"REGION":"us-
west-2","IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
     1 | spectrumdb   | {"REGION":"us-
west-2","IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
```

To view details of external tables, query the SVV_EXTERNAL_TABLES and SVV_EXTERNAL_COLUMNS system views.

The following example queries the SVV_EXTERNAL_TABLES view.

```
select schemaname, tablename, location from svv_external_tables;
```

```
schemaname | tablename            | location
-----------+----------------------
+-------------------------------------------------
spectrum   | sales                | s3://redshift-downloads/tickit/spectrum/sales
spectrum   | sales_part           | s3://redshift-downloads/tickit/spectrum/
sales_partition
```

The following example queries the SVV_EXTERNAL_COLUMNS view.

```
select * from svv_external_columns where schemaname like 'spectrum%' and tablename
 ='sales';
```

```
schemaname | tablename | columnname | external_type | columnnum | part_key
-----------+-----------+------------+---------------+-----------+---------
spectrum   | sales     | salesid    | int           |         1 |        0
spectrum   | sales     | listid     | int           |         2 |        0
spectrum   | sales     | sellerid   | int           |         3 |        0
spectrum   | sales     | buyerid    | int           |         4 |        0
spectrum   | sales     | eventid    | int           |         5 |        0
spectrum   | sales     | saledate   | date          |         6 |        0
spectrum   | sales     | qtysold    | smallint      |         7 |        0
spectrum   | sales     | pricepaid  | decimal(8,2)  |         8 |        0
spectrum   | sales     | commission | decimal(8,2)  |         9 |        0
spectrum   | sales     | saletime   | timestamp     |        10 |        0
```

To view table partitions, use the following query.

```
select schemaname, tablename, values, location
from svv_external_partitions
where tablename = 'sales_part';
```

```
schemaname | tablename  | values         | location
-----------+------------+----------------
+-------------------------------------------------------------------
spectrum   | sales_part | ["2008-01-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-01
spectrum   | sales_part | ["2008-02-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-02
```

```
spectrum   | sales_part | ["2008-03-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-03
spectrum   | sales_part | ["2008-04-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-04
spectrum   | sales_part | ["2008-05-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-05
spectrum   | sales_part | ["2008-06-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-06
spectrum   | sales_part | ["2008-07-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-07
spectrum   | sales_part | ["2008-08-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-08
spectrum   | sales_part | ["2008-09-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-09
spectrum   | sales_part | ["2008-10-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-10
spectrum   | sales_part | ["2008-11-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-11
spectrum   | sales_part | ["2008-12-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-12
```

The following example returns the total size of related data files for an external table.

```
select distinct "$path", "$size"
   from spectrum.sales_part;

 $path                                                                     | $size
---------------------------------------------------------------------------+-------
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/ |  1616
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-02/ |  1444
s3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-02/ |  1444
```

Partitioning examples

To create an external table partitioned by date, run the following command.

```
create external table spectrum.sales_part(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
```

```
qtysold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
partitioned by (saledate date)
row format delimited
fields terminated by '|'
stored as textfile
location 's3://redshift-downloads/tickit/spectrum/sales_partition/'
table properties ('numRows'='170000');
```

To add the partitions, run the following ALTER TABLE commands.

```
alter table spectrum.sales_part
add if not exists partition (saledate='2008-01-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-01/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-02-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-02/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-03-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-03/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-04-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-04/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-05-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-05/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-06-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-06/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-07-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-07/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-08-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-08/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-09-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-09/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-10-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-10/';
```

```
alter table spectrum.sales_part
add if not exists partition (saledate='2008-11-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-11/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-12-01')
location 's3://redshift-downloads/tickit/spectrum/sales_partition/saledate=2008-12/';
```

To select data from the partitioned table, run the following query.

```
select top 10 spectrum.sales_part.eventid, sum(spectrum.sales_part.pricepaid)
from spectrum.sales_part, event
where spectrum.sales_part.eventid = event.eventid
  and spectrum.sales_part.pricepaid > 30
  and saledate = '2008-12-01'
group by spectrum.sales_part.eventid
order by 2 desc;
```

```
eventid | sum
--------+---------
    914 | 36173.00
   5478 | 27303.00
   5061 | 26383.00
   4406 | 26252.00
   5324 | 24015.00
   1829 | 23911.00
   3601 | 23616.00
   3665 | 23214.00
   6069 | 22869.00
   5638 | 22551.00
```

To view external table partitions, query the SVV_EXTERNAL_PARTITIONS system view.

```
select schemaname, tablename, values, location from svv_external_partitions
where tablename = 'sales_part';
```

```
schemaname | tablename  | values         | location
-----------+------------+----------------
+-------------------------------------------------
spectrum   | sales_part | ["2008-01-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-01
spectrum   | sales_part | ["2008-02-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-02
```

```
spectrum   | sales_part | ["2008-03-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-03
spectrum   | sales_part | ["2008-04-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-04
spectrum   | sales_part | ["2008-05-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-05
spectrum   | sales_part | ["2008-06-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-06
spectrum   | sales_part | ["2008-07-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-07
spectrum   | sales_part | ["2008-08-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-08
spectrum   | sales_part | ["2008-09-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-09
spectrum   | sales_part | ["2008-10-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-10
spectrum   | sales_part | ["2008-11-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-11
spectrum   | sales_part | ["2008-12-01"] | s3://redshift-downloads/tickit/spectrum/
sales_partition/saledate=2008-12
```

Row format examples

The following shows an example of specifying the ROW FORMAT SERDE parameters for data files stored in AVRO format.

```
create external table spectrum.sales(salesid int, listid int, sellerid int,
 buyerid int, eventid int, dateid int, qtysold int, pricepaid decimal(8,2), comment
 VARCHAR(255))
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.avro.AvroSerDe'
WITH SERDEPROPERTIES ('avro.schema.literal'='{\"namespace\": \"dory.sample\",\"name\":
 \"dory_avro\",\"type\": \"record\", \"fields\": [{\"name\":\"salesid\", \"type\":\"int
\"},
{\"name\":\"listid\", \"type\":\"int\"},
{\"name\":\"sellerid\", \"type\":\"int\"},
{\"name\":\"buyerid\", \"type\":\"int\"},
{\"name\":\"eventid\",\"type\":\"int\"},
{\"name\":\"dateid\",\"type\":\"int\"},
{\"name\":\"qtysold\",\"type\":\"int\"},
{\"name\":\"pricepaid\", \"type\": {\"type\": \"bytes\", \"logicalType\": \"decimal\",
 \"precision\": 8, \"scale\": 2}}, {\"name\":\"comment\",\"type\":\"string\"}]}')
STORED AS AVRO
location 's3://amzn-s3-demo-bucket/avro/sales' ;
```

The following shows an example of specifying the ROW FORMAT SERDE parameters using RegEx.

```
create external table spectrum.types(
cbigint bigint,
cbigint_null bigint,
cint int,
cint_null int)
row format serde 'org.apache.hadoop.hive.serde2.RegexSerDe'
with serdeproperties ('input.regex'='([^\\x01]+)\\x01([^\\x01]+)\\x01([^\\x01]+)\
\x01([^\\x01]+)')
stored as textfile
location 's3://amzn-s3-demo-bucket/regex/types';
```

The following shows an example of specifying the ROW FORMAT SERDE parameters using Grok.

```
create external table spectrum.grok_log(
timestamp varchar(255),
pid varchar(255),
loglevel varchar(255),
progname varchar(255),
message varchar(255))
row format serde 'com.amazonaws.glue.serde.GrokSerDe'
with serdeproperties ('input.format'='[DFEWI], \\[%{TIMESTAMP_ISO8601:timestamp} #
%{POSINT:pid:int}\\] *(?<loglevel>:DEBUG|FATAL|ERROR|WARN|INFO) -- +%{DATA:progname}:
 %{GREEDYDATA:message}')
stored as textfile
location 's3://DOC-EXAMPLE-BUCKET/grok/logs';
```

The following shows an example of defining an Amazon S3 server access log in an S3 bucket. You can use Redshift Spectrum to query Amazon S3 access logs.

```
CREATE EXTERNAL TABLE spectrum.mybucket_s3_logs(
bucketowner varchar(255),
bucket varchar(255),
requestdatetime varchar(2000),
remoteip varchar(255),
requester varchar(255),
requested varchar(255),
operation varchar(255),
key varchar(255),
requesturi_operation varchar(255),
requesturi_key varchar(255),
```

```
requesturi_httpprotoversion varchar(255),
httpstatus varchar(255),
errorcode varchar(255),
bytessent bigint,
objectsize bigint,
totaltime varchar(255),
turnaroundtime varchar(255),
referrer varchar(255),
useragent varchar(255),
versionid varchar(255)
)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES (
'input.regex' = '([^ ]*) ([^ ]*) \\[(.*?)\\] ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*)
 \"([^ ]*)\\s*([^ ]*)\\s*([^ ]*)\" (- |[^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*)
 ([^ ]*) (\"[^\"]*\") ([^ ]*).*$')
LOCATION 's3://amzn-s3-demo-bucket/s3logs’;
```

The following shows an example of specifying the ROW FORMAT SERDE parameters for ION format data.

```
CREATE EXTERNAL TABLE tbl_name (columns)
ROW FORMAT SERDE 'com.amazon.ionhiveserde.IonHiveSerDe'
STORED AS
INPUTFORMAT 'com.amazon.ionhiveserde.formats.IonInputFormat'
OUTPUTFORMAT 'com.amazon.ionhiveserde.formats.IonOutputFormat'
LOCATION 's3://amzn-s3-demo-bucket/prefix'
```

Data handling examples

The following examples access the file: spi_global_rankings.csv. You can upload the `spi_global_rankings.csv` file to an Amazon S3 bucket to try these examples.

The following example creates the external schema `schema_spectrum_uddh` and database `spectrum_db_uddh`. For `aws-account-id`, enter your AWS account ID and for `role-name` enter your Redshift Spectrum role name.

```
create external schema schema_spectrum_uddh
from data catalog
database 'spectrum_db_uddh'
iam_role 'arn:aws:iam::aws-account-id:role/role-name'
```

```
create external database if not exists;
```

The following example creates the external table `soccer_league` in the external schema `schema_spectrum_uddh`.

```
CREATE EXTERNAL TABLE schema_spectrum_uddh.soccer_league
(
  league_rank smallint,
  prev_rank   smallint,
  club_name   varchar(15),
  league_name varchar(20),
  league_off  decimal(6,2),
  league_def  decimal(6,2),
  league_spi  decimal(6,2),
  league_nspi integer
)
ROW FORMAT DELIMITED
    FIELDS TERMINATED BY ','
    LINES TERMINATED BY '\n\l'
stored as textfile
LOCATION 's3://spectrum-uddh/league/'
table properties ('skip.header.line.count'='1');
```

Check the number of rows in the `soccer_league` table.

```
select count(*) from schema_spectrum_uddh.soccer_league;
```

The numbers of rows displays.

```
count
645
```

The following query displays the top 10 clubs. Because club `Barcelona` has an invalid character in the string, a NULL is displayed for the name.

```
select league_rank,club_name,league_name,league_nspi
from schema_spectrum_uddh.soccer_league
where league_rank between 1 and 10;
```

```
league_rank club_name league_name   league_nspi
1  Manchester City Barclays Premier Lea  34595
```

```
2  Bayern Munich German Bundesliga  34151
3  Liverpool Barclays Premier Lea  33223
4  Chelsea  Barclays Premier Lea  32808
5  Ajax  Dutch Eredivisie  32790
6  Atletico  Madrid Spanish Primera Divi 31517
7  Real Madrid Spanish Primera Divi  31469
8  NULL         Spanish Primera Divi            31321
9  RB Leipzig German Bundesliga  31014
10  Paris Saint-Ger French Ligue 1   30929
```

The following example alters the `soccer_league` table to specify the `invalid_char_handling`, `replacement_char`, and `data_cleansing_enabled` external table properties to insert a question mark (?) as a substitute for unexpected characters.

```
alter  table schema_spectrum_uddh.soccer_league
set table properties
 ('invalid_char_handling'='REPLACE','replacement_char'='?','data_cleansing_enabled'='true');
```

The following example queries the table `soccer_league` for teams with a rank from 1 to 10.

```
select league_rank,club_name,league_name,league_nspi
from schema_spectrum_uddh.soccer_league
where league_rank between 1 and 10;
```

Because the table properties were altered, the results show the top 10 clubs, with the question mark (?) replacement character in the eighth row for club `Barcelona`.

```
league_rank club_name league_name  league_nspi
1  Manchester City Barclays Premier Lea 34595
2  Bayern Munich German Bundesliga 34151
3  Liverpool Barclays Premier Lea 33223
4  Chelsea  Barclays Premier Lea 32808
5  Ajax  Dutch Eredivisie 32790
6  Atletico Madrid Spanish Primera Divi 31517
7  Real Madrid Spanish Primera Divi 31469
8  Barcel?na Spanish Primera Divi 31321
9  RB Leipzig German Bundesliga 31014
10  Paris Saint-Ger French Ligue 1  30929
```

The following example alters the `soccer_league` table to specify the `invalid_char_handling` external table properties to drop rows with unexpected characters.

```
alter table schema_spectrum_uddh.soccer_league
set table properties
 ('invalid_char_handling'='DROP_ROW','data_cleansing_enabled'='true');
```

The following example queries the table `soccer_league` for teams with a rank from 1 to 10.

```
select league_rank,club_name,league_name,league_nspi
from schema_spectrum_uddh.soccer_league
where league_rank between 1 and 10;
```

The results display the top clubs, not including the eighth row for club `Barcelona`.

```

league_rank   club_name         league_name           league_nspi
1             Manchester City   Barclays Premier Lea   34595
2             Bayern Munich     German Bundesliga      34151
3             Liverpool         Barclays Premier Lea   33223
4             Chelsea           Barclays Premier Lea   32808
5             Ajax              Dutch Eredivisie       32790
6             Atletico Madrid   Spanish Primera Divi   31517
7             Real Madrid       Spanish Primera Divi   31469
9             RB Leipzig        German Bundesliga      31014
10            Paris Saint-Ger   French Ligue 1         30929
```

CREATE EXTERNAL VIEW

The Data Catalog views preview feature is available only in the following Regions.

- US East (Ohio) (us-east-2)
- US East (N. Virginia) (us-east-1)
- US West (N. California) (us-west-1)
- Asia Pacific (Tokyo) (ap-northeast-1)
- Europe (Ireland) (eu-west-1)
- Europe (Stockholm) (eu-north-1)

Creates a view in the Data Catalog. Data Catalog views are a single view schema that works with other SQL engines such as Amazon Athena and Amazon EMR. You can query the view from your choice of engine. For more information about Data Catalog views, see Creating Data Catalog views.

Syntax

```
CREATE EXTERNAL VIEW schema_name.view_name [ IF NOT EXISTS ]
{catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name |
 external_schema_name.view_name}
AS query_definition;
```

Parameters

schema_name.view_name

The schema that's attached to your AWS Glue database, followed by the name of the view.

PROTECTED

Specifies that the CREATE EXTERNAL VIEW command should only complete if the query within the query_definition can successfully complete.

IF NOT EXISTS

Creates the view if the view doesn't already exist.

catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name | external_schema_name.view_name

The notation of the schema to use when creating the view. You can specify to use the AWS Glue Data Catalog, a Glue database that you created, or an external schema that you created. See CREATE DATABASE and CREATE EXTERNAL SCHEMA for more information.

query_definition

The definition of the SQL query that Amazon Redshift runs to alter the view.

Examples

The following example creates a Data Catalog view named sample_schema.glue_data_catalog_view.

```
CREATE EXTERNAL PROTECTED VIEW sample_schema.glue_data_catalog_view IF NOT EXISTS
AS SELECT * FROM sample_database.remote_table "remote-table-name";
```

CREATE FUNCTION

Creates a new scalar user-defined function (UDF) using either a SQL SELECT clause or a Python program.

For more information and examples, see User-defined functions in Amazon Redshift.

Required privileges

You must have permission by one of the following ways to run CREATE OR REPLACE FUNCTION:

- For CREATE FUNCTION:
  - Superuser can use both trusted and untrusted languages to create functions.
  - Users with the CREATE [OR REPLACE] FUNCTION privilege can create functions with trusted languages.
- For REPLACE FUNCTION:
  - Superuser
  - Users with the CREATE [OR REPLACE] FUNCTION privilege
  - Function owner

Syntax

```
CREATE [ OR REPLACE ] FUNCTION f_function_name
( { [py_arg_name  py_arg_data_type |
sql_arg_data_type } [ , ... ] ] )
RETURNS data_type
{ VOLATILE | STABLE | IMMUTABLE }
AS $$
  { python_program | SELECT_clause }
$$ LANGUAGE { plpythonu | sql }
```

Parameters

OR REPLACE

Specifies that if a function with the same name and input argument data types, or *signature*, as this one already exists, the existing function is replaced. You can only replace a function with a new function that defines an identical set of data types. You must be a superuser to replace a function.

If you define a function with the same name as an existing function but a different signature, you create a new function. In other words, the function name is overloaded. For more information, see Overloading function names.

f_function_name

The name of the function. If you specify a schema name (such as `myschema.myfunction`), the function is created using the specified schema. Otherwise, the function is created in the current schema. For more information about valid names, see Names and identifiers.

We recommend that you prefix all UDF names with `f_`. Amazon Redshift reserves the `f_` prefix for UDF names, so by using the `f_` prefix, you ensure that your UDF name will not conflict with any existing or future Amazon Redshift built-in SQL function names. For more information, see Preventing UDF naming conflicts.

You can define more than one function with the same function name if the data types for the input arguments are different. In other words, the function name is overloaded. For more information, see Overloading function names.

py_arg_name py_arg_data_type | sql_arg_data_type

For a Python UDF, a list of input argument names and data types. For a SQL UDF, a list of data types, without argument names. In a Python UDF, refer to arguments using the argument names. In a SQL UDF, refer to arguments using $1, $2, and so on, based on the order of the arguments in the argument list.

For a SQL UDF, the input and return data types can be any standard Amazon Redshift data type. For a Python UDF, the input and return data types can be SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, or TIMESTAMP. In addition, Python user-defined functions (UDFs) support a data type of ANYELEMENT. This is automatically converted to a standard data type based on the data type of the corresponding argument supplied at runtime. If multiple arguments use ANYELEMENT, they all resolve to the same data type at runtime, based on the first ANYELEMENT argument in the list. For more information, see Python UDF data types and Data types.

You can specify a maximum of 32 arguments.

RETURNS *data_type*

The data type of the value returned by the function. The RETURNS data type can be any standard Amazon Redshift data type. In addition, Python UDFs can use a data type of ANYELEMENT, which is automatically converted to a standard data type based on the argument supplied at runtime. If you specify ANYELEMENT for the return data type, at least one argument must use ANYELEMENT. The actual return data type matches the data type supplied for the ANYELEMENT argument when the function is called. For more information, see Python UDF data types.

VOLATILE | STABLE | IMMUTABLE

Informs the query optimizer about the volatility of the function.

You will get the best optimization if you label your function with the strictest volatility category that is valid for it. However, if the category is too strict, there is a risk that the optimizer will erroneously skip some calls, resulting in an incorrect result set. In order of strictness, beginning with the least strict, the volatility categories are as follows:

- VOLATILE
- STABLE
- IMMUTABLE

VOLATILE

Given the same arguments, the function can return different results on successive calls, even for the rows in a single statement. The query optimizer can't make any assumptions about the behavior of a volatile function, so a query that uses a volatile function must reevaluate the function for every input row.

STABLE

Given the same arguments, the function is guaranteed to return the same results for all rows processed within a single statement. The function can return different results when called in different statements. This category allows the optimizer to optimize multiple calls of the function within a single statement to a single call for the statement.

IMMUTABLE

Given the same arguments, the function always returns the same result, forever. When a query calls an `IMMUTABLE` function with constant arguments, the optimizer pre-evaluates the function.

AS $$ *statement* $$

A construct that encloses the statement to be run. The literal keywords `AS $$` and `$$` are required.

Amazon Redshift requires you to enclose the statement in your function by using a format called dollar quoting. Anything within the enclosure is passed exactly as is. You don't need to escape any special characters because the contents of the string are written literally.

With *dollar quoting*, you use a pair of dollar signs ($$) to signify the start and the end of the statement to run, as shown in the following example.

```
$$ my statement $$
```

Optionally, between the dollar signs in each pair, you can specify a string to help identify the statement. The string that you use must be the same in both the start and the end of the enclosure pairs. This string is case-sensitive, and it follows the same constraints as an unquoted identifier except that it can't contain dollar signs. The following example uses the string `test`.

```
$test$ my statement $test$
```

For more information about dollar quoting, see "Dollar-quoted String Constants" under Lexical Structure in the PostgreSQL documentation.

python_program

A valid executable Python program that returns a value. The statement that you pass in with the function must conform to indentation requirements as specified in the Style Guide for Python Code on the Python website. For more information, see Python language support for UDFs.

SQL_clause

A SQL SELECT clause.

The SELECT clause can't include any of the following types of clauses:

- FROM
- INTO
- WHERE
- GROUP BY
- ORDER BY
- LIMIT

LANGUAGE { plpythonu | sql }

For Python, specify `plpythonu`. For SQL, specify `sql`. You must have permission for usage on language for SQL or plpythonu. For more information, see UDF security and permissions.

Usage notes

Nested functions

You can call another SQL user-defined function (UDF) from within a SQL UDF. The nested function must exist when you run the CREATE FUNCTION command. Amazon Redshift doesn't track dependencies for UDFs, so if you drop the nested function, Amazon Redshift doesn't return an error. However, the UDF will fail if the nested function doesn't exist. For example, the following function calls the `f_sql_greater` function in the SELECT clause.

```
create function f_sql_commission (float, float )
  returns float
stable
as $$
  select f_sql_greater ($1, $2)
$$ language sql;
```

UDF security and privileges

To create a UDF, you must have permission for usage on language for SQL or plpythonu (Python). By default, USAGE ON LANGUAGE SQL is granted to PUBLIC. However, you must explicitly grant USAGE ON LANGUAGE PLPYTHONU to specific users or groups.

To revoke usage for SQL, first revoke usage from PUBLIC. Then grant usage on SQL only to the specific users or groups permitted to create SQL UDFs. The following example revokes usage on SQL from PUBLIC then grants usage to the user group `udf_devs`.

```
revoke usage on language sql from PUBLIC;
grant usage on language sql to group udf_devs;
```

To run a UDF, you must have execute permission for each function. By default, execute permission for new UDFs is granted to PUBLIC. To restrict usage, revoke execute permission from PUBLIC for the function. Then grant the privilege to specific individuals or groups.

The following example revokes execute permission on function `f_py_greater` from PUBLIC then grants usage to the user group `udf_devs`.

```
revoke execute on function f_py_greater(a float, b float) from PUBLIC;
grant execute on function f_py_greater(a float, b float) to group udf_devs;
```

Superusers have all privileges by default.

For more information, see GRANT and REVOKE.

Examples

Scalar Python UDF example

The following example creates a Python UDF that compares two integers and returns the larger value.

```
create function f_py_greater (a float, b float)
  returns float
stable
as $$
  if a > b:
    return a
  return b
$$ language plpythonu;
```

The following example queries the SALES table and calls the new `f_py_greater` function to return either COMMISSION or 20 percent of PRICEPAID, whichever is greater.

```
select f_py_greater (commission, pricepaid*0.20) from sales;
```

Scalar SQL UDF example

The following example creates a function that compares two numbers and returns the larger value.

```
create function f_sql_greater (float, float)
  returns float
stable
as $$
  select case when $1 > $2 then $1
    else $2
```

```
  end
$$ language sql;
```

The following query calls the new `f_sql_greater` function to query the SALES table and returns either COMMISSION or 20 percent of PRICEPAID, whichever is greater.

```
select f_sql_greater (commission, pricepaid*0.20) from sales;
```

CREATE GROUP

Defines a new user group. Only a superuser can create a group.

Syntax

```
CREATE GROUP group_name
[ [ WITH ] [ USER username ] [, ...] ]
```

Parameters

group_name

Name of the new user group. Group names beginning with two underscores are reserved for Amazon Redshift internal use. For more information about valid names, see Names and identifiers.

WITH

Optional syntax to indicate additional parameters for CREATE GROUP.

USER

Add one or more users to the group.

username

Name of the user to add to the group.

Examples

The following example creates a user group named ADMIN_GROUP with a two users, ADMIN1 and ADMIN2.

```
create group admin_group with user admin1, admin2;
```

CREATE IDENTITY PROVIDER

Defines a new identity provider. Only a superuser can create an identity provider.

Syntax

```
CREATE IDENTITY PROVIDER identity_provider_name TYPE type_name
NAMESPACE namespace_name
[PARAMETERS parameter_string]
[APPLICATION_ARN arn]
[IAM_ROLE iam_role]
[AUTO_CREATE_ROLES
    [ TRUE [ { INCLUDE | EXCLUDE } GROUPS LIKE filter_pattern] |
      FALSE
    ]
  ];
```

Parameters

identity_provider_name

Name of the new identity provider. For more information about valid names, see Names and identifiers.

type_name

The identity provider to interface with. Azure and AWSIDC are currently the only supported identity providers.

namespace_name

The namespace. This is a unique, shorthand identifier for the identity provider directory.

parameter_string

A string containing a properly formatted JSON object that contains parameters and values required for the identity provider.

arn

The Amazon resource name (ARN) for an IAM Identity Center managed application. This parameter is applicable only when the identity-provider type is AWSIDC.

iam_role

The IAM role that provides permissions to make the connection to IAM Identity Center. This parameter is applicable only when the identity-provider type is AWSIDC.

auto_create_roles

Enables or disables the auto-create role feature. If the value is TRUE, Amazon Redshift enables the auto-create role feature. If the value is FALSE, Amazon Redshift disables the auto-create role feature. If the value for this parameter isn't specified, Amazon Redshift determines the value using the following logic:

- If `AUTO_CREATE_ROLES` is provided but the value isn't specified, the value is set to TRUE.
- If `AUTO_CREATE_ROLES` isn't provided and the identity provider is AWSIDC, the value is set to FALSE.
- If `AUTO_CREATE_ROLES` isn't provided and the identity provider is Azure, the value is set to TRUE.

To include groups, specify `INCLUDE`. The default is empty, which means include all groups if `AUTO_CREATE_ROLES` is on.

To exclude groups, specify `EXCLUDE`. The default is empty, which means do not exclude any groups if `AUTO_CREATE_ROLES` is on.

filter_pattern

A valid UTF-8 character expression with a pattern to match group names. The LIKE option performs a case-sensitive match that supports the following pattern-matching metacharacters:

Metacharacter	Description
`%`	Matches any sequence of zero or more characters.
`_`	Matches any single character.

If *filter_pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

filter_pattern supports the following characters:

- Uppercase and lowercase alphabetic characters (A-Z and a-z)
- Numerals (0-9)
- The following special characters:

```
_ % ^ * + ? { } , $
```

Examples

The following example creates an identity provider named *oauth_standard*, with a TYPE *azure*, to establish communication with Microsoft Azure Active Directory (AD).

```
CREATE IDENTITY PROVIDER oauth_standard TYPE azure
NAMESPACE 'aad'
PARAMETERS '{"issuer":"https://sts.windows.net/2sdfdsf-d475-420d-b5ac-667adad7c702/",
"client_id":"87f4aa26-78b7-410e-bf29-57b39929ef9a",
"client_secret":"BUAH~ewrqewrqwerUUY^%tHe1oNZShoiU7",
"audience":["https://analysis.windows.net/powerbi/connector/AmazonRedshift"]
}'
```

You can connect an IAM Identity Center managed application with an existing provisioned cluster or Amazon Redshift Serverless workgroup. This gives you the ability to manage access to a Redshift database through IAM Identity Center. To do so, run a SQL command like the following sample. You have to be a database administrator.

```
CREATE IDENTITY PROVIDER "redshift-idc-app" TYPE AWSIDC
NAMESPACE 'awsidc'
APPLICATION_ARN 'arn:aws:sso::123456789012:application/ssoins-12345f67fe123d4/apl-
a0b0a12dc123b1a4'
IAM_ROLE 'arn:aws:iam::123456789012:role/MyRedshiftRole';
```

The application ARN in this case identifies the managed application to connect to. You can find it by running `SELECT * FROM SVV_IDENTITY_PROVIDERS;`.

For more information about using CREATE IDENTITY PROVIDER, including additional examples, see Native identity provider (IdP) federation for Amazon Redshift. For more information about setting up a connection to IAM Identity Center from Redshift, see Connect Redshift with IAM Identity Center to give users a single sign-on experience.

CREATE LIBRARY

Installs a Python library, which is available for users to incorporate when creating a user-defined function (UDF) with the CREATE FUNCTION command. The total size of user-installed libraries can't exceed 100 MB.

CREATE LIBRARY can't be run inside a transaction block (BEGIN … END). For more information about transactions, see Serializable isolation.

Amazon Redshift supports Python version 2.7. For more information, see www.python.org.

For more information, see Example: Importing custom Python library modules.

Required privileges

Following are required privileges for CREATE LIBRARY:

- Superuser
- Users with the CREATE LIBRARY privilege or with the privilege of the specified language

Syntax

```
CREATE [ OR REPLACE ] LIBRARY library_name LANGUAGE plpythonu
FROM
{ 'https://file_url'
| 's3://bucketname/file_name'
authorization
  [ REGION [AS] 'aws_region']
  IAM_ROLE { default | 'arn:aws:iam::<AWS account-id>:role/<role-name>' }
}
```

Parameters

OR REPLACE

Specifies that if a library with the same name as this one already exists, the existing library is replaced. REPLACE commits immediately. If a UDF that depends on the library is running concurrently, the UDF might fail or return unexpected results, even if the UDF is running within a transaction. You must be the owner or a superuser to replace a library.

library_name

The name of the library to be installed. You can't create a library that contains a module with the same name as a Python Standard Library module or an Amazon Redshift preinstalled Python module. If an existing user-installed library uses the same Python package as the library to be installed, you must drop the existing library before installing the new library. For more information, see Python language support for UDFs.

LANGUAGE plpythonu

The language to use. Python (plpythonu) is the only supported language. Amazon Redshift supports Python version 2.7. For more information, see www.python.org.

FROM

The location of the library file. You can specify an Amazon S3 bucket and object name, or you can specify a URL to download the file from a public website. The library must be packaged in the form of a `.zip` file. For more information, see Building and Installing Python Modules in the Python documentation.

https://*file_url*

The URL to download the file from a public website. The URL can contain up to three redirects. The following is an example of a file URL.

```
'https://www.example.com/pylib.zip'
```

s3://*bucket_name/file_name*

The path to a single Amazon S3 object that contains the library file. The following is an example of an Amazon S3 object path.

```
's3://amzn-s3-demo-bucket/my-pylib.zip'
```

If you specify an Amazon S3 bucket, you must also provide credentials for an AWS user that has permission to download the file.

> **Important**
>
> If the Amazon S3 bucket doesn't reside in the same AWS Region as your Amazon Redshift cluster, you must use the REGION option to specify the AWS Region in which

the data is located. The value for *aws_region* must match an AWS Region listed in the table in the REGION parameter description for the COPY command.

authorization

A clause that indicates the method your cluster uses for authentication and authorization to access the Amazon S3 bucket that contains the library file. Your cluster must have permission to access the Amazon S3 with the LIST and GET actions.

The syntax for authorization is the same as for the COPY command authorization. For more information, see Authorization parameters.

```
IAM_ROLE { default | 'arn:aws:iam::<AWS account-id>:role/<role-name>'
```

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE LIBRARY command runs.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. If you specify IAM_ROLE, you can't use ACCESS_KEY_ID and SECRET_ACCESS_KEY, SESSION_TOKEN, or CREDENTIALS.

Optionally, if the Amazon S3 bucket uses server-side encryption, provide the encryption key in the credentials-args string. If you use temporary security credentials, provide the temporary token in the *credentials-args* string.

For more information, see Temporary security credentials.

REGION [AS] *aws_region*

The AWS Region where the Amazon S3 bucket is located. REGION is required when the Amazon S3 bucket isn't in the same AWS Region as the Amazon Redshift cluster. The value for *aws_region* must match an AWS Region listed in the table in the REGION parameter description for the COPY command.

By default, CREATE LIBRARY assumes that the Amazon S3 bucket is located in the same AWS Region as the Amazon Redshift cluster.

Examples

The following two examples install the urlparse Python module, which is packaged in a file named `urlparse3-1.0.3.zip`.

The following command installs a UDF library named `f_urlparse` from a package that has been uploaded to an Amazon S3 bucket located in the US East Region.

```
create library f_urlparse
language plpythonu
from 's3://amzn-s3-demo-bucket/urlparse3-1.0.3.zip'
credentials 'aws_iam_role=arn:aws:iam::<aws-account-id>:role/<role-name>'
region as 'us-east-1';
```

The following example installs a library named `f_urlparse` from a library file on a website.

```
create library f_urlparse
language plpythonu
from 'https://example.com/packages/urlparse3-1.0.3.zip';
```

CREATE MASKING POLICY

Creates a new dynamic data masking policy to obfuscate data of a given format. For more information on dynamic data masking, see Dynamic data masking.

Superusers and users or roles that have the sys:secadmin role can create a masking policy.

Syntax

```
CREATE MASKING POLICY
   policy_name [IF NOT EXISTS]
   WITH (input_columns)
   USING (masking_expression);
```

Parameters

policy_name

The name of the masking policy. The masking policy can't have the same name as another masking policy that already exists in the database.

input_columns

A tuple of column names in the format (col1 type, col2 type ...).

Column names are used as the input for the masking expression. Column names don't have to match the names of the columns being masked, but the input and output data types must match.

masking_expression

The SQL expression used to transform the target columns. It can be written using data manipulation functions such as String manipulation functions, or in conjunction with user-defined functions written in SQL, Python, or with AWS Lambda. You can include a tuple of column expressions for masking policies that have multiple outputs. If you use a constant as your masking expression, you must explicitly cast it to a type that matches the input type.

You must have the USAGE permission on any user-defined functions that you use in the masking expression.

CREATE MATERIALIZED VIEW

Creates a materialized view based on one or more Amazon Redshift tables. You can also base materialized views on external tables created using Spectrum or federated query. For information about Spectrum, see Amazon Redshift Spectrum. For information about federated query, see Querying data with federated queries in Amazon Redshift.

Syntax

```
CREATE MATERIALIZED VIEW mv_name
[ BACKUP { YES | NO } ]
[ table_attributes ]
[ AUTO REFRESH { YES | NO } ]
AS query
```

Parameters

BACKUP

A clause that specifies whether the materialized view should be included in automated and manual cluster snapshots.

For materialized views that don't contain critical data, specify BACKUP NO to save processing time when creating snapshots and restoring from snapshots and to reduce storage space on Amazon Simple Storage Service. The BACKUP NO setting has no affect on automatic replication of data to other nodes within the cluster, so materialized views with BACKUP NO specified are restored in the event of a node failure. The default is BACKUP YES.

table_attributes

A clause that specifies how the data in the materialized view is distributed, including the following:

- The distribution style for the materialized view, in the format `DISTSTYLE { EVEN | ALL | KEY }`. If you omit this clause, the distribution style is `EVEN`. For more information, see Distribution styles.
- The distribution key for the materialized view, in the format `DISTKEY ( distkey_identifier )`. For more information, see Designating distribution styles.
- The sort key for the materialized view, in the format `SORTKEY ( column_name [, ...] )`. For more information, see Sort keys.

AS *query*

A valid `SELECT` statement that defines the materialized view and its content. The result set from the query defines the columns and rows of the materialized view. For information about limitations when creating materialized views, see Limitations.

Furthermore, specific SQL language constructs used in the query determines whether the materialized view can be incrementally or fully refreshed. For information about the refresh method, see REFRESH MATERIALIZED VIEW. For information about the limitations for incremental refresh, see Limitations for incremental refresh.

If the query contains an SQL command that doesn't support incremental refresh, Amazon Redshift displays a message indicating that the materialized view will use a full refresh. The message may or may not be displayed, depending on the SQL client application. Check the `state` column of the STV_MV_INFO to see the refresh type used by a materialized view.

AUTO REFRESH

A clause that defines whether the materialized view should be automatically refreshed with latest changes from its base tables. The default value is `NO`. For more information, see Refreshing a materialized view.

Usage notes

To create a materialized view, you must have the following privileges:

- CREATE privileges for a schema.
- Table-level or column-level SELECT privilege on the base tables to create a materialized view. If you have column-level privileges on specific columns, you can create a materialized view on only those columns.

Incremental refresh for materialized views in a datashare

Amazon Redshift supports automatic and incremental refresh for materialized views in a consumer datashare when the base tables are shared. Incremental refresh is an operation where Amazon Redshift identifies changes in the base table or tables that happened after the previous refresh and updates only the corresponding records in the materialized view. This runs more quickly than a full refresh and improves workload performance. You don't have to change your materialized-view definition to take advantage of incremental refresh.

There are a couple limitations to note for taking advantage of incremental refresh with a materialized view:

- The materialized view must reference only one database, either local or remote.
- Incremental refresh is available only on new materialized views. Therefore, you must drop existing materialized views and recreate them for incremental refresh to occur.

For more information about creating materialized views in a datashare, see Working with views in Amazon Redshift data sharing, which contains several query examples.

DDL updates to materialized views or base tables

When using materialized views in Amazon Redshift, follow these usage notes for data definition language (DDL) updates to materialized views or base tables.

- You can add columns to a base table without affecting any materialized views that reference the base table.
- Some operations can leave the materialized view in a state that can't be refreshed at all. Examples are operations such as renaming or dropping a column, changing the type of a column,

and changing the name of a schema. Such materialized views can be queried but can't be refreshed. In this case, you must drop and recreate the materialized view.

- In general, you can't alter a materialized view's definition (its SQL statement).
- You can't rename a materialized view.

Limitations

You can't define a materialized view that references or includes any of the following:

- Standard views, or system tables and views.
- Temporary tables.
- User-defined functions.
- The ORDER BY, LIMIT, or OFFSET clause.
- Late-binding references to base tables. In other words, any base tables or related columns referenced in the defining SQL query of the materialized view must exist and must be valid.
- Leader node-only functions: CURRENT_SCHEMA, CURRENT_SCHEMAS, HAS_DATABASE_PRIVILEGE, HAS_SCHEMA_PRIVILEGE, HAS_TABLE_PRIVILEGE.
- You can't use the AUTO REFRESH YES option when the materialized view definition includes mutable functions or external schemas. You also can't use it when you define a materialized view on another materialized view.
- You don't have to manually run ANALYZE on materialized views. This happens currently only via AUTO ANALYZE. For more information, see Analyzing tables.
- RLS-protected or DDM-protected tables.

Examples

The following example creates a materialized view from three base tables that are joined and aggregated. Each row represents a category with the number of tickets sold. When you query the tickets_mv materialized view, you directly access the precomputed data in the tickets_mv materialized view.

```
CREATE MATERIALIZED VIEW tickets_mv AS
    select   catgroup,
    sum(qtysold) as sold
    from     category c, event e, sales s
    where    c.catid = e.catid
```

```
    and      e.eventid = s.eventid
    group by catgroup;
```

The following example creates a materialized view similar to the previous example and uses the aggregate function MAX().

```
CREATE MATERIALIZED VIEW tickets_mv_max AS
    select   catgroup,
    max(qtysold) as sold
    from     category c, event e, sales s
    where    c.catid = e.catid
    and      e.eventid = s.eventid
    group by catgroup;

SELECT name, state FROM STV_MV_INFO;
```

The following example uses a UNION ALL clause to join the Amazon Redshift `public_sales` table and the Redshift Spectrum `spectrum.sales` table to create a material view `mv_sales_vw`. For information about the CREATE EXTERNAL TABLE command for Amazon Redshift Spectrum, see CREATE EXTERNAL TABLE. The Redshift Spectrum external table references the data on Amazon S3.

```
CREATE MATERIALIZED VIEW mv_sales_vw as
select salesid, qtysold, pricepaid, commission, saletime from public.sales
union all
select salesid, qtysold, pricepaid, commission, saletime from spectrum.sales
```

The following example creates a materialized view `mv_fq` based on a federated query external table. For information about federated query, see CREATE EXTERNAL SCHEMA.

```
CREATE MATERIALIZED VIEW mv_fq as select firstname, lastname from apg.mv_fq_example;

select firstname, lastname from mv_fq;
 firstname | lastname
-----------+----------
 John      | Day
 Jane      | Doe
(2 rows)
```

The following example shows the definition of a materialized view.

```
SELECT pg_catalog.pg_get_viewdef('mv_sales_vw'::regclass::oid, true);

pg_get_viewdef
---------------------------------------------------
create materialized view mv_sales_vw as select a from t;
```

The following sample shows how to set AUTO REFRESH in the materialized view definition and also specifies a DISTSTYLE. First, create a simple base table.

```
CREATE TABLE baseball_table (ball int, bat int);
```

Then, create a materialized view.

```
CREATE MATERIALIZED VIEW mv_baseball DISTSTYLE ALL AUTO REFRESH YES AS SELECT ball AS
 baseball FROM baseball_table;
```

Now you can query the mv_baseball materialized view. To check if AUTO REFRESH is turned on for a materialized view, see STV_MV_INFO.

The following sample creates a materialized view that references a source table in another database. It assumes that the database containing the source table, database_A, is in the same cluster or workgroup as your materialized view, which you create in database_B. (You can substitute your own databases for the sample.) First, create a table in database_A called *cities*, with a *cityname* column. Make the column's data type a VARCHAR. After you create the source table, run the following command in database_B to create a materialized view whose source is your *cities* table. Make sure to specify the source table's database and schema in the FROM clause:

```
CREATE MATERIALIZED VIEW cities_mv AS
SELECT  cityname
FROM    database_A.public.cities;
```

Query the materialized view you created. The query retrieves records whose original source is the *cities* table in database_A:

```
select * from cities_mv;
```

When you run the SELECT statement, *cities_mv* returns the records. Records are refreshed from the source table only when a REFRESH statement is run. Also, note that you can't update records directly in the materialized view. For information about refreshing the data in a materialized view, see REFRESH MATERIALIZED VIEW.

For details about materialized view overview and SQL commands used to refresh and drop materialized views, see the following topics:

- Materialized views in Amazon Redshift
- REFRESH MATERIALIZED VIEW
- DROP MATERIALIZED VIEW

CREATE MODEL

Topics

Prerequisites

Before you use the CREATE MODEL statement, complete the prerequisites in Cluster setup for using Amazon Redshift ML. The following is a high-level summary of the prerequisites.

- Create an Amazon Redshift cluster with the AWS Management Console or the AWS Command Line Interface (AWS CLI).
- Attach the AWS Identity and Access Management (IAM) policy while creating the cluster.
- To allow Amazon Redshift and SageMaker AI to assume the role to interact with other services, add the appropriate trust policy to the IAM role.

For details for the IAM role, trust policy, and other prerequisites, see Cluster setup for using Amazon Redshift ML.

Following, you can find different use cases for the CREATE MODEL statement.

- Simple CREATE MODEL
- CREATE MODEL with user guidance
- CREATE XGBoost models with AUTO OFF
- Bring your own model (BYOM) - local inference
- Bring your own model (BYOM) - remote inference
- CREATE MODEL with K-MEANS
- Full CREATE MODEL

Required privileges

Following are required privileges for CREATE MODEL:

- Superuser
- Users with the CREATE MODEL privilege
- Roles with the GRANT CREATE MODEL privilege

Cost control

Amazon Redshift ML uses existing cluster resources to create prediction models, so you don't have to pay additional costs. However, you might have additional costs if you need to resize your cluster or want to train your models. Amazon Redshift ML uses Amazon SageMaker AI to train models, which does have an additional associated cost. There are ways to control additional costs, such as limiting the maximum amount of time training can take or by limiting the number of training examples used to train your model. For more information, see Costs for using Amazon Redshift ML.

Full CREATE MODEL

The following summarizes the basic options of the full CREATE MODEL syntax.

Full CREATE MODEL syntax

The following is the full syntax of the CREATE MODEL statement.

> **Important**
>
> When creating a model using the CREATE MODEL statement, follow the order of the keywords in the syntax following.

```
CREATE MODEL model_name
FROM { table_name | ( select_statement )  | 'job_name' }
[ TARGET column_name ]
FUNCTION function_name [ ( data_type [, ...] ) ]
[ RETURNS data_type ]
  -- supported only for BYOM
[ SAGEMAKER 'endpoint_name'[:'model_name']]
  -- supported only for BYOM remote inference
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }
[ AUTO ON / OFF ]
  -- default is AUTO ON
[ MODEL_TYPE { XGBOOST | MLP | LINEAR_LEARNER | KMEANS | FORECAST } ]
  -- not required for non AUTO OFF case, default is the list of all supported types
  -- required for AUTO OFF
[ PROBLEM_TYPE ( REGRESSION | BINARY_CLASSIFICATION | MULTICLASS_CLASSIFICATION ) ]
  -- not supported when AUTO OFF
[ OBJECTIVE ( 'MSE' | 'Accuracy' | 'F1' | 'F1_Macro' | 'AUC' |
             'reg:squarederror' | 'reg:squaredlogerror'| 'reg:logistic'|
             'reg:pseudohubererror' | 'reg:tweedie' | 'binary:logistic' |
 'binary:hinge',
             'multi:softmax' | 'RMSE' | 'WAPE' | 'MAPE' | 'MASE' |
 'AverageWeightedQuantileLoss' ) ]
  -- for AUTO ON: first 5 are valid
  -- for AUTO OFF: 6-13 are valid
  -- for FORECAST: 14-18 are valid
[ PREPROCESSORS 'string' ]
  -- required for AUTO OFF, when it has to be 'none'
  -- optional for AUTO ON
[ HYPERPARAMETERS { DEFAULT | DEFAULT EXCEPT ( Key 'value' (,...) ) } ]
  -- support XGBoost hyperparameters, except OBJECTIVE
  -- required and only allowed for AUTO OFF
  -- default NUM_ROUND is 100
  -- NUM_CLASS is required if objective is multi:softmax (only possible for AUTO OFF)
 [ SETTINGS (
   S3_BUCKET 'amzn-s3-demo-bucket',  |
    -- required
```

```
  TAGS 'string', |
    -- optional
  KMS_KEY_ID 'kms_string', |
    -- optional
  S3_GARBAGE_COLLECT on / off, |
    -- optional, defualt is on.
  MAX_CELLS integer, |
    -- optional, default is 1,000,000
  MAX_RUNTIME integer (, ...) |
    -- optional, default is 5400 (1.5 hours)
  HORIZON integer, |
    -- required if creating a forecast model
  FREQUENCY integer, |
    -- required if creating a forecast model
  PERCENTILES string, |
    -- optional if creating a forecast model
  MAX_BATCH_ROWS integer -- optional for BYOM remote inference
    ) ]
```

Parameters

model_name

The name of the model. The model name in a schema must be unique.

FROM { *table_name* | (*select_query*) | *'job_name'*}

The table_name or the query that specifies the training data. They can either be an existing table in the system, or an Amazon Redshift-compatible SELECT query enclosed with parentheses, that is (). There must be at least two columns in the query result.

TARGET *column_name*

The name of the column that becomes the prediction target. The column must exist in the FROM clause.

FUNCTION *function_name* (*data_type* [, ...])

The name of the function to be created and the data types of the input arguments. You can provide the schema name of a schema in your database instead of a function name.

RETURNS *data_type*

The data type to be returned from the model's function. The returned SUPER data type is applicable only to BYOM with remote inference.

SAGEMAKER '*endpoint_name*'[:'*model_name*']

The name of the Amazon SageMaker AI endpoint. If the endpoint name points to a multimodel endpoint, add the name of the model to use. The endpoint must be hosted in the same AWS Region as the Amazon Redshift cluster.

IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE MODEL command runs. Alternatively, you can specify an ARN of an IAM role to use that role.

[AUTO ON / OFF]

Turns on or off CREATE MODEL automatic discovery of preprocessor, algorithm, and hyper-parameters selection. Specifying on when creating a Forecast model indicates to use an AutoPredictor, where Amazon Forecast applies the optimal combinations of algorithms to each time series in your dataset.

MODEL_TYPE { XGBOOST | MLP | LINEAR_LEARNER | KMEANS | FORECAST }

(Optional) Specifies the model type. You can specify if you want to train a model of a specific model type, such as XGBoost, multilayer perceptron (MLP), KMEANS, or Linear Learner, which are all algorithms that Amazon SageMaker AI Autopilot supports. If you don't specify the parameter, then all supported model types are searched during training for the best model. You can also create a forecast model in Redshift ML to create accurate time-series forecasts.

PROBLEM_TYPE (REGRESSION | BINARY_CLASSIFICATION | MULTICLASS_CLASSIFICATION)

(Optional) Specifies the problem type. If you know the problem type, you can restrict Amazon Redshift to only search of the best model of that specific model type. If you don't specify this parameter, a problem type is discovered during the training, based on your data.

OBJECTIVE ('MSE' | 'Accuracy' | 'F1' | 'F1Macro' | 'AUC' | 'reg:squarederror' | 'reg:squaredlogerror' | 'reg:logistic' | 'reg:pseudohubererror' | 'reg:tweedie' | 'binary:logistic' | 'binary:hinge' | 'multi:softmax' | 'RMSE' | 'WAPE' | 'MAPE' | 'MASE' | 'AverageWeightedQuantileLoss')

(Optional) Specifies the name of the objective metric used to measure the predictive quality of a machine learning system. This metric is optimized during training to provide the best estimate for model parameter values from data. If you don't specify a metric explicitly, the default behavior is to automatically use MSE: for regression, F1: for binary classification, Accuracy: for multiclass classification. For more information about objectives, see AutoMLJobObjective in the *Amazon SageMaker AI API Reference* and Learning task parametersin the XGBOOST documentation. The values RMSE, WAPE, MAPE, MASE, and AverageWeightedQuantileLoss are only applicable to Forecast models. For more information, see the CreateAutoPredictor API operation.

PREPROCESSORS 'string'

(Optional) Specifies certain combinations of preprocessors to certain sets of columns. The format is a list of columnSets, and the appropriate transforms to be applied to each set of columns. Amazon Redshift applies all the transformers in a specific transformers list to all columns in the corresponding ColumnSet. For example, to apply OneHotEncoder with Imputer to columns t1 and t2, use the sample command following.

```
CREATE MODEL customer_churn
FROM customer_data
TARGET 'Churn'
FUNCTION predict_churn
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }
PROBLEM_TYPE BINARY_CLASSIFICATION
OBJECTIVE 'F1'
PREPROCESSORS '[
...
  {"ColumnSet": [
      "t1",
      "t2"
    ],
    "Transformers": [
      "OneHotEncoder",
      "Imputer"
    ]
  },
  {"ColumnSet": [
      "t3"
    ],
    "Transformers": [
      "OneHotEncoder"
    ]
  },
  {"ColumnSet": [
      "temp"
    ],
    "Transformers": [
      "Imputer",
      "NumericPassthrough"
```

```
    ]
  }
]'
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket'
)
```

HYPERPARAMETERS { DEFAULT | DEFAULT EXCEPT (key 'value' (,..)) }

Specifies whether the default XGBoost parameters are used or overridden by user-specified values. The values must be enclosed with single quotes. Following are examples of parameters for XGBoost and their defaults.

Parameter name	Parameter value	Default value	Notes
num_class	Integer	Required for Multiclass classification.	N/A
num_round	Integer	100	N/A
tree_method	String	Auto	N/A
max_depth	Integer	6	[0 , 10]
min_child_weight	Float	1	MinValue: 0, MaxValue: 120
subsample	Float	1	MinValue: 0.5, MaxValue: 1
gamma	Float	0	MinValue: 0, MaxValue: 5
alpha	Float	0	MinValue: 0, MaxValue: 1000
eta	Float	0.3	MinValue: 0.1, MaxValue: 0.5

Parameter name	Parameter value	Defaul value	Notes
colsample _byleve	Float	1	MinValue: 0.1, MaxValue: 1
colsample _bynode	Float	1	MinValue: 0.1, MaxValue: 1
colsample _bytree	Float	1	MinValue: 0.5, MaxValue: 1
lambda	Float	1	MinValue: 0, MaxValue: 1000
max_delta _step	Integer	0	[0, 10]

SETTINGS (S3_BUCKET *'amzn-s3-demo-bucket'*, | TAGS 'string', | KMS_KEY_ID *'kms_string'* , | S3_GARBAGE_COLLECT on / off, | MAX_CELLS integer , | MAX_RUNTIME (,...) , | HORIZON integer, | FREQUENCY forecast_frequency, | PERCENTILES array of strings)

S3_BUCKET clause specifies the Amazon S3 location that is used to store intermediate results.

(Optional) The TAGS parameter is a comma-separated list of key-value pairs that you can use to tag resources created in Amazon SageMaker AI; and Amazon Forecast. Tags help you organize resources and allocate costs. Values in the pair are optional, so you can create tags by using the format `key=value` or just by creating a key. For more information about tags in Amazon Redshift, see [Tagging overview](#).

(Optional) KMS_KEY_ID specifies if Amazon Redshift uses server-side encryption with an AWS KMS key to protect data at rest. Data in transit is protected with Secure Sockets Layer (SSL).

(Optional) S3_GARBAGE_COLLECT { ON | OFF } specifies whether Amazon Redshift performs garbage collection on the resulting datasets used to train models and the models. If set to OFF, the resulting datasets used to train models and the models remains in Amazon S3 and can be used for other purposes. If set to ON, Amazon Redshift deletes the artifacts in Amazon S3 after the training completes. The default is ON.

(Optional) MAX_CELLS specifies the number of cells in the training data. This value is the product of the number of records (in the training query or table) times the number of columns. The default is 1,000,000.

(Optional) MAX_RUNTIME specifies the maximum amount of time to train. Training jobs often complete sooner depending on dataset size. This specifies the maximum amount of time the training should take. The default is 5,400 (90 minutes).

HORIZON specifies the maximum number of predictions the forecast model can return. Once the model is trained, you can't change this integer. This parameter is required if training a forecast model.

FREQUENCY specifies how granular in time units you want the forecasts to be. Available options are `Y | M | W | D | H | 30min | 15min | 10min | 5min | 1min`. This parameter is required if training a forecast model.

(Optional) PERCENTILES is a comma-delimited string that specifies the forecast types used to train a predictor. Forecast types can be quantiles from 0.01 to 0.99, in increments of 0.01 or higher. You can also specify the mean forecast with mean. You can specify a maximum of five forecast types.

MAX_BATCH_ROWS *integer*

(Optional) The maximum number of rows that Amazon Redshift sends in a single batch request for a single SageMaker AI invocation. It is supported only for BYOM with remote inference. This parameter's minimum value is 1. The maximum value is `INT_MAX`, or 2,147,483,647. This parameter is required only when both input and returned data types are *SUPER*. The default value is `INT_MAX`, or 2,147,483,647.

Usage notes

When using CREATE MODEL, consider the following:

- The CREATE MODEL statement operates in an asynchronous mode and returns upon the export of training data to Amazon S3. The remaining steps of training in Amazon SageMaker AI occur in the background. While training is in progress, the corresponding inference function is visible but can't be run. You can query STV_ML_MODEL_INFO to see the state of training.
- The training can run for up to 90 minutes in the background, by default in the Auto model and can be extended. To cancel the training, simply run the DROP MODEL command.

- The Amazon Redshift cluster that you use to create the model and the Amazon S3 bucket that is used to stage the training data and model artifacts must be in the same AWS Region.
- During the model training, Amazon Redshift and SageMaker AI store intermediate artifacts in the Amazon S3 bucket that you provide. By default, Amazon Redshift performs garbage collection at the end of the CREATE MODEL operation. Amazon Redshift removes those objects from Amazon S3. To retain those artifacts on Amazon S3, set the S3_GARBAGE COLLECT OFF option.
- You must use at least 500 rows in the training data provided in the FROM clause.
- You can only specify up to 256 feature (input) columns in the FROM { table_name | (select_query) } clause when using the CREATE MODEL statement.
- For AUTO ON, the column types that you can use as the training set are SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE, BOOLEAN, CHAR, VARCHAR, DATE, TIME, TIMETZ, TIMESTAMP, and TIMESTAMPTZ. For AUTO OFF, the column types that you can use as the training set are SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE, and BOOLEAN.
- You can't use DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, TIMESTAMPTZ, GEOMETRY, GEOGRAPHY, HLLSKETCH, SUPER, or VARBYTE as the target column type.
- To improve model accuracy, do one of the following:
  - Add as many relevant columns in the CREATE MODEL command as possible when you specify the training data in the FROM clause.
  - Use a larger value for MAX_RUNTIME and MAX_CELLS. Larger values for this parameter increase the cost of training a model.
- The CREATE MODEL statement execution returns as soon as the training data is computed and exported to the Amazon S3 bucket. After that point, you can check the status of the training using the SHOW MODEL command. When a model being trained in the background fails, you can check the error using SHOW MODEL. You can't retry a failed model. Use DROP MODEL to remove a failed model and recreate a new model. For more information about SHOW MODEL, see SHOW MODEL.
- Local BYOM supports the same kind of models that Amazon Redshift ML supports for non-BYOM cases. Amazon Redshift supports plain XGBoost (using XGBoost version 1.0 or later), KMEANS models without preprocessors, and XGBOOST/MLP/Linear Learner models trained by trained by Amazon SageMaker AI Autopilot. It supports the latter with preprocessors that Autopilot has specified that are also supported by Amazon SageMaker AI Neo.
- If your Amazon Redshift cluster has enhanced routing enabled for your virtual private cloud (VPC), make sure to create an Amazon S3 VPC endpoint and an SageMaker AI VPC endpoint for the VPC that your cluster is in. Doing this enables the traffic to run through your VPC between

these services during CREATE MODEL. For more information, see [SageMaker AI Clarify Job Amazon VPC Subnets and Security Groups].

Use cases

The following use cases demonstrate how to use CREATE MODEL to suit your needs.

Simple CREATE MODEL

The following summarizes the basic options of the CREATE MODEL syntax.

Simple CREATE MODEL syntax

```
CREATE MODEL model_name
FROM { table_name | ( select_query ) }
TARGET column_name
FUNCTION prediction_function_name
IAM_ROLE { default }
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket',
  [ MAX_CELLS integer ]
)
```

Simple CREATE MODEL parameters

model_name

The name of the model. The model name in a schema must be unique.

FROM { *table_name* | (*select_query*) }

The table_name or the query that specifies the training data. They can either be an existing table in the system, or an Amazon Redshift-compatible SELECT query enclosed with parentheses, that is (). There must be at least two columns in the query result.

TARGET *column_name*

The name of the column that becomes the prediction target. The column must exist in the FROM clause.

FUNCTION *prediction_function_name*

A value that specifies the name of the Amazon Redshift machine learning function to be generated by the CREATE MODEL and used to make predictions using this model. The function is created in the same schema as the model object and can be overloaded.

Amazon Redshift machine learning supports models, such as Xtreme Gradient Boosted tree (XGBoost) models for regression and classification.

IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREAT MODEL command runs. Alternatively, you can specify the ARN of an IAM role to use that role.

S3_BUCKET 'amzn-s3-demo-bucket'

The name of the Amazon S3 bucket that you previously created used to share training data and artifacts between Amazon Redshift and SageMaker AI. Amazon Redshift creates a subfolder in this bucket prior to unload of the training data. When training is complete, Amazon Redshift deletes the created subfolder and its contents.

MAX_CELLS integer

The maximum number of cells to export from the FROM clause. The default is 1,000,000.

The number of cells is the product of the number of rows in the training data (produced by the FROM clause table or query) times the number of columns. If the number of cells in the training data are more than that specified by the max_cells parameter, CREATE MODEL downsamples the FROM clause training data to reduce the size of the training set below MAX_CELLS. Allowing larger training datasets can produce higher accuracy but also can mean the model takes longer to train and costs more.

For information about costs of using Amazon Redshift, see Costs for using Amazon Redshift ML.

For more information about costs associated with various cell numbers and free trial details, see Amazon Redshift pricing.

CREATE MODEL with user guidance

Following, you can find a description of options for CREATE MODEL in addition to the options described in Simple CREATE MODEL.

By default, CREATE MODEL searches for the best combination of preprocessing and model for your specific dataset. You might want additional control or introduce additional domain knowledge (such as problem type or objective) over your model. In a customer churn scenario, if the outcome “customer is not active” is rare, then the F1 objective is often preferred to the accuracy objective. Because high accuracy models might predict “customer is active” all the time, this results in high accuracy but little business value. For information about F1 objective, see [AutoMLJobObjective]() in the *Amazon SageMaker AI API Reference*.

Then the CREATE MODEL follows your suggestions on the specified aspects, such as the objective. At the same time, the CREATE MODEL automatically discovers the best preprocessors and the best hyperparameters.

CREATE MODEL with user guidance syntax

CREATE MODEL offers more flexibility on the aspects that you can specify and the aspects that Amazon Redshift automatically discovers.

```
CREATE MODEL model_name
FROM { table_name | ( select_statement ) }
TARGET column_name
FUNCTION function_name
IAM_ROLE { default }
[ MODEL_TYPE { XGBOOST | MLP | LINEAR_LEARNER} ]
[ PROBLEM_TYPE ( REGRESSION | BINARY_CLASSIFICATION | MULTICLASS_CLASSIFICATION ) ]
[ OBJECTIVE ( 'MSE' | 'Accuracy' | 'F1' | 'F1Macro' | 'AUC') ]
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket', |
  S3_GARBAGE_COLLECT { ON | OFF }, |
  KMS_KEY_ID 'kms_key_id', |
  MAX_CELLS integer, |
  MAX_RUNTIME integer (, ...)
)
```

CREATE MODEL with user guidance parameters

MODEL_TYPE { XGBOOST | MLP | LINEAR_LEARNER }

(Optional) Specifies the model type. You can specify if you want to train a model of a specific model type, such as XGBoost, multilayer perceptron (MLP), or Linear Learner, which are all algorithms that Amazon SageMaker AI Autopilot supports. If you don't specify the parameter, then all supported model types are searched during training for the best model.

PROBLEM_TYPE (REGRESSION | BINARY_CLASSIFICATION | MULTICLASS_CLASSIFICATION)

(Optional) Specifies the problem type. If you know the problem type, you can restrict Amazon Redshift to only search of the best model of that specific model type. If you don't specify this parameter, a problem type is discovered during the training, based on your data.

OBJECTIVE ('MSE' | 'Accuracy' | 'F1' | 'F1Macro' | 'AUC')

(Optional) Specifies the name of the objective metric used to measure the predictive quality of a machine learning system. This metric is optimized during training to provide the best estimate for model parameter values from data. If you don't specify a metric explicitly, the default behavior is to automatically use MSE: for regression, F1: for binary classification, Accuracy: for multiclass classification. For more information about objectives, see AutoMLJobObjective in the *Amazon SageMaker AI API Reference*.

MAX_CELLS integer

(Optional) Specifies the number of cells in the training data. This value is the product of the number of records (in the training query or table) times the number of columns. The default is 1,000,000.

MAX_RUNTIME integer

(Optional) Specifies the maximum amount of time to train. Training jobs often complete sooner depending on dataset size. This specifies the maximum amount of time the training should take. The default is 5,400 (90 minutes).

S3_GARBAGE_COLLECT { ON | OFF }

(Optional) Specifies whether Amazon Redshift performs garbage collection on the resulting datasets used to train models and the models. If set to OFF, the resulting datasets used to train models and the models remains in Amazon S3 and can be used for other purposes. If set to ON, Amazon Redshift deletes the artifacts in Amazon S3 after the training completes. The default is ON.

KMS_KEY_ID 'kms_key_id'

(Optional) Specifies if Amazon Redshift uses server-side encryption with an AWS KMS key to protect data at rest. Data in transit is protected with Secure Sockets Layer (SSL).

PREPROCESSORS 'string'

(Optional) Specifies certain combinations of preprocessors to certain sets of columns. The format is a list of columnSets, and the appropriate transforms to be applied to each set of columns. Amazon Redshift applies all the transformers in a specific transformers list to all columns in the corresponding ColumnSet. For example, to apply OneHotEncoder with Imputer to columns t1 and t2, use the sample command following.

```
CREATE MODEL customer_churn
FROM customer_data
TARGET 'Churn'
FUNCTION predict_churn
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }
PROBLEM_TYPE BINARY_CLASSIFICATION
OBJECTIVE 'F1'
PREPROCESSORS '[
...
{"ColumnSet": [
    "t1",
    "t2"
  ],
  "Transformers": [
    "OneHotEncoder",
    "Imputer"
  ]
},
{"ColumnSet": [
    "t3"
  ],
  "Transformers": [
    "OneHotEncoder"
  ]
},
{"ColumnSet": [
    "temp"
  ],
  "Transformers": [
    "Imputer",
    "NumericPassthrough"
  ]
}
]'
SETTINGS (
S3_BUCKET 'amzn-s3-demo-bucket'
)
```

Amazon Redshift supports the following transformers:

- OneHotEncoder – Typically used to encode a discrete value into a binary vector with one nonzero value. This transformer is suitable for many machine learning models.
- OrdinalEncoder – Encodes discrete values into a single integer. This transformer is suitable for certain machine learning models, such as MLP and Linear Learner.
- NumericPassthrough – Passes input as is into the model.
- Imputer – Fills in missing values and not a number (NaN) values.
- ImputerWithIndicator – Fills in missing values and NaN values. This transformer also creates an indicator of whether any values were missing and filled in.
- Normalizer – Normalizes values, which can improve the performance of many machine learning algorithms.
- DateTimeVectorizer – Creates a vector embedding, representing a column of datetime data type that can be used in machine learning models.
- PCA – Projects the data into a lower dimensional space to reduce the number of features while keeping as much information as possible.
- StandardScaler – Standardizes features by removing the mean and scaling to unit variance.
- MinMax – Transforms features by scaling each feature to a given range.

Amazon Redshift ML stores the trained transformers, and automatically applies them as part of the prediction query. You don't need to specify them when generating predictions from your model.

CREATE XGBoost models with AUTO OFF

The AUTO OFF CREATE MODEL has generally different objectives from the default CREATE MODEL.

As an advanced user who already knows the model type that you want and hyperparameters to use when training these models, you can use CREATE MODEL with AUTO OFF to turn off the CREATE MODEL automatic discovery of preprocessors and hyperparameters. To do so, you explicitly specify the model type. XGBoost is currently the only model type supported when AUTO is set to OFF. You can specify hyperparameters. Amazon Redshift uses default values for any hyperparameters that you specified.

CREATE XGBoost models with AUTO OFF syntax

```
CREATE MODEL model_name
FROM { table_name | (select_statement ) }
TARGET column_name
FUNCTION function_name
```

```
IAM_ROLE { default }
AUTO OFF
MODEL_TYPE XGBOOST
OBJECTIVE { 'reg:squarederror' | 'reg:squaredlogerror' | 'reg:logistic' |
            'reg:pseudohubererror' | 'reg:tweedie' | 'binary:logistic' | 'binary:hinge'
 |
            'multi:softmax' | 'rank:pairwise' | 'rank:ndcg' }
HYPERPARAMETERS DEFAULT EXCEPT (
    NUM_ROUND '10',
    ETA '0.2',
    NUM_CLASS '10',
    (, ...)
)
PREPROCESSORS 'none'
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket', |
  S3_GARBAGE_COLLECT { ON | OFF }, |
  KMS_KEY_ID 'kms_key_id', |
  MAX_CELLS integer, |
  MAX_RUNTIME integer (, ...)
)
```

CREATE XGBoost models with AUTO OFF parameters

AUTO OFF

Turns off CREATE MODEL automatic discovery of preprocessor, algorithm, and hyper-parameters selection.

MODEL_TYPE XGBOOST

Specifies to use XGBOOST to train the model.

OBJECTIVE str

Specifies an objective recognized by the algorithm. Amazon Redshift supports reg:squarederror, reg:squaredlogerror, reg:logistic, reg:pseudohubererror, reg:tweedie, binary:logistic, binary:hinge, multi:softmax. For more information about these objectives, see [Learning task parameters] in the XGBoost documentation.

HYPERPARAMETERS { DEFAULT | DEFAULT EXCEPT (key 'value' (,..)) }

Specifies whether the default XGBoost parameters are used or overridden by user-specified values. The values must be enclosed with single quotes. Following are examples of parameters for XGBoost and their defaults.

Parameter name	Parameter value	Default value	Notes
num_class	Integer	Required for Multiclass classification.	N/A
num_round	Integer	100	N/A
tree_method	String	Auto	N/A
max_depth	Integer	6	[0 , 10]
min_child_weight	Float	1	MinValue: 0, MaxValue: 120
subsample	Float	1	MinValue: 0.5, MaxValue: 1
gamma	Float	0	MinValue: 0, MaxValue: 5
alpha	Float	0	MinValue: 0, MaxValue: 1000
eta	Float	0.3	MinValue: 0.1, MaxValue: 0.5
colsample_byleve	Float	1	MinValue: 0.1, MaxValue: 1
colsample_bynode	Float	1	MinValue: 0.1, MaxValue: 1
colsample_bytree	Float	1	MinValue: 0.5, MaxValue: 1
lambda	Float	1	MinValue: 0, MaxValue: 1000

Parameter name	Parameter value	Default value	Notes
max_delta_step	Integer	0	[0, 10]

The following example prepares data for XGBoost.

```
DROP TABLE IF EXISTS abalone_xgb;

CREATE TABLE abalone_xgb (
length_val float,
diameter float,
height float,
whole_weight float,
shucked_weight float,
viscera_weight float,
shell_weight float,
rings int,
record_number int);

COPY abalone_xgb
FROM 's3://redshift-downloads/redshift-ml/abalone_xg/'
REGION 'us-east-1'
IAM_ROLE default
IGNOREHEADER 1 CSV;
```

The following example creates an XGBoost model with specified advanced options, such as MODEL_TYPE, OBJECTIVE, and PREPROCESSORS.

```
DROP MODEL abalone_xgboost_multi_predict_age;

CREATE MODEL abalone_xgboost_multi_predict_age
FROM ( SELECT length_val,
              diameter,
              height,
              whole_weight,
              shucked_weight,
              viscera_weight,
              shell_weight,
              rings
```

```
   FROM abalone_xgb WHERE record_number < 2500 )
TARGET rings FUNCTION ml_fn_abalone_xgboost_multi_predict_age
IAM_ROLE default
AUTO OFF
MODEL_TYPE XGBOOST
OBJECTIVE 'multi:softmax'
PREPROCESSORS 'none'
HYPERPARAMETERS DEFAULT EXCEPT (NUM_ROUND '100', NUM_CLASS '30')
SETTINGS (S3_BUCKET 'amzn-s3-demo-bucket');
```

The following example uses an inference query to predict the age of the fish with a record number greater than 2500. It uses the function ml_fn_abalone_xgboost_multi_predict_age created from the above command.

```
select ml_fn_abalone_xgboost_multi_predict_age(length_val,
                                                   diameter,
                                                   height,
                                                   whole_weight,
                                                   shucked_weight,
                                                   viscera_weight,
                                                   shell_weight)+1.5 as age
from abalone_xgb where record_number > 2500;
```

Bring your own model (BYOM) - local inference

Amazon Redshift ML supports using bring your own model (BYOM) for local inference.

The following summarizes the options for the CREATE MODEL syntax for BYOM. You can use a model trained outside of Amazon Redshift with Amazon SageMaker AI for in-database inference locally in Amazon Redshift.

CREATE MODEL syntax for local inference

The following describes the CREATE MODEL syntax for local inference.

```
CREATE MODEL model_name
FROM ('job_name' | 's3_path' )
FUNCTION function_name ( data_type [, ...] )
RETURNS data_type
IAM_ROLE { default }
[ SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket', | --required
```

```
  KMS_KEY_ID 'kms_string') --optional
];
```

Amazon Redshift currently only supports pretrained XGBoost, MLP, and Linear Learner models for BYOM. You can import SageMaker AI Autopilot and models directly trained in Amazon SageMaker AI for local inference using this path.

CREATE MODEL parameters for local inference

model_name

The name of the model. The model name in a schema must be unique.

FROM (*'job_name'* | *'s3_path'*)

The *job_name* uses an Amazon SageMaker AI job name as the input. The job name can either be an Amazon SageMaker AI training job name or an Amazon SageMaker AI Autopilot job name. The job must be created in the same AWS account that owns the Amazon Redshift cluster. To find the job name, launch Amazon SageMaker AI. In the **Training** dropdown menu, choose **Training jobs**.

The *'s3_path'* specifies the S3 location of the .tar.gz model artifacts file that is to be used when creating the model.

FUNCTION *function_name* (*data_type* [, ...])

The name of the function to be created and the data types of the input arguments. You can provide a schema name.

RETURNS *data_type*

The data type of the value returned by the function.

IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>'}

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE MODEL command runs.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization.

SETTINGS (S3_BUCKET *'amzn-s3-demo-bucket'*, | KMS_KEY_ID *'kms_string'*)

The S3_BUCKET clause specifies the Amazon S3 location that is used to store intermediate results.

(Optional) The KMS_KEY_ID clause specifies if Amazon Redshift uses server-side encryption with an AWS KMS key to protect data at rest. Data in transit is protected with Secure Sockets Layer (SSL).

For more information, see [CREATE MODEL with user guidance](#).

CREATE MODEL for local inference example

The following example creates a model that has been previously trained in Amazon SageMaker AI, outside of Amazon Redshift. Because the model type is supported by Amazon Redshift ML for local inference, the following CREATE MODEL creates a function that can be used locally in Amazon Redshift. You can provide a SageMaker AI training job name.

```
CREATE MODEL customer_churn
FROM 'training-job-customer-churn-v4'
FUNCTION customer_churn_predict (varchar, int, float, float)
RETURNS int
IAM_ROLE default
SETTINGS (S3_BUCKET 'amzn-s3-demo-bucket');
```

After the model is created, you can use the function *customer_churn_predict* with the specified argument types to make predictions.

Bring your own model (BYOM) - remote inference

Amazon Redshift ML also supports using bring your own model (BYOM) for remote inference.

The following summarizes the options for the CREATE MODEL syntax for BYOM.

CREATE MODEL syntax for remote inference

The following describes the CREATE MODEL syntax for remote inference.

```
CREATE MODEL model_name
FUNCTION function_name ( data_type [, ...] )
RETURNS data_type
SAGEMAKER 'endpoint_name'[:'model_name']
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }
[SETTINGS (MAX_BATCH_ROWS integer)];
```

CREATE MODEL parameters for remote inference

model_name

The name of the model. The model name in a schema must be unique.

FUNCTION *fn_name* ([*data_type*] [, ...])

The name of the function and the data types of the input arguments. See Data types for all of the supported data types. `Geography`, `geometry`, and `hllsketch` aren't supported.

You can also provide a function name inside a schema using two-part notation, such as `myschema.myfunction`.

RETURNS *data_type*

The data type of the value returned by the function. See Data types for all of the supported data types. `Geography`, `geometry`, and `hllsketch` aren't supported.

SAGEMAKER *'endpoint_name'*[:*'model_name'*]

The name of the Amazon SageMaker AI endpoint. If the endpoint name points to a multimodel endpoint, add the name of the model to use. The endpoint must be hosted in the same AWS Region and AWS account as the Amazon Redshift cluster. To find your endpoint, launch Amazon SageMaker AI. In the **Inference** dropdown menu, choose **Endpoints**.

IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>'}

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREATE MODEL command runs. Alternatively, you can specify the ARN of an IAM role to use that role.

MAX_BATCH_ROWS *integer*

The maximum number of rows that Amazon Redshift sends in a single batch request for a single SageMaker AI invocation. It is supported only for BYOM with remote inference. The actual number of rows in a batch also depends on the input size, but is less than or equal to this value. This parameter's minimum value is 1. The maximum value is `INT_MAX`, or 2,147,483,647. This parameter is required only when both input and returned data types are `SUPER`. The default value is `INT_MAX`, or 2,147,483,647.

When the model is deployed to a SageMaker AI endpoint, SageMaker AI creates the information of the model in Amazon Redshift. It then performs inference through the external function. You can use the SHOW MODEL command to view the model information on your Amazon Redshift cluster.

CREATE MODEL for remote inference usage notes

Before using CREATE MODEL for remote inference, consider the following:

- The endpoint must be hosted by the same AWS account that owns the Amazon Redshift cluster.
- Make sure either that the Amazon SageMaker AI endpoint has enough resources to accommodate inference calls from Amazon Redshift or that the Amazon SageMaker AI endpoint can be automatically scaled.
- If you're not using the `SUPER` data type as input, the model only accepts inputs in the format of comma-separated values (CSV) which corresponds to a content type of `text/CSV` in SageMaker AI.
- If you're not using the `SUPER` data type as input, the output of models is a single value of the type specified when you create the function. The output is in the format of comma-separated values (CSV) through a content type of `text/CSV` in SageMaker AI. `VARCHAR` data types cannot be in quotes and cannot contain new lines, and each output must be in a new line.
- Models accept nulls as empty strings.
- When the input data type is `SUPER`, only one input argument is supported.
- When the input data type is `SUPER`, the returned data type must also be `SUPER`.
- MAX_BATCH_ROWS is required when both input and returned data types are SUPER.
- When the input data type is `SUPER` the content type of the endpoint invocation is either `application/json` when MAX_BATCH_ROWS is 1 or `application/jsonlines` in all other cases.
- When the returned data type is `SUPER` the accept type of the endpoint invocation is either `application/json` when MAX_BATCH_ROWS is 1 or `application/jsonlines` in all other cases.

CREATE MODEL for remote inference example

The following example creates a model that uses a SageMaker AI endpoint to make predictions. Make sure that the endpoint is running to make predictions and specify its name in the CREATE MODEL command.

```
CREATE MODEL remote_customer_churn
FUNCTION remote_fn_customer_churn_predict (varchar, int, float, float)
RETURNS int
```

```
SAGEMAKER 'customer-churn-endpoint'
IAM_ROLE default;
```

The following example creates a BYOM with remote inference with a large language model model (LLM). LLMs hosted on Amazon SageMaker AI Jumpstart accept and return the `application/json` content type and they support a single JSON per invocation. The input and returned data types must be SUPER and MAX_BATCH_ROWS must be set to 1.

```
CREATE MODEL sample_super_data_model
FUNCTION sample_super_data_model_predict(super)
RETURNS super
SAGEMAKER 'sample_super_data_model_endpoint'
IAM_ROLE default
SETTINGS (MAX_BATCH_ROWS 1);
```

CREATE MODEL with K-MEANS

Amazon Redshift supports the K-Means algorithm that groups data that isn't labeled. This algorithm solves clustering problems where you want to discover groupings in the data. Unclassified data is grouped and partitioned based on its similarities and differences.

CREATE MODEL with K-MEANS syntax

```
CREATE MODEL model_name
FROM { table_name | ( select_statement ) }
FUNCTION function_name
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }
AUTO OFF
MODEL_TYPE KMEANS
PREPROCESSORS 'string'
HYPERPARAMETERS DEFAULT EXCEPT ( K 'val' [, ...] )
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket',
  KMS_KEY_ID 'kms_string', |
    -- optional
  S3_GARBAGE_COLLECT on / off, |
    -- optional
  MAX_CELLS integer, |
    -- optional
  MAX_RUNTIME integer
    -- optional);
```

CREATE MODEL with K-MEANS parameters

AUTO OFF

Turns off CREATE MODEL automatic discovery of preprocessor, algorithm, and hyper-parameters selection.

MODEL_TYPE KMEANS

Specifies to use KMEANS to train the model.

PREPROCESSORS 'string'

Specifies certain combinations of preprocessors to certain sets of columns. The format is a list of columnSets, and the appropriate transforms to be applied to each set of columns. Amazon Redshift supports 3 K-Means preprocessors, namely StandardScaler, MinMax, and NumericPassthrough. If you don't want to apply any preprocessing for K-Means, choose NumericPassthrough explicitly as a transformer. For more information about supported transformers, see CREATE MODEL with user guidance parameters.

The K-Means algorithm uses Euclidean distance to calculate similarity. Preprocessing the data ensures that the features of the model stay on the same scale and produce reliable results.

HYPERPARAMETERS DEFAULT EXCEPT (K 'val' [, ...])

Specifies whether the K-Means parameters are used. You must specify the K parameter when using the K-Means algorithm. For more information, see K-Means Hyperparameters in the *Amazon SageMaker AI Developer Guide*

The following example prepares data for K-Means.

```
CREATE MODEL customers_clusters
FROM customers
FUNCTION customers_cluster
IAM_ROLE default
AUTO OFF
MODEL_TYPE KMEANS
PREPROCESSORS '[
{
  "ColumnSet": [ "*" ],
  "Transformers": [ "NumericPassthrough" ]
}
```

```
]'
HYPERPARAMETERS DEFAULT EXCEPT ( K '5' )
SETTINGS (S3_BUCKET 'amzn-s3-demo-bucket');

select customer_id, customers_cluster(...) from customers;
customer_id | customers_cluster
--------------------
12345           1
12346           2
12347           4
12348
```

CREATE MODEL with Forecast

Forecast models in Redshift ML use Amazon Forecast to create accurate time-series forecasts. Doing so lets you use historical data over a time period to make predictions about future events. Common use cases of Amazon Forecast include using retail product data to decide how to price inventory, manufacturing quantity data to predict how much of one item to order, and web traffic data to forecast how much traffic a web server might receive.

[Quota limits from Amazon Forecast](https://docs.aws.amazon.com/forecast/latest/dg/limits.html) are enforced in Amazon Redshift forecast models. For example, the maximum number of forecasts is 100, but it's adjustable. Dropping a forecast model doesn’t automatically delete the associated resources in Amazon Forecast. If you delete a Redshift cluster, all associated models are dropped as well.

Note that Forecast models are currently only available in the following Regions:

- US East (Ohio) (us-east-2)
- US East (N. Virginia) (us-east-1)
- US West (Oregon) (us-west-2)
- Asia Pacific (Mumbai) (ap-south-1)
- Asia Pacific (Seoul) (ap-northeast-2)
- Asia Pacific (Singapore) (ap-southeast-1)
- Asia Pacific (Sydney) (ap-southeast-2)
- Asia Pacific (Tokyo) (ap-northeast-1)
- Europe (Frankfurt) (eu-central-1)
- Europe (Ireland) (eu-west-1)

CREATE MODEL with Forecast syntax

```
CREATE [ OR REPLACE ] MODEL forecast_model_name
FROM { table_name | ( select_query ) }
TARGET column_name
IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>'}
AUTO ON
MODEL_TYPE FORECAST
SETTINGS (
  S3_BUCKET 'amzn-s3-demo-bucket',
  HORIZON integer,
  FREQUENCY forecast_frequency
  [PERCENTILES '0.1', '0.5', '0.9']
  )
```

CREATE MODEL with Forecast parameters

forecast_model_name

The name of the model. The model name must be unique.

FROM { table_name | (select_query) }

The table_name or the query that specifies the training data. This can either be an existing table in the system, or an Amazon Redshift compatible SELECT query enclosed with parentheses. The table or query result must have at least three columns: (1) a varchar column that specifies the name of the time-series. Each dataset can have multiple time-series; (2) a datetime column; and (3) the target column to predict. This target column must be either an int or a float. If you supply a dataset that has more than three columns, Amazon Redshift assumes that all additional columns are part of a related time series. Note that related time series must be of type int or float. For more information about related time series, see Using Related Time Series Datasets.

TARGET column_name

The name of the column that becomes the prediction target. The column must exist in the FROM clause.

IAM_ROLE { default | 'arn:aws:iam::<account-id>:role/<role-name>' }

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the CREAT MODEL command runs. Alternatively, you can specify an ARN of an IAM role to use that role.

AUTO ON

Turns on the CREATE MODEL automatic discovery of algorithm and hyper-parameters selection. Specifying on when creating a Forecast model indicates to use a Forecast AutoPredictor, where Amazon Forecast applies the optimal combinations of algorithms to each time series in your dataset.

MODEL_TYPE FORECAST

Specifies to use FORECAST to train the model.

S3_BUCKET 'amzn-s3-demo-bucket'

The name of the Amazon Simple Storage Service bucket that you previously created and that's used to share training data and artifacts between Amazon Redshift and Amazon Forecast. Amazon Redshift creates a subfolder in this bucket before unloading the training data. When training is complete, Amazon Redshift deletes the created subfolder and its contents.

HORIZON integer

The maximum number of predictions the forecast model can return. Once the model is trained, you can't change this integer.

FREQUENCY forecast_frequency

Specifies how granular you want the forecasts to be. Available options are `Y | M | W | D | H | 30min | 15min | 10min | 5min | 1min`. Required if you're training a forecast model.

PERCENTILES string

A comma-delimited string that specifies the forecast types used to train a predictor. Forecast types can be quantiles from 0.01 to 0.99, by increments of 0.01 or higher. You can also specify the mean forecast with mean. You can specify a maximum of five forecast types.

The following example demonstrates how to create a simple forecast model.

```
CREATE MODEL forecast_example
FROM forecast_electricity_
TARGET target
IAM_ROLE 'arn:aws:iam::<account-id>:role/<role-name>'
AUTO ON
MODEL_TYPE FORECAST
```

```
SETTINGS (S3_BUCKET 'amzn-s3-demo-bucket',
          HORIZON 24,
          FREQUENCY 'H',
          PERCENTILES '0.25,0.50,0.75,mean',
          S3_GARBAGE_COLLECT OFF);
```

After you create the forecast model, you can create a new table with the prediction data.

```
CREATE TABLE forecast_model_results as SELECT Forecast(forecast_example)
```

You can then query the new table to get predictions.

```
SELECT * FROM forecast_model_results
```

CREATE PROCEDURE

Creates a new stored procedure or replaces an existing procedure for the current database.

For more information and examples, see Creating stored procedures in Amazon Redshift.

Required privileges

You must have permission by one of the following ways to run CREATE OR REPLACE PROCEDURE:

- For CREATE PROCEDURE:
  - Superuser
  - Users with CREATE and USAGE privilege on the schema where the stored procedure is created
- For REPLACE PROCEDURE:
  - Superuser
  - Procedure owner

Syntax

```
CREATE [ OR REPLACE ] PROCEDURE sp_procedure_name
  ( [ [ argname ] [ argmode ] argtype [, ...] ] )
[ NONATOMIC ]
AS $$
  procedure_body
```

```
$$ LANGUAGE plpgsql
[ { SECURITY INVOKER | SECURITY DEFINER } ]
[ SET configuration_parameter { TO value | = value } ]
```

Parameters

OR REPLACE

A clause that specifies that if a procedure with the same name and input argument data types, or signature, as this one already exists, the existing procedure is replaced. You can only replace a procedure with a new procedure that defines an identical set of data types.

If you define a procedure with the same name as an existing procedure, but a different signature, you create a new procedure. In other words, the procedure name is overloaded. For more information, see Overloading procedure names.

sp_procedure_name

The name of the procedure. If you specify a schema name (such as **`myschema.myprocedure`**), the procedure is created in the specified schema. Otherwise, the procedure is created in the current schema. For more information about valid names, see Names and identifiers.

We recommend that you prefix all stored procedure names with `sp_`. Amazon Redshift reserves the `sp_` prefix for stored procedure names. By using the `sp_` prefix, you ensure that your stored procedure name doesn't conflict with any existing or future Amazon Redshift built-in stored procedure or function names. For more information, see Naming stored procedures.

You can define more than one procedure with the same name if the data types for the input arguments, or signatures, are different. In other words, in this case the procedure name is overloaded. For more information, see Overloading procedure names

[argname] [argmode] argtype

A list of argument names, argument modes, and data types. Only the data type is required. Name and mode are optional and their position can be switched.

The argument mode can be IN, OUT, or INOUT. The default is IN.

You can use OUT and INOUT arguments to return one or more values from a procedure call. When there are OUT or INOUT arguments, the procedure call returns one result row containing *n* columns, where *n* is the total number of OUT or INOUT arguments.

INOUT arguments are input and output arguments at the same time. *Input arguments* include both IN and INOUT arguments, and *output arguments* include both OUT and INOUT arguments.

OUT arguments aren't specified as part of the CALL statement. Specify INOUT arguments in the stored procedure CALL statement. INOUT arguments can be useful when passing and returning values from a nested call, and also when returning a `refcursor`. For more information on `refcursor` types, see [Cursors](#).

The argument data types can be any standard Amazon Redshift data type. In addition, an argument data type can be `refcursor`.

You can specify a maximum of 32 input arguments and 32 output arguments.

AS $$ *procedure_body* $$

A construct that encloses the procedure to be run. The literal keywords AS $$ and $$ are required.

Amazon Redshift requires you to enclose the statement in your procedure by using a format called dollar quoting. Anything within the enclosure is passed exactly as is. You don't need to escape any special characters because the contents of the string are written literally.

With *dollar quoting,* you use a pair of dollar signs ($$) to signify the start and the end of the statement to run, as shown in the following example.

```
$$ my statement $$
```

Optionally, between the dollar signs in each pair, you can specify a string to help identify the statement. The string that you use must be the same in both the start and the end of the enclosure pairs. This string is case-sensitive, and it follows the same constraints as an unquoted identifier except that it can't contain dollar signs. The following example uses the string test.

```
$test$ my statement $test$
```

This syntax is also useful for nested dollar quoting. For more information about dollar quoting, see "Dollar-quoted String Constants" under [Lexical Structure](#) in the PostgreSQL documentation.

procedure_body

A set of valid PL/pgSQL statements. PL/pgSQL statements augment SQL commands with procedural constructs, including looping and conditional expressions, to control logical flow.

Most SQL commands can be used in the procedure body, including data modification language (DML) such as COPY, UNLOAD and INSERT, and data definition language (DDL) such as CREATE TABLE. For more information, see PL/pgSQL language reference.

LANGUAGE *plpgsql*

A language value. Specify `plpgsql`. You must have permission for usage on language to use `plpgsql`. For more information, see GRANT.

NONATOMIC

Creates the stored procedure in a nonatomic transaction mode. NONATOMIC mode automatically commits the statements inside the procedure. Additionally, when an error occurs inside the NONATOMIC procedure, the error is not re-thrown if it is handled by an exception block. For more information, see Managing transactions and RAISE.

When you define a stored procedure as `NONATOMIC`, consider the following:

- When you nest stored procedure calls, all the procedures must be created in the same transaction mode.
- The `SECURITY DEFINER` option and `SET configuration_parameter` option are not supported when creating a procedure in NONATOMIC mode.
- Any cursor that is opened (explicitly or implicitly) is closed automatically when an implicit commit is processed. Therefore, you must open an explicit transaction before beginning a cursor loop to ensure that any SQL within the loop's iteration is not implicitly committed.

SECURITY INVOKER | SECURITY DEFINER

The `SECURITY DEFINER` option is not supported when `NONATOMIC` is specified.

The security mode for the procedure determines the procedure's access privileges at runtime. The procedure must have permission to access the underlying database objects.

For SECURITY INVOKER mode, the procedure uses the privileges of the user calling the procedure. The user must have explicit permissions on the underlying database objects. The default is SECURITY INVOKER.

For SECURITY DEFINER mode, the procedure uses the privileges of the procedure owner. The procedure owner is defined as the user that owns the procedure at run time, not necessarily the user that initially defined the procedure. The user calling the procedure needs execute privilege on the procedure, but doesn't need any privileges on the underlying objects.

SET configuration_parameter { TO value | = value }

These options are not supported when `NONATOMIC` is specified.

The SET clause causes the specified `configuration_parameter` to be set to the specified value when the procedure is entered. This clause then restores `configuration_parameter` to its earlier value when the procedure exits.

Usage notes

If a stored procedure was created using the SECURITY DEFINER option, when invoking the CURRENT_USER function from within the stored procedure, Amazon Redshift returns the user name of the owner of the stored procedure.

Examples

Note

If when running these examples you encounter an error similar to:

```
ERROR: 42601: [Amazon](500310) unterminated dollar-quoted string at or near "$$
```

See Overview of stored procedures in Amazon Redshift.

The following example creates a procedure with two input parameters.

```
CREATE OR REPLACE PROCEDURE test_sp1(f1 int, f2 varchar(20))
AS $$
DECLARE
  min_val int;
BEGIN
  DROP TABLE IF EXISTS tmp_tbl;
  CREATE TEMP TABLE tmp_tbl(id int);
  INSERT INTO tmp_tbl values (f1),(10001),(10002);
  SELECT min_val MIN(id) FROM tmp_tbl;
  RAISE INFO 'min_val = %, f2 = %', min_val, f2;
END;
$$ LANGUAGE plpgsql;
```

> **Note**
>
> When you write stored procedures, we recommend a best practice for securing sensitive values:
>
> Don't hard code any sensitive information in stored procedure logic. For example, don't assign a user password in a CREATE USER statement in the body of a stored procedure. This poses a security risk, because hard-coded values can be recorded as schema metadata in catalog tables. Instead, pass sensitive values, such as passwords, as arguments to the stored procedure, by means of parameters.
>
> For more information about stored procedures, see CREATE PROCEDURE and Creating stored procedures in Amazon Redshift. For more information about catalog tables, see System catalog tables.

The following example creates a procedure with one IN parameter, one OUT parameter, and one INOUT parameter.

```
CREATE OR REPLACE PROCEDURE test_sp2(f1 IN int, f2 INOUT varchar(256), out_var OUT
 varchar(256))
AS $$
DECLARE
  loop_var int;
BEGIN
  IF f1 is null OR f2 is null THEN
    RAISE EXCEPTION 'input cannot be null';
  END IF;
  DROP TABLE if exists my_etl;
  CREATE TEMP TABLE my_etl(a int, b varchar);
    FOR loop_var IN 1..f1 LOOP
        insert into my_etl values (loop_var, f2);
        f2 := f2 || '+' || f2;
    END LOOP;
  SELECT INTO out_var count(*) from my_etl;
END;
$$ LANGUAGE plpgsql;
```

The following example creates a procedure that uses the `SECURITY DEFINER` parameter. This procedure runs using the privileges of the user who owns the procedure.

```
CREATE OR REPLACE PROCEDURE sp_get_current_user_definer()
```

```
AS $$
DECLARE curr_user varchar(250);
BEGIN
  SELECT current_user INTO curr_user;
  RAISE INFO '%', curr_user;
END;
$$ LANGUAGE plpgsql
SECURITY DEFINER;
```

The following example creates a procedure that uses the `SECURITY INVOKER` parameter. This procedure runs using the privileges of the user who runs the procedure.

```
CREATE OR REPLACE PROCEDURE sp_get_current_user_invoker()
AS $$
DECLARE curr_user varchar(250);
BEGIN
  SELECT current_user INTO curr_user;
  RAISE INFO '%', curr_user;
END;
$$ LANGUAGE plpgsql
SECURITY INVOKER;
```

CREATE RLS POLICY

Creates a new row-level security policy to provide granular access to database objects.

Superusers and users or roles that have the sys:secadmin role can create a policy.

Syntax

```
CREATE RLS POLICY policy_name
[ WITH (column_name data_type [, ...]) [ [AS] relation_alias ] ]
USING ( using_predicate_exp )
```

Parameters

policy_name

The name of the policy.

WITH (*column_name data_type [, ...]*)

Specifies the *column_name* and *data_type* referenced to the columns of tables to which the policy is attached.

You can omit the WITH clause only when the RLS policy doesn't reference any columns of tables to which the policy is attached.

AS *relation_alias*

Specifies an optional alias for the table that the RLS policy will be attached to.

USING (*using_predicate_exp*)

Specifies a filter that is applied to the WHERE clause of the query. Amazon Redshift applies a policy predicate before the query-level user predicates. For example, **`current_user = ‘joe’ and price > 10`** limits Joe to see only records with the price greater than $10.

Usage notes

When working with the CREATE RLS POLICY statement, observe the following:

- Amazon Redshift supports filters that can be part of a WHERE clause of a query.
- All policies being attached to a table must have been created with the same table alias.
- You don't require SELECT permission on lookup tables. When you create a policy, Amazon Redshift grants the SELECT permission on the lookup table for the respective policy. A lookup table is a table object used inside a policy definition.
- Amazon Redshift row-level security doesn't support the following object types inside a policy definition: catalog tables, cross-database relations, external tables, regular views, late-binding views, tables with RLS policies turned on, and temporary tables.

Examples

The following SQL statements create the tables, users, and roles for the CREATE RLS POLICY example.

```
-- Create users and roles reference in the policy statements.
CREATE ROLE analyst;

CREATE ROLE consumer;
```

```
CREATE USER bob WITH PASSWORD 'Name_is_bob_1';

CREATE USER alice WITH PASSWORD 'Name_is_alice_1';

CREATE USER joe WITH PASSWORD 'Name_is_joe_1';

GRANT ROLE sys:secadmin TO bob;

GRANT ROLE analyst TO alice;

GRANT ROLE consumer TO joe;

GRANT ALL ON TABLE tickit_category_redshift TO PUBLIC;
```

The following example creates a policy called policy_concerts.

```
CREATE RLS POLICY policy_concerts
WITH (catgroup VARCHAR(10))
USING (catgroup = 'Concerts');
```

CREATE ROLE

Creates a new custom role that is a collection of permissions. For a list of Amazon Redshift system-defined roles, see the section called "Amazon Redshift system-defined roles". Query SVV_ROLES to view the currently created roles in your cluster or workgroup.

There is a quota of the number of roles that can be created. For more information, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

Required permissions

Following are the required privileges for CREATE ROLE.

- Superuser
- Users with the CREATE ROLE privilege

Syntax

```
CREATE ROLE role_name
```

```
[ EXTERNALID external_id ]
```

Parameters

role_name

The name of the role. The role name must be unique and can't be the same as any user names. A role name can't be a reserved word.

A superuser or regular user with the CREATE ROLE privilege can create roles. A user that is not a superuser but that has been granted USAGE to the role WITH GRANT OPTION and ALTER privilege can grant this role to anyone.

EXTERNALID *external_id*

The identifier for the role, which is associated with an identity provider. For more information, see Native identity provider (IdP) federation for Amazon Redshift.

Examples

The following example creates a role `sample_role1`.

```
CREATE ROLE sample_role1;
```

The following example creates a role `sample_role1`, with an external ID that is associated with an identity provider.

```
CREATE ROLE sample_role1 EXTERNALID "ABC123";
```

CREATE SCHEMA

Defines a new schema for the current database.

Required privileges

Following are required privileges for CREATE SCHEMA:

- Superuser
- Users with the CREATE SCHEMA privilege

Syntax

```
CREATE SCHEMA [ IF NOT EXISTS ] schema_name [ AUTHORIZATION username ]
           [ QUOTA {quota [MB | GB | TB] | UNLIMITED} ] [ schema_element [ ... ]

CREATE SCHEMA AUTHORIZATION username[ QUOTA {quota [MB | GB | TB] | UNLIMITED} ]
 [ schema_element [ ... ] ]
```

Parameters

IF NOT EXISTS

Clause that indicates that if the specified schema already exists, the command should make no changes and return a message that the schema exists, rather than terminating with an error.

This clause is useful when scripting, so the script doesn't fail if CREATE SCHEMA tries to create a schema that already exists.

schema_name

Name of the new schema. The schema name can't be `PUBLIC`. For more information about valid names, see Names and identifiers.

> **Note**
>
> The list of schemas in the search_path configuration parameter determines the precedence of identically named objects when they are referenced without schema names.

AUTHORIZATION

Clause that gives ownership to a specified user.

username

Name of the schema owner.

schema_element

Definition for one or more objects to be created within the schema.

QUOTA

The maximum amount of disk space that the specified schema can use. This space is the collective disk usage. It includes all permanent tables, materialized views under the specified schema, and duplicate copies of all tables with ALL distribution on each compute node. The schema quota doesn't take into account temporary tables created as part of a temporary namespace or schema.

To view the configured schema quotas, see SVV_SCHEMA_QUOTA_STATE.

To view the records where schema quotas were exceeded, see STL_SCHEMA_QUOTA_VIOLATIONS.

Amazon Redshift converts the selected value to megabytes. Gigabytes is the default unit of measurement when you don't specify a value.

You must be a database superuser to set and change a schema quota. A user that is not a superuser but that has CREATE SCHEMA permission can create a schema with a defined quota. When you create a schema without defining a quota, the schema has an unlimited quota. When you set the quota below the current value used by the schema, Amazon Redshift doesn't allow further ingestion until you free disk space. A DELETE statement deletes data from a table and disk space is freed up only when VACUUM runs.

Amazon Redshift checks each transaction for quota violations before committing the transaction. Amazon Redshift checks the size (the disk space used by all tables in a schema) of each modified schema against the set quota. Because the quota violation check occurs at the end of a transaction, the size limit can exceed the quota temporarily within a transaction before it's committed. When a transaction exceeds the quota, Amazon Redshift stops the transaction, prohibits subsequent ingestions, and reverts all the changes until you free disk space. Due to background VACUUM and internal cleanup, it is possible that a schema isn't full by the time that you check the schema after a canceled transaction.

As an exception, Amazon Redshift disregards the quota violation and commits transactions in certain cases. Amazon Redshift does this for transactions that consist solely of one or more of the following statements where there isn't an INSERT or COPY ingestion statement in the same transaction:

- DELETE
- TRUNCATE
- VACUUM

- DROP TABLE
- ALTER TABLE APPEND only when moving data from the full schema to another non-full schema

UNLIMITED

Amazon Redshift imposes no limit to the growth of the total size of the schema.

Limits

Amazon Redshift enforces the following limits for schemas.

- There is a maximum of 9900 schemas per database.

Examples

The following example creates a schema named US_SALES and gives ownership to the user DWUSER.

```
create schema us_sales authorization dwuser;
```

The following example creates a schema named US_SALES, gives ownership to the user DWUSER, and sets the quota to 50 GB.

```
create schema us_sales authorization dwuser QUOTA 50 GB;
```

To view the new schema, query the PG_NAMESPACE catalog table as shown following.

```
select nspname as schema, usename as owner
from pg_namespace, pg_user
where pg_namespace.nspowner = pg_user.usesysid
and pg_user.usename ='dwuser';

   schema |  owner
----------+----------
 us_sales | dwuser
(1 row)
```

The following example either creates the US_SALES schema, or does nothing and returns a message if it already exists.

```
create schema if not exists us_sales;
```

CREATE TABLE

Creates a new table in the current database. You define a list of columns, which each hold data of a distinct type. The owner of the table is the issuer of the CREATE TABLE command.

Required privileges

Following are required privileges for CREATE TABLE:

- Superuser
- Users with the CREATE TABLE privilege

Syntax

```
CREATE [ [LOCAL ] { TEMPORARY | TEMP } ] TABLE
[ IF NOT EXISTS ] table_name
( { column_name data_type [column_attributes] [ column_constraints ]
  | table_constraints
  | LIKE parent_table [ { INCLUDING | EXCLUDING } DEFAULTS ] }
  [, ... ]  )
[ BACKUP { YES | NO } ]
[table_attributes]

where column_attributes are:
  [ DEFAULT default_expr ]
  [ IDENTITY ( seed, step ) ]
  [ GENERATED BY DEFAULT AS IDENTITY ( seed, step ) ]
  [ ENCODE encoding ]
  [ DISTKEY ]
  [ SORTKEY ]
  [ COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI } ]

and column_constraints are:
  [ { NOT NULL | NULL } ]
  [ { UNIQUE  |  PRIMARY KEY } ]
  [ REFERENCES reftable [ ( refcolumn ) ] ]

and table_constraints  are:
```

```
  [ UNIQUE ( column_name [, ... ] ) ]
  [ PRIMARY KEY ( column_name [, ... ] )  ]
  [ FOREIGN KEY (column_name [, ... ] ) REFERENCES reftable [ ( refcolumn ) ]


and table_attributes are:
  [ DISTSTYLE { AUTO | EVEN | KEY | ALL } ]
  [ DISTKEY ( column_name ) ]
  [ [COMPOUND | INTERLEAVED ] SORTKEY ( column_name [,...]) |  [ SORTKEY AUTO ] ]
  [ ENCODE AUTO ]
```

Parameters

LOCAL

Optional. Although this keyword is accepted in the statement, it has no effect in Amazon Redshift.

TEMPORARY | TEMP

Keyword that creates a temporary table that is visible only within the current session. The table is automatically dropped at the end of the session in which it is created. The temporary table can have the same name as a permanent table. The temporary table is created in a separate, session-specific schema. (You can't specify a name for this schema.) This temporary schema becomes the first schema in the search path, so the temporary table takes precedence over the permanent table unless you qualify the table name with the schema name to access the permanent table. For more information about schemas and precedence, see search_path.

> **Note**
>
> By default, database users have permission to create temporary tables by their automatic membership in the PUBLIC group. To deny this privilege to a user, revoke the TEMP privilege from the PUBLIC group, and then explicitly grant the TEMP privilege only to specific users or groups of users.

IF NOT EXISTS

Clause that indicates that if the specified table already exists, the command should make no changes and return a message that the table exists, rather than stopping with an error. Note that the existing table might be nothing like the one that would have been created; only the table name is compared.

This clause is useful when scripting, so the script doesn’t fail if CREATE TABLE tries to create a table that already exists.

table_name

Name of the table to be created.

> **Important**
>
> If you specify a table name that begins with '# ', the table is created as a temporary table. The following is an example:
>
> ```
> create table #newtable (id int);
> ```
>
> You also reference the table with the '# '. For example:
>
> ```
> select * from #newtable;
> ```

The maximum length for the table name is 127 bytes; longer names are truncated to 127 bytes. You can use UTF-8 multibyte characters up to a maximum of four bytes. Amazon Redshift enforces a quota of the number of tables per cluster by node type, including user-defined temporary tables and temporary tables created by Amazon Redshift during query processing or system maintenance. Optionally, the table name can be qualified with the database and schema name. In the following example, the database name is `tickit`, the schema name is `public`, and the table name is `test`.

```
create table tickit.public.test (c1 int);
```

If the database or schema doesn't exist, the table isn't created, and the statement returns an error. You can't create tables or views in the system databases `template0`, `template1`, `padb_harvest` , or `sys:internal`.

If a schema name is given, the new table is created in that schema (assuming the creator has access to the schema). The table name must be a unique name for that schema. If no schema is specified, the table is created by using the current database schema. If you are creating a temporary table, you can't specify a schema name, because temporary tables exist in a special schema.

Multiple temporary tables with the same name can exist at the same time in the same database if they are created in separate sessions because the tables are assigned to different schemas. For more information about valid names, see Names and identifiers.

column_name

Name of a column to be created in the new table. The maximum length for the column name is 127 bytes; longer names are truncated to 127 bytes. You can use UTF-8 multibyte characters up to a maximum of four bytes. The maximum number of columns you can define in a single table is 1,600. For more information about valid names, see Names and identifiers.

> **Note**
>
> If you are creating a "wide table," take care that your list of columns doesn't exceed row-width boundaries for intermediate results during loads and query processing. For more information, see Usage notes.

data_type

Data type of the column being created. For CHAR and VARCHAR columns, you can use the MAX keyword instead of declaring a maximum length. MAX sets the maximum length to 4,096 bytes for CHAR or 65535 bytes for VARCHAR. The maximum size of a GEOMETRY object is 1,048,447 bytes.

For information about the data types that Amazon Redshift supports, see Data types.

DEFAULT *default_expr*

Clause that assigns a default data value for the column. The data type of *default_expr* must match the data type of the column. The DEFAULT value must be a variable-free expression. Subqueries, cross-references to other columns in the current table, and user-defined functions aren't allowed.

The *default_expr* expression is used in any INSERT operation that doesn't specify a value for the column. If no default value is specified, the default value for the column is null.

If a COPY operation with a defined column list omits a column that has a DEFAULT value, the COPY command inserts the value of *default_expr*.

IDENTITY(*seed*, *step*)

Clause that specifies that the column is an IDENTITY column. An IDENTITY column contains unique autogenerated values. The data type for an IDENTITY column must be either INT or BIGINT.

When you add rows using an `INSERT` or `INSERT INTO [tablename] VALUES()` statement, these values start with the value specified as *seed* and increment by the number specified as *step*.

When you load the table using an `INSERT INTO [tablename] SELECT * FROM` or `COPY` statement, the data is loaded in parallel and distributed to the node slices. To be sure that the identity values are unique, Amazon Redshift skips a number of values when creating the identity values. Identity values are unique, but the order might not match the order in the source files.

GENERATED BY DEFAULT AS IDENTITY(*seed*, *step*)

Clause that specifies that the column is a default IDENTITY column and enables you to automatically assign a unique value to the column. The data type for an IDENTITY column must be either INT or BIGINT. When you add rows without values, these values start with the value specified as *seed* and increment by the number specified as *step*. For information about how values are generated, see IDENTITY .

Also, during INSERT, UPDATE, or COPY you can provide a value without EXPLICIT_IDS. Amazon Redshift uses that value to insert into the identity column instead of using the system-generated value. The value can be a duplicate, a value less than the seed, or a value between step values. Amazon Redshift doesn't check the uniqueness of values in the column. Providing a value doesn't affect the next system-generated value.

> **Note**
>
> If you require uniqueness in the column, don't add a duplicate value. Instead, add a unique value that is less than the seed or between step values.

Keep in mind the following about default identity columns:

- Default identity columns are NOT NULL. NULL can't be inserted.
- To insert a generated value into a default identity column, use the keyword `DEFAULT`.

```
INSERT INTO tablename (identity-column-name) VALUES (DEFAULT);
```

- Overriding values of a default identity column doesn't affect the next generated value.
- You can't add a default identity column with the ALTER TABLE ADD COLUMN statement.
- You can append a default identity column with the ALTER TABLE APPEND statement.

ENCODE *encoding*

The compression encoding for a column. ENCODE AUTO is the default for tables. Amazon Redshift automatically manages compression encoding for all columns in the table. If you specify compression encoding for any column in the table, the table is no longer set to ENCODE AUTO. Amazon Redshift no longer automatically manages compression encoding for all columns in the table. You can specify the ENCODE AUTO option for the table to enable Amazon Redshift to automatically manage compression encoding for all columns in the table.

Amazon Redshift automatically assigns an initial compression encoding to columns for which you don't specify compression encoding as follows:

- All columns in temporary tables are assigned RAW compression by default.
- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, DOUBLE PRECISION, GEOMETRY, or GEOGRAPHY data type are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR, VARCHAR, or VARBYTE are assigned LZO compression.

> **Note**
>
> If you don't want a column to be compressed, explicitly specify RAW encoding.

The following compression encodings (p. 62) are supported:

- AZ64
- BYTEDICT
- DELTA
- DELTA32K

- LZO
- MOSTLY8
- MOSTLY16
- MOSTLY32
- RAW (no compression)
- RUNLENGTH
- TEXT255
- TEXT32K
- ZSTD

DISTKEY

Keyword that specifies that the column is the distribution key for the table. Only one column in a table can be the distribution key. You can use the DISTKEY keyword after a column name or as part of the table definition by using the DISTKEY (*column_name*) syntax. Either method has the same effect. For more information, see the DISTSTYLE parameter later in this topic.

The data type of a distribution key column can be: BOOLEAN, REAL, DOUBLE PRECISION, SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ, CHAR, or VARCHAR.

SORTKEY

Keyword that specifies that the column is the sort key for the table. When data is loaded into the table, the data is sorted by one or more columns that are designated as sort keys. You can use the SORTKEY keyword after a column name to specify a single-column sort key, or you can specify one or more columns as sort key columns for the table by using the SORTKEY (*column_name* [, ...]) syntax. Only compound sort keys are created with this syntax.

You can define a maximum of 400 SORTKEY columns per table.

The data type of a sort key column can be: BOOLEAN, REAL, DOUBLE PRECISION, SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ, CHAR, or VARCHAR.

COLLATE { CASE_SENSITIVE | CS | CASE_INSENSITIVE | CI }

A clause that specifies whether string search or comparison on the column is case sensitive or case insensitive. The default value is the same as the current case sensitivity configuration of the database.

To find the database collation information, use the following command:

```
SELECT db_collation();

db_collation
----------------
 case_sensitive
(1 row)
```

CASE_SENSITIVE and CS are interchangeable and yield the same results. Similarly, CASE_INSENSITIVE and CI are interchangeable and yield the same results.

NOT NULL | NULL

NOT NULL specifies that the column isn't allowed to contain null values. NULL, the default, specifies that the column accepts null values. IDENTITY columns are declared NOT NULL by default.

UNIQUE

Keyword that specifies that the column can contain only unique values. The behavior of the unique table constraint is the same as that for column constraints, with the additional capability to span multiple columns. To define a unique table constraint, use the UNIQUE (*column_name* [, ...]) syntax.

> **Important**
>
> Unique constraints are informational and aren't enforced by the system.

PRIMARY KEY

Keyword that specifies that the column is the primary key for the table. Only one column can be defined as the primary key by using a column definition. To define a table constraint with a multiple-column primary key, use the PRIMARY KEY (*column_name* [, ...]) syntax.

Identifying a column as the primary key provides metadata about the design of the schema. A primary key implies that other tables can rely on this set of columns as a unique identifier for rows. One primary key can be specified for a table, whether as a column constraint or a table constraint. The primary key constraint should name a set of columns that is different from other sets of columns named by any unique constraint defined for the same table.

PRIMARY KEY columns are also defined as NOT NULL.

> **Important**
>
> Primary key constraints are informational only. They aren't enforced by the system, but they are used by the planner.

References *reftable* [(*refcolumn*)]

Clause that specifies a foreign key constraint, which implies that the column must contain only values that match values in the referenced column of some row of the referenced table. The referenced columns should be the columns of a unique or primary key constraint in the referenced table.

> **Important**
>
> Foreign key constraints are informational only. They aren't enforced by the system, but they are used by the planner.

LIKE *parent_table* [{ INCLUDING | EXCLUDING } DEFAULTS]

A clause that specifies an existing table from which the new table automatically copies column names, data types, and NOT NULL constraints. The new table and the parent table are decoupled, and any changes made to the parent table aren't applied to the new table. Default expressions for the copied column definitions are copied only if INCLUDING DEFAULTS is specified. The default behavior is to exclude default expressions, so that all columns of the new table have null defaults.

Tables created with the LIKE option don't inherit primary and foreign key constraints. Distribution style, sort keys, BACKUP, and NULL properties are inherited by LIKE tables, but you can't explicitly set them in the CREATE TABLE ... LIKE statement.

BACKUP { YES | NO }

A clause that specifies whether the table should be included in automated and manual cluster snapshots.

For tables, such as staging tables, that don't contain critical data, specify BACKUP NO to save processing time when creating snapshots and restoring from snapshots and to reduce storage space on Amazon Simple Storage Service. The BACKUP NO setting has no affect on automatic replication of data to other nodes within the cluster, so tables with BACKUP NO specified are restored in the event of a node failure. The default is BACKUP YES.

> **Note**
>
> No-backup tables are not supported for RA3 and Serverless. A table marked as no-backup in RA3 and Serverless will be treated as a permanent table that will always be backed up while taking a snapshot, and restored when restoring from a snapshot.

DISTSTYLE { AUTO | EVEN | KEY | ALL }

Keyword that defines the data distribution style for the whole table. Amazon Redshift distributes the rows of a table to the compute nodes according to the distribution style specified for the table. The default is AUTO.

The distribution style that you select for tables affects the overall performance of your database. For more information, see Data distribution for query optimization. Possible distribution styles are as follows:

- AUTO: Amazon Redshift assigns an optimal distribution style based on the table data. For example, if AUTO distribution style is specified, Amazon Redshift initially assigns the ALL distribution style to a small table. When the table grows larger, Amazon Redshift might change the distribution style to KEY, choosing the primary key (or a column of the composite primary key) as the DISTKEY. If the table grows larger and none of the columns are suitable to be the DISTKEY, Amazon Redshift changes the distribution style to EVEN. The change in distribution style occurs in the background with minimal impact to user queries.

  To view the distribution style applied to a table, query the PG_CLASS system catalog table. For more information, see Viewing distribution styles.
- EVEN: The data in the table is spread evenly across the nodes in a cluster in a round-robin distribution. Row IDs are used to determine the distribution, and roughly the same number of rows are distributed to each node.
- KEY: The data is distributed by the values in the DISTKEY column. When you set the joining columns of joining tables as distribution keys, the joining rows from both tables are collocated on the compute nodes. When data is collocated, the optimizer can perform joins more efficiently. If you specify DISTSTYLE KEY, you must name a DISTKEY column, either

for the table or as part of the column definition. For more information, see the DISTKEY parameter earlier in this topic.

- ALL: A copy of the entire table is distributed to every node. This distribution style ensures that all the rows required for any join are available on every node, but it multiplies storage requirements and increases the load and maintenance times for the table. ALL distribution can improve execution time when used with certain dimension tables where KEY distribution isn't appropriate, but performance improvements must be weighed against maintenance costs.

DISTKEY (*column_name*)

Constraint that specifies the column to be used as the distribution key for the table. You can use the DISTKEY keyword after a column name or as part of the table definition, by using the DISTKEY (*column_name*) syntax. Either method has the same effect. For more information, see the DISTSTYLE parameter earlier in this topic.

[COMPOUND | INTERLEAVED] SORTKEY (*column_name* [,...]) | [SORTKEY AUTO]

Specifies one or more sort keys for the table. When data is loaded into the table, the data is sorted by the columns that are designated as sort keys. You can use the SORTKEY keyword after a column name to specify a single-column sort key, or you can specify one or more columns as sort key columns for the table by using the `SORTKEY (column_name [ , ... ] )` syntax.

You can optionally specify COMPOUND or INTERLEAVED sort style. If you specify SORTKEY with columns the default is COMPOUND. For more information, see [Sort keys](#).

If you don't specify any sort keys options, the default is AUTO.

You can define a maximum of 400 COMPOUND SORTKEY columns or 8 INTERLEAVED SORTKEY columns per table.

AUTO

Specifies that Amazon Redshift assigns an optimal sort key based on the table data. For example, if AUTO sort key is specified, Amazon Redshift initially assigns no sort key to a table. If Amazon Redshift determines that a sort key will improve the performance of queries, then Amazon Redshift might change the sort key of your table. The actual sorting of the table is done by automatic table sort. For more information, see [Automatic table sort](#).

Amazon Redshift doesn't modify tables that have existing sort or distribution keys. With one exception, if a table has a distribution key that has never been used in a JOIN, then the key might be changed if Amazon Redshift determines there is a better key.

To view the sort key of a table, query the SVV_TABLE_INFO system catalog view. For more information, see SVV_TABLE_INFO. To view the Amazon Redshift Advisor recommendations for tables, query the SVV_ALTER_TABLE_RECOMMENDATIONS system catalog view. For more information, see SVV_ALTER_TABLE_RECOMMENDATIONS. To view the actions taken by Amazon Redshift, query the SVL_AUTO_WORKER_ACTION system catalog view. For more information, see SVL_AUTO_WORKER_ACTION.

COMPOUND

Specifies that the data is sorted using a compound key made up of all of the listed columns, in the order they are listed. A compound sort key is most useful when a query scans rows according to the order of the sort columns. The performance benefits of sorting with a compound key decrease when queries rely on secondary sort columns. You can define a maximum of 400 COMPOUND SORTKEY columns per table.

INTERLEAVED

Specifies that the data is sorted using an interleaved sort key. A maximum of eight columns can be specified for an interleaved sort key.

An interleaved sort gives equal weight to each column, or subset of columns, in the sort key, so queries don't depend on the order of the columns in the sort key. When a query uses one or more secondary sort columns, interleaved sorting significantly improves query performance. Interleaved sorting carries a small overhead cost for data loading and vacuuming operations.

> **Important**
>
> Don’t use an interleaved sort key on columns with monotonically increasing attributes, such as identity columns, dates, or timestamps.

ENCODE AUTO

Enables Amazon Redshift to automatically adjust the encoding type for all columns in the table to optimize query performance. ENCODE AUTO preserves the initial encode types that you specify in creating the table. Then, if Amazon Redshift determines that a new encoding type can improve query performance, Amazon Redshift can change the encoding type of the table columns. ENCODE AUTO is the default if you don't specify an encoding type on any column in the table.

UNIQUE (*column_name* [,...])

Constraint that specifies that a group of one or more columns of a table can contain only unique values. The behavior of the unique table constraint is the same as that for column constraints, with the additional capability to span multiple columns. In the context of unique constraints, null values aren't considered equal. Each unique table constraint must name a set of columns that is different from the set of columns named by any other unique or primary key constraint defined for the table.

> **Important**
>
> Unique constraints are informational and aren't enforced by the system.

PRIMARY KEY (*column_name* [,...])

Constraint that specifies that a column or a number of columns of a table can contain only unique (nonduplicate) non-null values. Identifying a set of columns as the primary key also provides metadata about the design of the schema. A primary key implies that other tables can rely on this set of columns as a unique identifier for rows. One primary key can be specified for a table, whether as a single column constraint or a table constraint. The primary key constraint should name a set of columns that is different from other sets of columns named by any unique constraint defined for the same table.

> **Important**
>
> Primary key constraints are informational only. They aren't enforced by the system, but they are used by the planner.

FOREIGN KEY (*column_name* [, ...]) REFERENCES *reftable* [(*refcolumn*)]

Constraint that specifies a foreign key constraint, which requires that a group of one or more columns of the new table must only contain values that match values in the referenced column or columns of some row of the referenced table. If *refcolumn* is omitted, the primary key of *reftable* is used. The referenced columns must be the columns of a unique or primary key constraint in the referenced table.

> **Important**
>
> Foreign key constraints are informational only. They aren't enforced by the system, but they are used by the planner.

Usage notes

Uniqueness, primary key, and foreign key constraints are informational only; *they are not enforced by Amazon Redshift* when you populate a table. For example, if you insert data into a table with dependencies, the insert can succeed even if it violates the constraint. Nonetheless, primary keys and foreign keys are used as planning hints and they should be declared if your ETL process or some other process in your application enforces their integrity. For information about how to drop a table with dependencies, see DROP TABLE.

Limits and quotas

Consider the following limits when you create a table.

- There is a limit for the maximum number of tables in a cluster by node type. For more information, see Limits in the *Amazon Redshift Management Guide*.
- The maximum number of characters for a table name is 127.
- The maximum number of columns you can define in a single table is 1,600.
- The maximum number of SORTKEY columns you can define in a single table is 400.

Summary of column-level settings and table-level settings

Several attributes and settings can be set at the column level or at the table level. In some cases, setting an attribute or constraint at the column level or at the table level has the same effect. In other cases, they produce different results.

The following list summarizes column-level and table-level settings:

DISTKEY

There is no difference in effect whether set at the column level or at the table level.

If DISTKEY is set, either at the column level or at the table level, DISTSTYLE must be set to KEY or not set at all. DISTSTYLE can be set only at the table level.

SORTKEY

If set at the column level, SORTKEY must be a single column. If SORTKEY is set at the table level, one or more columns can make up a compound or interleaved composite sort key.

COLLATE CASE_SENSITIVE | COLLATE CASE_INSENSITIVE

Amazon Redshift doesn't support altering case sensitivity configuration for a column. When you append a new column to the table, Amazon Redshift uses the default value for case sensitivity. Amazon Redshift doesn't support the COLLATE key word when appending a new column.

For information on how to create databases using database collation, see CREATE DATABASE.

For information on the COLLATE function, see COLLATE function.

UNIQUE

At the column level, one or more keys can be set to UNIQUE; the UNIQUE constraint applies to each column individually. If UNIQUE is set at the table level, one or more columns can make up a composite UNIQUE constraint.

PRIMARY KEY

If set at the column level, PRIMARY KEY must be a single column. If PRIMARY KEY is set at the table level, one or more columns can make up a composite primary key .

FOREIGN KEY

There is no difference in effect whether FOREIGN KEY is set at the column level or at the table level. At the column level, the syntax is simply `REFERENCES` *reftable* [(*refcolumn*)].

Distribution of incoming data

When the hash distribution scheme of the incoming data matches that of the target table, no physical distribution of the data is actually necessary when the data is loaded. For example, if a distribution key is set for the new table and the data is being inserted from another table that is distributed on the same key column, the data is loaded in place, using the same nodes and slices. However, if the source and target tables are both set to EVEN distribution, data is redistributed into the target table.

Wide tables

You might be able to create a very wide table but be unable to perform query processing, such as INSERT or SELECT statements, on the table. The maximum width of a table with fixed width columns, such as CHAR, is 64KB - 1 (or 65535 bytes). If a table includes VARCHAR columns, the table can have a larger declared width without returning an error because VARCHARS columns don't contribute their full declared width to the calculated query-processing limit. The effective query-processing limit with VARCHAR columns will vary based on a number of factors.

If a table is too wide for inserting or selecting, you receive the following error.

```
ERROR:  8001
DETAIL:  The combined length of columns processed in the SQL statement
exceeded the query-processing limit of 65535 characters (pid:7627)
```

Examples

For examples that show how to use the CREATE TABLE command, see the Examples topic.

Examples

The following examples demonstrate various column and table attributes in Amazon Redshift CREATE TABLE statements. For more information about CREATE TABLE, including parameter definitions, see CREATE TABLE.

Many of the examples use tables and data from the *TICKIT* sample data set. For more information, see Sample database.

You can prefix the table name with the database name and schema name in a CREATE TABLE command. For instance, `dev_database.public.sales`. The database name must be the database you are connected to. Any attempt to create database objects in another database fails with and invalid-operation error.

Create a table with a distribution key, a compound sort key, and compression

The following example creates a SALES table in the TICKIT database with compression defined for several columns. LISTID is declared as the distribution key, and LISTID and SELLERID are declared as a multicolumn compound sort key. Primary key and foreign key constraints are also defined for the table. Prior to creating the table in the example, you might need to add a UNIQUE constraint to each column referenced by a foreign key, if constraints don't exist.

```
create table sales(
salesid integer not null,
```

```
listid integer not null,
sellerid integer not null,
buyerid integer not null,
eventid integer not null encode mostly16,
dateid smallint not null,
qtysold smallint not null encode mostly8,
pricepaid decimal(8,2) encode delta32k,
commission decimal(8,2) encode delta32k,
saletime timestamp,
primary key(salesid),
foreign key(listid) references listing(listid),
foreign key(sellerid) references users(userid),
foreign key(buyerid) references users(userid),
foreign key(dateid) references date(dateid))
distkey(listid)
compound sortkey(listid,sellerid);
```

The results follow:

```
schemaname | tablename | column     | type                        | encoding | distkey
 | sortkey | notnull
-----------+-----------+------------+-----------------------------+----------+---------
+---------+--------
public     | sales     | salesid    | integer                     | lzo      | false
 |       0 | true
public     | sales     | listid     | integer                     | none     | true
 |       1 | true
public     | sales     | sellerid   | integer                     | none     | false
 |       2 | true
public     | sales     | buyerid    | integer                     | lzo      | false
 |       0 | true
public     | sales     | eventid    | integer                     | mostly16 | false
 |       0 | true
public     | sales     | dateid     | smallint                    | lzo      | false
 |       0 | true
public     | sales     | qtysold    | smallint                    | mostly8  | false
 |       0 | true
public     | sales     | pricepaid  | numeric(8,2)                | delta32k | false
 |       0 | false
public     | sales     | commission | numeric(8,2)                | delta32k | false
 |       0 | false
public     | sales     | saletime   | timestamp without time zone | lzo      | false
 |       0 | false
```

The following example creates table t1 with a case-insensitive column col1.

```
create table T1 (
  col1 Varchar(20) collate case_insensitive
 );

insert into T1 values ('bob'), ('john'), ('Tom'), ('JOHN'), ('Bob');
```

Query the table:

```
select * from T1 where col1 = 'John';

col1
------
 john
 JOHN
(2 rows)
```

Create a table using an interleaved sort key

The following example creates the CUSTOMER table with an interleaved sort key.

```
create table customer_interleaved (
  c_custkey      integer        not null,
  c_name         varchar(25)    not null,
  c_address      varchar(25)    not null,
  c_city         varchar(10)    not null,
  c_nation       varchar(15)    not null,
  c_region       varchar(12)    not null,
  c_phone        varchar(15)    not null,
  c_mktsegment      varchar(10)    not null)
diststyle all
interleaved sortkey (c_custkey, c_city, c_mktsegment);
```

Create a table using IF NOT EXISTS

The following example either creates the CITIES table, or does nothing and returns a message if it already exists:

```
create table if not exists cities(
cityid integer not null,
city varchar(100) not null,
```

```
state char(2) not null);
```

Create a table with ALL distribution

The following example creates the VENUE table with ALL distribution.

```
create table venue(
venueid smallint not null,
venuename varchar(100),
venuecity varchar(30),
venuestate char(2),
venueseats integer,
primary key(venueid))
diststyle all;
```

Create a Table with EVEN distribution

The following example creates a table called MYEVENT with three columns.

```
create table myevent(
eventid int,
eventname varchar(200),
eventcity varchar(30))
diststyle even;
```

The table is distributed evenly and isn't sorted. The table has no declared DISTKEY or SORTKEY columns.

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'myevent';

  column   |          type          | encoding | distkey | sortkey
-----------+------------------------+----------+---------+---------
 eventid   | integer                | lzo      | f       |       0
 eventname | character varying(200) | lzo      | f       |       0
 eventcity | character varying(30)  | lzo      | f       |       0
(3 rows)
```

Create a temporary table that is LIKE another table

The following example creates a temporary table called TEMPEVENT, which inherits its columns from the EVENT table.

```
create temp table tempevent(like event);
```

This table also inherits the DISTKEY and SORTKEY attributes of its parent table:

```
select "column", type, encoding, distkey, sortkey
 from pg_table_def where tablename = 'tempevent';

  column   |            type             | encoding | distkey | sortkey
-----------+-----------------------------+----------+---------+---------
 eventid   | integer                     | none     | t       |       1
 venueid   | smallint                    | none     | f       |       0
 catid     | smallint                    | none     | f       |       0
 dateid    | smallint                    | none     | f       |       0
 eventname | character varying(200)      | lzo      | f       |       0
 starttime | timestamp without time zone | bytedict | f       |       0
(6 rows)
```

Create a table with an IDENTITY column

The following example creates a table named VENUE_IDENT, which has an IDENTITY column named VENUEID. This column starts with 0 and increments by 1 for each record. VENUEID is also declared as the primary key of the table.

```
create table venue_ident(venueid bigint identity(0, 1),
venuename varchar(100),
venuecity varchar(30),
venuestate char(2),
venueseats integer,
primary key(venueid));
```

Create a table with a default IDENTITY column

The following example creates a table named `t1`. This table has an IDENTITY column named `hist_id` and a default IDENTITY column named `base_id`.

```
CREATE TABLE t1(
  hist_id BIGINT IDENTITY NOT NULL, /* Cannot be overridden */
  base_id BIGINT GENERATED BY DEFAULT AS IDENTITY NOT NULL, /* Can be overridden */
  business_key varchar(10) ,
  some_field varchar(10)
```

```
);
```

Inserting a row into the table shows that both `hist_id` and `base_id` values are generated.

```
INSERT INTO T1 (business_key, some_field) values ('A','MM');
```

```
SELECT * FROM t1;

 hist_id | base_id | business_key | some_field
---------+---------+--------------+------------
       1 |       1 | A            | MM
```

Inserting a second row shows that the default value for `base_id` is generated.

```
INSERT INTO T1 (base_id, business_key, some_field) values (DEFAULT, 'B','MNOP');
```

```
SELECT * FROM t1;

 hist_id | base_id | business_key | some_field
---------+---------+--------------+------------
       1 |       1 | A            | MM
       2 |       2 | B            | MNOP
```

Inserting a third row shows that the value for `base_id` doesn't need to be unique.

```
INSERT INTO T1 (base_id, business_key, some_field) values (2,'B','MNNN');
```

```
SELECT * FROM t1;

 hist_id | base_id | business_key | some_field
---------+---------+--------------+------------
       1 |       1 | A            | MM
       2 |       2 | B            | MNOP
       3 |       2 | B            | MNNN
```

Create a table with DEFAULT column values

The following example creates a CATEGORYDEF table that declares default values for each column:

```
create table categorydef(
```

```
catid smallint not null default 0,
catgroup varchar(10) default 'Special',
catname varchar(10) default 'Other',
catdesc varchar(50) default 'Special events',
primary key(catid));

insert into categorydef values(default,default,default,default);
```

```
select * from categorydef;

 catid | catgroup | catname |    catdesc
-------+----------+---------+----------------
     0 | Special  | Other   | Special events
(1 row)
```

DISTSTYLE, DISTKEY, and SORTKEY options

The following example shows how the DISTKEY, SORTKEY, and DISTSTYLE options work. In this example, COL1 is the distribution key; therefore, the distribution style must be either set to KEY or not set. By default, the table has no sort key and so isn't sorted:

```
create table t1(col1 int distkey, col2 int) diststyle key;
```

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't1';

column |  type   | encoding | distkey | sortkey
-------+---------+----------+---------+---------
col1   | integer | az64     | t       | 0
col2   | integer | az64     | f       | 0
```

In the following example, the same column is defined as the distribution key and the sort key. Again, the distribution style must be either set to KEY or not set.

```
create table t2(col1 int distkey sortkey, col2 int);
```

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't2';

column |  type   | encoding | distkey | sortkey
```

```
-------+---------+----------+---------+---------
col1   | integer | none     | t       | 1
col2   | integer | az64     | f       | 0
```

In the following example, no column is set as the distribution key, COL2 is set as the sort key, and the distribution style is set to ALL:

```
create table t3(col1 int, col2 int sortkey) diststyle all;
```

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't3';

Column |  Type   | Encoding | DistKey | SortKey
-------+---------+----------+---------+--------
col1   | integer | az64     | f       | 0
col2   | integer | none     | f       | 1
```

In the following example, the distribution style is set to EVEN and no sort key is defined explicitly; therefore the table is distributed evenly but isn't sorted.

```
create table t4(col1 int, col2 int) diststyle even;
```

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't4';

             column |  type   |encoding | distkey | sortkey
--------+---------+---------+---------+--------
col1    | integer | az64    | f       | 0
col2    | integer | az64    | f       | 0
```

Create a table with the ENCODE AUTO option

The following example creates the table `t1` with automatic compression encoding. ENCODE AUTO is the default for tables when you don't specify an encoding type for any column.

```
create table t1(c0 int, c1 varchar);
```

The following example creates the table `t2` with automatic compression encoding by specifying ENCODE AUTO.

```
create table t2(c0 int, c1 varchar) encode auto;
```

The following example creates the table `t3` with automatic compression encoding by specifying ENCODE AUTO. Column `c0` is defined with an initial encoding type of DELTA. Amazon Redshift can change the encoding if another encoding provides better query performance.

```
create table t3(c0 int encode delta, c1 varchar) encode auto;
```

The following example creates the table `t4` with automatic compression encoding by specifying ENCODE AUTO. Column `c0` is defined with an initial encoding of DELTA, and column `c1` is defined with an initial encoding of LZO. Amazon Redshift can change these encodings if other encodings provide better query performance.

```
create table t4(c0 int encode delta, c1 varchar encode lzo) encode auto;
```

CREATE TABLE AS

Topics

Creates a new table based on a query. The owner of this table is the user that issues the command.

The new table is loaded with data defined by the query in the command. The table columns have names and data types associated with the output columns of the query. The CREATE TABLE AS (CTAS) command creates a new table and evaluates the query to load the new table.

Syntax

```
CREATE [ [ LOCAL ] { TEMPORARY | TEMP } ]
TABLE table_name
[ ( column_name [, ... ] ) ]
[ BACKUP { YES | NO } ]
[ table_attributes ]
AS query
```

```
where table_attributes are:
[ DISTSTYLE { AUTO | EVEN | ALL | KEY } ]
[ DISTKEY( distkey_identifier ) ]
[ [ COMPOUND | INTERLEAVED ] SORTKEY( column_name [, ...] ) ]
```

Parameters

LOCAL

Although this optional keyword is accepted in the statement, it has no effect in Amazon Redshift.

TEMPORARY | TEMP

Creates a temporary table. A temporary table is automatically dropped at the end of the session in which it was created.

table_name

The name of the table to be created.

> **Important**
>
> If you specify a table name that begins with '# ', the table is created as a temporary table. For example:
>
> ```
> create table #newtable (id) as select * from oldtable;
> ```

The maximum table name length is 127 bytes; longer names are truncated to 127 bytes. Amazon Redshift enforces a quota of the number of tables per cluster by node type. The table name can be qualified with the database and schema name, as the following table shows.

```
create table tickit.public.test (c1) as select * from oldtable;
```

In this example, `tickit` is the database name and `public` is the schema name. If the database or schema doesn't exist, the statement returns an error.

If a schema name is given, the new table is created in that schema (assuming the creator has access to the schema). The table name must be a unique name for that schema. If no schema is specified, the table is created using the current database schema. If you are creating a temporary table, you can't specify a schema name, since temporary tables exist in a special schema.

Multiple temporary tables with the same name are allowed to exist at the same time in the same database if they are created in separate sessions. These tables are assigned to different schemas.

column_name

The name of a column in the new table. If no column names are provided, the column names are taken from the output column names of the query. Default column names are used for expressions. For more information about valid names, see Names and identifiers.

BACKUP { YES | NO }

A clause that specifies whether the table should be included in automated and manual cluster snapshots.

For tables, such as staging tables, that don't contain critical data, specify BACKUP NO to save processing time when creating snapshots and restoring from snapshots and to reduce storage space on Amazon Simple Storage Service. The BACKUP NO setting has no effect on automatic replication of data to other nodes within the cluster, so tables with BACKUP NO specified are restored in the event of a node failure. The default is BACKUP YES.

> **Note**
>
> No-backup tables are not supported for RA3 and Serverless. A table marked as no-backup in RA3 and Serverless will be treated as a permanent table that will always be backed up while taking a snapshot, and restored when restoring from a snapshot.

DISTSTYLE { AUTO | EVEN | KEY | ALL }

Keyword that defines the data distribution style for the whole table. Amazon Redshift distributes the rows of a table to the compute nodes according to the distribution style specified for the table. The default is DISTSTYLE AUTO.

The distribution style that you select for tables affects the overall performance of your database. For more information, see Data distribution for query optimization.

- AUTO: Amazon Redshift assigns an optimal distribution style based on the table data. To view the distribution style applied to a table, query the PG_CLASS system catalog table. For more information, see Viewing distribution styles.
- EVEN: The data in the table is spread evenly across the nodes in a cluster in a round-robin distribution. Row IDs are used to determine the distribution, and roughly the same number of rows are distributed to each node. This is the default distribution method.
- KEY: The data is distributed by the values in the DISTKEY column. When you set the joining columns of joining tables as distribution keys, the joining rows from both tables are collocated on the compute nodes. When data is collocated, the optimizer can perform joins more efficiently. If you specify DISTSTYLE KEY, you must name a DISTKEY column.
- ALL: A copy of the entire table is distributed to every node. This distribution style ensures that all the rows required for any join are available on every node, but it multiplies storage requirements and increases the load and maintenance times for the table. ALL distribution can improve execution time when used with certain dimension tables where KEY distribution isn't appropriate, but performance improvements must be weighed against maintenance costs.

DISTKEY (*column*)

Specifies a column name or positional number for the distribution key. Use the name specified in either the optional column list for the table or the select list of the query. Alternatively, use a positional number, where the first column selected is 1, the second is 2, and so on. Only one column in a table can be the distribution key:

- If you declare a column as the DISTKEY column, DISTSTYLE must be set to KEY or not set at all.
- If you don't declare a DISTKEY column, you can set DISTSTYLE to EVEN.
- If you don't specify DISTKEY or DISTSTYLE, CTAS determines the distribution style for the new table based on the query plan for the SELECT clause. For more information, see Inheritance of column and table attributes.

You can define the same column as the distribution key and the sort key; this approach tends to accelerate joins when the column in question is a joining column in the query.

[COMPOUND | INTERLEAVED] SORTKEY (*column_name* [, ...])

Specifies one or more sort keys for the table. When data is loaded into the table, the data is sorted by the columns that are designated as sort keys.

You can optionally specify COMPOUND or INTERLEAVED sort style. The default is COMPOUND. For more information, see Sort keys.

You can define a maximum of 400 COMPOUND SORTKEY columns or 8 INTERLEAVED SORTKEY columns per table.

If you don't specify SORTKEY, CTAS determines the sort keys for the new table based on the query plan for the SELECT clause. For more information, see Inheritance of column and table attributes.

COMPOUND

Specifies that the data is sorted using a compound key made up of all of the listed columns, in the order they are listed. A compound sort key is most useful when a query scans rows according to the order of the sort columns. The performance benefits of sorting with a compound key decrease when queries rely on secondary sort columns. You can define a maximum of 400 COMPOUND SORTKEY columns per table.

INTERLEAVED

Specifies that the data is sorted using an interleaved sort key. A maximum of eight columns can be specified for an interleaved sort key.

An interleaved sort gives equal weight to each column, or subset of columns, in the sort key, so queries don't depend on the order of the columns in the sort key. When a query uses one or more secondary sort columns, interleaved sorting significantly improves query performance. Interleaved sorting carries a small overhead cost for data loading and vacuuming operations.

AS *query*

Any query (SELECT statement) that Amazon Redshift supports.

CTAS usage notes

Limits

Amazon Redshift enforces a quota of the number of tables per cluster by node type.

The maximum number of characters for a table name is 127.

The maximum number of columns you can define in a single table is 1,600.

Inheritance of column and table attributes

CREATE TABLE AS (CTAS) tables don't inherit constraints, identity columns, default column values, or the primary key from the table that they were created from.

You can't specify column compression encodings for CTAS tables. Amazon Redshift automatically assigns compression encoding as follows:

- Columns that are defined as sort keys are assigned RAW compression.
- Columns that are defined as BOOLEAN, REAL, DOUBLE PRECISION, GEOMETRY, or GEOGRAPHY data type are assigned RAW compression.
- Columns that are defined as SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIME, TIMETZ, TIMESTAMP, or TIMESTAMPTZ are assigned AZ64 compression.
- Columns that are defined as CHAR, VARCHAR, or VARBYTE are assigned LZO compression.

For more information, see Compression encodings and Data types.

To explicitly assign column encodings, use CREATE TABLE.

CTAS determines distribution style and sort key for the new table based on the query plan for the SELECT clause.

For complex queries, such as queries that include joins, aggregations, an order by clause, or a limit clause, CTAS makes a best effort to choose the optimal distribution style and sort key based on the query plan.

> **Note**
>
> For best performance with large datasets or complex queries, we recommend testing using typical datasets.

You can often predict which distribution key and sort key CTAS chooses by examining the query plan to see which columns, if any, the query optimizer chooses for sorting and distributing data. If the top node of the query plan is a simple sequential scan from a single table (XN Seq Scan), then CTAS generally uses the source table's distribution style and sort key. If the top node of the query plan is anything other a sequential scan (such as XN Limit, XN Sort, XN HashAggregate, and so on), CTAS makes a best effort to choose the optimal distribution style and sort key based on the query plan.

For example, suppose you create five tables using the following types of SELECT clauses:

- A simple select statement
- A limit clause
- An order by clause using LISTID
- An order by clause using QTYSOLD
- A SUM aggregate function with a group by clause.

The following examples show the query plan for each CTAS statement.

```
explain create table sales1_simple as select listid, dateid, qtysold from sales;
                           QUERY PLAN
----------------------------------------------------------------
 XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=8)
(1 row)


explain create table sales2_limit as select listid, dateid, qtysold from sales limit
 100;
                              QUERY PLAN
----------------------------------------------------------------------
 XN Limit  (cost=0.00..1.00 rows=100 width=8)
   ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=8)
(2 rows)


explain create table sales3_orderbylistid as select listid, dateid, qtysold from sales
 order by listid;
                               QUERY PLAN
------------------------------------------------------------------------
 XN Sort  (cost=1000000016724.67..1000000017155.81 rows=172456 width=8)
   Sort Key: listid
   ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=8)
(3 rows)


explain create table sales4_orderbyqty as select listid, dateid, qtysold from sales
 order by qtysold;
                               QUERY PLAN
------------------------------------------------------------------------
 XN Sort  (cost=1000000016724.67..1000000017155.81 rows=172456 width=8)
```

```
   Sort Key: qtysold
   ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=8)
(3 rows)


explain create table sales5_groupby as select listid, dateid, sum(qtysold) from sales
 group by listid, dateid;
                              QUERY PLAN
----------------------------------------------------------------------
 XN HashAggregate  (cost=3017.98..3226.75 rows=83509 width=8)
   ->  XN Seq Scan on sales  (cost=0.00..1724.56 rows=172456 width=8)
(2 rows)
```

To view the distribution key and sort key for each table, query the PG_TABLE_DEF system catalog table, as shown following.

```
select * from pg_table_def where tablename like 'sales%';

      tablename       |   column   | distkey | sortkey
----------------------+------------+---------+---------
 sales                | salesid    | f       |       0
 sales                | listid     | t       |       0
 sales                | sellerid   | f       |       0
 sales                | buyerid    | f       |       0
 sales                | eventid    | f       |       0
 sales                | dateid     | f       |       1
 sales                | qtysold    | f       |       0
 sales                | pricepaid  | f       |       0
 sales                | commission | f       |       0
 sales                | saletime   | f       |       0
 sales1_simple        | listid     | t       |       0
 sales1_simple        | dateid     | f       |       1
 sales1_simple        | qtysold    | f       |       0
 sales2_limit         | listid     | f       |       0
 sales2_limit         | dateid     | f       |       0
 sales2_limit         | qtysold    | f       |       0
 sales3_orderbylistid | listid     | t       |       1
 sales3_orderbylistid | dateid     | f       |       0
 sales3_orderbylistid | qtysold    | f       |       0
 sales4_orderbyqty    | listid     | t       |       0
 sales4_orderbyqty    | dateid     | f       |       0
 sales4_orderbyqty    | qtysold    | f       |       1
 sales5_groupby       | listid     | f       |       0
```

```
 sales5_groupby         | dateid       | f         |        0
 sales5_groupby         | sum          | f         |        0
```

The following table summarizes the results. For simplicity, we omit cost, rows, and width details from the explain plan.

Table	CTAS SELECT statement	Explain plan top node	Dist key	Sort key
S1_SIMPLE	`select listid, dateid, qtysold from sales`	`XN Seq Scan on sales ...`	LISTID	DATEID
S2_LIMIT	`select listid, dateid, qtysold from sales limit 100`	`XN Limit ...`	None (EVEN)	None
S3_ORDER_BY_LISTID	`select listid, dateid, qtysold from sales order by listid`	`XN Sort ...` `Sort Key: listid`	LISTID	LISTID
S4_ORDER_BY_QTY	`select listid, dateid, qtysold from sales order by qtysold`	`XN Sort ...` `Sort Key: qtysold`	LISTID	QTYSOLD
S5_GROUP_BY	`select listid, dateid, sum(qtysold) from sales group by listid, dateid`	`XN HashAggregate ...`	None (EVEN)	None

You can explicitly specify distribution style and sort key in the CTAS statement. For example, the following statement creates a table using EVEN distribution and specifies SALESID as the sort key.

```
create table sales_disteven
```

```
diststyle even
sortkey (salesid)
as
select eventid, venueid, dateid, eventname
from event;
```

Compression encoding

ENCODE AUTO is used as the default for tables. Amazon Redshift automatically manages compression encoding for all columns in the table.

Distribution of incoming data

When the hash distribution scheme of the incoming data matches that of the target table, no physical distribution of the data is actually necessary when the data is loaded. For example, if a distribution key is set for the new table and the data is being inserted from another table that is distributed on the same key column, the data is loaded in place, using the same nodes and slices. However, if the source and target tables are both set to EVEN distribution, data is redistributed into the target table.

Automatic ANALYZE operations

Amazon Redshift automatically analyzes tables that you create with CTAS commands. You do not need to run the ANALYZE command on these tables when they are first created. If you modify them, you should analyze them in the same way as other tables.

CTAS examples

The following example creates a table called EVENT_BACKUP for the EVENT table:

```
create table event_backup as select * from event;
```

The resulting table inherits the distribution and sort keys from the EVENT table.

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'event_backup';

column    | type                          | encoding | distkey | sortkey
----------+-------------------------------+----------+---------+--------
catid     | smallint                      | none     | false   |       0
dateid    | smallint                      | none     | false   |       1
eventid   | integer                       | none     | true    |       0
```

```
eventname | character varying(200)      | none      | false    |        0
starttime | timestamp without time zone | none      | false    |        0
venueid   | smallint                    | none      | false    |        0
```

The following command creates a new table called EVENTDISTSORT by selecting four columns from the EVENT table. The new table is distributed by EVENTID and sorted by EVENTID and DATEID:

```
create table eventdistsort
distkey (1)
sortkey (1,3)
as
select eventid, venueid, dateid, eventname
from event;
```

The result is as follows:

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'eventdistsort';

column   |          type          | encoding | distkey | sortkey
---------+------------------------+----------+---------+-------
eventid   | integer                | none     | t       | 1
venueid   | smallint               | none     | f       | 0
dateid    | smallint               | none     | f       | 2
eventname | character varying(200)| none     | f       | 0
```

You could create exactly the same table by using column names for the distribution and sort keys. For example:

```
create table eventdistsort1
distkey (eventid)
sortkey (eventid, dateid)
as
select eventid, venueid, dateid, eventname
from event;
```

The following statement applies even distribution to the table but doesn't define an explicit sort key.

```
create table eventdisteven
```

```
diststyle even
as
select eventid, venueid, dateid, eventname
from event;
```

The table doesn't inherit the sort key from the EVENT table (EVENTID) because EVEN distribution is specified for the new table. The new table has no sort key and no distribution key.

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'eventdisteven';

column    |          type          | encoding | distkey | sortkey
----------+------------------------+----------+---------+---------
eventid   | integer                | none     | f       | 0
venueid   | smallint               | none     | f       | 0
dateid    | smallint               | none     | f       | 0
eventname | character varying(200) | none     | f       | 0
```

The following statement applies even distribution and defines a sort key:

```
create table eventdistevensort diststyle even sortkey (venueid)
as select eventid, venueid, dateid, eventname from event;
```

The resulting table has a sort key but no distribution key.

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'eventdistevensort';

column    |          type          | encoding | distkey | sortkey
----------+------------------------+----------+---------+-------
eventid   | integer                | none     | f       | 0
venueid   | smallint               | none     | f       | 1
dateid    | smallint               | none     | f       | 0
eventname | character varying(200) | none     | f       | 0
```

The following statement redistributes the EVENT table on a different key column from the incoming data, which is sorted on the EVENTID column, and defines no SORTKEY column; therefore the table isn't sorted.

```
create table venuedistevent distkey(venueid)
```

```
as select * from event;
```

The result is as follows:

```
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 'venuedistevent';

 column    |            type             | encoding | distkey | sortkey
----------+-----------------------------+----------+---------+-------
eventid   | integer                     | none     | f       | 0
venueid   | smallint                    | none     | t       | 0
catid     | smallint                    | none     | f       | 0
dateid    | smallint                    | none     | f       | 0
eventname | character varying(200)      | none     | f       | 0
starttime | timestamp without time zone | none     | f       | 0
```

CREATE USER

Creates a new database user. Database users can retrieve data, run commands, and perform other actions in a database, depending on their privileges and roles. You must be a database superuser to run this command.

Required privileges

Following are required privileges for CREATE USER:

- Superuser
- Users with the CREATE USER privilege

Syntax

```
CREATE USER name [ WITH ]
PASSWORD { 'password' | 'md5hash' | 'sha256hash' | DISABLE }
[ option [ ... ] ]

where option can be:

CREATEDB | NOCREATEDB
| CREATEUSER | NOCREATEUSER
| SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }
```

```
| IN GROUP groupname [, ... ]
| VALID UNTIL 'abstime'
| CONNECTION LIMIT { limit | UNLIMITED }
| SESSION TIMEOUT limit
| EXTERNALID external_id
```

Parameters

name

The name of the user to create. The user name can't be PUBLIC. For more information about valid names, see Names and identifiers.

WITH

Optional keyword. WITH is ignored by Amazon Redshift

PASSWORD { '*password*' | '*md5hash*' | '*sha256hash*' | DISABLE }

Sets the user's password.

By default, users can change their own passwords, unless the password is disabled. To disable a user's password, specify DISABLE. When a user's password is disabled, the password is deleted from the system and the user can log on only using temporary AWS Identity and Access Management (IAM) user credentials. For more information, see Using IAM Authentication to Generate Database User Credentials. Only a superuser can enable or disable passwords. You can't disable a superuser's password. To enable a password, run ALTER USER and specify a password.

You can specify the password in clear text, as an MD5 hash string, or as a SHA256 hash string.

> **Note**
>
> When you launch a new cluster using the AWS Management Console, AWS CLI, or Amazon Redshift API, you must supply a clear text password for the initial database user. You can change the password later by using ALTER USER.

For clear text, the password must meet the following constraints:

- It must be 8 to 64 characters in length.
- It must contain at least one uppercase letter, one lowercase letter, and one number.

- It can use any ASCII characters with ASCII codes 33–126, except ' (single quotation mark), " (double quotation mark), \, /, or @.

As a more secure alternative to passing the CREATE USER password parameter as clear text, you can specify an MD5 hash of a string that includes the password and user name.

> **Note**
>
> When you specify an MD5 hash string, the CREATE USER command checks for a valid MD5 hash string, but it doesn't validate the password portion of the string. It is possible in this case to create a password, such as an empty string, that you can't use to log on to the database.

To specify an MD5 password, follow these steps:

1. Concatenate the password and user name.

   For example, for password `ez` and user `user1`, the concatenated string is `ezuser1`.
2. Convert the concatenated string into a 32-character MD5 hash string. You can use any MD5 utility to create the hash string. The following example uses the Amazon Redshift MD5 function and the concatenation operator (||) to return a 32-character MD5-hash string.

```
select md5('ez' || 'user1');

md5
--------------------------------
153c434b4b77c89e6b94f12c5393af5b
```

3. Concatenate 'md5' in front of the MD5 hash string and provide the concatenated string as the *md5hash* argument.

```
create user user1 password 'md5153c434b4b77c89e6b94f12c5393af5b';
```

4. Log on to the database using the sign-in credentials.

   For this example, log on as `user1` with password `ez`.

Another secure alternative is to specify an SHA-256 hash of a password string; or you can provide your own valid SHA-256 digest and 256-bit salt that was used to create the digest.

- Digest – The output of a hashing function.
- Salt – Randomly generated data that is combined with the password to help reduce patterns in the hashing function output.

```
'sha256|Mypassword'
```

```
'sha256|digest|256-bit-salt'
```

In the following example, Amazon Redshift generates and manages the salt.

```
CREATE USER admin PASSWORD 'sha256|Mypassword1';
```

In the following example, a valid SHA-256 digest and 256-bit salt that was used to create the digest are supplied.

To specify a password and hash it with your own salt, follow these steps:

1. Create a 256-bit salt. You can obtain a salt by using any hexadecimal string generator to generate a string 64 characters long. For this example, the salt is `c721bff5d9042cf541ff7b9d48fa8a6e545c19a763e3710151f9513038b0f6c6`.
2. Use the FROM_HEX function to convert your salt to binary. This is because the SHA2 function requires the binary representation of the salt. See the following statement.

```
SELECT
 FROM_HEX('c721bff5d9042cf541ff7b9d48fa8a6e545c19a763e3710151f9513038b0f6c6');
```

3. Use the CONCAT function to append your salt to your password. For this example, the password is `Mypassword1`. See the following statement.

```
SELECT
 CONCAT('Mypassword1',FROM_HEX('c721bff5d9042cf541ff7b9d48fa8a6e545c19a763e3710151f951303
```

4. Use the SHA2 function to create a digest from your password and salt combination. See the following statement.

```
SELECT
 SHA2(CONCAT('Mypassword1',FROM_HEX('c721bff5d9042cf541ff7b9d48fa8a6e545c19a763e3710151f95
 0);
```

5. Using the digest and salt from the previous steps, create the user. See the following statement.

```
CREATE USER admin PASSWORD 'sha256|
821708135fcc42eb3afda85286dee0ed15c2c461d000291609f77eb113073ec2|
c721bff5d9042cf541ff7b9d48fa8a6e545c19a763e3710151f9513038b0f6c6';
```

6. Log on to the database using the sign-in credentials.

   For this example, log on as `admin` with password `Mypassword1`.

If you set a password in plain text without specifying the hashing function, then an MD5 digest is generated using the username as the salt.

CREATEDB | NOCREATEDB

The CREATEDB option allows the new user to create databases. The default is NOCREATEDB.

CREATEUSER | NOCREATEUSER

The CREATEUSER option creates a superuser with all database privileges, including CREATE USER. The default is NOCREATEUSER. For more information, see superuser.

SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }

A clause that specifies the level of access the user has to the Amazon Redshift system tables and views.

Regular users who have the SYSLOG ACCESS RESTRICTED permission can see only the rows generated by that user in user-visible system tables and views. The default is RESTRICTED.

Regular users who have the SYSLOG ACCESS UNRESTRICTED permission can see all rows in user-visible system tables and views, including rows generated by another user. UNRESTRICTED doesn't give a regular user access to superuser-visible tables. Only superusers can see superuser-visible tables.

Note

Giving a user unrestricted access to system tables gives the user visibility to data generated by other users. For example, STL_QUERY and STL_QUERYTEXT contain the full text of INSERT, UPDATE, and DELETE statements, which might contain sensitive user-generated data.

All rows in SVV_TRANSACTIONS are visible to all users.

For more information, see Visibility of data in system tables and views.

IN GROUP *groupname*

Specifies the name of an existing group that the user belongs to. Multiple group names may be listed.

VALID UNTIL *abstime*

The VALID UNTIL option sets an absolute time after which the user's password is no longer valid. By default the password has no time limit.

CONNECTION LIMIT { *limit* | UNLIMITED }

The maximum number of database connections the user is permitted to have open concurrently. The limit isn't enforced for superusers. Use the UNLIMITED keyword to permit the maximum number of concurrent connections. A limit on the number of connections for each database might also apply. For more information, see CREATE DATABASE. The default is UNLIMITED. To view current connections, query the STV_SESSIONS system view.

> **Note**
>
> If both user and database connection limits apply, an unused connection slot must be available that is within both limits when a user attempts to connect.

SESSION TIMEOUT *limit*

The maximum time in seconds that a session remains inactive or idle. The range is 60 seconds (one minute) to 1,728,000 seconds (20 days). If no session timeout is set for the user, the cluster setting applies. For more information, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

When you set the session timeout, it's applied to new sessions only.

To view information about active user sessions, including the start time, user name, and session timeout, query the STV_SESSIONS system view. To view information about user-session history, query the STL_SESSIONS view. To retrieve information about database users, including session-timeout values, query the SVL_USER_INFO view.

EXTERNALID *external_id*

The identifier for the user, which is associated with an identity provider. The user must have their password disabled. For more information, see Native identity provider (IdP) federation for Amazon Redshift.

Usage notes

By default, all users have CREATE and USAGE privileges on the PUBLIC schema. To disallow users from creating objects in the PUBLIC schema of a database, use the REVOKE command to remove that privilege.

When using IAM authentication to create database user credentials, you might want to create a superuser that is able to log on only using temporary credentials. You can't disable a superuser's password, but you can create an unknown password using a randomly generated MD5 hash string.

```
create user iam_superuser password 'md5A1234567890123456780123456789012' createuser;
```

The case of a *username* enclosed in double quotation marks is always preserved regardless of the setting of the `enable_case_sensitive_identifier` configuration option. For more information, see enable_case_sensitive_identifier.

Examples

The following command creates a user named dbuser, with the password "abcD1234", database creation privileges, and a connection limit of 30.

```
create user dbuser with password 'abcD1234' createdb connection limit 30;
```

Query the PG_USER_INFO catalog table to view details about a database user.

```
select * from pg_user_info;

 usename   | usesysid | usecreatedb | usesuper | usecatupd | passwd   | valuntil |
 useconfig | useconnlimit
-----------+----------+-------------+----------+-----------+----------+----------
+-----------+-------------
 rdsdb     |        1 | true        | true     | true      | ******** | infinity |
      |
 adminuser |      100 | true        | true     | false     | ******** |          |
      | UNLIMITED
```

```
 dbuser     |       102 | true          | false      | false       | ******** |           |
      | 30
```

In the following example, the account password is valid until June 10, 2017.

```
create user dbuser with password 'abcD1234' valid until '2017-06-10';
```

The following example creates a user with a case-sensitive password that contains special characters.

```
create user newman with password '@AbC4321!';
```

To use a backslash ('\') in your MD5 password, escape the backslash with a backslash in your source string. The following example creates a user named `slashpass` with a single backslash ('\') as the password.

```
select md5('\\'||'slashpass');

md5
--------------------------------
0c983d1a624280812631c5389e60d48c
```

Create a user with the md5 password.

```
create user slashpass password 'md50c983d1a624280812631c5389e60d48c';
```

The following example creates a user named `dbuser` with an idle-session timeout set to 120 seconds.

```
CREATE USER dbuser password 'abcD1234' SESSION TIMEOUT 120;
```

The following example creates a user named bob. The namespace is `myco_aad`. This is only a sample. To run the command successfully, you must have a registered identity provider. For more information, see Native identity provider (IdP) federation for Amazon Redshift.

```
CREATE USER myco_aad:bob EXTERNALID "ABC123" PASSWORD DISABLE;
```

CREATE VIEW

Creates a view in a database. The view isn't physically materialized; the query that defines the view is run every time the view is referenced in a query. To create a view with an external table, include the WITH NO SCHEMA BINDING clause.

To create a standard view, you need access to the underlying tables, or to underlying views. To query a standard view, you need select permissions for the view itself, but you don't need select permissions for the underlying tables. In a case where you create a view that references a table or view in another schema, or if you create a view that references a materialized view, you need usage permissions. To query a late binding view, you need select permissions for the late binding view itself. You should also make sure the owner of the late binding view has select permissions for the referenced objects (tables, views, or user-defined functions). For more information about late-binding views, see [Usage notes](#).

Required permissions

To use CREATE VIEW, one of the following permissions is required.

- To create a view using CREATE [OR REPLACE] VIEW:
  - Superuser
  - Users with the CREATE [REPLACE] VIEW permission
- To replace an existing view using CREATE OR REPLACE VIEW:
  - Superuser
  - Users with the CREATE [OR REPLACE] VIEW permission
  - View owner

If a user wants to access a view that incorporates a user-defined function, the user must have the EXECUTE permission on that function.

Syntax

```
CREATE [ OR REPLACE ] VIEW name [ ( column_name [, ...] ) ] AS query
[ WITH NO SCHEMA BINDING ]
```

Parameters

OR REPLACE

If a view of the same name already exists, the view is replaced. You can only replace a view with a new query that generates the identical set of columns, using the same column names and data types. CREATE OR REPLACE VIEW locks the view for reads and writes until the operation completes.

When a view is replaced, its other properties such as ownership and granted privileges are preserved.

name

The name of the view. If a schema name is given (such as `myschema.myview`) the view is created using the specified schema. Otherwise, the view is created in the current schema. The view name must be different from the name of any other view or table in the same schema.

If you specify a view name that begins with '# ', the view is created as a temporary view that is visible only in the current session.

For more information about valid names, see Names and identifiers. You can't create tables or views in the system databases template0, template1, padb_harvest, or sys:internal.

column_name

Optional list of names to be used for the columns in the view. If no column names are given, the column names are derived from the query. The maximum number of columns you can define in a single view is 1,600.

query

A query (in the form of a SELECT statement) that evaluates to a table. This table defines the columns and rows in the view.

WITH NO SCHEMA BINDING

Clause that specifies that the view isn't bound to the underlying database objects, such as tables and user-defined functions. As a result, there is no dependency between the view and the objects it references. You can create a view even if the referenced objects don't exist. Because there is no dependency, you can drop or alter a referenced object without affecting the view. Amazon Redshift doesn't check for dependencies until the view is queried. Recursive common table expressions (rCTE) are not supported with late-binding views. To view details about late-binding views, run the PG_GET_LATE_BINDING_VIEW_COLS function.

When you include the WITH NO SCHEMA BINDING clause, tables and views referenced in the SELECT statement must be qualified with a schema name. The schema must exist when the view is created, even if the referenced table doesn't exist. For example, the following statement returns an error.

```
create view myevent as select eventname from event
with no schema binding;
```

The following statement runs successfully.

```
create view myevent as select eventname from public.event
with no schema binding;
```

Note

You can't update, insert into, or delete from a view.

Usage notes

Late-binding views

A late-binding view doesn't check the underlying database objects, such as tables and other views, until the view is queried. As a result, you can alter or drop the underlying objects without dropping and recreating the view. If you drop underlying objects, queries to the late-binding view will fail. If the query to the late-binding view references columns in the underlying object that aren't present, the query will fail.

If you drop and then re-create a late-binding view's underlying table or view, the new object is created with default access permissions. You might need to grant permissions to the underlying objects for users who will query the view.

To create a late-binding view, include the WITH NO SCHEMA BINDING clause. The following example creates a view with no schema binding.

```
create view event_vw as select * from public.event
with no schema binding;
```

```
select * from event_vw limit 1;

eventid | venueid | catid | dateid | eventname     | starttime
--------+---------+-------+--------+---------------+--------------------
      2 |     306 |     8 |   2114 | Boris Godunov | 2008-10-15 20:00:00
```

The following example shows that you can alter an underlying table without recreating the view.

```
alter table event rename column eventname to title;
```

```
select * from event_vw limit 1;

eventid | venueid | catid | dateid | title         | starttime
--------+---------+-------+--------+---------------+--------------------
      2 |     306 |     8 |   2114 | Boris Godunov | 2008-10-15 20:00:00
```

You can reference Amazon Redshift Spectrum external tables only in a late-binding view. One application of late-binding views is to query both Amazon Redshift and Redshift Spectrum tables. For example, you can use the UNLOAD command to archive older data to Amazon S3. Then, create a Redshift Spectrum external table that references the data on Amazon S3 and create a view that queries both tables. The following example uses a UNION ALL clause to join the Amazon Redshift SALES table and the Redshift Spectrum SPECTRUM.SALES table.

```
create view sales_vw as
select * from public.sales
union all
select * from spectrum.sales
with no schema binding;
```

For more information about creating Redshift Spectrum external tables, including the SPECTRUM.SALES table, see Getting started with Amazon Redshift Spectrum.

Important

When you create a standard view from a late-binding view, the standard view's definition contains the definition of the late-binding view at the time the standard view was made, including the owner of the late-binding view. If you make a change in the underlying late-binding view, those changes will not be used in the standard view until you re-create the standard view. Therefore, when the standard view is queried, it will always use the late-binding view's definition and the late-binding view's owner for permission checking at the time of that standard view creation.

To update the standard view to refer to the latest definition of the late-binding view, run CREATE OR REPLACE VIEW with the initial view definition you used to create the standard view.

See the following example of creating a standard view from a late-binding view.

```
create view sales_vw_lbv as
select * from public.sales
with no schema binding;

show view sales_vw_lbv;
                            Show View DDL statement
--------------------------------------------------------------------------------
 create view sales_vw_lbv as select * from public.sales with no schema binding;
(1 row)

create view sales_vw as
select * from sales_vw_lbv;

show view sales_vw;
                                               Show View DDL statement
---------------------------------------------------------------------------------------------------
 SELECT sales_vw_lbv.price, sales_vw_lbv."region" FROM (SELECT sales.price,
 sales."region" FROM sales) sales_vw_lbv;
(1 row)
```

Note that the late-binding view as shown in the DDL statement for the standard view is defined when the standard view is created, and won't update with any changes you make to the late-binding view afterward.

Examples

The example commands use a sample set of objects and data called the *TICKIT* database. For more information, see Sample database.

The following command creates a view called *myevent* from a table called EVENT.

```
create view myevent as select eventname from event
```

```
where eventname = 'LeAnn Rimes';
```

The following command creates a view called *myuser* from a table called USERS.

```
create view myuser as select lastname from users;
```

The following command creates or replaces a view called *myuser* from a table called USERS.

```
create or replace view myuser as select lastname from users;
```

The following example creates a view with no schema binding.

```
create view myevent as select eventname from public.event
with no schema binding;
```

DEALLOCATE

Deallocates a prepared statement.

Syntax

```
DEALLOCATE [PREPARE] plan_name
```

Parameters

PREPARE

This keyword is optional and is ignored.

plan_name

The name of the prepared statement to deallocate.

Usage Notes

DEALLOCATE is used to deallocate a previously prepared SQL statement. If you don't explicitly deallocate a prepared statement, it is deallocated when the current session ends. For more information on prepared statements, see PREPARE.

See Also

EXECUTE, PREPARE

DECLARE

Defines a new cursor. Use a cursor to retrieve a few rows at a time from the result set of a larger query.

When the first row of a cursor is fetched, the entire result set is materialized on the leader node, in memory or on disk, if needed. Because of the potential negative performance impact of using cursors with large result sets, we recommend using alternative approaches whenever possible. For more information, see Performance considerations when using cursors.

You must declare a cursor within a transaction block. Only one cursor at a time can be open per session.

For more information, see FETCH, CLOSE.

Syntax

```
DECLARE cursor_name CURSOR FOR query
```

Parameters

cursor_name

Name of the new cursor.

query

A SELECT statement that populates the cursor.

DECLARE CURSOR usage notes

If your client application uses an ODBC connection and your query creates a result set that is too large to fit in memory, you can stream the result set to your client application by using a cursor. When you use a cursor, the entire result set is materialized on the leader node, and then your client can fetch the results incrementally.

> **Note**
>
> To enable cursors in ODBC for Microsoft Windows, enable the **Use Declare/Fetch** option in the ODBC DSN you use for Amazon Redshift. We recommend setting the ODBC cache size, using the **Cache Size** field in the ODBC DSN options dialog, to 4,000 or greater on multi-node clusters to minimize round trips. On a single-node cluster, set Cache Size to 1,000.

Because of the potential negative performance impact of using cursors, we recommend using alternative approaches whenever possible. For more information, see Performance considerations when using cursors.

Amazon Redshift cursors are supported with the following limitations:

- Only one cursor at a time can be open per session.
- Cursors must be used within a transaction (BEGIN … END).
- The maximum cumulative result set size for all cursors is constrained based on the cluster node type. If you need larger result sets, you can resize to an XL or 8XL node configuration.

  For more information, see Cursor constraints.

Cursor constraints

When the first row of a cursor is fetched, the entire result set is materialized on the leader node. If the result set doesn't fit in memory, it is written to disk as needed. To protect the integrity of the leader node, Amazon Redshift enforces constraints on the size of all cursor result sets, based on the cluster's node type.

The following table shows the maximum total result set size for each cluster node type. Maximum result set sizes are in megabytes.

Node type	Maximum result set per cluster (MB)
DC2 Large multiple nodes	192,000
DC2 Large single node	8,000
DC2 8XL multiple nodes	3,200,000

Node type	Maximum result set per cluster (MB)
RA3 16XL multiple nodes	14,400,000
RA3 4XL multiple nodes	3,200,000
RA3 XLPLUS multiple nodes	1,000,000
RA3 XLPLUS single node	64,000
RA3 LARGE multiple nodes	240,000
RA3 LARGE single node	8,000
Amazon Redshift Serverless	150,000

To view the active cursor configuration for a cluster, query the STV_CURSOR_CONFIGURATION system table as a superuser. To view the state of active cursors, query the STV_ACTIVE_CURSORS system table. Only the rows for a user's own cursors are visible to the user, but a superuser can view all cursors.

Performance considerations when using cursors

Because cursors materialize the entire result set on the leader node before beginning to return results to the client, using cursors with very large result sets can have a negative impact on performance. We strongly recommend against using cursors with very large result sets. In some cases, such as when your application uses an ODBC connection, cursors might be the only feasible solution. If possible, we recommend using these alternatives:

- Use UNLOAD to export a large table. When you use UNLOAD, the compute nodes work in parallel to transfer the data directly to data files on Amazon Simple Storage Service. For more information, see Unloading data in Amazon Redshift.
- Set the JDBC fetch size parameter in your client application. If you use a JDBC connection and you are encountering client-side out-of-memory errors, you can enable your client to retrieve result sets in smaller batches by setting the JDBC fetch size parameter. For more information, see Setting the JDBC fetch size parameter.

DECLARE CURSOR examples

The following example declares a cursor named LOLLAPALOOZA to select sales information for the Lollapalooza event, and then fetches rows from the result set using the cursor:

```
-- Begin a transaction

begin;

-- Declare a cursor

declare lollapalooza cursor for
select eventname, starttime, pricepaid/qtysold as costperticket, qtysold
from sales, event
where sales.eventid = event.eventid
and eventname='Lollapalooza';

-- Fetch the first 5 rows in the cursor lollapalooza:

fetch forward 5 from lollapalooza;

  eventname   |      starttime      | costperticket | qtysold
--------------+---------------------+---------------+---------
 Lollapalooza | 2008-05-01 19:00:00 |   92.00000000 |       3
 Lollapalooza | 2008-11-15 15:00:00 |  222.00000000 |       2
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       3
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       4
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       1
(5 rows)

-- Fetch the next row:

fetch next from lollapalooza;

  eventname   |      starttime      | costperticket | qtysold
--------------+---------------------+---------------+---------
 Lollapalooza | 2008-10-06 14:00:00 |  114.00000000 |       2

-- Close the cursor and end the transaction:

close lollapalooza;
commit;
```

The following example loops over a refcursor with all the results from a table:

```
CREATE TABLE tbl_1 (a int, b int);
INSERT INTO tbl_1 values (1, 2),(3, 4);

CREATE OR REPLACE PROCEDURE sp_cursor_loop() AS $$
DECLARE
    target record;
    curs1 cursor for select * from tbl_1;
BEGIN
    OPEN curs1;
    LOOP
        fetch curs1 into target;
        exit when not found;
        RAISE INFO 'a %', target.a;
    END LOOP;
    CLOSE curs1;
END;
$$ LANGUAGE plpgsql;

CALL sp_cursor_loop();

SELECT message
   from svl_stored_proc_messages
   where querytxt like 'CALL sp_cursor_loop()%';

  message
----------
      a 1
      a 3
```

DELETE

Deletes rows from tables.

> **Note**
>
> The maximum size for a single SQL statement is 16 MB.

Syntax

```
[ WITH [RECURSIVE] common_table_expression [, common_table_expression , ...] ]
DELETE [ FROM ] { table_name | materialized_view_name }
    [ { USING } table_name, ... ]
    [ WHERE condition ]
```

Parameters

WITH clause

Optional clause that specifies one or more *common-table-expressions*. See WITH clause.

FROM

The FROM keyword is optional, except when the USING clause is specified. The statements `delete from event;` and `delete event;` are equivalent operations that remove all of the rows from the EVENT table.

> **Note**
>
> To delete all the rows from a table, TRUNCATE the table. TRUNCATE is much more efficient than DELETE and doesn't require a VACUUM and ANALYZE. However, be aware that TRUNCATE commits the transaction in which it is run.

table_name

A temporary or persistent table. Only the owner of the table or a user with DELETE privilege on the table may delete rows from the table.

Consider using the TRUNCATE command for fast unqualified delete operations on large tables; see TRUNCATE.

> **Note**
>
> After deleting a large number of rows from a table:
>
> - Vacuum the table to reclaim storage space and re-sort rows.
> - Analyze the table to update statistics for the query planner.

materialized_view_name

A materialized view. The DELETE statement works on a materialized view used for Streaming ingestion to a materialized view. Only the owner of the materialized view or a user with DELETE privilege on the materialized view may delete rows from it.

You can't run DELETE on a materialized view for streaming ingestion with a row-level security (RLS) policy that doesn't have the IGNORE RLS permission granted to the user. There is an exception to this: If the user performing the DELETE has IGNORE RLS granted, it runs successfully. For more information, see RLS policy ownership and management.

USING *table_name*, ...

The USING keyword is used to introduce a table list when additional tables are referenced in the WHERE clause condition. For example, the following statement deletes all of the rows from the EVENT table that satisfy the join condition over the EVENT and SALES tables. The SALES table must be explicitly named in the FROM list:

```
delete from event using sales where event.eventid=sales.eventid;
```

If you repeat the target table name in the USING clause, the DELETE operation runs a self-join. You can use a subquery in the WHERE clause instead of the USING syntax as an alternative way to write the same query.

WHERE *condition*

Optional clause that limits the deletion of rows to those that match the condition. For example, the condition can be a restriction on a column, a join condition, or a condition based on the result of a query. The query can reference tables other than the target of the DELETE command. For example:

```
delete from t1
where col1 in(select col2 from t2);
```

If no condition is specified, all of the rows in the table are deleted.

Usage notes

- DELETE operations hold exclusive locks when run on Amazon Redshift streaming materialized views connected to any of the following:

- An Amazon Kinesis data stream
- An Amazon Managed Streaming for Apache Kafka topic
- A supported external stream, such as a Confluent Cloud Kafka topic

For more information, see Streaming ingestion to a materialized view.

Examples

Delete all of the rows from the CATEGORY table:

```
delete from category;
```

Delete rows with CATID values between 0 and 9 from the CATEGORY table:

```
delete from category
where catid between 0 and 9;
```

Delete rows from the LISTING table whose SELLERID values don't exist in the SALES table:

```
delete from listing
where listing.sellerid not in(select sales.sellerid from sales);
```

The following two queries both delete one row from the CATEGORY table, based on a join to the EVENT table and an additional restriction on the CATID column:

```
delete from category
using event
where event.catid=category.catid and category.catid=9;
```

```
delete from category
where catid in
(select category.catid from category, event
where category.catid=event.catid and category.catid=9);
```

The following query deletes all rows from the `mv_cities` materialized view. The materialized view name in this example is a sample:

```
delete from mv_cities;
```

DESC DATASHARE

Displays a list of the database objects within a datashare that are added to it using ALTER DATASHARE. Amazon Redshift displays the names, databases, schemas, and types of tables, views, and functions.

Additional information about datashare objects can be found by using system views. For more information, see SVV_DATASHARE_OBJECTS and SVV_DATASHARES.

Syntax

```
DESC DATASHARE datashare_name [ OF [ ACCOUNT account_id ] NAMESPACE namespace_guid ]
```

Parameters

datashare_name

The name of the datashare .

NAMESPACE *namespace_guid*

A value that specifies the namespace that the datashare uses. When you run DESC DATAHSARE as a consumer cluster administrator, specify the NAMESPACE parameter to view inbound datashares.

ACCOUNT *account_id*

A value that specifies the account that the datashare belongs to.

Usage Notes

As a consumer account administrator, when you run DESC DATASHARE to see inbound datashares within the AWS account, specify the NAMESPACE option. When you run DESC DATASHARE to see inbound datashares across AWS accounts, specify the ACCOUNT and NAMESPACE options.

Examples

The following example displays the information for outbound datashares on a producer cluster.

```
DESC DATASHARE salesshare;
```

```
producer_account |          producer_namespace          | share_type  | share_name   |
 object_type |        object_name           |  include_new
-----------------+---------------------------------------+-------------+--------------
+-------------+-----------------------------+--------------
 123456789012    | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d  | OUTBOUND    |  salesshare  |
 TABLE       | public.tickit_sales_redshift |
 123456789012    | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d  | OUTBOUND    |  salesshare  |
 SCHEMA      | public                       |   t
```

The following example displays the information for inbound datashares on a consumer cluster.

```
DESC DATASHARE salesshare of ACCOUNT '123456789012' NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';

 producer_account |          producer_namespace          | share_type | share_name |
 object_type |          object_name          |  include_new
------------------+---------------------------------------+------------+------------
+-------------+-----------------------------+--------------
 123456789012     | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare |
 table       | public.tickit_sales_redshift |
 123456789012     | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d | INBOUND    | salesshare |
 schema      | public                       |
(2 rows)
```

DESC IDENTITY PROVIDER

Displays information about an identity provider. Only a superuser can describe an identity provider.

Syntax

```
DESC IDENTITY PROVIDER identity_provider_name
```

Parameters

identity_provider_name

The name of the identity provider.

Example

The following example displays information about the identity provider.

```
DESC IDENTITY PROVIDER azure_idp;
```

Sample output.

```
  uid   |   name    | type  |                 instanceid                | namespc |

                                                       params

                              | enabled
--------+-----------+-------+--------------------------------------+---------
+---------------------------------------------------------------------------------------------------------
+---------
 126692 | azure_idp | azure | e40d4bb2-7670-44ae-bfb8-5db013221d73 | aad     |
 {"issuer":"https://login.microsoftonline.com/e40d4bb2-7670-44ae-bfb8-5db013221d73/
v2.0", "client_id":"871c010f-5e61-4fb1-83ac-98610a7e9110", "client_secret":'',
 "audience":["https://analysis.windows.net/powerbi/connector/AmazonRedshift", "https://
analysis.windows.net/powerbi/connector/AWSRDS"]} | t
(1 row)
```

DETACH MASKING POLICY

Detaches an already attached dynamic data masking policy from a column. For more information on dynamic data masking, see Dynamic data masking.

Superusers and users or roles that have the sys:secadmin role can detach a masking policy.

Syntax

```
DETACH MASKING POLICY policy_name
   ON { table_name }
   ( output_column_names )
   FROM { user_name | ROLE role_name | PUBLIC };
```

Parameters

policy_name

The name of the masking policy to detach.

table_name

The name of the table to detach the masking policy from.

output_column_names

The names of the columns to which the masking policy was attached.

user_name

The name of the user to whom the masking policy was attached.

You can only set one of user_name, role_name, and PUBLIC in a single DETACH MASKING POLICY statement.

role_name

The name of the role to which the masking policy was attached.

You can only set one of user_name, role_name, and PUBLIC in a single DETACH MASKING POLICY statement.

PUBLIC

Shows that the policy was attached to all users in the table.

You can only set one of user_name, role_name, and PUBLIC in a single DETACH MASKING POLICY statement.

DETACH RLS POLICY

Detach a row-level security policy on a table from one or more users or roles.

Superusers and users or roles that have the `sys:secadmin` role can detach a policy.

Syntax

```
DETACH RLS POLICY policy_name ON [TABLE] table_name [, ...]
FROM { user_name | ROLE role_name | PUBLIC } [, ...]
```

Parameters

policy_name

The name of the policy.

ON [TABLE] *table_name* [, ...]

The table or view that the row-level security policy is detached from.

FROM { *user_name* | ROLE *role_name* | PUBLIC} [, ...]

Specifies whether the policy is detached from one or more specified users or roles.

Usage notes

When working with the DETACH RLS POLICY statement, observe the following:

- You can detach a policy from a relation, user, role, or public.

Examples

The following example detaches a policy on a table from a role.

```
DETACH RLS POLICY policy_concerts ON tickit_category_redshift FROM ROLE analyst, ROLE
 dbadmin;
```

DROP DATABASE

Drops a database.

You can't run DROP DATABASE within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

Syntax

```
DROP DATABASE database_name [ FORCE ]
```

Parameters

database_name

Name of the database to be dropped. You can't drop the dev, padb_harvest, template0, template1, or sys:internal databases, and you can't drop the current database.

To drop an external database, drop the external schema. For more information, see DROP SCHEMA.

FORCE

When you specify FORCE, DROP DATABASE attempts to terminate active connections prior to dropping the database. If all active connections successfully terminate within a timeout, the drop proceeds. If not all connections terminate, the command throws an error.

DROP DATABASE usage notes

When using the DROP DATABASE statement, consider the following:

- In general, we recommend that you don't drop a database that contains an AWS Data Exchange datashare using the DROP DATABASE statement. If you do, the AWS accounts that have access to the datashare lose access. Performing this type of alteration can breach data product terms in AWS Data Exchange.

  The following example shows an error when a database that contains an AWS Data Exchange datashare is dropped.

  ```
  DROP DATABASE test_db;
  ERROR:   Drop of database test_db that contains ADX-managed datashare(s)
   requires session variable datashare_break_glass_session_var to be set to value
   'ce8d280c10ad41'
  ```

  To allow dropping the database, set the following variable and run the DROP DATABASE statement again.

  ```
  SET datashare_break_glass_session_var to 'ce8d280c10ad41';
  ```

  ```
  DROP DATABASE test_db;
  ```

  In this case, Amazon Redshift generates a random one-time value to set the session variable to allow DROP DATABASE for a database that contains an AWS Data Exchange datashare.

Examples

The following example drops a database named TICKIT_TEST:

```
drop database tickit_test;
```

DROP DATASHARE

Drops a datashare. This command isn't reversible.

Only a superuser or the datashare owner can drop a datashare.

Required privileges

Following are required privileges for DROP DATASHARE:

- Superuser
- Users with the DROP DATASHARE privilege
- Datashare owner

Syntax

```
DROP DATASHARE datashare_name;
```

Parameters

datashare_name

The name of the datashare to be dropped.

DROP DATASHARE usage notes

When using the DROP DATASHARE statement, consider the following:

- In general, we recommend that you don't drop an AWS Data Exchange datashare using the DROP DATASHARE statement. If you do, the AWS accounts that have access to the datashare lose access. Performing this type of alteration can breach data product terms in AWS Data Exchange.

  The following example shows an error when an AWS Data Exchange datashare is dropped.

  ```
  DROP DATASHARE salesshare;
  ERROR:  Drop of ADX-managed datashare salesshare requires session variable
   datashare_break_glass_session_var to be set to value '620c871f890c49'
  ```

To allow dropping an AWS Data Exchange datashare, set the following variable and run the DROP DATASHARE statement again.

```
SET datashare_break_glass_session_var to '620c871f890c49';
```

```
DROP DATASHARE salesshare;
```

In this case, Amazon Redshift generates a random one-time value to set the session variable to allow DROP DATASHARE for an AWS Data Exchange datashare.

Examples

The following example drops a datashare named `salesshare`.

```
DROP DATASHARE salesshare;
```

DROP EXTERNAL VIEW

Drops an external view from the database. Dropping an external view removes it from all SQL engines the view is associated with, such as Amazon Athena and Amazon EMR Spark. This command can't be reversed. For more information about Data Catalog views, see AWS Glue Data Catalog views.

Syntax

```
DROP EXTERNAL VIEW schema_name.view_name [ IF EXISTS ]
{catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name |
 external_schema_name.view_name}
```

Parameters

schema_name.view_name

The schema that's attached to your AWS Glue database, followed by the name of the view.

IF EXISTS

Drops the view only if it exists.

catalog_name.schema_name.view_name | awsdatacatalog.dbname.view_name | external_schema_name.view_name

The notation of the schema to use when dropping the view. You can specify to use the AWS Glue Data Catalog, a Glue database that you created, or an external schema that you created. See CREATE DATABASE and CREATE EXTERNAL SCHEMA for more information.

query_definition

The definition of the SQL query that Amazon Redshift runs to alter the view.

Examples

The following example drops a Data Catalog view named sample_schema.glue_data_catalog_view.

```
DROP EXTERNAL VIEW sample_schema.glue_data_catalog_view IF EXISTS
```

DROP FUNCTION

Removes a user-defined function (UDF) from the database. The function's signature, or list of argument data types, must be specified because multiple functions can exist with the same name but different signatures. You can't drop an Amazon Redshift built-in function.

This command isn't reversible.

Required privileges

Following are required privileges for DROP FUNCTION:

- Superuser
- Users with the DROP FUNCTION privilege
- Function owner

Syntax

```
DROP FUNCTION name
( [arg_name] arg_type   [, ...] )
[ CASCADE | RESTRICT ]
```

Parameters

name

The name of the function to be removed.

arg_name

The name of an input argument. DROP FUNCTION ignores argument names, because only the argument data types are needed to determine the function's identity.

arg_type

The data type of the input argument. You can supply a comma-separated list with a maximum of 32 data types.

CASCADE

Keyword specifying to automatically drop objects that depend on the function, such as views.

To create a view that isn't dependent on a function, include the WITH NO SCHEMA BINDING clause in the view definition. For more information, see CREATE VIEW.

RESTRICT

Keyword specifying that if any objects depend on the function, do not drop the function and return a message. This action is the default.

Examples

The following example drops the function named `f_sqrt`:

```
drop function f_sqrt(int);
```

To remove a function that has dependencies, use the CASCADE option, as shown in the following example:

```
drop function f_sqrt(int)cascade;
```

DROP GROUP

Deletes a user group. This command isn't reversible. This command doesn't delete the individual users in a group.

See DROP USER to delete an individual user.

Syntax

```
DROP GROUP name
```

Parameter

name

Name of the user group to delete.

Example

The following example deletes the `guests` user group:

```
DROP GROUP guests;
```

You can't drop a group if the group has any privileges on an object. If you attempt to drop such a group, you will receive the following error.

```
ERROR: group "guests" can't be dropped because the group has a privilege on some object
```

If the group has privileges for an object, you must revoke the privileges before dropping the group. To find the objects that the `guests` group has privileges for, use the following example. For more information about the metadata view used in the example, see SVV_RELATION_PRIVILEGES.

```
SELECT DISTINCT namespace_name, relation_name, identity_name, identity_type
FROM svv_relation_privileges
WHERE identity_type='group' AND identity_name='guests';

+----------------+---------------+---------------+---------------+
| namespace_name | relation_name | identity_name | identity_type |
+----------------+---------------+---------------+---------------+
| public         | table1        | guests        | group         |
+----------------+---------------+---------------+---------------+
| public         | table2        | guests        | group         |
+----------------+---------------+---------------+---------------+
```

The following example revokes all privileges on all tables in the public schema from the guests user group, and then drops the group.

```
REVOKE ALL ON ALL TABLES IN SCHEMA public FROM GROUP guests;
DROP GROUP guests;
```

DROP IDENTITY PROVIDER

Deletes an identity provider. This command isn't reversible. Only a superuser can drop an identity provider.

Syntax

```
DROP IDENTITY PROVIDER identity_provider_name [ CASCADE ]
```

Parameters

identity_provider_name

Name of the identity provider to delete.

CASCADE

Deletes users and roles attached to the identity provider, when it is deleted.

Example

The following example deletes the *oauth_provider* identity provider.

```
DROP IDENTITY PROVIDER oauth_provider;
```

If you drop the identity provider, some users may not be able to log in or use client tools configured to use the identity provider.

DROP LIBRARY

Removes a custom Python library from the database. Only the library owner or a superuser can drop a library.

DROP LIBRARY can't be run inside a transaction block (BEGIN … END). For more information about transactions, see Serializable isolation.

This command isn't reversible. The DROP LIBRARY command commits immediately. If a UDF that depends on the library is running concurrently, the UDF might fail, even if the UDF is running within a transaction.

For more information, see CREATE LIBRARY.

Required privileges

Following are required privileges for DROPLIBRARY:

- Superuser
- Users with the DROP LIBRARY privilege
- Library owner

Syntax

```
DROP LIBRARY library_name
```

Parameters

library_name

The name of the library.

DROP MASKING POLICY

Drops a dynamic data masking policy from all databases. You can't drop a masking policy that's still attached to one or more tables. For more information on dynamic data masking, see Dynamic data masking.

Superusers and users or roles that have the sys:secadmin role can drop a masking policy.

Syntax

```
DROP MASKING POLICY policy_name;
```

Parameters

policy_name

The name of the masking policy to drop.

DROP MODEL

Removes a model from the database. Only the model owner or a superuser can drop a model.

DROP MODEL also deletes all the associated prediction function that is derived from this model, all Amazon Redshift artifacts related to the model, and all Amazon S3 data related to the model. While the model is still being trained in Amazon SageMaker AI, DROP MODEL will cancel those operations.

This command isn't reversible. The DROP MODEL command commits immediately.

Required permissions

Following are required permissions for DROP MODEL:

- Superuser
- Users with the DROP MODEL permission
- Model owner
- Schema owner

Syntax

```
DROP MODEL [ IF EXISTS ] model_name
```

Parameters

IF EXISTS

A clause that indicates that if the specified schema already exists, the command should make no changes and return a message that the schema exists.

model_name

The name of the model. The model name in a schema must be unique.

Examples

The following example drops the model demo_ml.customer_churn.

```
DROP MODEL demo_ml.customer_churn
```

DROP MATERIALIZED VIEW

Removes a materialized view.

For more information about materialized views, see Materialized views in Amazon Redshift.

Syntax

```
DROP MATERIALIZED VIEW [ IF EXISTS ] mv_name [ CASCADE | RESTRICT ]
```

Parameters

IF EXISTS

A clause that specifies to check if the named materialized view exists. If the materialized view doesn't exist, then the `DROP MATERIALIZED VIEW` command returns an error message. This clause is useful when scripting, to keep the script from failing if you drop a nonexistent materialized view.

mv_name

The name of the materialized view to be dropped.

CASCADE

A clause that indicates to automatically drop objects that the materialized view depends on, such as other views.

RESTRICT

A clause that indicates to not drop the materialized view if any objects depend on it. This is the default.

Usage Notes

Only the owner of a materialized view can use `DROP MATERIALIZED VIEW` on that view. A superuser or a user who has specifically been granted DROP privileges can be exceptions to this.

When you write a drop statement for a materialized view and a view with a matching name exists, it results in an error that instructs you to use DROP VIEW. An error occurs even in a case where you use `DROP MATERIALIZED VIEW IF EXISTS`.

Example

The following example drops the `tickets_mv` materialized view.

```
DROP MATERIALIZED VIEW tickets_mv;
```

DROP PROCEDURE

Drops a procedure. To drop a procedure, both the procedure name and input argument data types (signature), are required. Optionally, you can include the full argument data types, including OUT arguments. To find the signature for a procedure, use the SHOW PROCEDURE command. For more information about procedure signatures, see PG_PROC_INFO.

Required privileges

Following are required privileges for DROP PROCEDURE:

- Superuser
- Users with the DROP PROCEDURE privilege
- Procedure owner

Syntax

```
DROP PROCEDURE sp_name ( [ [ argname ] [ argmode ] argtype [, ...] ] )
```

Parameters

sp_name

The name of the procedure to be removed.

argname

The name of an input argument. DROP PROCEDURE ignores argument names, because only the argument data types are needed to determine the procedure's identity.

argmode

The mode of an argument, which can be IN, OUT, or INOUT. OUT arguments are optional because they aren't used to identify a stored procedure.

argtype

The data type of the input argument. For a list of the supported data types, see Data types.

Examples

The following example drops a stored procedure named `quarterly_revenue`.

```
DROP PROCEDURE quarterly_revenue(volume INOUT bigint, at_price IN numeric,result OUT
 int);
```

DROP RLS POLICY

Drops a row-level security policy for all tables in all databases.

Superusers and users or roles that have the sys:secadmin role can drop a policy.

Syntax

```
DROP RLS POLICY [ IF EXISTS ] policy_name [ CASCADE | RESTRICT ]
```

Parameters

IF EXISTS

A clause that indicates if the specified policy already exists.

policy_name

The name of the policy.

CASCADE

A clause that indicates to automatically detach the policy from all attached tables before dropping the policy.

RESTRICT

A clause that indicates not to drop the policy when it is attached to some tables. This is the default.

Examples

The following example drops the row-level security policy.

```
DROP RLS POLICY policy_concerts;
```

DROP ROLE

Removes a role from a database. Only the role owner who either created the role, a user with the WITH ADMIN option, or a superuser can drop a role.

You can't drop a role that is granted to a user or another role that is dependent on this role.

Required privileges

Following are the required privileges for DROP ROLE:

- Superuser
- Role owner who is either the user that created the role or a user that has been granted the role with the WITH ADMIN OPTION privilege.

Syntax

```
DROP ROLE role_name [ FORCE | RESTRICT ]
```

Parameters

role_name

The name of the role.

[FORCE | RESTRICT]

The default setting is RESTRICT. Amazon Redshift throws an error when you try to drop a role that has inherited another role. Use FORCE to remove all role assignments, if any exists.

Examples

The following example drops the role `sample_role`.

```
DROP ROLE sample_role FORCE;
```

The following example attempts to drop the role sample_role1 that has been granted to a user with the default RESTRICT option.

```
CREATE ROLE sample_role1;
GRANT ROLE sample_role1 TO user1;
DROP ROLE sample_role1;
ERROR:  cannot drop this role since it has been granted on a user
```

To successfully drop the sample_role1 that has been granted to a user, use the FORCE option.

```
DROP ROLE sample_role1 FORCE;
```

The following example attempts to drop the role sample_role2 that has another role dependent on it with the default RESTRICT option.

```
CREATE ROLE sample_role1;
CREATE ROLE sample_role2;
GRANT ROLE sample_role1 TO sample_role2;
DROP ROLE sample_role2;
ERROR:  cannot drop this role since it depends on another role
```

To successfully drop the sample_role2 that has another role dependent on it, use the FORCE option.

```
DROP ROLE sample_role2 FORCE;
```

DROP SCHEMA

Deletes a schema. For an external schema, you can also drop the external database associated with the schema. This command isn't reversible.

Required privileges

Following are required privileges for DROP SCHEMA:

- Superuser
- Schema owner
- Users with the DROP SCHEMA privilege

Syntax

```
DROP SCHEMA [ IF EXISTS ] name [, ...]
[ DROP EXTERNAL DATABASE ]
[ CASCADE | RESTRICT ]
```

Parameters

IF EXISTS

Clause that indicates that if the specified schema doesn’t exist, the command should make no changes and return a message that the schema doesn't exist, rather than terminating with an error.

This clause is useful when scripting, so the script doesn’t fail if DROP SCHEMA runs against a nonexistent schema.

name

Names of the schemas to drop. You can specify multiple schema names separated by commas.

DROP EXTERNAL DATABASE

Clause that indicates that if an external schema is dropped, drop the external database associated with the external schema, if one exists. If no external database exists, the command returns a message stating that no external database exists. If multiple external schemas are dropped, all databases associated with the specified schemas are dropped.

If an external database contains dependent objects such as tables, include the CASCADE option to drop the dependent objects as well.

When you drop an external database, the database is also dropped for any other external schemas associated with the database. Tables defined in other external schemas using the database are also dropped.

DROP EXTERNAL DATABASE doesn't support external databases stored in a HIVE metastore.

CASCADE

Keyword that indicates to automatically drop all objects in the schema. If DROP EXTERNAL DATABASE is specified, all objects in the external database are also dropped.

RESTRICT

Keyword that indicates not to drop a schema or external database if it contains any objects. This action is the default.

Example

The following example deletes a schema named S_SALES. This example uses RESTRICT as a safety mechanism so that the schema isn't deleted if it contains any objects. In this case, you need to delete the schema objects before deleting the schema.

```
drop schema s_sales restrict;
```

The following example deletes a schema named S_SALES and all objects that depend on that schema.

```
drop schema s_sales cascade;
```

The following example either drops the S_SALES schema if it exists, or does nothing and returns a message if it doesn't.

```
drop schema if exists s_sales;
```

The following example deletes an external schema named S_SPECTRUM and the external database associated with it. This example uses RESTRICT so that the schema and database aren't deleted if they contain any objects. In this case, you need to delete the dependent objects before deleting the schema and the database.

```
drop schema s_spectrum drop external database restrict;
```

The following example deletes multiple schemas and the external databases associated with them, along with any dependent objects.

```
drop schema s_sales, s_profit, s_revenue drop external database cascade;
```

DROP TABLE

Removes a table from a database.

If you are trying to empty a table of rows, without removing the table, use the DELETE or TRUNCATE command.

DROP TABLE removes constraints that exist on the target table. Multiple tables can be removed with a single DROP TABLE command.

DROP TABLE with an external table can't be run inside a transaction (BEGIN … END). For more information about transactions, see Serializable isolation.

To find an example where the DROP privilege is granted to a group, see GRANT Examples.

Required privileges

Following are required privileges for DROP TABLE:

- Superuser
- Users with the DROP TABLE privilege
- Table owner with the USAGE privilege on the schema

Syntax

```
DROP TABLE [ IF EXISTS ] name [, ...] [ CASCADE | RESTRICT ]
```

Parameters

IF EXISTS

Clause that indicates that if the specified table doesn’t exist, the command should make no changes and return a message that the table doesn't exist, rather than terminating with an error.

This clause is useful when scripting, so the script doesn’t fail if DROP TABLE runs against a nonexistent table.

name

Name of the table to drop.

CASCADE

Clause that indicates to automatically drop objects that depend on the table, such as views.

To create a view that isn't dependent on other database objects, such as views and tables, include the WITH NO SCHEMA BINDING clause in the view definition. For more information, see CREATE VIEW.

RESTRICT

Clause that indicates not to drop the table if any objects depend on it. This action is the default.

Examples

Dropping a table with no dependencies

The following example creates and drops a table called FEEDBACK that has no dependencies:

```
create table feedback(a int);

drop table feedback;
```

If a table contains columns that are referenced by views or other tables, Amazon Redshift displays a message such as the following.

```
Invalid operation: cannot drop table feedback because other objects depend on it
```

Dropping two tables simultaneously

The following command set creates a FEEDBACK table and a BUYERS table and then drops both tables with a single command:

```
create table feedback(a int);

create table buyers(a int);

drop table feedback, buyers;
```

Dropping a table with a dependency

The following steps show how to drop a table called FEEDBACK using the CASCADE switch.

First, create a simple table called FEEDBACK using the CREATE TABLE command:

```
create table feedback(a int);
```

Next, use the CREATE VIEW command to create a view called FEEDBACK_VIEW that relies on the table FEEDBACK:

```
create view feedback_view as select * from feedback;
```

The following example drops the table FEEDBACK and also drops the view FEEDBACK_VIEW, because FEEDBACK_VIEW is dependent on the table FEEDBACK:

```
drop table feedback cascade;
```

Viewing the dependencies for a table

To return the dependencies for your table, use the following example. Replace *my_schema* and *my_table* with your own schema and table.

```
SELECT dependent_ns.nspname as dependent_schema
, dependent_view.relname as dependent_view
, source_ns.nspname as source_schema
, source_table.relname as source_table
, pg_attribute.attname as column_name
FROM pg_depend
JOIN pg_rewrite ON pg_depend.objid = pg_rewrite.oid
```

```
JOIN pg_class as dependent_view ON pg_rewrite.ev_class = dependent_view.oid
JOIN pg_class as source_table ON pg_depend.refobjid = source_table.oid
JOIN pg_attribute ON pg_depend.refobjid = pg_attribute.attrelid
    AND pg_depend.refobjsubid = pg_attribute.attnum
JOIN pg_namespace dependent_ns ON dependent_ns.oid = dependent_view.relnamespace
JOIN pg_namespace source_ns ON source_ns.oid = source_table.relnamespace
WHERE
source_ns.nspname = 'my_schema'
AND source_table.relname = 'my_table'
AND pg_attribute.attnum > 0
ORDER BY 1,2
LIMIT 10;
```

To drop *my_table* and its dependencies, use the following example. This example also returns all dependencies for the table that has been dropped.

```
DROP TABLE my_table CASCADE;

SELECT dependent_ns.nspname as dependent_schema
, dependent_view.relname as dependent_view
, source_ns.nspname as source_schema
, source_table.relname as source_table
, pg_attribute.attname as column_name
FROM pg_depend
JOIN pg_rewrite ON pg_depend.objid = pg_rewrite.oid
JOIN pg_class as dependent_view ON pg_rewrite.ev_class = dependent_view.oid
JOIN pg_class as source_table ON pg_depend.refobjid = source_table.oid
JOIN pg_attribute ON pg_depend.refobjid = pg_attribute.attrelid
    AND pg_depend.refobjsubid = pg_attribute.attnum
JOIN pg_namespace dependent_ns ON dependent_ns.oid = dependent_view.relnamespace
JOIN pg_namespace source_ns ON source_ns.oid = source_table.relnamespace
WHERE
source_ns.nspname = 'my_schema'
AND source_table.relname = 'my_table'
AND pg_attribute.attnum > 0
ORDER BY 1,2
LIMIT 10;

+------------------+----------------+---------------+--------------+-------------+
| dependent_schema | dependent_view | source_schema | source_table | column_name |
+------------------+----------------+---------------+--------------+-------------+
```

Dropping a table Using IF EXISTS

The following example either drops the FEEDBACK table if it exists, or does nothing and returns a message if it doesn't:

```
drop table if exists feedback;
```

DROP USER

Drops a user from a database. Multiple users can be dropped with a single DROP USER command. You must be a database superuser or have the DROP USER permission to run this command.

Syntax

```
DROP USER [ IF EXISTS ] name [, ... ]
```

Parameters

IF EXISTS

Clause that indicates that if the specified user doesn’t exist, the command should make no changes and return a message that the user doesn't exist, rather than terminating with an error.

This clause is useful when scripting, so the script doesn’t fail if DROP USER runs against a nonexistent user.

name

Name of the user to remove. You can specify multiple users, with a comma separating each user name from the next.

Usage notes

You can't drop the user named `rdsdb` or the administrator user of the database which is typically named `awsuser` or `admin`.

You can't drop a user if the user owns any database object, such as a schema, database, table, or view, or if the user has any privileges on a database, table, column, or group. If you attempt to drop such a user, you receive one of the following errors.

```
ERROR: user "username" can't be dropped because the user owns some object [SQL
 State=55006]
```

```
ERROR: user "username" can't be dropped because the user has a privilege on some object
 [SQL State=55006]
```

For detailed instructions on how to find the objects owned by a database user, see [How do I resolve the "user cannot be dropped" error in Amazon Redshift?] in *Knowledge Center*.

> **Note**
>
> Amazon Redshift checks only the current database before dropping a user. DROP USER doesn't return an error if the user owns database objects or has any privileges on objects in another database. If you drop a user that owns objects in another database, the owner for those objects is changed to 'unknown'.

If a user owns an object, first drop the object or change its ownership to another user before dropping the original user. If the user has privileges for an object, first revoke the privileges before dropping the user. The following example shows dropping an object, changing ownership, and revoking privileges before dropping the user.

```
drop database dwdatabase;
alter schema dw owner to dwadmin;
revoke all on table dwtable from dwuser;
drop user dwuser;
```

Examples

The following example drops a user called paulo:

```
drop user paulo;
```

The following example drops two users, paulo and martha:

```
drop user paulo, martha;
```

The following example drops the user paulo if it exists, or does nothing and returns a message if it doesn't:

```
drop user if exists paulo;
```

DROP VIEW

Removes a view from the database. Multiple views can be dropped with a single DROP VIEW command. This command isn't reversible.

Required privileges

Following are required privileges for DROP VIEW:

- Superuser
- Users with the DROP VIEW privilege
- View owner

Syntax

```
DROP VIEW [ IF EXISTS ] name [, ... ] [ CASCADE | RESTRICT ]
```

Parameters

IF EXISTS

Clause that indicates that if the specified view doesn’t exist, the command should make no changes and return a message that the view doesn't exist, rather than terminating with an error.

This clause is useful when scripting, so the script doesn’t fail if DROP VIEW runs against a nonexistent view.

name

Name of the view to be removed.

CASCADE

Clause that indicates to automatically drop objects that depend on the view, such as other views.

To create a view that isn't dependent on other database objects, such as views and tables, include the WITH NO SCHEMA BINDING clause in the view definition. For more information, see CREATE VIEW.

Note that if you include CASCADE and the count of database objects dropped runs to ten or more, it's possible that your database client won't list all of the dropped objects in the summary results. This is typically because SQL client tools have default limitations on the results returned.

RESTRICT

Clause that indicates not to drop the view if any objects depend on it. This action is the default.

Examples

The following example drops the view called *event*:

```
drop view event;
```

To remove a view that has dependencies, use the CASCADE option. For example, say we start with a table called EVENT. We then create the eventview view of the EVENT table, using the CREATE VIEW command, as shown in the following example:

```
create view eventview as
select dateid, eventname, catid
from event where catid = 1;
```

Now, we create a second view called *myeventview*, that is based on the first view *eventview*:

```
create view myeventview as
select eventname, catid
from eventview where eventname <> ' ';
```

At this point, two views have been created: *eventview* and *myeventview*.

The *myeventview* view is a child view with*eventview* as its parent.

To delete the *eventview* view, the obvious command to use is the following:

```
drop view eventview;
```

Notice that if you run this command in this case, you get the following error:

```
drop view eventview;
```

```
ERROR: can't drop view eventview because other objects depend on it
HINT: Use DROP ... CASCADE to drop the dependent objects too.
```

To remedy this, run the following command (as suggested in the error message):

```
drop view eventview cascade;
```

Both *eventview* and *myeventview* have now been dropped successfully.

The following example either drops the *eventview* view if it exists, or does nothing and returns a message if it doesn't:

```
drop view if exists eventview;
```

END

Commits the current transaction. Performs exactly the same function as the COMMIT command.

See COMMIT for more detailed documentation.

Syntax

```
END [ WORK | TRANSACTION ]
```

Parameters

WORK

Optional keyword.

TRANSACTION

Optional keyword; WORK and TRANSACTION are synonyms.

Examples

The following examples all end the transaction block and commit the transaction:

```
end;
```

```
end work;
```

```
end transaction;
```

After any of these commands, Amazon Redshift ends the transaction block and commits the changes.

EXECUTE

Runs a previously prepared statement.

Syntax

```
EXECUTE plan_name [ (parameter [, ...]) ]
```

Parameters

plan_name

Name of the prepared statement to be run.

parameter

The actual value of a parameter to the prepared statement. This must be an expression yielding a value of a type compatible with the data type specified for this parameter position in the PREPARE command that created the prepared statement.

Usage notes

EXECUTE is used to run a previously prepared statement. Because prepared statements only exist for the duration of a session, the prepared statement must have been created by a PREPARE statement run earlier in the current session.

If the previous PREPARE statement specified some parameters, a compatible set of parameters must be passed to the EXECUTE statement, or else Amazon Redshift returns an error. Unlike functions, prepared statements aren't overloaded based on the type or number of specified parameters; the name of a prepared statement must be unique within a database session.

When an EXECUTE command is issued for the prepared statement, Amazon Redshift may optionally revise the query execution plan (to improve performance based on the specified parameter values) before running the prepared statement. Also, for each new execution of a prepared statement, Amazon Redshift may revise the query execution plan again based on the different parameter values specified with the EXECUTE statement. To examine the query execution plan that Amazon Redshift has chosen for any given EXECUTE statements, use the EXPLAIN command.

For examples and more information on the creation and usage of prepared statements, see PREPARE.

See also

DEALLOCATE, PREPARE

EXPLAIN

Displays the execution plan for a query statement without running the query. For information about the query analysis workflow, see Query analysis workflow.

Syntax

```
EXPLAIN [ VERBOSE ] query
```

Parameters

VERBOSE

Displays the full query plan instead of just a summary.

query

Query statement to explain. The query can be a SELECT, INSERT, CREATE TABLE AS, UPDATE, or DELETE statement.

Usage notes

EXPLAIN performance is sometimes influenced by the time it takes to create temporary tables. For example, a query that uses the common subexpression optimization requires temporary tables to be created and analyzed in order to return the EXPLAIN output. The query plan depends on the schema and statistics of the temporary tables. Therefore, the EXPLAIN command for this type of query might take longer to run than expected.

You can use EXPLAIN only for the following commands:

- SELECT
- SELECT INTO
- CREATE TABLE AS
- INSERT
- UPDATE
- DELETE

The EXPLAIN command will fail if you use it for other SQL commands, such as data definition language (DDL) or database operations.

The EXPLAIN output relative unit costs are used by Amazon Redshift to choose a query plan. Amazon Redshift compares the sizes of various resource estimates to determine the plan.

Query planning and execution steps

The execution plan for a specific Amazon Redshift query statement breaks down execution and calculation of a query into a discrete sequence of steps and table operations that eventually produce a final result set for the query. For information about query planning, see Query processing.

The following table provides a summary of steps that Amazon Redshift can use in developing an execution plan for any query a user submits for execution.

EXPLAIN operators	Query execution steps	Description
SCAN:		
Sequential Scan	scan	Amazon Redshift relation scan or table scan operator or step. Scans whole table sequentia lly from beginning to end; also evaluates query constraints for every row (Filter) if specified with WHERE clause. Also used to run INSERT, UPDATE, and DELETE statements.

EXPLAIN operators	Query execution steps	Description
JOINS: Amazon Redshift uses different join operators based on the physical design of the tables being joined, the location of the data required for the join, and specific attributes of the query itself. Subquery Scan -- Subquery scan and append are used to run UNION queries.		
Nested Loop	nloop	Least optimal join; mainly used for cross-joins (Cartesian products; without a join condition) and some inequality joins.
Hash Join	hjoin	Also used for inner joins and left and right outer joins and typically faster than a nested loop join. Hash Join reads the outer table, hashes the joining column, and finds matches in the inner hash table. Step can spill to disk. (Inner input of hjoin is hash step which can be disk-based.)
Merge Join	mjoin	Also used for inner joins and outer joins (for join tables that are both distributed and sorted on the joining columns). Typically the fastest Amazon Redshift join algorithm, not including other cost considerations.
AGGREGATION: Operators and steps used for queries that involve aggregate functions and GROUP BY operations.		
Aggregate	aggr	Operator/step for scalar aggregate functions.
HashAggregate	aggr	Operator/step for grouped aggregate functions. Can operate from disk by virtue of hash table spilling to disk.
GroupAggregate	aggr	Operator sometimes chosen for grouped aggregate queries if the Amazon Redshift configuration setting for force_hash_grouping setting is off.

EXPLAIN operators	Query execution steps	Description
SORT: Operators and steps used when queries have to sort or merge result sets.		
Sort	sort	Sort performs the sorting specified by the ORDER BY clause as well as other operations such as UNIONs and joins. Can operate from disk.
Merge	merge	Produces final sorted results of a query based on intermediate sorted results derived from operations performed in parallel.
EXCEPT, INTERSECT, and UNION operations:		
SetOp Except [Distinct]	hjoin	Used for EXCEPT queries. Can operate from disk based on virtue of fact that input hash can be disk-based.
Hash Intersect [Distinct]	hjoin	Used for INTERSECT queries. Can operate from disk based on virtue of fact that input hash can be disk-based.
Append [All |Distinct]	save	Append used with Subquery Scan to implement UNION and UNION ALL queries. Can operate from disk based on virtue of "save".
Miscellaneous/Other:		
Hash	hash	Used for inner joins and left and right outer joins (provides input to a hash join). The Hash operator creates the hash table for the inner table of a join. (The inner table is the table that is checked for matches and, in a join of two tables, is usually the smaller of the two.)
Limit	limit	Evaluates the LIMIT clause.

EXPLAIN operators	Query execution steps	Description
Materialize	save	Materialize rows for input to nested loop joins and some merge joins. Can operate from disk.
--	parse	Used to parse textual input data during a load.
--	project	Used to rearrange columns and compute expressions, that is, project data.
Result	--	Run scalar functions that don't involve any table access.
--	return	Return rows to the leader or client.
Subplan	--	Used for certain subqueries.
Unique	unique	Eliminates duplicates from SELECT DISTINCT and UNION queries.
Window	window	Compute aggregate and ranking window functions. Can operate from disk.
Network Operations:		
Network (Broadcast)	bcast	Broadcast is also an attribute of Join Explain operators and steps.
Network (Distribute)	dist	Distribute rows to compute nodes for parallel processing by data warehouse cluster.
Network (Send to Leader)	return	Sends results back to the leader for further processing.
DML Operations (operators that modify data):		
Insert (using Result)	insert	Inserts data.

EXPLAIN operators	Query execution steps	Description
Delete (Scan + Filter)	delete	Deletes data. Can operate from disk.
Update (Scan + Filter)	delete, insert	Implemented as delete and Insert.

Using EXPLAIN for RLS

If a query contains a table that is subject to row-level security (RLS) policies, EXPLAIN displays a special RLS SecureScan node. Amazon Redshift also logs the same node type to the STL_EXPLAIN system table. EXPLAIN doesn't reveal the RLS predicate that applies to dim_tbl. The RLS SecureScan node type serves as an indicator that the execution plan contains additional operations that are invisible to the current user.

The following example illustrates an RLS SecureScan node.

```
EXPLAIN
SELECT D.cint
FROM fact_tbl F INNER JOIN dim_tbl D ON F.k_dim = D.k
WHERE F.k_dim / 10 > 0;
                               QUERY PLAN
------------------------------------------------------------------------
 XN Hash Join DS_DIST_ALL_NONE  (cost=0.08..0.25 rows=1 width=4)
   Hash Cond: ("outer".k_dim = "inner"."k")
   ->  *XN* *RLS SecureScan f  (cost=0.00..0.14 rows=2 width=4)*
         Filter: ((k_dim / 10) > 0)
   ->  XN Hash  (cost=0.07..0.07 rows=2 width=8)
         ->  XN Seq Scan on dim_tbl d  (cost=0.00..0.07 rows=2 width=8)
               Filter: (("k" / 10) > 0)
```

To enable full investigation of query plans that are subject to RLS, Amazon Redshift offers the EXPLAIN RLS system permissions. Users that have been granted this permission can inspect complete query plans that also include RLS predicates.

The following example illustrates an additional Seq Scan below the RLS SecureScan node also includes the RLS policy predicate (k_dim > 1).

```
EXPLAIN SELECT D.cint
```

```
FROM fact_tbl F INNER JOIN dim_tbl D ON F.k_dim = D.k
WHERE F.k_dim / 10 > 0;
                                   QUERY PLAN
------------------------------------------------------------------------------------
 XN Hash Join DS_DIST_ALL_NONE  (cost=0.08..0.25 rows=1 width=4)
   Hash Cond: ("outer".k_dim = "inner"."k")
   *->  XN RLS SecureScan f  (cost=0.00..0.14 rows=2 width=4)
         Filter: ((k_dim / 10) > 0)*
         ->  *XN* *Seq Scan on fact_tbl rls_table  (cost=0.00..0.06 rows=5 width=8)
               Filter: (k_dim > 1)*
   ->  XN Hash  (cost=0.07..0.07 rows=2 width=8)
         ->  XN Seq Scan on dim_tbl d  (cost=0.00..0.07 rows=2 width=8)
               Filter: (("k" / 10) > 0)
```

While the EXPLAIN RLS permission is granted to a user, Amazon Redshift logs the full query plan including RLS predicates in the STL_EXPLAIN system table. Queries that are run while this permission is not granted will be logged without RLS internals. Granting or removing the EXPLAIN RLS permission won't change what Amazon Redshift has logged to STL_EXPLAIN for previous queries.

AWS Lake Formation-RLS protected Redshift relations

The following example illustrates an LF SecureScan node, which you can use to view Lake Formation-RLS relations.

```
EXPLAIN
SELECT *
FROM lf_db.public.t_share
WHERE a > 1;
QUERY PLAN
---------------------------------------------------------------
XN LF SecureScan t_share  (cost=0.00..0.02 rows=2 width=11)
(2 rows)
```

Examples

> **Note**
>
> For these examples, the sample output might vary depending on Amazon Redshift configuration.

The following example returns the query plan for a query that selects the EVENTID, EVENTNAME, VENUEID, and VENUENAME from the EVENT and VENUE tables:

```
explain
select eventid, eventname, event.venueid, venuename
from event, venue
where event.venueid = venue.venueid;
```

```
                                QUERY PLAN
--------------------------------------------------------------------------
XN Hash Join DS_DIST_OUTER  (cost=2.52..58653620.93 rows=8712 width=43)
Hash Cond: ("outer".venueid = "inner".venueid)
->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=23)
->  XN Hash  (cost=2.02..2.02 rows=202 width=22)
->  XN Seq Scan on venue  (cost=0.00..2.02 rows=202 width=22)
(5 rows)
```

The following example returns the query plan for the same query with verbose output:

```
explain verbose
select eventid, eventname, event.venueid, venuename
from event, venue
where event.venueid = venue.venueid;
```

```
                                QUERY PLAN
--------------------------------------------------------------------------
{HASHJOIN
:startup_cost 2.52
:total_cost 58653620.93
:plan_rows 8712
:plan_width 43
:best_pathkeys <>
:dist_info DS_DIST_OUTER
:dist_info.dist_keys (
TARGETENTRY
{
VAR
:varno 2
:varattno 1
...
```

```
XN Hash Join DS_DIST_OUTER  (cost=2.52..58653620.93 rows=8712 width=43)
Hash Cond: ("outer".venueid = "inner".venueid)
->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=23)
->  XN Hash  (cost=2.02..2.02 rows=202 width=22)
->  XN Seq Scan on venue  (cost=0.00..2.02 rows=202 width=22)
(519 rows)
```

The following example returns the query plan for a CREATE TABLE AS (CTAS) statement:

```
explain create table venue_nonulls as
select * from venue
where venueseats is not null;

QUERY PLAN
-----------------------------------------------------------
XN Seq Scan on venue  (cost=0.00..2.02 rows=187 width=45)
Filter: (venueseats IS NOT NULL)
(2 rows)
```

FETCH

Retrieves rows using a cursor. For information about declaring a cursor, see DECLARE.

FETCH retrieves rows based on the current position within the cursor. When a cursor is created, it is positioned before the first row. After a FETCH, the cursor is positioned on the last row retrieved. If FETCH runs off the end of the available rows, such as following a FETCH ALL, the cursor is left positioned after the last row.

FORWARD 0 fetches the current row without moving the cursor; that is, it fetches the most recently fetched row. If the cursor is positioned before the first row or after the last row, no row is returned.

When the first row of a cursor is fetched, the entire result set is materialized on the leader node, in memory or on disk, if needed. Because of the potential negative performance impact of using cursors with large result sets, we recommend using alternative approaches whenever possible. For more information, see Performance considerations when using cursors.

For more information, see DECLARE, CLOSE.

Syntax

```
FETCH [ NEXT | ALL | {FORWARD [ count | ALL ] } ] FROM cursor
```

Parameters

NEXT

Fetches the next row. This is the default.

ALL

Fetches all remaining rows. (Same as FORWARD ALL.) ALL isn't supported for single-node clusters.

FORWARD [*count* | ALL]

Fetches the next *count* rows, or all remaining rows. `FORWARD 0` fetches the current row. For single-node clusters, the maximum value for count is `1000`. FORWARD ALL isn't supported for single-node clusters.

cursor

Name of the new cursor.

FETCH example

The following example declares a cursor named LOLLAPALOOZA to select sales information for the Lollapalooza event, and then fetches rows from the result set using the cursor:

```
-- Begin a transaction

begin;

-- Declare a cursor

declare lollapalooza cursor for
select eventname, starttime, pricepaid/qtysold as costperticket, qtysold
from sales, event
where sales.eventid = event.eventid
and eventname='Lollapalooza';

-- Fetch the first 5 rows in the cursor lollapalooza:

fetch forward 5 from lollapalooza;

  eventname   |      starttime      | costperticket | qtysold
```

```
--------------+---------------------+---------------+---------
 Lollapalooza | 2008-05-01 19:00:00 |   92.00000000 |       3
 Lollapalooza | 2008-11-15 15:00:00 |  222.00000000 |       2
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       3
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       4
 Lollapalooza | 2008-04-17 15:00:00 |  239.00000000 |       1
(5 rows)

-- Fetch the next row:

fetch next from lollapalooza;

  eventname   |      starttime      | costperticket | qtysold
--------------+---------------------+---------------+---------
 Lollapalooza | 2008-10-06 14:00:00 |  114.00000000 |       2

-- Close the cursor and end the transaction:

close lollapalooza;
commit;
```

GRANT

Defines access permissions for a user or role.

Permissions include access options such as being able to read data in tables and views, write data, create tables, and drop tables. Use this command to give specific permissions for a table, database, schema, function, procedure, language, or column. To revoke permissions from a database object, use the REVOKE command.

Permissions also include the following datashare producer access options:

- Granting datashare access to consumer namespaces and accounts.
- Granting permission to alter a datashare by adding or removing objects from the datashare.
- Granting permission to share a datashare by adding or removing consumer namespaces from the datashare.

Datashare consumer access options are as follows:

- Granting users full access to databases created from a datashare or to external schemas that point to such databases.

- Granting users object-level permissions on databases created from a datashare like you can for local database objects. To grant this level of permission, you must use the WITH PERMISSIONS clause when creating a database from the datashare. For more information, see CREATE DATABASE.

For more information about datashare permissions, see Permissions you can grant to datashares.

You can also grant roles to manage database permissions and control what users can do relative to your data. By defining roles and assigning roles to users, you can limit the the actions those users can take, such as limiting users to only the CREATE TABLE and INSERT commands. For more information about the CREATE ROLE command, see the section called “CREATE ROLE”. Amazon Redshift has some system-defined roles that you can also use to grant specific permissions to your users. For more information, see the section called “Amazon Redshift system-defined roles”.

You can only GRANT or REVOKE USAGE permissions on an external schema to database users and user groups that use the ON SCHEMA syntax. When using ON EXTERNAL SCHEMA with AWS Lake Formation, you can only GRANT and REVOKE permissions to an AWS Identity and Access Management (IAM) role. For the list of permissions, see the syntax.

For stored procedures, the only permission that you can grant is EXECUTE.

You can't run GRANT (on an external resource) within a transaction block (BEGIN ... END). For more information about transactions, see Serializable isolation.

To see which permissions users have been granted for a database, use HAS_DATABASE_PRIVILEGE. To see which permissions users have been granted for a schema, use HAS_SCHEMA_PRIVILEGE. To see which permissions users have been granted for a table, use HAS_TABLE_PRIVILEGE.

Syntax

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | DROP | REFERENCES | ALTER | TRUNCATE }
 [,...] | ALL [ PRIVILEGES ] }
    ON { [ TABLE ] table_name [, ...] | ALL TABLES IN SCHEMA schema_name [, ...] }
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { { CREATE | USAGE | TEMPORARY | TEMP | ALTER } [,...] | ALL [ PRIVILEGES ] }
    ON DATABASE db_name [, ...]
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]
```

```
GRANT { { CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }
    ON SCHEMA schema_name [, ...]
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
    ON { FUNCTION function_name ( [ [ argname ] argtype [, ...] ] ) [, ...] | ALL
 FUNCTIONS IN SCHEMA schema_name [, ...] }
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
    ON { PROCEDURE procedure_name ( [ [ argname ] argtype [, ...] ] ) [, ...] | ALL
 PROCEDURES IN SCHEMA schema_name [, ...] }
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT USAGE
    ON LANGUAGE language_name [, ...]
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { { ALTER | DROP} [,...] | ALL [ PRIVILEGES ] }
    ON COPY JOB job_name [,...]
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]
```

Granting column-level permissions for tables

The following is the syntax for column-level permissions on Amazon Redshift tables and views.

```
GRANT { { SELECT | UPDATE } ( column_name [, ...] ) [, ...] | ALL [ PRIVILEGES ]
 ( column_name [,...] ) }
     ON { [ TABLE ] table_name [, ...] }

     TO { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
```

Granting ASSUMEROLE permissions

The following is the syntax for the ASSUMEROLE permissions granted to users and groups with a specified role. To begin using the ASSUMEROLE privilege, see Usage notes for granting the ASSUMEROLE permission.

```
GRANT ASSUMEROLE
       ON { 'iam_role' [, ...] | default | ALL }
       TO { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
       FOR { ALL | COPY | UNLOAD | EXTERNAL FUNCTION | CREATE MODEL } [, ...]
```

Granting permissions for Redshift Spectrum integration with Lake Formation

The following is the syntax for Redshift Spectrum integration with Lake Formation.

```
GRANT { SELECT | ALL [ PRIVILEGES ] } ( column_list )
    ON EXTERNAL TABLE schema_name.table_name
    TO { IAM_ROLE iam_role } [, ...] [ WITH GRANT OPTION ]

GRANT { { SELECT | ALTER | DROP | DELETE | INSERT }  [, ...] | ALL [ PRIVILEGES ] }
    ON EXTERNAL TABLE schema_name.table_name [, ...]
    TO { { IAM_ROLE iam_role } [, ...] | PUBLIC } [ WITH GRANT OPTION ]

GRANT { { CREATE | ALTER | DROP }  [, ...] | ALL [ PRIVILEGES ] }
    ON EXTERNAL SCHEMA schema_name [, ...]
    TO { IAM_ROLE iam_role } [, ...] [ WITH GRANT OPTION ]
```

Granting datashare permissions

Producer-side datashare permissions

The following is the syntax for using GRANT to grant ALTER or SHARE permissions to a user or role. The user can alter the datashare with the ALTER permission, or grant usage to a consumer with the SHARE permission. ALTER and SHARE are the only permissions that you can grant on a datashare to users and roles.

```
GRANT { ALTER | SHARE } ON DATASHARE datashare_name
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]
```

The following is the syntax for using GRANT for datashare usage permissions on Amazon Redshift. You grant access to a datashare to a consumer using the USAGE permission. You can't grant this permission to users or user groups. This permission also doesn't support the WITH GRANT OPTION for the GRANT statement. Only users or user groups with the SHARE permission previously granted to them FOR the datashare can run this type of GRANT statement.

```
GRANT USAGE
```

```
    ON DATASHARE datashare_name
    TO NAMESPACE 'namespaceGUID' | ACCOUNT 'accountnumber' [ VIA DATA CATALOG ]
```

The following is an example of how to grant usage of a datashare to a Lake Formation account.

```
GRANT USAGE ON DATASHARE salesshare TO ACCOUNT '123456789012' VIA DATA CATALOG;
```

Consumer-side datashare permissions

The following is the syntax for GRANT data-sharing usage permissions on a specific database or schema created from a datashare.

Further permissions required for consumers to access a database created from a datashare vary depending on whether or not the CREATE DATABASE command used to create the database from the datashare used the WITH PERMISSIONS clause. For more information about the CREATE DATABASE command and WITH PERMISSIONS clause, see CREATE DATABASE.

Databases created without using the WITH PERMISSIONS clause

When you grant USAGE on a database created from a datashare without the WITH PERMISSIONS clause, you don't need to grant permissions separately on the objects in the shared database. Entities granted usage on databases created from datashares without the WITH PERMISSIONS clause automatically have access to all objects in the database.

Databases created using the WITH PERMISSIONS clause

When you grant USAGE on a database where the shared database was created from a datashare with the WITH PERMISSIONS clause, consumer-side identities must still be granted the relevant permissions for database objects in the shared database in order to access them, just as you would grant permissions for local database objects. To grant permissions to objects in a database created from a datashare, use the three-part syntax `database_name.schema_name.object_name`. To grant permissions to objects in an external schema pointing to a shared schema within the shared database, use the two-part syntax `schema_name.object_name`.

```
GRANT USAGE ON { DATABASE shared_database_name [, ...] | SCHEMA shared_schema}
    TO { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
```

Granting scoped permissions

Scoped permissions let you grant permissions to a user or role on all objects of a type within a database or schema. Users and roles with scoped permissions have the specified permissions on all current and future objects within the database or schema.

You can view the scope of database-level scoped permissions in SVV_DATABASE_PRIVILEGES. You can view the scope of schema-level scoped permissions in SVV_SCHEMA_PRIVILEGES.

For more information about scoped permissions, see Scoped permissions.

The following is the syntax for granting scoped permissions to users and roles.

```
GRANT { CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }
FOR SCHEMAS IN
DATABASE db_name
TO { username [ WITH GRANT OPTION ] | ROLE role_name } [, ...]

GRANT
{ { SELECT | INSERT | UPDATE | DELETE | DROP | ALTER | TRUNCATE | REFERENCES }
 [, ...] } | ALL [PRIVILEGES] } }
FOR TABLES IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO { username [ WITH GRANT OPTION ] | ROLE role_name} [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
FOR FUNCTIONS IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO { username [ WITH GRANT OPTION ] | ROLE role_name | } [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
FOR PROCEDURES IN
{SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
TO { username [ WITH GRANT OPTION ] | ROLE role_name | } [, ...]

GRANT USAGE
FOR LANGUAGES IN
{DATABASE db_name}
TO { username [ WITH GRANT OPTION ] | ROLE role_name } [, ...]

GRANT { { CREATE | ALTER | DROP} [,...] | ALL [ PRIVILEGES ] }
FOR COPY JOBS
IN DATABASE db_name
```

```
TO { username [ WITH GRANT OPTION ] | ROLE role_name } [, ...]
```

Note that scoped permissions don't distinguish between permissions for functions and for procedures. For example, the following statement grants bob the EXECUTE permission for both functions and procedures in the schema Sales_schema.

```
GRANT EXECUTE FOR FUNCTIONS IN SCHEMA Sales_schema TO bob;
```

Granting machine learning permissions

The following is the syntax for machine learning model permissions on Amazon Redshift.

```
GRANT CREATE MODEL
    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
    ON MODEL model_name [, ...]

    TO { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]
```

Granting role permissions

The following is the syntax for granting roles on Amazon Redshift.

```
GRANT { ROLE role_name } [, ...] TO { { user_name [ WITH ADMIN OPTION ] } |
 ROLE role_name }[, ...]
```

The following is the syntax for granting system permissions to roles on Amazon Redshift. Note that you can only grant permissions to roles, not users.

```
GRANT
  {
    { CREATE USER | DROP USER | ALTER USER |
    CREATE SCHEMA | DROP SCHEMA |
    ALTER DEFAULT PRIVILEGES |
    ACCESS CATALOG | ACCESS SYSTEM TABLE
    CREATE TABLE | DROP TABLE | ALTER TABLE |
    CREATE OR REPLACE FUNCTION | CREATE OR REPLACE EXTERNAL FUNCTION |
    DROP FUNCTION |
```

```
    CREATE OR REPLACE PROCEDURE | DROP PROCEDURE |
    CREATE OR REPLACE VIEW | DROP VIEW |
    CREATE MODEL | DROP MODEL |
    CREATE DATASHARE | ALTER DATASHARE | DROP DATASHARE |
    CREATE LIBRARY | DROP LIBRARY |
    CREATE ROLE | DROP ROLE |
    TRUNCATE TABLE
    VACUUM | ANALYZE | CANCEL |
    IGNORE RLS | EXPLAIN RLS |
    EXPLAIN MASKING }[, ...]
  }
  | { ALL [ PRIVILEGES ] }
TO ROLE role_name [, ...]
```

Granting explain permissions for row-level security policy filters

The following is the syntax for granting permissions to explain the row-level security policy filters of a query in the EXPLAIN plan. You can revoke the privilege using the REVOKE statement.

```
GRANT EXPLAIN RLS TO ROLE rolename
```

The following is the syntax for granting permissions to bypass row-level security policies for a query.

```
GRANT IGNORE RLS TO ROLE rolename
```

Granting permissions for RLS lookup tables to a policy object

The following is the syntax for granting permissions to the specified row-level security policy.

```
GRANT SELECT ON [ TABLE ] table_name [, ...]
TO RLS POLICY policy_name [, ...]
```

Parameters

SELECT

Grants permission to select data from a table or view using a SELECT statement. The SELECT permission is also required to reference existing column values for UPDATE or DELETE operations.

INSERT

Grants permission to load data into a table using an INSERT statement or a COPY statement.

UPDATE

Grants permission to update a table column using an UPDATE statement. UPDATE operations also require the SELECT permission, because they must reference table columns to determine which rows to update, or to compute new values for columns.

DELETE

Grants permission to delete a data row from a table. DELETE operations also require the SELECT permission, because they must reference table columns to determine which rows to delete.

DROP

Depending on the database object, grants the following permissions to the user or role:

- For tables, DROP grants permission to drop a table or view. For more information, see DROP TABLE.
- For databases, DROP grants permission to drop a database. For more information, see DROP DATABASE.
- For schemas, DROP grants permission to drop a schema. For more information, see DROP SCHEMA.

REFERENCES

Grants permission to create a foreign key constraint. You need to grant this permission on both the referenced table and the referencing table; otherwise, the user can't create the constraint.

ALTER

Depending on the database object, grants the following permissions to the user or user group:

- For tables, ALTER grants permission to alter a table or view. For more information, see ALTER TABLE.
- For databases, ALTER grants permission to alter a database. For more information, see ALTER DATABASE.
- For schemas, ALTER grants permission to alter a schema. For more information, see ALTER SCHEMA.
- For external tables, ALTER grants permission to alter a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This permission only applies when using Lake Formation.

TRUNCATE

Grants permission to truncate a table. Without this permission, only the owner of a table or a superuser can truncate a table. For more information about the TRUNCATE command, see the section called "TRUNCATE".

ALL [PRIVILEGES]

Grants all available permissions at once to the specified user or role. The PRIVILEGES keyword is optional.

GRANT ALL ON SCHEMA doesn't grant CREATE permissions for external schemas.

You can grant the ALL permission to a table in an AWS Glue Data Catalog that is enabled for Lake Formation. In this case, individual permissions (such as SELECT, ALTER, and so on) are recorded in the Data Catalog.

> **Note**
>
> Amazon Redshift doesn't support the RULE and TRIGGER permissions. For more information, go to Unsupported PostgreSQL features.

ASSUMEROLE

Grants permission to run COPY, UNLOAD, EXTERNAL FUNCTION, and CREATE MODEL commands to users, roles, or groups with a specified role. The user, role, or group assumes that role when running the specified command. To begin using the ASSUMEROLE permission, see Usage notes for granting the ASSUMEROLE permission.

ON [TABLE] *table_name*

Grants the specified permissions on a table or a view. The TABLE keyword is optional. You can list multiple tables and views in one statement.

ON ALL TABLES IN SCHEMA *schema_name*

Grants the specified permissions on all tables and views in the referenced schema.

(*column_name* [,...]) ON TABLE *table_name*

Grants the specified permissions to users, groups, or PUBLIC on the specified columns of the Amazon Redshift table or view.

(*column_list*) ON EXTERNAL TABLE *schema_name.table_name*

Grants the specified permissions to an IAM role on the specified columns of the Lake Formation table in the referenced schema.

ON EXTERNAL TABLE *schema_name.table_name*

Grants the specified permissions to an IAM role on the specified Lake Formation tables in the referenced schema.

ON EXTERNAL SCHEMA *schema_name*

Grants the specified permissions to an IAM role on the referenced schema.

ON *iam_role*

Grants the specified permissions to an IAM role.

TO *username*

Indicates the user receiving the permissions.

TO IAM_ROLE *iam_role*

Indicates the IAM role receiving the permissions.

WITH GRANT OPTION

Indicates that the user receiving the permissions can in turn grant the same permissions to others. WITH GRANT OPTION can't be granted to a group or to PUBLIC.

ROLE *role_name*

Grants the permissions to a role.

GROUP *group_name*

Grants the permissions to a user group. Can be a comma-separated list to specify multiple user groups.

PUBLIC

Grants the specified permissions to all users, including users created later. PUBLIC represents a group that always includes all users. An individual user's permissions consist of the sum of permissions granted to PUBLIC, permissions granted to any groups that the user belongs to, and any permissions granted to the user individually.

Granting PUBLIC to a Lake Formation EXTERNAL TABLE results in granting the permission to the Lake Formation *everyone* group.

CREATE

Depending on the database object, grants the following permissions to the user or user group:

- For databases, CREATE allows users to create schemas within the database.
- For schemas, CREATE allows users to create objects within a schema. To rename an object, the user must have the CREATE permission and own the object to be renamed.
- CREATE ON SCHEMA isn't supported for Amazon Redshift Spectrum external schemas. To grant usage of external tables in an external schema, grant USAGE ON SCHEMA to the users that need access. Only the owner of an external schema or a superuser is permitted to create external tables in the external schema. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner.

TEMPORARY | TEMP

Grants the permission to create temporary tables in the specified database. To run Amazon Redshift Spectrum queries, the database user must have permission to create temporary tables in the database.

> **Note**
>
> By default, users are granted permission to create temporary tables by their automatic membership in the PUBLIC group. To remove the permission for any users to create temporary tables, revoke the TEMP permission from the PUBLIC group. Then explicitly grant the permission to create temporary tables to specific users or groups of users.

ON DATABASE *db_name*

Grants the specified permissions on a database.

USAGE

Grants USAGE permission on a specific schema, which makes objects in that schema accessible to users. Specific actions on these objects must be granted separately (for example, SELECT or UPDATE permission on tables) for local Amazon Redshift schemas. By default, all users have CREATE and USAGE permission on the PUBLIC schema.

When you grant USAGE to external schemas using ON SCHEMA syntax, you don't need to grant actions separately on the objects in the external schema. The corresponding catalog permissions control granular permissions on the external schema objects.

ON SCHEMA *schema_name*

Grants the specified permissions on a schema.

GRANT CREATE ON SCHEMA and the CREATE permission in GRANT ALL ON SCHEMA aren't supported for Amazon Redshift Spectrum external schemas. To grant usage of external tables in an external schema, grant USAGE ON SCHEMA to the users that need access. Only the owner of an external schema or a superuser is permitted to create external tables in the external schema. To transfer ownership of an external schema, use ALTER SCHEMA to change the owner.

EXECUTE ON ALL FUNCTIONS IN SCHEMA *schema_name*

Grants the specified permissions on all functions in the referenced schema.

Amazon Redshift doesn't support GRANT or REVOKE statements for pg_proc builtin entries defined in pg_catalog namespace.

EXECUTE ON PROCEDURE *procedure_name*

Grants the EXECUTE permission on a specific stored procedure. Because stored procedure names can be overloaded, you must include the argument list for the procedure. For more information, see Naming stored procedures.

EXECUTE ON ALL PROCEDURES IN SCHEMA *schema_name*

Grants the specified permissions on all stored procedures in the referenced schema.

USAGE ON LANGUAGE *language_name*

Grants the USAGE permission on a language.

> **Note**
>
> Starting November 1, 2025, Amazon Redshift will no longer support the creation of new Python UDFs. Existing Python UDFs will continue to function until June 30, 2026. Starting July 1, 2026, Amazon Redshift will no longer support Python UDFs. We recommend that you migrate your existing Python UDFs to Lambda UDFs before November 1, 2025. For information on creating and using Lambda UDFs, see Scalar Lambda UDFs. For information on converting existing Python UDFs to Lambda UDFs, see the blog post .

The USAGE ON LANGUAGE permission is required to create user-defined functions (UDFs) by running the CREATE FUNCTION command. For more information, see UDF security and permissions.

The USAGE ON LANGUAGE permission is required to create stored procedures by running the CREATE PROCEDURE command. For more information, see Security and privileges for stored procedures .

For Python UDFs, use `plpythonu`. For SQL UDFs, use `sql`. For stored procedures, use `plpgsql`.

ON COPY JOB *job_name*

Grants the specified permissions on a copy job.

FOR { ALL | COPY | UNLOAD | EXTERNAL FUNCTION | CREATE MODEL } [, ...]

Specifies the SQL command for which the permission is granted. You can specify ALL to grant the permission on the COPY, UNLOAD, EXTERNAL FUNCTION, and CREATE MODEL statements. This clause applies only to granting the ASSUMEROLE permission.

ALTER

Grants the ALTER permission to users to add or remove objects from a datashare, or to set the property PUBLICACCESSIBLE. For more information, see ALTER DATASHARE.

SHARE

Grants pemrissions to users and user groups to add data consumers to a datashare. This permission is required to enable the particular consumer (account or namespace) to access the datashare from their clusters. The consumer can be the same or a different AWS account, with the same or a different cluster namespace as specified by a globally unique identifier (GUID).

ON DATASHARE *datashare_name*

Grants the specified permissions on the referenced datashare. For information about consumer access control granularity, see Data sharing at different levels in Amazon Redshift.

USAGE

When USAGE is granted to a consumer account or namespace within the same account, the specific consumer account or namespace within the account can access the datashare and the objects of the datashare in read-only fashion.

TO NAMESPACE 'clusternamespace GUID'

Indicates a namespace in the same account where consumers can receive the specified permissions to the datashare. Namespaces use a 128-bit alphanumeric GUID.

TO ACCOUNT 'accountnumber' [VIA DATA CATALOG]

Indicates the number of another account whose consumers can receive the specified permissions to the datashare. Specifying ‘VIA DATA CATALOG’ indicates that you are granting usage of the datashare to a Lake Formation account. Omitting this parameter means you're granting usage to an account that owns the cluster.

ON DATABASE *shared_database_name> [, ...]*

Grants the specified usage permissions on the specified database that is created in the specified datashare.

ON SCHEMA *shared_schema*

Grants the specified permissions on the specified schema that is created in the specified datashare.

FOR { SCHEMAS | TABLES | FUNCTIONS | PROCEDURES | LANGUAGES | COPY JOBS} IN

Specifies the database objects to grant permission to. The parameters following IN define the scope of the granted permission.

CREATE MODEL

Grants the CREATE MODEL permission to specific users or user groups.

ON MODEL *model_name*

Grants the EXECUTE permission on a specific model.

ACCESS CATALOG

Grants the permission to view relevant metadata of objects that the role has access to.

{ role } [, ...]

The role to be granted to another role, a user, or PUBLIC.

PUBLIC represents a group that always includes all users. An individual user's permissions consist of the sum of permissions granted to PUBLIC, permissions granted to any groups that the user belongs to, and any permissions granted to the user individually.

TO { { *user_name* [WITH ADMIN OPTION] } | role }[, ...]

Grants the specified role to a specified user with the WITH ADMIN OPTION, another role, or PUBLIC.

The WITH ADMIN OPTION clause provides the administration options for all the granted roles to all the grantees.

EXPLAIN RLS TO ROLE *rolename*

Grants the permission to explain the row-level security policy filters of a query in the EXPLAIN plan to a role.

IGNORE RLS TO ROLE *rolename*

Grants the permission to bypass row-level security policies for a query to a role.

Usage notes

To learn more about the usage notes for GRANT, see the section called “Usage notes”.

Examples

For examples of how to use GRANT, see the section called “Examples”.

Usage notes

To grant privileges on an object, you must meet one of the following criteria:

- Be the object owner.
- Be a superuser.
- Have a grant privilege for that object and privilege.

For example, the following command enables the user HR both to perform SELECT commands on the employees table and to grant and revoke the same privilege for other users.

```
grant select on table employees to HR with grant option;
```

HR can't grant privileges for any operation other than SELECT, or on any other table than employees.

As another example, the following command enables the user HR both to perform ALTER commands on the employees table and to grant and revoke the same privilege for other users.

```
grant ALTER on table employees to HR with grant option;
```

HR can't grant privileges for any operation other than ALTER, or on any other table than employees.

Having privileges granted on a view doesn't imply having privileges on the underlying tables. Similarly, having privileges granted on a schema doesn't imply having privileges on the tables in the schema. Instead, grant access to the underlying tables explicitly.

To grant privileges to an AWS Lake Formation table, the IAM role associated with the table's external schema must have permission to grant privileges to the external table. The following example creates an external schema with an associated IAM role `myGrantor`. The IAM role `myGrantor` has the permission to grant permissions to others. The GRANT command uses the permission of the IAM role `myGrantor` that is associated with the external schema to grant permission to the IAM role `myGrantee`.

```
create external schema mySchema
from data catalog
database 'spectrum_db'
iam_role 'arn:aws:iam::123456789012:role/myGrantor'
create external database if not exists;
```

```
grant select
on external table mySchema.mytable
to iam_role 'arn:aws:iam::123456789012:role/myGrantee';
```

If you GRANT ALL privileges to an IAM role, individual privileges are granted in the related Lake Formation–enabled Data Catalog. For example, the following GRANT ALL results in the granted individual privileges (SELECT, ALTER, DROP, DELETE, and INSERT) showing in the Lake Formation console.

```
grant all
on external table mySchema.mytable
to iam_role 'arn:aws:iam::123456789012:role/myGrantee';
```

Superusers can access all objects regardless of GRANT and REVOKE commands that set object privileges.

Usage notes for column-level access control

The following usage notes apply to column-level privileges on Amazon Redshift tables and views. These notes describe tables; the same notes apply to views unless we explicitly note an exception.

- For an Amazon Redshift table, you can grant only the SELECT and UPDATE privileges at the column level. For an Amazon Redshift view, you can grant only the SELECT privilege at the column level.
- The ALL keyword is a synonym for SELECT and UPDATE privileges combined when used in the context of a column-level GRANT on a table.
- If you don't have the SELECT privilege on all columns in a table, performing a SELECT * operation returns only those columns that you have access to. When using a view, a SELECT * operation attempts to access all columns in the view. If you do not have permission to access all columns, these queries fail with a permission denied error.
- SELECT * doesn't expand to only accessible columns in the following cases:
  - You can't create a regular view with only accessible columns using SELECT *.
  - You can't create a materialized view with only accessible columns using SELECT *.
- If you have SELECT or UPDATE privilege on a table or view and add a column, you still have the same privileges on the table or view and thus all its columns.
- Only a table's owner or a superuser can grant column-level privileges.
- The WITH GRANT OPTION clause isn't supported for column-level privileges.
- You can't hold the same privilege at both the table level and the column level. For example, the user `data_scientist` can't have both SELECT privilege on the table `employee` and SELECT privilege on the column `employee.department`. Consider the following results when granting the same privilege to a table and a column within the table:
  - If a user has a table-level privilege on a table, then granting the same privilege at the column level has no effect.
  - If a user has a table-level privilege on a table, then revoking the same privilege for one or more columns of the table returns an error. Instead, revoke the privilege at the table level.
  - If a user has a column-level privilege, then granting the same privilege at the table level returns an error.

- If a user has a column-level privilege, then revoking the same privilege at the table level revokes both column and table privileges for all columns on the table.
- You can't grant column-level privileges on late-binding views.
- To create a materialized view, you must have table-level SELECT privilege on the base tables. Even if you have column-level privileges on specific columns, you can't create a materialized view on only those columns. However, you can grant SELECT privilege to columns of a materialized view, similar to regular views.
- To look up grants of column-level privileges, use the PG_ATTRIBUTE_INFO view.

Usage notes for granting the ASSUMEROLE permission

The following usage notes apply to granting the ASSUMEROLE permission in Amazon Redshift.

You use the ASSUMEROLE permission to control IAM role access permissions for database users, roles, or groups on commands such as COPY, UNLOAD, EXTERNAL FUNCTION, or CREATE MODEL. After you grant the ASSUMEROLE permission to a user, role, or group for an IAM role, the user, role, or group can assume that role when running the command. The ASSUMEROLE permission enables you to grant access to the appropriate commands as required.

Only a database superuser can grant or revoke the ASSUMEROLE permission for users, roles, and groups. A superuser always retains the ASSUMEROLE permission.

To enable the use of the ASSUMEROLE permission for users, roles, and groups, a superuser performs the following two actions:

- Run the following statement once on the cluster:

```
revoke assumerole on all from public for all;
```

- Grant the ASSUMEROLE permission to users, roles, and groups for the appropriate commands.

You can specify role chaining in the ON clause when granting the ASSUMEROLE permission. You use commas to separate roles in a role chain, for example, `Role1,Role2,Role3`. If role chaining was specified when granting the ASSUMEROLE permission, you must specify the role chain when performing operations granted by the ASSUMEROLE permission. You can't specify individual roles within the role chain when performing operations granted by the ASSUMEROLE permission. For example, if a user, role, or group is granted the role chain `Role1,Role2,Role3`, you can't specify only `Role1` to perform operations.

If a user attempts to perform a COPY, UNLOAD, EXTERNAL FUNCTION, or CREATE MODEL operation and hasn't been granted the ASSUMEROLE permission, a message similar to the following appears.

```
ERROR:  User awsuser does not have ASSUMEROLE permission on IAM role
 "arn:aws:iam::123456789012:role/RoleA" for COPY
```

To list users that have been granted access to IAM roles and commands through the ASSUMEROLE permission, see HAS_ASSUMEROLE_PRIVILEGE. To list IAM roles and command permissions that have been granted to a user that you specify, see PG_GET_IAM_ROLE_BY_USER. To list users, roles, and groups that have been granted access to an IAM role that you specify, see PG_GET_GRANTEE_BY_IAM_ROLE.

Usage notes for granting machine learning permissions

You can't directly grant or revoke permissions related to an ML function. An ML function belongs to an ML model and permissions are controlled through the model. Instead, you can grant permissions related to the ML model. The following example demonstrates how to grant permisisons to all users to run the ML function associated with the model `customer_churn`.

```
GRANT EXECUTE ON MODEL customer_churn TO PUBLIC;
```

You can also grant all permissions to a user for the ML model `customer_churn`.

```
GRANT ALL on MODEL customer_churn TO ml_user;
```

Granting the `EXECUTE` permission related to an ML function will fail if there is an ML function in the schema, even if that ML function already has the `EXECUTE` permission through `GRANT EXECUTE ON MODEL`. We recommend using a separate schema when using the `CREATE MODEL` command to keep the ML functions in a separate schema by themselves. The following example demonstrates how to do so.

```
CREATE MODEL ml_schema.customer_churn
FROM customer_data
TARGET churn
FUNCTION ml_schema.customer_churn_prediction
IAM_ROLE default
SETTINGS (
```

```
 S3_BUCKET 'amzn-s3-demo-bucket'
);
```

Examples

The following example grants the SELECT privilege on the SALES table to the user `fred`.

```
grant select on table sales to fred;
```

The following example grants the SELECT privilege on all tables in the QA_TICKIT schema to the user `fred`.

```
grant select on all tables in schema qa_tickit to fred;
```

The following example grants all schema privileges on the schema QA_TICKIT to the user group QA_USERS. Schema privileges are CREATE and USAGE. USAGE grants users access to the objects in the schema, but doesn't grant privileges such as INSERT or SELECT on those objects. Grant privileges on each object separately.

```
create group qa_users;
grant all on schema qa_tickit to group qa_users;
```

The following example grants all privileges on the SALES table in the QA_TICKIT schema to all users in the group QA_USERS.

```
grant all on table qa_tickit.sales to group qa_users;
```

The following example grants all privileges on the SALES table in the QA_TICKIT schema to all users in the groups QA_USERS and RO_USERS.

```
grant all on table qa_tickit.sales to group qa_users, group ro_users;
```

The following example grants the DROP privilege on the SALES table in the QA_TICKIT schema to all users in the group QA_USERS.

```
grant drop on table qa_tickit.sales to group qa_users;>
```

The following sequence of commands shows how access to a schema doesn't grant privileges on a table in the schema.

```
create user schema_user in group qa_users password 'Abcd1234';
create schema qa_tickit;
create table qa_tickit.test (col1 int);
grant all on schema qa_tickit to schema_user;

set session authorization schema_user;
select current_user;


current_user
--------------
schema_user
(1 row)


select count(*) from qa_tickit.test;


ERROR: permission denied for relation test [SQL State=42501]


set session authorization dw_user;
grant select on table qa_tickit.test to schema_user;
set session authorization schema_user;
select count(*) from qa_tickit.test;


count
-------
0
(1 row)
```

The following sequence of commands shows how access to a view doesn't imply access to its underlying tables. The user called VIEW_USER can't select from the DATE table, although this user has been granted all privileges on VIEW_DATE.

```
create user view_user password 'Abcd1234';
create view view_date as select * from date;
grant all on view_date to view_user;
set session authorization view_user;
```

```
select current_user;


current_user
--------------
view_user
(1 row)


select count(*) from view_date;


count
-------
365
(1 row)


select count(*) from date;


ERROR:  permission denied for relation date
```

The following example grants SELECT privilege on the `cust_name` and `cust_phone` columns of the `cust_profile` table to the user `user1`.

```
grant select(cust_name, cust_phone) on cust_profile to user1;
```

The following example grants SELECT privilege on the `cust_name` and `cust_phone` columns and UPDATE privilege on the `cust_contact_preference` column of the `cust_profile` table to the `sales_group` group.

```
grant select(cust_name, cust_phone), update(cust_contact_preference) on cust_profile to
 group sales_group;
```

The following example shows the usage of the ALL keyword to grant both SELECT and UPDATE privileges on three columns of the table `cust_profile` to the `sales_admin` group.

```
grant ALL(cust_name, cust_phone,cust_contact_preference) on cust_profile to group
 sales_admin;
```

The following example grants the SELECT privilege on the `cust_name` column of the `cust_profile_vw` view to the `user2` user.

```
grant select(cust_name) on cust_profile_vw to user2;
```

Examples of granting access to datashares

The following examples show GRANT datasharing usage permissions on a specific database or schema created from a datashare.

In the following example, a producer-side admin grants the USAGE permission on the `salesshare` datashare to the specified namespace.

```
GRANT USAGE ON DATASHARE salesshare TO NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

In the following example, a consumer-side admin grants the USAGE permission on the `sales_db` to Bob.

```
GRANT USAGE ON DATABASE sales_db TO Bob;
```

In the following example, a consumer-side admin grants the GRANT USAGE permission on the `sales_schema` schema to the `Analyst_role` role. `sales_schema` is an external schema that points to sales_db.

```
GRANT USAGE ON SCHEMA sales_schema TO ROLE Analyst_role;
```

At this point, Bob and `Analyst_role` can access all database objects in `sales_schema` and `sales_db`.

The following example shows granting additional object-level permission for objects in a shared database. These extra permissions are only necessary if the CREATE DATABASE command that was used to create the shared database used the WITH PERMISSIONS clause. If the CREATE DATABASE command didn't use WITH PERMISSIONS, granting USAGE on the shared database grants full access to all objects in that database.

```
GRANT SELECT ON sales_db.sales_schema.tickit_sales_redshift to Bob;
```

Examples of granting scoped permissions

The following example grants usage for all current and future schemas in the Sales_db database to the Sales role.

```
GRANT USAGE FOR SCHEMAS IN DATABASE Sales_db TO ROLE Sales;
```

The following example grants the SELECT permission for all current and future tables in the Sales_db database to the user alice, and also gives alice the permission to grant scoped permissions on tables in Sales_db to other users.

```
GRANT SELECT FOR TABLES IN DATABASE Sales_db TO alice WITH GRANT OPTION;
```

The following example grants the EXECUTE permission for functions in the Sales_schema schema to the user bob.

```
GRANT EXECUTE FOR FUNCTIONS IN SCHEMA Sales_schema TO bob;
```

The following example grants all permissions for all tables in the ShareDb database's ShareSchema schema to the Sales role. When specifying the schema, you can specify the schema's database using the two-part format database.schema.

```
GRANT ALL FOR TABLES IN SCHEMA ShareDb.ShareSchema TO ROLE Sales;
```

The following example is the same as the preceding one. You can specify the database using the DATABASE keyword instead of using a two-part format.

```
GRANT ALL FOR TABLES IN SCHEMA ShareSchema DATABASE ShareDb TO ROLE Sales;
```

Examples of granting the ASSUMEROLE privilege

The following are examples of granting the ASSUMEROLE privilege.

The following example shows the REVOKE statement that a superuser runs once on the cluster to enable the use of the ASSUMEROLE privilege for users and groups. Then, the superuser grants the ASSUMEROLE privilege to users and groups for the appropriate commands. For information on enabling the use of the ASSUMEROLE privilege for users and groups, see Usage notes for granting the ASSUMEROLE permission.

```
revoke assumerole on all from public for all;
```

The following example grants the ASSUMEROLE privilege to the user `reg_user1` for the IAM role `Redshift-S3-Read` to perform COPY operations.

```
grant assumerole on 'arn:aws:iam::123456789012:role/Redshift-S3-Read'
to reg_user1 for copy;
```

The following example grants the ASSUMEROLE privilege to the user `reg_user1` for the IAM role chain `RoleA`, `RoleB` to perform UNLOAD operations.

```
grant assumerole
on 'arn:aws:iam::123456789012:role/RoleA,arn:aws:iam::210987654321:role/RoleB'
to reg_user1
for unload;
```

The following is an example of the UNLOAD command using the IAM role chain `RoleA`, `RoleB`.

```
unload ('select * from venue limit 10')
to 's3://companyb/redshift/venue_pipe_'
iam_role 'arn:aws:iam::123456789012:role/RoleA,arn:aws:iam::210987654321:role/RoleB';
```

The following example grants the ASSUMEROLE privilege to the user `reg_user1` for the IAM role `Redshift-Exfunc` to create external functions.

```
grant assumerole on 'arn:aws:iam::123456789012:role/Redshift-Exfunc'
to reg_user1 for external function;
```

The following example grants the ASSUMEROLE privilege to the user `reg_user1` for the IAM role `Redshift-model` to create machine learning models.

```
grant assumerole on 'arn:aws:iam::123456789012:role/Redshift-ML'
to reg_user1 for create model;
```

Examples of granting the ROLE privileges

The following example grants sample_role1 to user1.

```
CREATE ROLE sample_role1;
```

```
GRANT ROLE sample_role1 TO user1;
```

The following example grants sample_role1 to user1 with the WITH ADMIN OPTION, sets the current session for user1, and user1 grants sample_role1 to user2.

```
GRANT ROLE sample_role1 TO user1 WITH ADMIN OPTION;
SET SESSION AUTHORIZATION user1;
GRANT ROLE sample_role1 TO user2;
```

The following example grants sample_role1 to sample_role2.

```
GRANT ROLE sample_role1 TO ROLE sample_role2;
```

The following example grants sample_role2 to sample_role3 and sample_role4. Then it attempts to grants sample_role3 to sample_role1.

```
GRANT ROLE sample_role2 TO ROLE sample_role3;
GRANT ROLE sample_role3 TO ROLE sample_role2;
ERROR: cannot grant this role, a circular dependency was detected between these roles
```

The following example grants the CREATE USER system privileges to sample_role1.

```
GRANT CREATE USER TO ROLE sample_role1;
```

The following example grants the system-defined role `sys:dba` to user1.

```
GRANT ROLE sys:dba TO user1;
```

The following example attempts to grant sample_role3 in a circular dependency to sample_role2.

```
CREATE ROLE sample_role3;
GRANT ROLE sample_role2 TO ROLE sample_role3;
GRANT ROLE sample_role3 TO ROLE sample_role2; -- fail
ERROR:  cannot grant this role, a circular dependency was detected between these roles
```

INSERT

Topics

- Syntax

- Parameters
- Usage notes
- INSERT examples

Inserts new rows into a table. You can insert a single row with the VALUES syntax, multiple rows with the VALUES syntax, or one or more rows defined by the results of a query (INSERT INTO...SELECT).

> **Note**
>
> We strongly encourage you to use the COPY command to load large amounts of data. Using individual INSERT statements to populate a table might be prohibitively slow. Alternatively, if your data already exists in other Amazon Redshift database tables, use INSERT INTO SELECT or CREATE TABLE AS to improve performance. For more information about using the COPY command to load tables, see Loading data in Amazon Redshift.

> **Note**
>
> The maximum size for a single SQL statement is 16 MB.

Syntax

```
INSERT INTO table_name [ ( column [, ...] ) ]
{DEFAULT VALUES |
VALUES ( { expression | DEFAULT } [, ...] )
[, ( { expression | DEFAULT } [, ...] )
[, ...] ] |
query }
```

Parameters

table_name

A temporary or persistent table. Only the owner of the table or a user with INSERT privilege on the table can insert rows. If you use the *query* clause to insert rows, you must have SELECT privilege on the tables named in the query.

> **Note**
>
> Use INSERT (external table) to insert results of a SELECT query into existing tables on external catalog. For more information, see INSERT (external table).

column

You can insert values into one or more columns of the table. You can list the target column names in any order. If you don't specify a column list, the values to be inserted must correspond to the table columns in the order in which they were declared in the CREATE TABLE statement. If the number of values to be inserted is less than the number of columns in the table, the first *n* columns are loaded.

Either the declared default value or a null value is loaded into any column that isn't listed (implicitly or explicitly) in the INSERT statement.

DEFAULT VALUES

If the columns in the table were assigned default values when the table was created, use these keywords to insert a row that consists entirely of default values. If any of the columns don't have default values, nulls are inserted into those columns. If any of the columns are declared NOT NULL, the INSERT statement returns an error.

VALUES

Use this keyword to insert one or more rows, each row consisting of one or more values. The VALUES list for each row must align with the column list. To insert multiple rows, use a comma delimiter between each list of expressions. Do not repeat the VALUES keyword. All VALUES lists for a multiple-row INSERT statement must contain the same number of values.

expression

A single value or an expression that evaluates to a single value. Each value must be compatible with the data type of the column where it is being inserted. If possible, a value whose data type doesn't match the column's declared data type is automatically converted to a compatible data type. For example:

- A decimal value `1.1` is inserted into an INT column as 1.
- A decimal value `100.8976` is inserted into a DEC(5,2) column as `100.90`.

You can explicitly convert a value to a compatible data type by including type cast syntax in the expression. For example, if column COL1 in table T1 is a CHAR(3) column:

```
insert into t1(col1) values('Incomplete'::char(3));
```

This statement inserts the value `Inc` into the column.

For a single-row INSERT VALUES statement, you can use a scalar subquery as an expression. The result of the subquery is inserted into the appropriate column.

> **Note**
>
> Subqueries aren't supported as expressions for multiple-row INSERT VALUES statements.

DEFAULT

Use this keyword to insert the default value for a column, as defined when the table was created. If no default value exists for a column, a null is inserted. You can't insert a default value into a column that has a NOT NULL constraint if that column doesn't have an explicit default value assigned to it in the CREATE TABLE statement.

query

Insert one or more rows into the table by defining any query. All of the rows that the query produces are inserted into the table. The query must return a column list that is compatible with the columns in the table, but the column names don't have to match.

Usage notes

> **Note**
>
> We strongly encourage you to use the COPY command to load large amounts of data. Using individual INSERT statements to populate a table might be prohibitively slow. Alternatively, if your data already exists in other Amazon Redshift database tables, use INSERT INTO SELECT or CREATE TABLE AS to improve performance. For more information about using the COPY command to load tables, see Loading data in Amazon Redshift.

The data format for the inserted values must match the data format specified by the CREATE TABLE definition.

After inserting a large number of new rows into a table:

- Vacuum the table to reclaim storage space and re-sort rows.
- Analyze the table to update statistics for the query planner.

When values are inserted into DECIMAL columns and they exceed the specified scale, the loaded values are rounded up as appropriate. For example, when a value of `20.259` is inserted into a DECIMAL(8,2) column, the value that is stored is `20.26`.

You can insert into a GENERATED BY DEFAULT AS IDENTITY column. You can update columns defined as GENERATED BY DEFAULT AS IDENTITY with values that you supply. For more information, see GENERATED BY DEFAULT AS IDENTITY.

INSERT examples

The CATEGORY table in the TICKIT database contains the following rows:

```
 catid | catgroup |  catname  |                  catdesc
-------+----------+-----------+--------------------------------------------
     1 | Sports   | MLB       | Major League Baseball
     2 | Sports   | NHL       | National Hockey League
     3 | Sports   | NFL       | National Football League
     4 | Sports   | NBA       | National Basketball Association
     5 | Sports   | MLS       | Major League Soccer
     6 | Shows    | Musicals  | Musical theatre
     7 | Shows    | Plays     | All non-musical theatre
     8 | Shows    | Opera     | All opera and light opera
     9 | Concerts | Pop       | All rock and pop music concerts
    10 | Concerts | Jazz      | All jazz singers and bands
    11 | Concerts | Classical | All symphony, concerto, and choir concerts
(11 rows)
```

Create a CATEGORY_STAGE table with a similar schema to the CATEGORY table but define default values for the columns:

```
create table category_stage
(catid smallint default 0,
```

```
catgroup varchar(10) default 'General',
catname varchar(10) default 'General',
catdesc varchar(50) default 'General');
```

The following INSERT statement selects all of the rows from the CATEGORY table and inserts them into the CATEGORY_STAGE table.

```
insert into category_stage
(select * from category);
```

The parentheses around the query are optional.

This command inserts a new row into the CATEGORY_STAGE table with a value specified for each column in order:

```
insert into category_stage values
(12, 'Concerts', 'Comedy', 'All stand-up comedy performances');
```

You can also insert a new row that combines specific values and default values:

```
insert into category_stage values
(13, 'Concerts', 'Other', default);
```

Run the following query to return the inserted rows:

```
select * from category_stage
where catid in(12,13) order by 1;

 catid | catgroup | catname |             catdesc
-------+----------+---------+----------------------------------
    12 | Concerts | Comedy  | All stand-up comedy performances
    13 | Concerts | Other   | General
(2 rows)
```

The following examples show some multiple-row INSERT VALUES statements. The first example inserts specific CATID values for two rows and default values for the other columns in both rows.

```
insert into category_stage values
(14, default, default, default),
```

```
(15, default, default, default);

select * from category_stage where catid in(14,15) order by 1;
 catid | catgroup | catname | catdesc
-------+----------+---------+---------
    14 | General  | General | General
    15 | General  | General | General
(2 rows)
```

The next example inserts three rows with various combinations of specific and default values:

```
insert into category_stage values
(default, default, default, default),
(20, default, 'Country', default),
(21, 'Concerts', 'Rock', default);

select * from category_stage where catid in(0,20,21) order by 1;
 catid | catgroup | catname | catdesc
-------+----------+---------+---------
     0 | General  | General | General
    20 | General  | Country | General
    21 | Concerts | Rock    | General
(3 rows)
```

The first set of VALUES in this example produces the same results as specifying DEFAULT VALUES for a single-row INSERT statement.

The following examples show INSERT behavior when a table has an IDENTITY column. First, create a new version of the CATEGORY table, then insert rows into it from CATEGORY:

```
create table category_ident
(catid int identity not null,
catgroup varchar(10) default 'General',
catname varchar(10) default 'General',
catdesc varchar(50) default 'General');



insert into category_ident(catgroup,catname,catdesc)
select catgroup,catname,catdesc from category;
```

Note that you can't insert specific integer values into the CATID IDENTITY column. IDENTITY column values are automatically generated.

The following example demonstrates that subqueries can't be used as expressions in multiple-row INSERT VALUES statements:

```
insert into category(catid) values
((select max(catid)+1 from category)),
((select max(catid)+2 from category));

ERROR: can't use subqueries in multi-row VALUES
```

The following example shows an insert into a temporary table populated with data from the `venue` table using the `WITH SELECT` clause. For more information about the `venue` table, see Sample database.

First, create the temporary table `#venuetemp`.

```
CREATE TABLE #venuetemp AS SELECT * FROM venue;
```

List the rows in the `#venuetemp` table.

```
SELECT * FROM #venuetemp ORDER BY venueid;

venueid | venuename                | venuecity   | venuestate| venueseats
--------+--------------------------+-------------+-----------+------------
1        Toyota Park                Bridgeview    IL          0
2        Columbus Crew Stadium      Columbus      OH          0
3        RFK Stadium                Washington    DC          0
4        CommunityAmerica Ballpark  Kansas City   KS          0
5        Gillette Stadium           Foxborough    MA          68756
...
```

Insert 10 duplicate rows in the `#venuetemp` table using the `WITH SELECT` clause.

```
INSERT INTO #venuetemp (WITH venuecopy AS (SELECT * FROM venue) SELECT * FROM venuecopy
 ORDER BY 1 LIMIT 10);
```

List the rows in the `#venuetemp` table.

```
SELECT * FROM #venuetemp ORDER BY venueid;

venueid | venuename                | venuecity   | venuestate| venueseats
```

```
--------+-------------------------+------------+-----------+------------
1        Toyota Park               Bridgeview   IL          0
1        Toyota Park               Bridgeview   IL          0
2        Columbus Crew Stadium     Columbus     OH          0
2        Columbus Crew Stadium     Columbus     OH          0
3        RFK Stadium               Washington   DC          0
3        RFK Stadium               Washington   DC          0
4        CommunityAmerica Ballpark  Kansas City  KS          0
4        CommunityAmerica Ballpark  Kansas City  KS          0
5        Gillette Stadium          Foxborough   MA          68756
5        Gillette Stadium          Foxborough   MA          68756
...
```

INSERT (external table)

Inserts the results of a SELECT query into existing external tables on external catalog such as for AWS Glue, AWS Lake Formation, or an Apache Hive metastore. Use the same AWS Identity and Access Management (IAM) role used for the CREATE EXTERNAL SCHEMA command to interact with external catalogs and Amazon S3.

For nonpartitioned tables, the INSERT (external table) command writes data to the Amazon S3 location defined in the table, based on the specified table properties and file format.

For partitioned tables, INSERT (external table) writes data to the Amazon S3 location according to the partition key specified in the table. It also automatically registers new partitions in the external catalog after the INSERT operation completes.

You can't run INSERT (external table) within a transaction block (BEGIN … END). For more information about transactions, see Serializable isolation.

Syntax

```
INSERT INTO external_schema.table_name
{ select_statement }
```

Parameters

external_schema.table_name

The name of an existing external schema and a target external table to insert into.

select_statement

A statement that inserts one or more rows into the external table by defining any query. All of the rows that the query produces are written to Amazon S3 in either text or Parquet format based on the table definition. The query must return a column list that is compatible with the column data types in the external table. However, the column names don't have to match.

Usage notes

The number of columns in the SELECT query must be the same as the sum of data columns and partition columns. The location and the data type of each data column must match that of the external table. The location of partition columns must be at the end of the SELECT query, in the same order they were defined in CREATE EXTERNAL TABLE command. The column names don't have to match.

In some cases, you might want to run the INSERT (external table) command on an AWS Glue Data Catalog or a Hive metastore. In the case of AWS Glue, the IAM role used to create the external schema must have both read and write permissions on Amazon S3 and AWS Glue. If you use an AWS Lake Formation catalog, this IAM role becomes the owner of the new Lake Formation table. This IAM role must at least have the following permissions:

- SELECT, INSERT, UPDATE permission on the external table
- Data location permission on the Amazon S3 path of the external table

To ensure that file names are unique, Amazon Redshift uses the following format for the name of each file uploaded to Amazon S3 by default.

<date>_<time>_<microseconds>_<query_id>_<slice-number>_part_<part-number>.<format>.

An example is `20200303_004509_810669_1007_0001_part_00.parquet`.

Consider the following when running the INSERT (external table) command:

- External tables that have a format other than PARQUET or TEXTFILE aren't supported.
- This command supports existing table properties such as 'write.parallel', 'write.maxfilesize.mb', 'compression_type', and 'serialization.null.format'. To update those values, run the ALTER TABLE SET TABLE PROPERTIES command.

- The 'numRows' table property is automatically updated toward the end of the INSERT operation. The table property must be defined or added to the table already if it wasn't created by CREATE EXTERNAL TABLE AS operation.
- The LIMIT clause isn't supported in the outer SELECT query. Instead, use a nested LIMIT clause.
- You can use the STL_UNLOAD_LOG table to track the files that got written to Amazon S3 by each INSERT (external table) operation.
- Amazon Redshift supports only Amazon S3 standard encryption for INSERT (external table).

INSERT (external table) examples

The following example inserts the results of the SELECT statement into the external table.

```
INSERT INTO spectrum.lineitem
SELECT * FROM local_lineitem;
```

The following example inserts the results of the SELECT statement into a partitioned external table using static partitioning. The partition columns are hardcoded in the SELECT statement. The partition columns must be at the end of the query.

```
INSERT INTO spectrum.customer
SELECT name, age, gender, 'May', 28 FROM local_customer;
```

The following example inserts the results of the SELECT statement into a partitioned external table using dynamic partitioning. The partition columns aren't hardcoded. Data is automatically added to the existing partition folders, or to new folders if a new partition is added.

```
INSERT INTO spectrum.customer
SELECT name, age, gender, month, day FROM local_customer;
```

LOCK

Restricts access to a database table. This command is only meaningful when it is run inside a transaction block.

The LOCK command obtains a table-level lock in "ACCESS EXCLUSIVE" mode, waiting if necessary for any conflicting locks to be released. Explicitly locking a table in this way causes reads and writes on the table to wait when they are attempted from other transactions or sessions. An explicit table lock created by one user temporarily prevents another user from selecting data from that table or loading data into it. The lock is released when the transaction that contains the LOCK command completes.

Less restrictive table locks are acquired implicitly by commands that refer to tables, such as write operations. For example, if a user tries to read data from a table while another user is updating the table, the data that is read will be a snapshot of the data that has already been committed. (In some cases, queries will stop if they violate serializable isolation rules.) See Managing concurrent write operations.

Some DDL operations, such as DROP TABLE and TRUNCATE, create exclusive locks. These operations prevent data reads.

If a lock conflict occurs, Amazon Redshift displays an error message to alert the user who started the transaction in conflict. The transaction that received the lock conflict is stopped. Every time a lock conflict occurs, Amazon Redshift writes an entry to the STL_TR_CONFLICT table.

Syntax

```
LOCK [ TABLE ] table_name [, ...]
```

Parameters

TABLE

Optional keyword.

table_name

Name of the table to lock. You can lock more than one table by using a comma-delimited list of table names. You can't lock views.

Example

```
begin;

lock event, sales;

...
```

MERGE

Conditionally merges rows from a source table into a target table. Traditionally, this can only be achieved by using multiple insert, update or delete statements separately. For more information on the operations that MERGE lets you combine, see UPDATE, DELETE, and INSERT.

Syntax

```
MERGE INTO target_table
USING source_table [ [ AS ] alias ]
ON match_condition
[ WHEN MATCHED THEN { UPDATE SET col_name = { expr } [,...] | DELETE }
WHEN NOT MATCHED THEN INSERT [ ( col_name [,...] ) ] VALUES ( { expr } [, ...] ) |
REMOVE DUPLICATES ]
```

Parameters

target_table

The temporary or permanent table that the MERGE statement merges into.

source_table

The temporary or permanent table supplying the rows to merge into *target_table*. *source_table* can also be a Spectrum table.

alias

The temporary alternative name for *source_table*.

This parameter is optional. Preceding *alias* with AS is also optional.

match_condition

Specifies equal predicates between the source table column and target table column that are used to determine whether the rows in *source_table* can be matched with rows in *target_table*. If the condition is met, MERGE runs *matched_clause* for that row. Otherwise MERGE runs *not_matched_clause* for that row.

WHEN MATCHED

Specifies the action to be run when the match condition between a source row and a target row evaluates to True. You can specify either an UPDATE action or a DELETE action.

UPDATE

Updates the matched row in *target_table*. Only values in the *col_name* you specify are updated.

DELETE

Deletes the matched row in *target_table*.

WHEN NOT MATCHED

Specifies the action to be run when the match condition is evaluated to False or Unknown. You can only specify the INSERT insert action for this clause.

INSERT

Inserts into *target_table* rows from *source_table* that don't match any rows in *target_table*, according to *match_condition*. The target *col_name* can be listed in any order. If you don’t provide any *col_name* values, the default order is all the table’s columns in their declared order.

col_name

One or more column names that you want to modify. Don't include the table name when specifying the target column.

expr

The expression defining the new value for *col_name*.

REMOVE DUPLICATES

Specifies that the MERGE command runs in simplified mode. Simplified mode has the following requirements:

- *target_table* and *source_table* must have the same number of columns and compatible column types.
- Omit the WHEN clause and the UPDATE and INSERT clauses from your MERGE command.
- Use the REMOVE DUPLICATES clause in your MERGE command.

In simplified mode, MERGE does the following:

- Rows in *target_table* that have a match in *source_table* are updated to match the values in *source_table*.
- Rows in *source_table* that don't have a match in *target_table* are inserted into *target_table*.

- When multiple rows in *target_table* match the same row in *source_table*, the duplicate rows are removed. Amazon Redshift keeps one row and updates it. Duplicate rows that don't match a row in *source_table* remain unchanged.

Using REMOVE DUPLICATES gives better performance than using WHEN MATCHED and WHEN NOT MATCHED. We recommend using REMOVE DUPLICATES if *target_table* and *source_table* are compatible and you don't need to preserve duplicate rows in *target_table*.

Usage notes

- To run MERGE statements, you must be the owner of both *source_table* and *target_table*, or have the SELECT permission for those tables. Additionally, you must have UPDATE, DELETE, and INSERT permissions for *target_table* depending on the operations included in your MERGE statement.
- *target_table* can't be a system table, catalog table, or external table.
- *source_table* and *target_table* can't be the same table.
- You can't use the WITH clause in a MERGE statement.
- Rows in *target_table* can't match multiple rows in *source_table*.

  Consider the following example:

```
CREATE TABLE target (id INT, name CHAR(10));
CREATE TABLE source (id INT, name CHAR(10));

INSERT INTO target VALUES (1, 'Bob'), (2, 'John');
INSERT INTO source VALUES (1, 'Tony'), (1, 'Alice'), (3, 'Bill');

MERGE INTO target USING source ON target.id = source.id
WHEN MATCHED THEN UPDATE SET id = source.id, name = source.name
WHEN NOT MATCHED THEN INSERT VALUES (source.id, source.name);
ERROR: Found multiple matches to update the same tuple.

MERGE INTO target USING source ON target.id = source.id
WHEN MATCHED THEN DELETE
WHEN NOT MATCHED THEN INSERT VALUES (source.id, source.name);
ERROR: Found multiple matches to update the same tuple.
```

  In both MERGE statements, the operation fails because there are multiple rows in the `source` table with an ID value of 1.

- *match_condition* and *expr* can't partially reference SUPER type columns. For example, if your SUPER type object is an array or a structure, you can't use individual elements of that column for *match_condition* or *expr*, but you can use the entire column.

  Consider the following example:

```
CREATE TABLE IF NOT EXISTS target (key INT, value SUPER);
CREATE TABLE IF NOT EXISTS source (key INT, value SUPER);

INSERT INTO target VALUES (1, JSON_PARSE('{"key": 88}'));
INSERT INTO source VALUES (1, ARRAY(1, 'John')), (2, ARRAY(2, 'Bill'));

MERGE INTO target USING source ON target.key = source.key
WHEN matched THEN UPDATE SET value = source.value[0]
WHEN NOT matched THEN INSERT VALUES (source.key, source.value[0]);
ERROR: Partial reference of SUPER column is not supported in MERGE statement.
```

  For more information on the SUPER type, see [SUPER type](#).
- If *source_table* is large, defining the join columns from both *target_table* and *source_table* as the distribution keys can improve performance.
- To use the REMOVE DUPLICATES clause, you need SELECT, INSERT, and DELETE permissions for *target_table*.
- *source_table* can be a view or subquery. Following is an example of a MERGE statement where *source_table* is a subquery that removes duplicate rows.

```
MERGE INTO target
USING (SELECT id, name FROM source GROUP BY 1, 2) as my_source
ON target.id = my_source.id
WHEN MATCHED THEN UPDATE SET id = my_source.id, name = my_source.name
WHEN NOT MATCHED THEN INSERT VALUES (my_source.id, my_source.name);
```

- The target cannot be a data source of any subquery of the same MERGE statement. For example, the following SQL command returns an error like ERROR: Source view/subquery in Merge statement cannot reference target table. because the subquery references `target` instead of `source`.

```
MERGE INTO target
USING (SELECT id, name FROM target GROUP BY 1, 2) as my_source
ON target.id = my_source.id
WHEN MATCHED THEN UPDATE SET id = my_source.id, name = my_source.name
```

```
WHEN NOT MATCHED THEN INSERT VALUES (my_source.id, my_source.name);
```

Examples

The following example creates two tables, then runs a MERGE operation on them, updating matching rows in the target table and inserting rows that don't match. Then it inserts another value into the source table and runs another MERGE operation, this time deleting matching rows and inserting the new row from the source table.

First create and populate the source and target tables.

```
CREATE TABLE target (id INT, name CHAR(10));
CREATE TABLE source (id INT, name CHAR(10));

INSERT INTO target VALUES (101, 'Bob'), (102, 'John'), (103, 'Susan');
INSERT INTO source VALUES (102, 'Tony'), (103, 'Alice'), (104, 'Bill');

SELECT * FROM target;
 id  |    name
-----+------------
 101 | Bob
 102 | John
 103 | Susan
(3 rows)

SELECT * FROM source;
 id  |    name
-----+------------
 102 | Tony
 103 | Alice
 104 | Bill
(3 rows)
```

Next, merge the source table into the target table, updating the target table with matching rows and insert rows from the source table that have no match.

```
MERGE INTO target USING source ON target.id = source.id
WHEN MATCHED THEN UPDATE SET id = source.id, name = source.name
WHEN NOT MATCHED THEN INSERT VALUES (source.id, source.name);

SELECT * FROM target;
```

```
 id  |    name
-----+------------
 101 | Bob
 102 | Tony
 103 | Alice
 104 | Bill
(4 rows)
```

Note that the rows with id values of 102 and 103 are updated to match the name values from the target table. Also, a new row with an id value of 104 and name value of Bill is inserted into the target table.

Next, insert a new row into the source table.

```
INSERT INTO source VALUES (105, 'David');

SELECT * FROM source;
 id  |    name
-----+------------
 102 | Tony
 103 | Alice
 104 | Bill
 105 | David
(4 rows)
```

Finally, run a merge operation deleting matching rows in the target table, and inserting rows that don't match.

```
MERGE INTO target USING source ON target.id = source.id
WHEN MATCHED THEN DELETE
WHEN NOT MATCHED THEN INSERT VALUES (source.id, source.name);

SELECT * FROM target;
 id  |    name
-----+------------
 101 | Bob
 105 | David
(2 rows)
```

The rows with id values 102, 103, and 104 are deleted from the target table, and a new row with an id value of 105 and name value of David is inserted into the target table.

The following example shows the simplified syntax of a MERGE command that uses the REMOVE DUPLICATES clause.

```
CREATE TABLE target (id INT, name CHAR(10));
CREATE TABLE source (id INT, name CHAR(10));

INSERT INTO target VALUES (30, 'Tony'), (11, 'Alice'), (23, 'Bill');
INSERT INTO source VALUES (23, 'David'), (22, 'Clarence');

MERGE INTO target USING source ON target.id = source.id REMOVE DUPLICATES;

SELECT * FROM target;
id | name
---+------------
30 | Tony
11 | Alice
23 | David
22 | Clarence
(4 rows)
```

The following example shows the simplified syntax of a MERGE command that uses the REMOVE DUPLICATES clause, removing duplicate rows from *target_table* if they have matching rows in *source_table*.

```
CREATE TABLE target (id INT, name CHAR(10));
CREATE TABLE source (id INT, name CHAR(10));

INSERT INTO target VALUES (30, 'Tony'), (30, 'Daisy'), (11, 'Alice'), (23, 'Bill'),
 (23, 'Nikki');
INSERT INTO source VALUES (23, 'David'), (22, 'Clarence');

MERGE INTO target USING source ON target.id = source.id REMOVE DUPLICATES;

SELECT * FROM target;
id | name
---+------------
30 | Tony
30 | Daisy
11 | Alice
23 | David
22 | Clarence
(5 rows)
```

After MERGE runs, there's only one row with an ID value of 23 in *target_table*. Because there was no row in *source_table* with the ID value 30, the two duplicate rows with ID values of 30 remain in *target_table*.

See also

INSERT, UPDATE, DELETE

PREPARE

Prepare a statement for execution.

PREPARE creates a prepared statement. When the PREPARE statement is run, the specified statement (SELECT, INSERT, UPDATE, or DELETE) is parsed, rewritten, and planned. When an EXECUTE command is then issued for the prepared statement, Amazon Redshift may optionally revise the query execution plan (to improve performance based on the specified parameter values) before running the prepared statement.

Syntax

```
PREPARE plan_name [ (datatype [, ...] ) ] AS statement
```

Parameters

plan_name

An arbitrary name given to this particular prepared statement. It must be unique within a single session and is subsequently used to run or deallocate a previously prepared statement.

datatype

The data type of a parameter to the prepared statement. To refer to the parameters in the prepared statement itself, use $1, $2, and so on, up to a maximum of $32767.

statement

Any SELECT, INSERT, UPDATE, or DELETE statement.

Usage notes

Prepared statements can take parameters: values that are substituted into the statement when it is run. To include parameters in a prepared statement, supply a list of data types in the PREPARE statement, and, in the statement to be prepared itself, refer to the parameters by position using the notation $1, $2, ... The maximum number of parameters is 32767. When running the statement, specify the actual values for these parameters in the EXECUTE statement. For more details, see EXECUTE.

Prepared statements only last for the duration of the current session. When the session ends, the prepared statement is discarded, so it must be re-created before being used again. This also means that a single prepared statement can't be used by multiple simultaneous database clients; however, each client can create its own prepared statement to use. The prepared statement can be manually removed using the DEALLOCATE command.

Prepared statements have the largest performance advantage when a single session is being used to run a large number of similar statements. As mentioned, for each new execution of a prepared statement, Amazon Redshift may revise the query execution plan to improve performance based on the specified parameter values. To examine the query execution plan that Amazon Redshift has chosen for any specific EXECUTE statements, use the EXPLAIN command.

For more information on query planning and the statistics collected by Amazon Redshift for query optimization, see the ANALYZE command.

Examples

Create a temporary table, prepare INSERT statement and then run it:

```
DROP TABLE IF EXISTS prep1;
CREATE TABLE prep1 (c1 int, c2 char(20));
PREPARE prep_insert_plan (int, char)
AS insert into prep1 values ($1, $2);
EXECUTE prep_insert_plan (1, 'one');
EXECUTE prep_insert_plan (2, 'two');
EXECUTE prep_insert_plan (3, 'three');
DEALLOCATE prep_insert_plan;
```

Prepare a SELECT statement and then run it:

```
PREPARE prep_select_plan (int)
```

```
AS select * from prep1 where c1 = $1;
EXECUTE prep_select_plan (2);
EXECUTE prep_select_plan (3);
DEALLOCATE prep_select_plan;
```

See also

DEALLOCATE, EXECUTE

REFRESH MATERIALIZED VIEW

Refreshes a materialized view.

When you create a materialized view, its contents reflect the state of the underlying database table or tables at that time. The data in the materialized view remains unchanged, even when applications make changes to the data in the underlying tables.

To update the data in a materialized view, you can use the `REFRESH MATERIALIZED VIEW` statement at any time. When you use this statement, Amazon Redshift identifies changes that have taken place in the base table or tables, and then applies those changes to the materialized view.

For more information about materialized views, see Materialized views in Amazon Redshift.

Syntax

```
REFRESH MATERIALIZED VIEW mv_name [ RESTRICT | CASCADE ]
```

Parameters

mv_name

The name of the materialized view to be refreshed.

RESTRICT

Optional keyword. Refreshes the specified materialized view but not its dependent materialized views. The default if neither RESTRICT nor CASCADE is specified.

CASCADE

Optional keyword. Refreshes the specified materialized view and all its dependent materialized views.

Usage notes

Only the owner of a materialized view can perform a `REFRESH MATERIALIZED VIEW` operation on that materialized view. Furthermore, the owner must have SELECT privilege on the underlying base tables to successfully run `REFRESH MATERIALIZED VIEW`.

The `REFRESH MATERIALIZED VIEW` command runs as a transaction of its own. Amazon Redshift transaction semantics are followed to determine what data from base tables is visible to the `REFRESH` command, or when the changes made by the `REFRESH` command are made visible to other transactions running in Amazon Redshift.

- For incremental materialized views, `REFRESH MATERIALIZED VIEW` uses only those base table rows that are already committed. Therefore, if the refresh operation runs after a data manipulation language (DML) statement in the same transaction, then changes of that DML statement aren't visible to refresh.
- For a full refresh of a materialized view, `REFRESH MATERIALIZED VIEW` sees all base table rows visible to the refresh transaction, according to usual Amazon Redshift transaction semantics.
- Depending on the input argument type, Amazon Redshift still supports incremental refresh for materialized views for the following functions with specific input argument types: DATE (timestamp), DATE_PART (date, time, interval, time-tz), DATE_TRUNC (timestamp, interval).
- Incremental refresh is supported on a materialized view where the base table is in a datashare.

Some operations in Amazon Redshift interact with materialized views. Some of these operations might force a `REFRESH MATERIALIZED VIEW` operation to fully recompute the materialized view even though the query defining the materialized view only uses the SQL features eligible for incremental refresh. For example:

- Background vacuum operations might be blocked if materialized views aren't refreshed. After an internally defined threshold period, a vacuum operation is allowed to run. When this vacuum operation happens, any dependent materialized views are marked for recomputation upon the next refresh (even if they are incremental). For information about VACUUM, see VACUUM. For more information about events and state changes, see STL_MV_STATE.
- Some user-initiated operations on base tables force a materialized view to be fully recomputed next time that a REFRESH operation is run. Examples of such operations are a manually invoked VACUUM, a classic resize, an ALTER DISTKEY operation, an ALTER SORTKEY operation, and a truncate operation. Automatic operations in some cases can also result in a materialized view being fully recomputed the next time a REFRESH operation is run. For example, an auto-vacuum

delete operation can cause a full recompute. For more information about events and state changes, see STL_MV_STATE.

Cascading refresh

The CASCADE option refreshes the specified materialized view and all its dependent materialized views, in order of dependence: base MVs are REFRESHed before the MVs on top (topological ordering). This allows you to update a nested set of materialized views in a single command.

The RESTRICT option (the default if neither RESTRICT nor CASCADE is specified) refreshes only the specified materialized view.

When using the CASCADE option, the following rules apply:

- Only the owner of the materialized view or a superuser can execute the `REFRESH MATERIALIZED VIEW ... CASCADE`command.
- If any of the materialized views in the cascade cannot be refreshed, the entire cascade operation will stop.

The cascading refresh functionality is only supported for MVs nested on top of local and streaming materialized views. Materialized views with other source types, such as Spectrum or Data Sharing, are not supported in cascade mode. CASCADE executes refresh in a single transaction for all nested MVs.

Incremental refresh for materialized views in a datashare

Amazon Redshift supports automatic and incremental refresh for materialized views in a consumer datashare when the base tables are shared. Incremental refresh is an operation where Amazon Redshift identifies changes in the base table or tables that happened after the previous refresh and updates only the corresponding records in the materialized view. For more information about this behavior, see CREATE MATERIALIZED VIEW.

Limitations for incremental refresh

Amazon Redshift currently doesn't support incremental refresh for materialized views that are defined with a query using any of the following SQL elements:

- OUTER JOIN (RIGHT, LEFT, or FULL).
- Set operations: UNION, INTERSECT, EXCEPT, MINUS.

- UNION ALL when it occurs in a subquery and an aggregate function or a GROUP BY clause is present in the query.
- Aggregate functions: MEDIAN, PERCENTILE_CONT, LISTAGG, STDDEV_SAMP, STDDEV_POP, APPROXIMATE COUNT, APPROXIMATE PERCENTILE, and bitwise aggregate functions.

> **Note**
>
> The COUNT, SUM, MIN, MAX, and AVG aggregate functions are supported.

- DISTINCT aggregate functions, such as DISTINCT COUNT, DISTINCT SUM, and so on.
- Window functions.
- A query that uses temporary tables for query optimization, such as optimizing common subexpressions.
- Subqueries
- External tables referencing the following formats in the query that defines the materialized view.
  - Delta Lake
  - Hudi

  Incremental refresh is supported for materialized views defined using formats other than those listed above. For more information, see Materialized views on external data lake tables in Amazon Redshift Spectrum.
- Mutable functions, such as date-time functions, RANDOM and non-STABLE user-defined functions.
- For limitations regarding incremental refresh for zero-ETL integrations, see Considerations when using zero-ETL integrations with Amazon Redshift.
- Accessing tables from more than one database.

For more information about materialized-view limitations, including the effect of background operations like VACUUM on materialized-view refresh operations, see Usage notes.

Examples

The following example refreshes the `tickets_mv` materialized view.

```
REFRESH MATERIALIZED VIEW tickets_mv;
```

The following example refreshes the `products_mv` materialized view and all its dependent materialized views:

```
REFRESH MATERIALIZED VIEW products_mv CASCADE;
```

RESET

Restores the value of a configuration parameter to its default value.

You can reset either a single specified parameter or all parameters at once. To set a parameter to a specific value, use the SET command. To display the current value of a parameter, use the SHOW command.

Syntax

```
RESET { parameter_name | ALL }
```

The following statement sets the value of a session context variable to NULL.

```
RESET { variable_name | ALL }
```

Parameters

parameter_name

Name of the parameter to reset. See Modifying the server configuration for more documentation about parameters.

ALL

Resets all runtime parameters, including all the session context variables.

variable

The name of the variable to reset. If the value to RESET is a session context variable, Amazon Redshift sets it to NULL.

Examples

The following example resets the `query_group` parameter to its default value:

```
reset query_group;
```

The following example resets all runtime parameters to their default values.

```
reset all;
```

The following example resets the context variable.

```
RESET app_context.user_id;
```

REVOKE

Removes access permissions, such as permissions to create, drop, or update tables, from a user or role.

You can only GRANT or REVOKE USAGE permissions on an external schema to database users and roles using the ON SCHEMA syntax. When using ON EXTERNAL SCHEMA with AWS Lake Formation, you can only GRANT and REVOKE permissions to an AWS Identity and Access Management (IAM) role. For the list of permissions, see the syntax.

For stored procedures, USAGE ON LANGUAGE `plpgsql` permissions are granted to PUBLIC by default. EXECUTE ON PROCEDURE permission is granted only to the owner and superusers by default.

Specify in the REVOKE command the permissions that you want to remove. To give permissions, use the GRANT command.

Syntax

```
REVOKE [ GRANT OPTION FOR ]
{ { SELECT | INSERT | UPDATE | DELETE | DROP | REFERENCES | ALTER | TRUNCATE } [,...] |
 ALL [ PRIVILEGES ] }
ON { [ TABLE ] table_name [, ...] | ALL TABLES IN SCHEMA schema_name [, ...] }
FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
{ { CREATE | TEMPORARY | TEMP | ALTER } [,...] | ALL [ PRIVILEGES ] }
```

```
ON DATABASE db_name [, ...]
FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
{ { CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }
ON SCHEMA schema_name [, ...]
FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
EXECUTE
    ON FUNCTION function_name ( [ [ argname ] argtype [, ...] ] ) [, ...]
    FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
{ { EXECUTE } [,...] | ALL [ PRIVILEGES ] }
    ON PROCEDURE procedure_name ( [ [ argname ] argtype [, ...] ] ) [, ...]
    FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
USAGE
    ON LANGUAGE language_name [, ...]
    FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
[ RESTRICT ]

REVOKE [GRANT OPTION FOR]
{ { ALTER | DROP} [,...] | ALL [ PRIVILEGES ] }
    ON COPY JOB job_name [,...]
    FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
```

Revoking column-level permissions for tables

The following is the syntax for column-level permissions on Amazon Redshift tables and views.

```
REVOKE { { SELECT | UPDATE } ( column_name [, ...] ) [, ...] | ALL [ PRIVILEGES ]
 ( column_name [,...] ) }
     ON { [ TABLE ] table_name [, ...] }
     FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
     [ RESTRICT ]
```

Revoking ASSUMEROLE permissions

The following is the syntax to revoke the ASSUMEROLE permission from users and groups with a specified role.

```
REVOKE ASSUMEROLE
    ON { 'iam_role' [, ...]  | default | ALL }
    FROM { user_name | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
    FOR { ALL | COPY | UNLOAD | EXTERNAL FUNCTION | CREATE MODEL }
```

Revoking permissions for Redshift Spectrum for Lake Formation

The following is the syntax for Redshift Spectrum integration with Lake Formation.

```
REVOKE [ GRANT OPTION FOR ]
{ SELECT | ALL [ PRIVILEGES ] } ( column_list )
    ON EXTERNAL TABLE schema_name.table_name
    FROM { IAM_ROLE iam_role } [, ...]

REVOKE [ GRANT OPTION FOR ]
{ { SELECT | ALTER | DROP | DELETE | INSERT }  [, ...] | ALL [ PRIVILEGES ] }
    ON EXTERNAL TABLE schema_name.table_name [, ...]
    FROM { { IAM_ROLE iam_role } [, ...] | PUBLIC }

REVOKE [ GRANT OPTION FOR ]
{ { CREATE | ALTER | DROP }  [, ...] | ALL [ PRIVILEGES ] }
    ON EXTERNAL SCHEMA schema_name [, ...]
    FROM { IAM_ROLE iam_role } [, ...]
```

Revoking datashare permissions

Producer-side datashare permissions

The following is the syntax for using REVOKE to remove ALTER or SHARE permissions from a user or role. The user whose permissions have been revoked can no longer alter the datashare, or grant usage to a consumer.

```
REVOKE { ALTER | SHARE } ON DATASHARE datashare_name
 FROM { username [ WITH GRANT OPTION ] | ROLE role_name | GROUP group_name | PUBLIC }
 [, ...]
```

The following is the syntax for using REVOKE to remove a consumer’s access to a datashare.

```
REVOKE USAGE
 ON DATASHARE datashare_name
 FROM NAMESPACE 'namespaceGUID' [, ...] | ACCOUNT 'accountnumber' [ VIA DATA CATALOG ]
 [, ...]
```

The following is an example of revoking usage of a datashare from a Lake Formation account.

```
REVOKE USAGE ON DATASHARE salesshare FROM ACCOUNT '123456789012' VIA DATA CATALOG;
```

Consumer-side datashare permissions

The following is the REVOKE syntax for data-sharing usage permissions on a specific database or schema created from a datashare. Revoking usage permission from a database created with the WITH PERMISSIONS clause doesn't revoke any additional permissions you granted a user or role, including object-level permissions granted for underlying objects. If you re-grant usage permission to that user or role, they will retain all additional permissions that they had before you revoked usage.

```
REVOKE USAGE ON { DATABASE shared_database_name [, ...] | SCHEMA shared_schema}
 FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
```

Revoking scoped permissions

Scoped permissions let you grant permissions to a user or role on all objects of a type within a database or schema. Users and roles with scoped permissions have the specified permissions on all current and future objects within the database or schema.

You can view the scope of database-level scoped permissions in SVV_DATABASE_PRIVILEGES. You can view the scope of schema-level scoped permissions in SVV_SCHEMA_PRIVILEGES.

For more information about scoped permissions, see Scoped permissions.

The following is the syntax for revoking scoped permissions from users and roles.

```
REVOKE [ GRANT OPTION ]
{ CREATE | USAGE | ALTER | DROP } [,...] | ALL [ PRIVILEGES ] }
FOR SCHEMAS IN
DATABASE db_name
FROM { username | ROLE role_name } [, ...]

REVOKE [ GRANT OPTION ]
```

```
{ { SELECT | INSERT | UPDATE | DELETE | DROP | ALTER | TRUNCATE | REFERENCES }
 [, ...] } | ALL [PRIVILEGES] } }
FOR TABLES IN
{ SCHEMA schema_name [ DATABASE db_name ] | DATABASE db_name }
FROM { username | ROLE role_name } [, ...]

REVOKE [ GRANT OPTION ] { EXECUTE | ALL [ PRIVILEGES ] }
FOR FUNCTIONS IN
{ SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
FROM { username | ROLE role_name } [, ...]

REVOKE [ GRANT OPTION ] { EXECUTE | ALL [ PRIVILEGES ] }
FOR PROCEDURES IN
{ SCHEMA schema_name [DATABASE db_name ] | DATABASE db_name }
FROM { username | ROLE role_name } [, ...]

REVOKE [ GRANT OPTION ] USAGE
FOR LANGUAGES IN
DATABASE db_name
FROM { username | ROLE role_name } [, ...]

REVOKE [GRANT_OPTION]
{ { CREATE | ALTER | DROP} [,...] | ALL [ PRIVILEGES ] }
FOR COPY JOBS
IN DATABASE db_name
FROM { username [ WITH GRANT OPTION ] | ROLE role_name } [, ...]
```

Note that scoped permissions don't distinguish between permissions for functions and for procedures. For example, the following statement revokes EXECUTE permissions for both functions and procedures from bob in the schema `Sales_schema`.

```
REVOKE EXECUTE FOR FUNCTIONS IN SCHEMA Sales_schema FROM bob;
```

Revoking machine learning permissions

The following is the syntax for machine learning model permissions on Amazon Redshift.

```
REVOKE [ GRANT OPTION FOR ]
    CREATE MODEL FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
    [ RESTRICT ]

REVOKE [ GRANT OPTION FOR ]
    { EXECUTE | ALL [ PRIVILEGES ] }
```

```
    ON MODEL model_name [, ...]

    FROM { username | ROLE role_name | GROUP group_name | PUBLIC } [, ...]
    [ RESTRICT ]
```

Revoking role permissions

The following is the syntax for revoking role permissions on Amazon Redshift.

```
REVOKE [ ADMIN OPTION FOR ] { ROLE role_name } [, ...] FROM { user_name } [, ...]
```

```
REVOKE { ROLE role_name } [, ...] FROM { ROLE role_name } [, ...]
```

The following is the syntax for revoking system permissions to roles on Amazon Redshift.

```
REVOKE
  {
    { CREATE USER | DROP USER | ALTER USER |
    CREATE SCHEMA | DROP SCHEMA |
    ALTER DEFAULT PRIVILEGES |
    ACCESS CATALOG |
    CREATE TABLE | DROP TABLE | ALTER TABLE |
    CREATE OR REPLACE FUNCTION | CREATE OR REPLACE EXTERNAL FUNCTION |
    DROP FUNCTION |
    CREATE OR REPLACE PROCEDURE | DROP PROCEDURE |
    CREATE OR REPLACE VIEW | DROP VIEW |
    CREATE MODEL | DROP MODEL |
    CREATE DATASHARE | ALTER DATASHARE | DROP DATASHARE |
    CREATE LIBRARY | DROP LIBRARY |
    CREATE ROLE | DROP ROLE
    TRUNCATE TABLE
    VACUUM | ANALYZE | CANCEL }[, ...]
  }
  | { ALL [ PRIVILEGES ] }
FROM { ROLE role_name } [, ...]
```

Revoking explain permissions for row-level security policy filters

The following is the syntax for revoking permissions to explain the row-level security policy filters of a query in the EXPLAIN plan. You can revoke the privilege using the REVOKE statement.

```
REVOKE EXPLAIN RLS FROM ROLE rolename
```

The following is the syntax for granting permissions to bypass row-level security policies for a query.

```
REVOKE IGNORE RLS FROM ROLE rolename
```

The following is the syntax for revoking permissions from the specified row-level security policy.

```
REVOKE SELECT ON [ TABLE ] table_name [, ...]
            FROM RLS POLICY policy_name [, ...]
```

Parameters

GRANT OPTION FOR

Revokes only the option to grant a specified permission to other users and doesn't revoke the permission itself. You can't revoke GRANT OPTION from a group or from PUBLIC.

SELECT

Revokes the permission to select data from a table or a view using a SELECT statement.

INSERT

Revokes the permission to load data into a table using an INSERT statement or a COPY statement.

UPDATE

Revokes the permission to update a table column using an UPDATE statement.

DELETE

Revokes the permission to delete a data row from a table.

REFERENCES

Revokes the permission to create a foreign key constraint. You should revoke this permission on both the referenced table and the referencing table.

TRUNCATE

Revokes the permission to truncate a table. Without this permission, only the owner of a table or a superuser can truncate a table. For more information about the TRUNCATE command, see the section called "TRUNCATE".

ALL [PRIVILEGES]

Revokes all available permissions at once from the specified user or group. The PRIVILEGES keyword is optional.

> **Note**
>
> Amazon Redshift doesn't support the RULE and TRIGGER permissions. For more information, go to Unsupported PostgreSQL features.

ALTER

Depending on the database object, revokes the following permissions from the user or user group:

- For tables, ALTER revokes permission to alter a table or view. For more information, see ALTER TABLE.
- For databases, ALTER revokes permission to alter a database. For more information, see ALTER DATABASE.
- For schemas, ALTER grants revokes to alter a schema. For more information, see ALTER SCHEMA.
- For external tables, ALTER revokes permission to alter a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This permission only applies when using Lake Formation.

DROP

Depending on the database object, revokes the following permissions from the user or role:

- For tables, DROP revokes permission to drop a table or view. For more information, see DROP TABLE.
- For databases, DROP revokes permission to drop a database. For more information, see DROP DATABASE.
- For schemas, DROP revokes permission to drop a schema. For more information, see DROP SCHEMA.

ASSUMEROLE

Revokes the permission to run COPY, UNLOAD, EXTERNAL FUNCTION, or CREATE MODEL commands from users, roles, or groups with a specified role.

ON [TABLE] *table_name*

Revokes the specified permissions on a table or a view. The TABLE keyword is optional.

ON ALL TABLES IN SCHEMA *schema_name*

Revokes the specified permissions on all tables in the referenced schema.

(*column_name* [,...]) ON TABLE *table_name*

Revokes the specified permissions from users, groups, or PUBLIC on the specified columns of the Amazon Redshift table or view.

(*column_list*) ON EXTERNAL TABLE *schema_name.table_name*

Revokes the specified permissions from an IAM role on the specified columns of the Lake Formation table in the referenced schema.

ON EXTERNAL TABLE *schema_name.table_name*

Revokes the specified permissions from an IAM role on the specified Lake Formation tables in the referenced schema.

ON EXTERNAL SCHEMA *schema_name*

Revokes the specified permissions from an IAM role on the referenced schema.

FROM IAM_ROLE *iam_role*

Indicates the IAM role losing the permissions.

ROLE *role_name*

Revokes the permissions from the specified role.

GROUP *group_name*

Revokes the permissions from the specified user group.

PUBLIC

Revokes the specified permissions from all users. PUBLIC represents a group that always includes all users. An individual user's permissions consist of the sum of permissions granted to PUBLIC, permissions granted to any groups that the user belongs to, and any permissions granted to the user individually.

Revoking PUBLIC from a Lake Formation external table results in revoking the permission from the Lake Formation *everyone* group.

CREATE

Depending on the database object, revokes the following permissions from the user or group:

- For databases, using the CREATE clause for REVOKE prevents users from creating schemas within the database.
- For schemas, using the CREATE clause for REVOKE prevents users from creating objects within a schema. To rename an object, the user must have the CREATE permission and own the object to be renamed.

> **Note**
>
> By default, all users have CREATE and USAGE permissions on the PUBLIC schema.

TEMPORARY | TEMP

Revokes the permission to create temporary tables in the specified database.

> **Note**
>
> By default, users are granted permission to create temporary tables by their automatic membership in the PUBLIC group. To remove the permission for any users to create temporary tables, revoke the TEMP permission from the PUBLIC group and then explicitly grant the permission to create temporary tables to specific users or groups of users.

ON DATABASE *db_name*

Revokes the permissions on the specified database.

USAGE

Revokes USAGE permissions on objects within a specific schema, which makes these objects inaccessible to users. Specific actions on these objects must be revoked separately (such as the EXECUTE permission on functions).

> **Note**
>
> By default, all users have CREATE and USAGE permissions on the PUBLIC schema.

ON SCHEMA *schema_name*

Revokes the permissions on the specified schema. You can use schema permissions to control the creation of tables; the CREATE permission for a database only controls the creation of schemas.

RESTRICT

Revokes only those permissions that the user directly granted. This behavior is the default.

EXECUTE ON PROCEDURE *procedure_name*

Revokes the EXECUTE permission on a specific stored procedure. Because stored procedure names can be overloaded, you must include the argument list for the procedure. For more information, see Naming stored procedures.

EXECUTE ON ALL PROCEDURES IN SCHEMA *procedure_name*

Revokes the specified permissions on all procedures in the referenced schema.

USAGE ON LANGUAGE *language_name*

Revokes the USAGE permission on a language. For Python user-defined functions (UDFs), use `plpythonu`. For SQL UDFs, use `sql`. For stored procedures, use `plpgsql`.

To create a UDF, you must have permission for usage on language for SQL or `plpythonu` (Python). By default, USAGE ON LANGUAGE SQL is granted to PUBLIC. However, you must explicitly grant USAGE ON LANGUAGE PLPYTHONU to specific users or groups.

To revoke usage for SQL, first revoke usage from PUBLIC. Then grant usage on SQL only to the specific users or groups permitted to create SQL UDFs. The following example revokes usage on SQL from PUBLIC then grants usage to the user group `udf_devs`.

```
revoke usage on language sql from PUBLIC;
grant usage on language sql to group udf_devs;
```

For more information, see UDF security and permissions.

To revoke usage for stored procedures, first revoke usage from PUBLIC. Then grant usage on `plpgsql` only to the specific users or groups permitted to create stored procedures. For more information, see Security and privileges for stored procedures .

ON COPY JOB *job_name*

Revokes the specified permissions on a copy job.

FOR { ALL | COPY | UNLOAD | EXTERNAL FUNCTION | CREATE MODEL } [, ...]

Specifes the SQL command for which the permission is revoked. You can specify ALL to revoke the permission on the COPY, UNLOAD, EXTERNAL FUNCTION, and CREATE MODEL statements. This clause applies only to revoking the ASSUMEROLE permission.

ALTER

Revokes the ALTER permission for users or user groups that allows those that don't own a datashare to alter the datashare. This permission is required to add or remove objects from a datashare, or to set the property PUBLICACCESSIBLE. For more information, see ALTER DATASHARE.

SHARE

Revokes permissions for users and user groups to add consumers to a datashare. Revoking this permissionis required to stop the particular consumer from accessing the datashare from its clusters.

ON DATASHARE *datashare_name*

Grants the specified permissions on the referenced datashare.

FROM username

Indicates the user losing the permissions.

FROM GROUP *group_name*

Indicates the user group losing the permissions.

WITH GRANT OPTION

Indicates that the user losing the permissions can in turn revoke the same permissions for others. You can't revoke WITH GRANT OPTION for a group or for PUBLIC.

USAGE

When USAGE is revoked for a consumer account or namespace within the same account, the specified consumer account or namespace within an account can't access the datashare and the objects of the datashare in read-only fashion.

Revoking the USAGE permission revokes the access to a datashare from consumers.

FROM NAMESPACE 'clusternamespace GUID'

Indicates the namespace in the same account that has consumers losing the permissions to the datashare. Namespaces use a 128-bit alphanumeric globally unique identifier (GUID).

FROM ACCOUNT 'accountnumber' [VIA DATA CATALOG]

Indicates the account number of another account that has the consumers losing the permissions to the datashare. Specifying ‘VIA DATA CATALOG’ indicates that you are revoking usage of the datashare from a Lake Formation account. Omitting the account number means that you're revoking from the account that owns the cluster.

ON DATABASE *shared_database_name> [, ...]*

Revokes the specified usage permissions on the specified database that was created in the specified datashare.

ON SCHEMA *shared_schema*

Revokes the specified permissions on the specified schema that was created in the specified datashare.

FOR { SCHEMAS | TABLES | FUNCTIONS | PROCEDURES | LANGUAGES | COPY JOBS} IN

Specifies the database objects to revoke permission from. The parameters following IN define the scope of the revoked permission.

CREATE MODEL

Revokes the CREATE MODEL permission to create machine learning models in the specified database.

ON MODEL *model_name*

Revokes the EXECUTE permission for a specific model.

ACCESS CATALOG

Revokes the permission to view relevant metadata of objects that the role has access to.

[ADMIN OPTION FOR] { role } [, ...]

The role that you revoke from a specified user that has the WITH ADMIN OPTION.

FROM { role } [, ...]

The role that you revoke the specified role from.

Usage notes

To learn more about the usage notes for REVOKE, see the section called “Usage notes”.

Examples

For examples of how to use REVOKE, see the section called “Examples”.

Usage notes

To revoke privileges from an object, you must meet one of the following criteria:

- Be the object owner.
- Be a superuser.
- Have a grant privilege for that object and privilege.

  For example, the following command enables the user HR both to perform SELECT commands on the employees table and to grant and revoke the same privilege for other users.

  ```
  grant select on table employees to HR with grant option;
  ```

  HR can't revoke privileges for any operation other than SELECT, or on any other table than employees.

Superusers can access all objects regardless of GRANT and REVOKE commands that set object privileges.

PUBLIC represents a group that always includes all users. By default all members of PUBLIC have CREATE and USAGE privileges on the PUBLIC schema. To restrict any user's permissions on the PUBLIC schema, you must first revoke all permissions from PUBLIC on the PUBLIC schema, then grant privileges to specific users or groups. The following example controls table creation privileges in the PUBLIC schema.

```
revoke create on schema public from public;
```

To revoke privileges from a Lake Formation table, the IAM role associated with the table's external schema must have permission to revoke privileges to the external table. The following example creates an external schema with an associated IAM role `myGrantor`. IAM role `myGrantor` has the permission to revoke permissions from others. The REVOKE command uses the permission of the IAM role `myGrantor` that is associated with the external schema to revoke permission to the IAM role `myGrantee`.

```
create external schema mySchema
from data catalog
database 'spectrum_db'
iam_role 'arn:aws:iam::123456789012:role/myGrantor'
create external database if not exists;
```

```
revoke select
on external table mySchema.mytable
from iam_role 'arn:aws:iam::123456789012:role/myGrantee';
```

> **Note**
>
> If the IAM role also has the `ALL` permission in an AWS Glue Data Catalog that is enabled for Lake Formation, the `ALL` permission isn't revoked. Only the `SELECT` permission is revoked. You can view the Lake Formation permissions in the Lake Formation console.

Usage notes for revoking the ASSUMEROLE permission

The following usage notes apply to revoking the ASSUMEROLE privilege in Amazon Redshift.

Only a database superuser can revoke the ASSUMEROLE privilege for users and groups. A superuser always retains the ASSUMEROLE privilege.

To enable the use of the ASSUMEROLE privilege for users and groups, a superuser runs the following statement once on the cluster. Before granting the ASSUMEROLE privilege to users and groups, a superuser must run the following statement once on the cluster.

```
revoke assumerole on all from public for all;
```

Usage notes for revoking machine learning permissions

You can't directly grant or revoke permissions related to an ML function. An ML function belongs to an ML model and permissions are controlled through the model. Instead, you can revoke permissions related to the ML model. The following example demonstrates how to revoke the run permisison from all users associated with the model `customer_churn`.

```
REVOKE EXECUTE ON MODEL customer_churn FROM PUBLIC;
```

You can also revoke all permissions from a user for the ML model `customer_churn`.

```
REVOKE ALL on MODEL customer_churn FROM ml_user;
```

Granting or revoking the `EXECUTE` permission related to an ML function will fail if there is an ML function in the schema, even if that ML function already has the `EXECUTE` permission through `GRANT EXECUTE ON MODEL`. We recommend using a separate schema when using the `CREATE MODEL` command to keep the ML functions in a separate schema by themselves. The following example demonstrates how to do so.

```
CREATE MODEL ml_schema.customer_churn
FROM customer_data
TARGET churn
FUNCTION ml_schema.customer_churn_prediction
IAM_ROLE default
SETTINGS (
 S3_BUCKET 'amzn-s3-demo-bucket'
);
```

Examples

The following example revokes INSERT privileges on the SALES table from the GUESTS user group. This command prevents members of GUESTS from being able to load data into the SALES table by using the INSERT command.

```
revoke insert on table sales from group guests;
```

The following example revokes the SELECT privilege on all tables in the QA_TICKIT schema from the user `fred`.

```
revoke select on all tables in schema qa_tickit from fred;
```

The following example revokes the privilege to select from a view for user `bobr`.

```
revoke select on table eventview from bobr;
```

The following example revokes the privilege to create temporary tables in the TICKIT database from all users.

```
revoke temporary on database tickit from public;
```

The following example revokes SELECT privilege on the `cust_name` and `cust_phone` columns of the `cust_profile` table from the user `user1`.

```
revoke select(cust_name, cust_phone) on cust_profile from user1;
```

The following example revokes SELECT privilege on the `cust_name` and `cust_phone` columns and UPDATE privilege on the `cust_contact_preference` column of the `cust_profile` table from the `sales_group` group.

```
revoke select(cust_name, cust_phone), update(cust_contact_preference) on cust_profile
 from group sales_group;
```

The following example shows the usage of the ALL keyword to revoke both SELECT and UPDATE privileges on three columns of the table `cust_profile` from the `sales_admin` group.

```
revoke ALL(cust_name, cust_phone,cust_contact_preference) on cust_profile from group
 sales_admin;
```

The following example revokes the SELECT privilege on the `cust_name` column of the `cust_profile_vw` view from the `user2` user.

```
revoke select(cust_name) on cust_profile_vw from user2;
```

Examples of revoking the USAGE permission from databases created from datashares

The following example revokes access to the `salesshare` datashare from the from the `13b8833d-17c6-4f16-8fe4-1a018f5ed00d` namespace.

```
REVOKE USAGE ON DATASHARE salesshare FROM NAMESPACE
 '13b8833d-17c6-4f16-8fe4-1a018f5ed00d';
```

The following example revokes the USAGE permission on the sales_db from Bob.

```
REVOKE USAGE ON DATABASE sales_db FROM Bob;
```

The following example REVOKE USAGE permission on the sales_schema from the Analyst_role.

```
REVOKE USAGE ON SCHEMA sales_schema FROM ROLE Analyst_role;
```

Examples of revoking scoped permissions

The following example revokes usage for all current and future schemas in the Sales_db database from the Sales role.

```
REVOKE USAGE FOR SCHEMAS IN DATABASE Sales_db FROM ROLE Sales;
```

The following example revokes the ability to grant the SELECT permission for all current and future tables in the Sales_db database from the user alice. alice retains access to all tables in Sales_db.

```
REVOKE GRANT OPTION SELECT FOR TABLES IN DATABASE Sales_db FROM alice;
```

The following example revokes the EXECUTE permission for functions in the Sales_schema schema from the user bob.

```
REVOKE EXECUTE FOR FUNCTIONS IN SCHEMA Sales_schema FROM bob;
```

The following example revokes all permissions for all tables in the ShareDb database's ShareSchema schema from the Sales role. When specifying the schema, you can also specify the schema's database using the two-part format database.schema.

```
REVOKE ALL FOR TABLES IN SCHEMA ShareDb.ShareSchema FROM ROLE Sales;
```

The following example is the same as the preceding one. You can specify the schema's database using the DATABASE keyword instead of using a two-part format.

```
REVOKE ALL FOR TABLES IN SCHEMA ShareSchema DATABASE ShareDb FROM ROLE Sales;
```

Examples of revoking the ASSUMEROLE privilege

The following are examples of revoking the ASSUMEROLE privilege.

A superuser must enable the use of the ASSUMEROLE privilege for users and groups by running the following statement once on the cluster:

```
revoke assumerole on all from public for all;
```

The following statement revokes the ASSUMEROLE privilege from user reg_user1 on all roles for all operations.

```
revoke assumerole on all from reg_user1 for all;
```

Examples of revoking the ROLE privilege

The following example revokes the sample_role1 from to sample_role2.

```
CREATE ROLE sample_role2;
GRANT ROLE sample_role1 TO ROLE sample_role2;
REVOKE ROLE sample_role1 FROM ROLE sample_role2;
```

The following example revokes system privileges from user1.

```
GRANT ROLE sys:DBA TO user1;
REVOKE ROLE sys:DBA FROM user1;
```

The following example revokes sample_role1 and sample_role2 from user1.

```
CREATE ROLE sample_role1;
CREATE ROLE sample_role2;
GRANT ROLE sample_role1, ROLE sample_role2 TO user1;
REVOKE ROLE sample_role1, ROLE sample_role2 FROM user1;
```

The following example revokes sample_role2 with the ADMIN OPTION from user1.

```
GRANT ROLE sample_role2 TO user1 WITH ADMIN OPTION;
REVOKE ADMIN OPTION FOR ROLE sample_role2 FROM user1;
```

```
REVOKE ROLE sample_role2 FROM user1;
```

The following example revokes sample_role1 and sample_role2 from sample_role5.

```
CREATE ROLE sample_role5;
GRANT ROLE sample_role1, ROLE sample_role2 TO ROLE sample_role5;
REVOKE ROLE sample_role1, ROLE sample_role2 FROM ROLE sample_role5;
```

The following example revokes the CREATE SCHEMA and DROP SCHEMA system privileges to sample_role1.

```
GRANT CREATE SCHEMA, DROP SCHEMA TO ROLE sample_role1;
REVOKE CREATE SCHEMA, DROP SCHEMA FROM ROLE sample_role1;
```

ROLLBACK

Stops the current transaction and discards all updates made by that transaction.

This command performs the same function as the ABORT command.

Syntax

```
ROLLBACK [ WORK | TRANSACTION ]
```

Parameters

WORK

Optional keyword. This keyword isn't supported within a stored procedure.

TRANSACTION

Optional keyword. WORK and TRANSACTION are synonyms. Neither is supported within a stored procedure.

For information about using ROLLBACK within a stored procedure, see Managing transactions.

Example

The following example creates a table then starts a transaction where data is inserted into the table. The ROLLBACK command then rolls back the data insertion to leave the table empty.

The following command creates an example table called MOVIE_GROSS:

```
create table movie_gross( name varchar(30), gross bigint );
```

The next set of commands starts a transaction that inserts two data rows into the table:

```
begin;

insert into movie_gross values ( 'Raiders of the Lost Ark', 23400000);

insert into movie_gross values ( 'Star Wars', 10000000 );
```

Next, the following command selects the data from the table to show that it was successfully inserted:

```
select * from movie_gross;
```

The command output shows that both rows successfully inserted:

```
name           |  gross
-------------------------+----------
Raiders of the Lost Ark | 23400000
Star Wars               | 10000000
(2 rows)
```

This command now rolls back the data changes to where the transaction began:

```
rollback;
```

Selecting data from the table now shows an empty table:

```
select * from movie_gross;

name | gross
------+-------
(0 rows)
```

SELECT

Returns rows from tables, views, and user-defined functions.

> **Note**
>
> The maximum size for a single SQL statement is 16 MB.

Syntax

```
[ WITH with_subquery [, ...] ]
SELECT
[ TOP number | [ ALL | DISTINCT ]
* | expression [ AS output_name ] [, ...] ]
[ EXCLUDE column_list ]
[ FROM table_reference [, ...] ]
[ WHERE condition ]
[ [ START WITH expression ] CONNECT BY expression ]
[ GROUP BY ALL | expression [, ...] ]
[ HAVING condition ]
[ QUALIFY condition ]
[ { UNION | ALL | INTERSECT | EXCEPT | MINUS } query ]
[ ORDER BY expression [ ASC | DESC ] ]
[ LIMIT { number | ALL } ]
[ OFFSET start ]
```

Topics

- Correlated subqueries

WITH clause

A WITH clause is an optional clause that precedes the SELECT list in a query. The WITH clause defines one or more *common_table_expressions*. Each common table expression (CTE) defines a temporary table, which is similar to a view definition. You can reference these temporary tables in the FROM clause. They're used only while the query they belong to runs. Each CTE in the WITH clause specifies a table name, an optional list of column names, and a query expression that evaluates to a table (a SELECT statement). When you reference the temporary table name in the FROM clause of the same query expression that defines it, the CTE is recursive.

WITH clause subqueries are an efficient way of defining tables that can be used throughout the execution of a single query. In all cases, the same results can be achieved by using subqueries in the main body of the SELECT statement, but WITH clause subqueries may be simpler to write and read. Where possible, WITH clause subqueries that are referenced multiple times are optimized as common subexpressions; that is, it may be possible to evaluate a WITH subquery once and reuse its results. (Note that common subexpressions aren't limited to those defined in the WITH clause.)

Syntax

```
[ WITH [RECURSIVE] common_table_expression [, common_table_expression , ...] ]
```

where *common_table_expression* can be either non-recursive or recursive. Following is the non-recursive form:

```
CTE_table_name [ ( column_name [, ...] ) ] AS ( query )
```

Following is the recursive form of *common_table_expression*:

```
CTE_table_name (column_name [, ...] ) AS ( recursive_query )
```

Parameters

RECURSIVE

Keyword that identifies the query as a recursive CTE. This keyword is required if any *common_table_expression* defined in the WITH clause is recursive. You can only specify the RECURSIVE keyword once, immediately following the WITH keyword, even when the WITH clause contains multiple recursive CTEs. In general, a recursive CTE is a UNION ALL subquery with two parts.

common_table_expression

Defines a temporary table that you can reference in the FROM clause and is used only during the execution of the query to which it belongs.

CTE_table_name

A unique name for a temporary table that defines the results of a WITH clause subquery. You can't use duplicate names within a single WITH clause. Each subquery must be given a table name that can be referenced in the FROM clause.

column_name

A list of output column names for the WITH clause subquery, separated by commas. The number of column names specified must be equal to or less than the number of columns defined by the subquery. For a CTE that is non-recursive, the *column_name* clause is optional. For a recursive CTE, the *column_name* list is required.

query

Any SELECT query that Amazon Redshift supports. See SELECT.

recursive_query

A UNION ALL query that consists of two SELECT subqueries:

- The first SELECT subquery doesn't have a recursive reference to the same *CTE_table_name*. It returns a result set that is the initial seed of the recursion. This part is called the initial member or seed member.
- The second SELECT subquery references the same *CTE_table_name* in its FROM clause. This is called the recursive member. The *recursive_query* contains a WHERE condition to end the *recursive_query*.

Usage notes

You can use a WITH clause in the following SQL statements:

- SELECT
- SELECT INTO
- CREATE TABLE AS

- CREATE VIEW
- DECLARE
- EXPLAIN
- INSERT INTO...SELECT
- PREPARE
- UPDATE (within a WHERE clause subquery. You can't define a recursive CTE in the subquery. The recursive CTE must precede the UPDATE clause.)
- DELETE

If the FROM clause of a query that contains a WITH clause doesn't reference any of the tables defined by the WITH clause, the WITH clause is ignored and the query runs as normal.

A table defined by a WITH clause subquery can be referenced only in the scope of the SELECT query that the WITH clause begins. For example, you can reference such a table in the FROM clause of a subquery in the SELECT list, WHERE clause, or HAVING clause. You can't use a WITH clause in a subquery and reference its table in the FROM clause of the main query or another subquery. This query pattern results in an error message of the form `relation table_name doesn't exist` for the WITH clause table.

You can't specify another WITH clause inside a WITH clause subquery.

You can't make forward references to tables defined by WITH clause subqueries. For example, the following query returns an error because of the forward reference to table W2 in the definition of table W1:

```
with w1 as (select * from w2), w2 as (select * from w1)
select * from sales;
ERROR:  relation "w2" does not exist
```

A WITH clause subquery may not consist of a SELECT INTO statement; however, you can use a WITH clause in a SELECT INTO statement.

Recursive common table expressions

A recursive *common table expression (CTE)* is a CTE that references itself. A recursive CTE is useful in querying hierarchical data, such as organization charts that show reporting relationships between employees and managers. See Example: Recursive CTE.

Another common use is a multilevel bill of materials, when a product consists of many components and each component itself also consists of other components or subassemblies.

Be sure to limit the depth of recursion by including a WHERE clause in the second SELECT subquery of the recursive query. For an example, see Example: Recursive CTE. Otherwise, an error can occur similar to the following:

- `Recursive CTE out of working buffers.`
- `Exceeded recursive CTE max rows limit, please add correct CTE termination predicates or change the max_recursion_rows parameter.`

> **Note**
>
> `max_recursion_rows` is a parameter setting the maximum number of rows a recursive CTE can return in order to prevent infinite recursion loops. We recommend against changing this to a larger value than the default. This prevents infinite recursion problems in your queries from taking up excessive space in your cluster.

You can specify a sort order and limit on the result of the recursive CTE. You can include group by and distinct options on the final result of the recursive CTE.

You can't specify a WITH RECURSIVE clause inside a subquery. The *recursive_query* member can't include an order by or limit clause.

Examples

The following example shows the simplest possible case of a query that contains a WITH clause. The WITH query named VENUECOPY selects all of the rows from the VENUE table. The main query in turn selects all of the rows from VENUECOPY. The VENUECOPY table exists only for the duration of this query.

```
with venuecopy as (select * from venue)
select * from venuecopy order by 1 limit 10;
```

```
 venueid |         venuename          |    venuecity    | venuestate | venueseats
---------+----------------------------+-----------------+------------+------------
1 | Toyota Park                 | Bridgeview      | IL          |          0
```

```
2 | Columbus Crew Stadium      | Columbus        | OH         |          0
3 | RFK Stadium                | Washington      | DC         |          0
4 | CommunityAmerica Ballpark  | Kansas City     | KS         |          0
5 | Gillette Stadium           | Foxborough      | MA         |      68756
6 | New York Giants Stadium    | East Rutherford | NJ         |      80242
7 | BMO Field                  | Toronto         | ON         |          0
8 | The Home Depot Center      | Carson          | CA         |          0
9 | Dick's Sporting Goods Park | Commerce City   | CO         |          0
v     10 | Pizza Hut Park             | Frisco          | TX         |          0
(10 rows)
```

The following example shows a WITH clause that produces two tables, named VENUE_SALES and TOP_VENUES. The second WITH query table selects from the first. In turn, the WHERE clause of the main query block contains a subquery that constrains the TOP_VENUES table.

```
with venue_sales as
(select venuename, venuecity, sum(pricepaid) as venuename_sales
from sales, venue, event
where venue.venueid=event.venueid and event.eventid=sales.eventid
group by venuename, venuecity),

top_venues as
(select venuename
from venue_sales
where venuename_sales > 800000)

select venuename, venuecity, venuestate,
sum(qtysold) as venue_qty,
sum(pricepaid) as venue_sales
from sales, venue, event
where venue.venueid=event.venueid and event.eventid=sales.eventid
and venuename in(select venuename from top_venues)
group by venuename, venuecity, venuestate
order by venuename;
```

```
        venuename       |   venuecity   | venuestate | venue_qty | venue_sales
------------------------+---------------+------------+-----------+-------------
August Wilson Theatre   | New York City | NY         |      3187 |  1032156.00
Biltmore Theatre        | New York City | NY         |      2629 |   828981.00
Charles Playhouse       | Boston        | MA         |      2502 |   857031.00
Ethel Barrymore Theatre | New York City | NY         |      2828 |   891172.00
Eugene O'Neill Theatre  | New York City | NY         |      2488 |   828950.00
```

```
Greek Theatre          | Los Angeles   | CA        |      2445 |   838918.00
Helen Hayes Theatre    | New York City | NY        |      2948 |   978765.00
Hilton Theatre         | New York City | NY        |      2999 |   885686.00
Imperial Theatre       | New York City | NY        |      2702 |   877993.00
Lunt-Fontanne Theatre  | New York City | NY        |      3326 |  1115182.00
Majestic Theatre       | New York City | NY        |      2549 |   894275.00
Nederlander Theatre    | New York City | NY        |      2934 |   936312.00
Pasadena Playhouse     | Pasadena      | CA        |      2739 |   820435.00
Winter Garden Theatre  | New York City | NY        |      2838 |   939257.00
(14 rows)
```

The following two examples demonstrate the rules for the scope of table references based on WITH clause subqueries. The first query runs, but the second fails with an expected error. The first query has WITH clause subquery inside the SELECT list of the main query. The table defined by the WITH clause (HOLIDAYS) is referenced in the FROM clause of the subquery in the SELECT list:

```
select caldate, sum(pricepaid) as daysales,
(with holidays as (select * from date where holiday ='t')
select sum(pricepaid)
from sales join holidays on sales.dateid=holidays.dateid
where caldate='2008-12-25') as dec25sales
from sales join date on sales.dateid=date.dateid
where caldate in('2008-12-25','2008-12-31')
group by caldate
order by caldate;

caldate   | daysales | dec25sales
-----------+----------+------------
2008-12-25 | 70402.00 |   70402.00
2008-12-31 | 12678.00 |   70402.00
(2 rows)
```

The second query fails because it attempts to reference the HOLIDAYS table in the main query as well as in the SELECT list subquery. The main query references are out of scope.

```
select caldate, sum(pricepaid) as daysales,
(with holidays as (select * from date where holiday ='t')
select sum(pricepaid)
from sales join holidays on sales.dateid=holidays.dateid
where caldate='2008-12-25') as dec25sales
from sales join holidays on sales.dateid=holidays.dateid
where caldate in('2008-12-25','2008-12-31')
```

```
group by caldate
order by caldate;

ERROR:  relation "holidays" does not exist
```

Example: Recursive CTE

The following is an example of a recursive CTE that returns the employees who report directly or indirectly to John. The recursive query contains a WHERE clause to limit the depth of recursion to less than 4 levels.

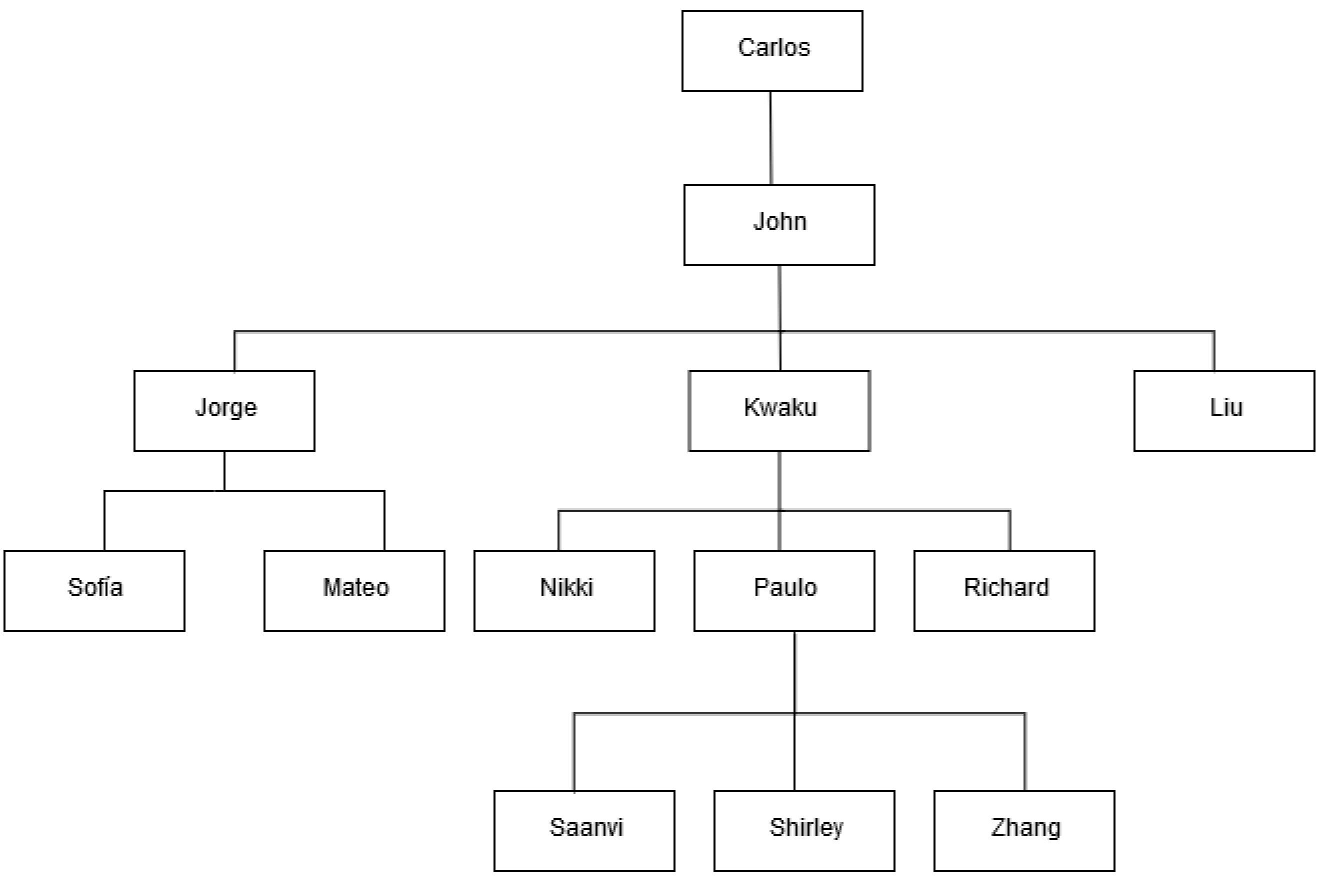
```
--create and populate the sample table
  create table employee (
  id int,
  name varchar (20),
  manager_id int
  );

  insert into employee(id, name, manager_id)  values
(100, 'Carlos', null),
(101, 'John', 100),
(102, 'Jorge', 101),
(103, 'Kwaku', 101),
(110, 'Liu', 101),
(106, 'Mateo', 102),
(110, 'Nikki', 103),
(104, 'Paulo', 103),
(105, 'Richard', 103),
(120, 'Saanvi', 104),
(200, 'Shirley', 104),
(201, 'Sofía', 102),
(205, 'Zhang', 104);

--run the recursive query
  with recursive john_org(id, name, manager_id, level) as
( select id, name, manager_id, 1 as level
  from employee
  where name = 'John'
  union all
  select e.id, e.name, e.manager_id, level + 1 as next_level
  from employee e, john_org j
  where e.manager_id = j.id and level < 4
  )
```

```
select distinct id, name, manager_id from john_org order by manager_id;
```

Following is the result of the query.

```
  id        name      manager_id
------+-----------+--------------
 101    John          100
 102    Jorge         101
 103    Kwaku         101
 110    Liu           101
 201    Sofía         102
 106    Mateo         102
 110    Nikki         103
 104    Paulo         103
 105    Richard       103
 120    Saanvi        104
 200    Shirley       104
 205    Zhang         104
```

Following is an organization chart for John's department.



SELECT list

Topics

- Syntax
- Parameters
- Usage notes
- Examples

The SELECT list names the columns, functions, and expressions that you want the query to return. The list represents the output of the query.

For more information about SQL functions, see SQL functions reference. For more information about expressions, see Conditional expressions.

Syntax

```
SELECT
[ TOP number ]
[ ALL | DISTINCT ] * | expression [ AS column_alias ] [, ...]
```

Parameters

TOP *number*

TOP takes a positive integer as its argument, which defines the number of rows that are returned to the client. The behavior with the TOP clause is the same as the behavior with the LIMIT clause. The number of rows that is returned is fixed, but the set of rows isn't. To return a consistent set of rows, use TOP or LIMIT in conjunction with an ORDER BY clause.

ALL

A redundant keyword that defines the default behavior if you don't specify DISTINCT. `SELECT ALL *` means the same as `SELECT *` (select all rows for all columns and retain duplicates).

DISTINCT

Option that eliminates duplicate rows from the result set, based on matching values in one or more columns.

> **Note**
>
> If your application allows invalid foreign keys or primary keys, it can cause queries to return incorrect results. For example, a SELECT DISTINCT query might return duplicate rows if the primary key column doesn't contain all unique values. For more information, see Defining table constraints.

* (asterisk)

Returns the entire contents of the table (all columns and all rows).

expression

An expression formed from one or more columns that exist in the tables referenced by the query. An expression can contain SQL functions. For example:

```
avg(datediff(day, listtime, saletime))
```

AS *column_alias*

A temporary name for the column that is used in the final result set. The AS keyword is optional. For example:

```
avg(datediff(day, listtime, saletime)) as avgwait
```

If you don't specify an alias for an expression that isn't a simple column name, the result set applies a default name to that column.

> **Note**
>
> The alias is recognized right after it is defined in the target list. You can use an alias in other expressions defined after it in the same target list. The following example illustrates this.
>
> ```
> select clicks / impressions as probability, round(100 * probability, 1) as
>  percentage from raw_data;
> ```

The benefit of the lateral alias reference is you don't need to repeat the aliased expression when building more complex expressions in the same target list. When Amazon Redshift parses this type of reference, it just inlines the previously defined aliases. If there is a column with the same name defined in the `FROM` clause as the previously aliased expression, the column in the `FROM` clause takes priority. For example, in the above query if there is a column named 'probability' in table raw_data, the 'probability' in the second expression in the target list refers to that column instead of the alias name 'probability'.

Usage notes

TOP is a SQL extension; it provides an alternative to the LIMIT behavior. You can't use TOP and LIMIT in the same query.

Examples

The following example returns 10 rows from the SALES table. Though the query uses the TOP clause, it still returns an unpredictable set of rows because no ORDER BY clause is specified,

```
select top 10 *
from sales;
```

The following query is functionally equivalent, but uses a LIMIT clause instead of a TOP clause:

```
select *
from sales
limit 10;
```

The following example returns the first 10 rows from the SALES table using the TOP clause, ordered by the QTYSOLD column in descending order.

```
select top 10 qtysold, sellerid
from sales
order by qtysold desc, sellerid;

qtysold | sellerid
--------+----------
```

```
8 |      518
8 |      520
8 |      574
8 |      718
8 |      868
8 |     2663
8 |     3396
8 |     3726
8 |     5250
8 |     6216
(10 rows)
```

The following example returns the first two QTYSOLD and SELLERID values from the SALES table, ordered by the QTYSOLD column:

```
select top 2 qtysold, sellerid
from sales
order by qtysold desc, sellerid;

qtysold | sellerid
--------+----------
8 |      518
8 |      520
(2 rows)
```

The following example shows the list of distinct category groups from the CATEGORY table:

```
select distinct catgroup from category
order by 1;

catgroup
----------
Concerts
Shows
Sports
(3 rows)

--the same query, run without distinct
select catgroup from category
order by 1;

catgroup
----------
```

```
Concerts
Concerts
Concerts
Shows
Shows
Shows
Sports
Sports
Sports
Sports
Sports
(11 rows)
```

The following example returns the distinct set of week numbers for December 2008. Without the DISTINCT clause, the statement would return 31 rows, or one for each day of the month.

```
select distinct week, month, year
from date
where month='DEC' and year=2008
order by 1, 2, 3;

week | month | year
-----+-------+------
49 | DEC   | 2008
50 | DEC   | 2008
51 | DEC   | 2008
52 | DEC   | 2008
53 | DEC   | 2008
(5 rows)
```

EXCLUDE column_list

The EXCLUDE column_list names the columns that are excluded from the query results. Using the EXCLUDE option is helpful when only a subset of columns need to be excluded from a *wide* table, which is a table that contains many columns.

Topics

Syntax

```
EXCLUDE column_list
```

Parameters

column_list

A comma-separated list of one or more column names that exist in the tables referenced by the query. The *column_list* can optionally be enclosed in parentheses. Only column names are supported in the exclude list of column names, not expressions (such as `upper(col1)`) or asterisk (*).

```
column-name, ... | ( column-name, ... )
```

For example:

```
SELECT * EXCLUDE col1, col2 FROM tablea;
```

```
SELECT * EXCLUDE (col1, col2) FROM tablea;
```

Examples

The following examples use the SALES table that contains columns: salesid, listid, sellerid, buyerid, eventid, dateid, qtysold, pricepaid, commission, and saletime. For more information about the SALES table, see Sample database.

The following example returns rows from the SALES table, but excludes the SALETIME column.

```
SELECT * EXCLUDE saletime FROM sales;

salesid | listid  | sellerid | buyerid | eventid | dateid  | qtysold  | pricepaid  |
 commission
--------+---------+----------+---------+---------+---------+----------+------------
+-----------
150314  | 173969  | 48680    | 816     | 8762    | 1827    | 2        | 688        |
 103.2
8325    | 8942    | 23600    | 1078    | 2557    | 1828    | 5        | 525        |
 78.75
```

```
46807    | 52711   | 34388    | 1047    | 2046    | 1828    | 2         | 482         |
 72.3
...
```

The following example returns rows from the SALES table, but excludes the QTYSOLD and SALETIME columns.

```
SELECT * EXCLUDE (qtysold, saletime) FROM sales;

salesid | listid  | sellerid | buyerid | eventid | dateid  | pricepaid  | commission
--------+---------+----------+---------+---------+---------+------------+-----------
150314  | 173969  | 48680    | 816     | 8762    | 1827    | 688        | 103.2
8325    | 8942    | 23600    | 1078    | 2557    | 1828    | 525        |  78.75
46807   | 52711   | 34388    | 1047    | 2046    | 1828    | 482        |  72.3
...
```

The following example creates a view that returns rows from the SALES table, but excludes the SALETIME column.

```
CREATE VIEW sales_view AS SELECT * EXCLUDE saletime FROM sales;
SELECT * FROM sales_view;

salesid | listid  | sellerid | buyerid | eventid | dateid  | qtysold  | pricepaid  |
 commission
--------+---------+----------+---------+---------+---------+----------+-----------
+-----------
150314  | 173969  | 48680    | 816     | 8762    | 1827    | 2        | 688        |
 103.2
8325    | 8942    | 23600    | 1078    | 2557    | 1828    | 5        | 525        |
 78.75
46807   | 52711   | 34388    | 1047    | 2046    | 1828    | 2        | 482        |
 72.3
...
```

The following example selects only the columns that are not excluded into a temp table.

```
SELECT * EXCLUDE saletime INTO TEMP temp_sales FROM sales;
SELECT * FROM temp_sales;

salesid | listid  | sellerid | buyerid | eventid | dateid  | qtysold  | pricepaid  |
 commission
```

```
--------+---------+----------+---------+---------+---------+----------+------------
+-----------
150314  | 173969  | 48680    | 816     | 8762    | 1827    | 2          | 688         |
 103.2
8325    | 8942    | 23600    | 1078    | 2557    | 1828    | 5          | 525         |
 78.75
46807   | 52711   | 34388    | 1047    | 2046    | 1828    | 2          | 482         |
 72.3
...
```

FROM clause

The FROM clause in a query lists the table references (tables, views, and subqueries) that data is selected from. If multiple table references are listed, the tables must be joined, using appropriate syntax in either the FROM clause or the WHERE clause. If no join criteria are specified, the system processes the query as a cross-join (Cartesian product).

Topics

Syntax

```
FROM table_reference [, ...]
```

where *table_reference* is one of the following:

```
with_subquery_table_name [ table_alias ]
table_name [ * ] [ table_alias ]
( subquery ) [ table_alias ]
table_reference [ NATURAL ] join_type table_reference
   [ ON join_condition | USING ( join_column [, ...] ) ]
table_reference PIVOT (
```

```
    aggregate(expr) [ [ AS ] aggregate_alias ]
    FOR column_name IN ( expression [ AS ] in_alias [, ...] )
) [ table_alias ]
table_reference UNPIVOT [ INCLUDE NULLS | EXCLUDE NULLS ] (
    value_column_name
    FOR name_column_name IN ( column_reference [ [ AS ]
    in_alias ] [, ...] )
) [ table_alias ]
UNPIVOT expression AS value_alias [ AT attribute_alias ]
UNNEST ( column_reference )
  [AS] table_alias ( unnested_column_name )
UNNEST ( column_reference ) WITH OFFSET
  [AS] table_alias ( unnested_column_name, [offset_column_name] )
```

The optional *table_alias* can be used to give temporary names to tables and complex table references and, if desired, their columns as well, like the following:

```
[ AS ] alias [ ( column_alias [, ...] ) ]
```

Parameters

with_subquery_table_name

A table defined by a subquery in the WITH clause.

table_name

Name of a table or view.

alias

Temporary alternative name for a table or view. An alias must be supplied for a table derived from a subquery. In other table references, aliases are optional. The AS keyword is always optional. Table aliases provide a convenient shortcut for identifying tables in other parts of a query, such as the WHERE clause. For example:

```
select * from sales s, listing l
where s.listid=l.listid
```

column_alias

Temporary alternative name for a column in a table or view.

subquery

A query expression that evaluates to a table. The table exists only for the duration of the query and is typically given a name or *alias*. However, an alias isn't required. You can also define column names for tables that derive from subqueries. Naming column aliases is important when you want to join the results of subqueries to other tables and when you want to select or constrain those columns elsewhere in the query.

A subquery may contain an ORDER BY clause, but this clause may have no effect if a LIMIT or OFFSET clause isn't also specified.

NATURAL

Defines a join that automatically uses all pairs of identically named columns in the two tables as the joining columns. No explicit join condition is required. For example, if the CATEGORY and EVENT tables both have columns named CATID, a natural join of those tables is a join over their CATID columns.

> **Note**
>
> If a NATURAL join is specified but no identically named pairs of columns exist in the tables to be joined, the query defaults to a cross-join.

join_type

Specify one of the following types of join:

- [INNER] JOIN
- LEFT [OUTER] JOIN
- RIGHT [OUTER] JOIN
- FULL [OUTER] JOIN
- CROSS JOIN

Cross-joins are unqualified joins; they return the Cartesian product of the two tables.

Inner and outer joins are qualified joins. They are qualified either implicitly (in natural joins); with the ON or USING syntax in the FROM clause; or with a WHERE clause condition.

An inner join returns matching rows only, based on the join condition or list of joining columns. An outer join returns all of the rows that the equivalent inner join would return plus non-matching rows from the "left" table, "right" table, or both tables. The left table is the first-listed table, and the right table is the second-listed table. The non-matching rows contain NULL values to fill the gaps in the output columns.

ON *join_condition*

Type of join specification where the joining columns are stated as a condition that follows the ON keyword. For example:

```
sales join listing
on sales.listid=listing.listid and sales.eventid=listing.eventid
```

USING (*join_column* [, ...])

Type of join specification where the joining columns are listed in parentheses. If multiple joining columns are specified, they are delimited by commas. The USING keyword must precede the list. For example:

```
sales join listing
using (listid,eventid)
```

PIVOT

Rotates output from rows to columns, for the purpose of representing tabular data in a format that is easy to read. Output is represented horizontally across multiple columns. PIVOT is similar to a GROUP BY query with an aggregation, using an aggregate expression to specify an output format. However, in contrast to GROUP BY, the results are returned in columns instead of rows.

For examples that show how to query with PIVOT and UNPIVOT, see PIVOT and UNPIVOT examples.

UNPIVOT

Rotating columns into rows with UNPIVOT – The operator transforms result columns, from an input table or query results, into rows, to make the output easier to read. UNPIVOT combines the data of its input columns into two result columns: a name column and a value column. The name column contains column names from the input, as row entries. The value column contains values from the input columns, such as results of an aggregation. For example, the counts of items in various categories.

Object unpivoting with UNPIVOT (SUPER) – You can perform object unpivoting, where *expression* is a SUPER expression referring to another FROM clause item. For more information, see Object unpivoting. It also has examples that show how to query semi-structured data, such as data that's JSON-formatted.

UNNEST

Expands a nested structure, typically a SUPER array, into columns containing the unnested elements. For more information on unnesting SUPER data, see Querying semi-structured data. For examples, see UNNEST examples.

unnested_column_name

The name of the column that contains the unnested elements.

UNNEST ... WITH OFFSET

Adds an offset column to the unnested output, with the offset representing the zero-based index of each element in the array. This variant is useful when you want to see the position of elements within an array. For more information on unnesting SUPER data, see Querying semi-structured data. For examples, see UNNEST examples.

offset_column_name

A custom name for the offset column that lets you explicitly define how the index column will appear in the output. This parameter is optional. By default, the offset column name is `offset_col`.

Usage notes

Joining columns must have comparable data types.

A NATURAL or USING join retains only one of each pair of joining columns in the intermediate result set.

A join with the ON syntax retains both joining columns in its intermediate result set.

See also WITH clause.

PIVOT and UNPIVOT examples

PIVOT and UNPIVOT are parameters in the FROM clause that rotate query output from rows to columns and columns to rows, respectively. They represent tabular query results in a format that's easy to read. The following examples use test data and queries to show how to use them.

For more information about these and other parameters, see FROM clause.

PIVOT examples

Set up the sample table and data and use them to run the subsequent example queries.

```
CREATE TABLE part (
    partname varchar,
    manufacturer varchar,
    quality int,
    price decimal(12, 2)
);

INSERT INTO part VALUES ('prop', 'local parts co', 2, 10.00);
INSERT INTO part VALUES ('prop', 'big parts co', NULL, 9.00);
INSERT INTO part VALUES ('prop', 'small parts co', 1, 12.00);

INSERT INTO part VALUES ('rudder', 'local parts co', 1, 2.50);
INSERT INTO part VALUES ('rudder', 'big parts co', 2, 3.75);
INSERT INTO part VALUES ('rudder', 'small parts co', NULL, 1.90);

INSERT INTO part VALUES ('wing', 'local parts co', NULL, 7.50);
INSERT INTO part VALUES ('wing', 'big parts co', 1, 15.20);
INSERT INTO part VALUES ('wing', 'small parts co', NULL, 11.80);
```

PIVOT on `partname` with an `AVG` aggregation on `price`.

```
SELECT *
FROM (SELECT partname, price FROM part) PIVOT (
    AVG(price) FOR partname IN ('prop', 'rudder', 'wing')
);
```

The query results in the following output.

```
  prop   |  rudder  |  wing
---------+----------+---------
 10.33   | 2.71     | 11.50
```

In the previous example, the results are transformed into columns. The following example shows a `GROUP BY` query that returns the average prices in rows, rather than in columns.

```
SELECT partname, avg(price)
FROM (SELECT partname, price FROM part)
WHERE partname IN ('prop', 'rudder', 'wing')
```

```
GROUP BY partname;
```

The query results in the following output.

```
 partname |  avg
----------+-------
 prop     | 10.33
 rudder   |  2.71
 wing     | 11.50
```

A PIVOT example with manufacturer as an implicit column.

```
SELECT *
FROM (SELECT quality, manufacturer FROM part) PIVOT (
    count(*) FOR quality IN (1, 2, NULL)
);
```

The query results in the following output.

```
 manufacturer      | 1  | 2  | null
-------------------+----+----+------
 local parts co    | 1  | 1  |  1
 big parts co      | 1  | 1  |  1
 small parts co    | 1  | 0  |  2
```

Input table columns that are not referenced in the PIVOT definition are added implicitly to the result table. This is the case for the manufacturer column in the previous example. The example also shows that NULL is a valid value for the IN operator.

PIVOT in the above example returns similar information as the following query, which includes GROUP BY. The difference is that PIVOT returns the value 0 for column 2 and the manufacturer small parts co. The GROUP BY query does not contain a corresponding row. In most cases, PIVOT inserts NULL if a row doesn't have input data for a given column. However, the count aggregate doesn't return NULL and 0 is the default value.

```
SELECT manufacturer, quality, count(*)
FROM (SELECT quality, manufacturer FROM part)
WHERE quality IN (1, 2) OR quality IS NULL
GROUP BY manufacturer, quality
ORDER BY manufacturer;
```

The query results in the following output.

```
 manufacturer        | quality | count
---------------------+---------+-------
 big parts co        |         |     1
 big parts co        |       2 |     1
 big parts co        |       1 |     1
 local parts co      |       2 |     1
 local parts co      |       1 |     1
 local parts co      |         |     1
 small parts co      |       1 |     1
 small parts co      |         |     2
```

The PIVOT operator accepts optional aliases on the aggregate expression and on each value for the IN operator. Use aliases to customize the column names. If there is no aggregate alias, only the IN list aliases are used. Otherwise, the aggregate alias is appended to the column name with an underscore to separate the names.

```
SELECT *
FROM (SELECT quality, manufacturer FROM part) PIVOT (
    count(*) AS count FOR quality IN (1 AS high, 2 AS low, NULL AS na)
);
```

The query results in the following output.

```
 manufacturer      | high_count  | low_count | na_count
-------------------+-------------+-----------+----------
 local parts co    |           1 |         1 |        1
 big parts co      |           1 |         1 |        1
 small parts co    |           1 |         0 |        2
```

Set up the following sample table and data and use them to run the subsequent example queries. The data represents booking dates for a collection of hotels.

```
CREATE TABLE bookings (
    booking_id int,
    hotel_code char(8),
    booking_date date,
    price decimal(12, 2)
);
```

```
INSERT INTO bookings VALUES (1, 'FOREST_L', '02/01/2023', 75.12);
INSERT INTO bookings VALUES (2, 'FOREST_L', '02/02/2023', 75.00);
INSERT INTO bookings VALUES (3, 'FOREST_L', '02/04/2023', 85.54);

INSERT INTO bookings VALUES (4, 'FOREST_L', '02/08/2023', 75.00);
INSERT INTO bookings VALUES (5, 'FOREST_L', '02/11/2023', 75.00);
INSERT INTO bookings VALUES (6, 'FOREST_L', '02/14/2023', 90.00);

INSERT INTO bookings VALUES (7, 'FOREST_L', '02/21/2023', 60.00);
INSERT INTO bookings VALUES (8, 'FOREST_L', '02/22/2023', 85.00);
INSERT INTO bookings VALUES (9, 'FOREST_L', '02/27/2023', 90.00);

INSERT INTO bookings VALUES (10, 'DESERT_S', '02/01/2023', 98.00);
INSERT INTO bookings VALUES (11, 'DESERT_S', '02/02/2023', 75.00);
INSERT INTO bookings VALUES (12, 'DESERT_S', '02/04/2023', 85.00);

INSERT INTO bookings VALUES (13, 'DESERT_S', '02/05/2023', 75.00);
INSERT INTO bookings VALUES (14, 'DESERT_S', '02/06/2023', 34.00);
INSERT INTO bookings VALUES (15, 'DESERT_S', '02/09/2023', 85.00);

INSERT INTO bookings VALUES (16, 'DESERT_S', '02/12/2023', 23.00);
INSERT INTO bookings VALUES (17, 'DESERT_S', '02/13/2023', 76.00);
INSERT INTO bookings VALUES (18, 'DESERT_S', '02/14/2023', 85.00);

INSERT INTO bookings VALUES (19, 'OCEAN_WV', '02/01/2023', 98.00);
INSERT INTO bookings VALUES (20, 'OCEAN_WV', '02/02/2023', 75.00);
INSERT INTO bookings VALUES (21, 'OCEAN_WV', '02/04/2023', 85.00);

INSERT INTO bookings VALUES (22, 'OCEAN_WV', '02/06/2023', 75.00);
INSERT INTO bookings VALUES (23, 'OCEAN_WV', '02/09/2023', 34.00);
INSERT INTO bookings VALUES (24, 'OCEAN_WV', '02/12/2023', 85.00);

INSERT INTO bookings VALUES (25, 'OCEAN_WV', '02/13/2023', 23.00);
INSERT INTO bookings VALUES (26, 'OCEAN_WV', '02/14/2023', 76.00);
INSERT INTO bookings VALUES (27, 'OCEAN_WV', '02/16/2023', 85.00);

INSERT INTO bookings VALUES (28, 'CITY_BLD', '02/01/2023', 98.00);
INSERT INTO bookings VALUES (29, 'CITY_BLD', '02/02/2023', 75.00);
INSERT INTO bookings VALUES (30, 'CITY_BLD', '02/04/2023', 85.00);

INSERT INTO bookings VALUES (31, 'CITY_BLD', '02/12/2023', 75.00);
INSERT INTO bookings VALUES (32, 'CITY_BLD', '02/13/2023', 34.00);
INSERT INTO bookings VALUES (33, 'CITY_BLD', '02/17/2023', 85.00);
```

```
INSERT INTO bookings VALUES (34, 'CITY_BLD', '02/22/2023', 23.00);
INSERT INTO bookings VALUES (35, 'CITY_BLD', '02/23/2023', 76.00);
INSERT INTO bookings VALUES (36, 'CITY_BLD', '02/24/2023', 85.00);
```

In this sample query, booking records are tallied to give a total for each week. The end date for each week becomes a column name.

```
SELECT * FROM
    (SELECT
       booking_id,
       (date_trunc('week', booking_date::date) + '5 days'::interval)::date as enddate,
       hotel_code AS "hotel code"
FROM bookings
) PIVOT (
    count(booking_id) FOR enddate IN ('2023-02-04','2023-02-11','2023-02-18')
);
```

The query results in the following output.

```
 hotel code | 2023-02-04  | 2023-02-11 | 2023-02-18
------------+-------------+------------+----------
 FOREST_L   |           3 |          2 |        1
 DESERT_S   |           4 |          3 |        2
 OCEAN_WV   |           3 |          3 |        3
 CITY_BLD   |           3 |          1 |        2
```

Amazon Redshift doesn't support CROSSTAB to pivot on multiple columns. But you can change row data to columns, in a similar manner to an aggregation with PIVOT, with a query like the following. This uses the same booking sample data as the previous example.

```
SELECT
  booking_date,
  MAX(CASE WHEN hotel_code = 'FOREST_L' THEN 'forest is booked' ELSE '' END) AS
 FOREST_L,
  MAX(CASE WHEN hotel_code = 'DESERT_S' THEN 'desert is booked' ELSE '' END) AS
 DESERT_S,
  MAX(CASE WHEN hotel_code = 'OCEAN_WV' THEN 'ocean is booked' ELSE '' END)  AS
 OCEAN_WV
FROM bookings
GROUP BY booking_date
ORDER BY booking_date asc;
```

The sample query results in booking dates listed next to short phrases that indicate which hotels are booked.

```
 booking_date  | forest_l         | desert_s         | ocean_wv
---------------+------------------+------------------+--------------------
 2023-02-01    | forest is booked | desert is booked |  ocean is booked
 2023-02-02    | forest is booked | desert is booked |  ocean is booked
 2023-02-04    | forest is booked | desert is booked |  ocean is booked
 2023-02-05    |                  | desert is booked |
 2023-02-06    |                  | desert is booked |
```

The following are usage notes for PIVOT:

- PIVOT can be applied to tables, sub-queries, and common table expressions (CTEs). PIVOT cannot be applied to any JOIN expressions, recursive CTEs, PIVOT, or UNPIVOT expressions. Also not supported are SUPER unnested expressions and Redshift Spectrum nested tables.
- PIVOT supports the COUNT, SUM, MIN, MAX, and AVG aggregate functions.
- The PIVOT aggregate expression has to be a call of a supported aggregate function. Complex expressions on top of the aggregate are not supported. The aggregate arguments cannot contain references to tables other than the PIVOT input table. Correlated references to a parent query are also not supported. The aggregate argument may contain sub-queries. These can be correlated internally or on the PIVOT input table.
- The PIVOT IN list values cannot be column references or sub-queries. Each value must be type compatible with the FOR column reference.
- If the IN list values do not have aliases, PIVOT generates default column names. For constant IN values such as 'abc' or 5 the default column name is the constant itself. For any complex expression, the column name is a standard Amazon Redshift default name such as ?column?.

UNPIVOT examples

Set up the sample data and use it to run the subsequent examples.

```
CREATE TABLE count_by_color (quality varchar, red int, green int, blue int);

INSERT INTO count_by_color VALUES ('high', 15, 20, 7);
INSERT INTO count_by_color VALUES ('normal', 35, NULL, 40);
INSERT INTO count_by_color VALUES ('low', 10, 23, NULL);
```

UNPIVOT on input columns red, green, and blue.

```
SELECT *
FROM (SELECT red, green, blue FROM count_by_color) UNPIVOT (
    cnt FOR color IN (red, green, blue)
);
```

The query results in the following output.

```
 color | cnt
-------+-----
 red   |  15
 red   |  35
 red   |  10
 green |  20
 green |  23
 blue  |   7
 blue  |  40
```

By default, NULL values in the input column are skipped and do not yield a result row.

The following example shows UNPIVOT with INCLUDE NULLS.

```
SELECT *
FROM (
    SELECT red, green, blue
    FROM count_by_color
) UNPIVOT INCLUDE NULLS (
    cnt FOR color IN (red, green, blue)
);
```

The following is the resulting output.

```
 color | cnt
-------+-----
 red   |  15
 red   |  35
 red   |  10
 green |  20
 green |
 green |  23
```

```
 blue  |   7
 blue  |  40
 blue  |
```

If the `INCLUDING NULLS` parameter is set, `NULL` input values generate result rows.

`The following query shows UNPIVOT` with `quality` as an implicit column.

```
SELECT *
FROM count_by_color UNPIVOT (
    cnt FOR color IN (red, green, blue)
);
```

The query results in the following output.

```
 quality | color | cnt
---------+-------+-----
 high    | red   |  15
 normal  | red   |  35
 low     | red   |  10
 high    | green |  20
 low     | green |  23
 high    | blue  |   7
 normal  | blue  |  40
```

Columns of the input table that are not referenced in the `UNPIVOT` definition are added implicitly to the result table. In the example, this is the case for the `quality` column.

The following example shows `UNPIVOT` with aliases for values in the `IN` list.

```
SELECT *
FROM count_by_color UNPIVOT (
    cnt FOR color IN (red AS r, green AS g, blue AS b)
);
```

The previous query results in the following output.

```
 quality | color | cnt
---------+-------+-----
 high    | r     |  15
 normal  | r     |  35
```

```
low     | r     |  10
high    | g     |  20
low     | g     |  23
high    | b     |   7
normal  | b     |  40
```

The UNPIVOT operator accepts optional aliases on each IN list value. Each alias provides customization of the data in each value column.

The following are usage notes for UNPIVOT.

- UNPIVOT can be applied to tables, sub-queries, and common table expressions (CTEs). UNPIVOT cannot be applied to any JOIN expressions, recursive CTEs, PIVOT, or UNPIVOT expressions. Also not supported are SUPER unnested expressions and Redshift Spectrum nested tables.
- The UNPIVOT IN list must contain only input table column references. The IN list columns must have a common type that they are all compatible with. The UNPIVOT value column has this common type. The UNPIVOT name column is of type VARCHAR.
- If an IN list value does not have an alias, UNPIVOT uses the column name as a default value.

JOIN examples

A SQL JOIN clause is used to combine the data from two or more tables based on common fields. The results might or might not change depending on the join method specified. For more information about the syntax of a JOIN clause, see Parameters.

The following examples use data from the TICKIT sample data. For more information about the database schema, see Sample database. To learn how to load sample data, see Loading data in the *Amazon Redshift Getting Started Guide*.

The following query is an inner join (without the JOIN keyword) between the LISTING table and SALES table, where the LISTID from the LISTING table is between 1 and 5. This query matches LISTID column values in the LISTING table (the left table) and SALES table (the right table). The results show that LISTID 1, 4, and 5 match the criteria.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
from listing, sales
where listing.listid = sales.listid
and listing.listid between 1 and 5
group by 1
```

```
order by 1;

listid | price  |  comm
-------+--------+--------
     1 | 728.00 | 109.20
     4 |  76.00 |  11.40
     5 | 525.00 |  78.75
```

The following query is a left outer join. Left and right outer joins retain values from one of the joined tables when no match is found in the other table. The left and right tables are the first and second tables listed in the syntax. NULL values are used to fill the "gaps" in the result set. This query matches LISTID column values in the LISTING table (the left table) and the SALES table (the right table). The results show that LISTIDs 2 and 3 did not result in any sales.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
from listing left outer join sales on sales.listid = listing.listid
where listing.listid between 1 and 5
group by 1
order by 1;

listid | price  |  comm
-------+--------+--------
     1 | 728.00 | 109.20
     2 | NULL   | NULL
     3 | NULL   | NULL
     4 |  76.00 |  11.40
     5 | 525.00 |  78.75
```

The following query is a right outer join. This query matches LISTID column values in the LISTING table (the left table) and the SALES table (the right table). The results show that LISTIDs 1, 4, and 5 match the criteria.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
from listing right outer join sales on sales.listid = listing.listid
where listing.listid between 1 and 5
group by 1
order by 1;

listid | price  |  comm
-------+--------+--------
     1 | 728.00 | 109.20
     4 |  76.00 |  11.40
```

```
     5 | 525.00 |  78.75
```

The following query is a full join. Full joins retain values from the joined tables when no match is found in the other table. The left and right tables are the first and second tables listed in the syntax. NULL values are used to fill the "gaps" in the result set. This query matches LISTID column values in the LISTING table (the left table) and the SALES table (the right table). The results show that LISTIDs 2 and 3 did not result in any sales.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
from listing full join sales on sales.listid = listing.listid
where listing.listid between 1 and 5
group by 1
order by 1;

listid | price  |  comm
-------+--------+--------
     1 | 728.00 | 109.20
     2 | NULL   | NULL
     3 | NULL   | NULL
     4 |  76.00 |  11.40
     5 | 525.00 |  78.75
```

The following query is a full join. This query matches LISTID column values in the LISTING table (the left table) and the SALES table (the right table). Only rows that do not result in any sales (LISTIDs 2 and 3) are in the results.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
from listing full join sales on sales.listid = listing.listid
where listing.listid between 1 and 5
and (listing.listid IS NULL or sales.listid IS NULL)
group by 1
order by 1;

listid | price  |  comm
-------+--------+--------
     2 | NULL   | NULL
     3 | NULL   | NULL
```

The following example is an inner join with the ON clause. In this case, NULL rows are not returned.

```
select listing.listid, sum(pricepaid) as price, sum(commission) as comm
```

```
from sales join listing
on sales.listid=listing.listid and sales.eventid=listing.eventid
where listing.listid between 1 and 5
group by 1
order by 1;

listid | price  |  comm
-------+--------+--------
     1 | 728.00 | 109.20
     4 |  76.00 |  11.40
     5 | 525.00 |  78.75
```

The following query is a cross join or Cartesian join of the LISTING table and the SALES table with a predicate to limit the results. This query matches LISTID column values in the SALES table and the LISTING table for LISTIDs 1, 2, 3, 4, and 5 in both tables. The results show that 20 rows match the criteria.

```
select sales.listid as sales_listid, listing.listid as listing_listid
from sales cross join listing
where sales.listid between 1 and 5
and listing.listid between 1 and 5
order by 1,2;

sales_listid | listing_listid
-------------+---------------
1            | 1
1            | 2
1            | 3
1            | 4
1            | 5
4            | 1
4            | 2
4            | 3
4            | 4
4            | 5
5            | 1
5            | 1
5            | 2
5            | 2
5            | 3
5            | 3
5            | 4
5            | 4
```

```
5             | 5
5             | 5
```

The following example is a natural join between two tables. In this case, the columns listid, sellerid, eventid, and dateid have identical names and data types in both tables and so are used as the join columns. The results are limited to five rows.

```
select listid, sellerid, eventid, dateid, numtickets
from listing natural join sales
order by 1
limit 5;

listid | sellerid  | eventid | dateid | numtickets
-------+-----------+---------+--------+-----------
113    | 29704     | 4699    | 2075   | 22
115    | 39115     | 3513    | 2062   | 14
116    | 43314     | 8675    | 1910   | 28
118    | 6079      | 1611    | 1862   | 9
163    | 24880     | 8253    | 1888   | 14
```

The following example is a join between two tables with the USING clause. In this case, the columns listid and eventid are used as the join columns. The results are limited to five rows.

```
select listid, listing.sellerid, eventid, listing.dateid, numtickets
from listing join sales
using (listid, eventid)
order by 1
limit 5;

listid | sellerid | eventid | dateid | numtickets
-------+----------+---------+--------+-----------
1      | 36861    | 7872    | 1850   | 10
4      | 8117     | 4337    | 1970   | 8
5      | 1616     | 8647    | 1963   | 4
5      | 1616     | 8647    | 1963   | 4
6      | 47402    | 8240    | 2053   | 18
```

The following query is an inner join of two subqueries in the FROM clause. The query finds the number of sold and unsold tickets for different categories of events (concerts and shows). The FROM clause subqueries are *table* subqueries; they can return multiple columns and rows.

```
select catgroup1, sold, unsold
from
(select catgroup, sum(qtysold) as sold
from category c, event e, sales s
where c.catid = e.catid and e.eventid = s.eventid
group by catgroup) as a(catgroup1, sold)
join
(select catgroup, sum(numtickets)-sum(qtysold) as unsold
from category c, event e, sales s, listing l
where c.catid = e.catid and e.eventid = s.eventid
and s.listid = l.listid
group by catgroup) as b(catgroup2, unsold)

on a.catgroup1 = b.catgroup2
order by 1;

catgroup1 |  sold  | unsold
----------+--------+--------
Concerts  | 195444 |1067199
Shows     | 149905 | 817736
```

UNNEST examples

UNNEST is a parameter in the FROM clause that expands nested data into columns that hold the data's unnested elements. For information on unnesting data, see Querying semi-structured data.

The following statement creates and populates the `orders` table, which contains a `products` column containing arrays of product IDs. The examples in this section use the sample data in this table.

```
CREATE TABLE orders (
    order_id INT,
    products SUPER
);

-- Populate table
INSERT INTO orders VALUES
(1001, JSON_PARSE('[
        {
            "product_id": "P456",
            "name": "Monitor",
            "price": 299.99,
```

```
            "quantity": 1,
            "specs": {
                "size": "27 inch",
                "resolution": "4K"
            }
        }
    ]
')),
(1002, JSON_PARSE('
    [
        {
            "product_id": "P567",
            "name": "USB Cable",
            "price": 9.99,
            "quantity": 3
        },
        {
            "product_id": "P678",
            "name": "Headphones",
            "price": 159.99,
            "quantity": 1,
            "specs": {
                "type": "Wireless",
                "battery_life": "20 hours"
            }
        }
    ]
'));
```

Following are some examples of unnesting queries with the sample data using PartiQL syntax.

Unnesting an array without an OFFSET column

The following query unnests the SUPER arrays in the products column, with each row representing an item from the order in `order_id`.

```
SELECT o.order_id, unnested_products.product
FROM orders o, UNNEST(o.products) AS unnested_products(product);

 order_id |                                                              product

----------
+--------------------------------------------------------------------------------------------------
```

```
     1001 | {"product_id":"P456","name":"Monitor","price":299.99,"quantity":1,"specs":
{"size":"27 inch","resolution":"4K"}}
     1002 | {"product_id":"P567","name":"USB Cable","price":9.99,"quantity":3}
     1002 |
 {"product_id":"P678","name":"Headphones","price":159.99,"quantity":1,"specs":
{"type":"Wireless","battery_life":"20 hours"}}
(3 rows)
```

The following query finds the most expensive product in each order.

```
SELECT o.order_id, MAX(unnested_products.product)
FROM orders o, UNNEST(o.products) AS unnested_products(product);

 order_id |                                                           product

----------
+-------------------------------------------------------------------------------------------------
     1001 | {"product_id":"P456","name":"Monitor","price":299.99,"quantity":1,"specs":
{"size":"27 inch","resolution":"4K"}}
     1002 |
 {"product_id":"P678","name":"Headphones","price":159.99,"quantity":1,"specs":
{"type":"Wireless","battery_life":"20 hours"}}
(2 rows)
```

Unnesting an array with an implicit OFFSET column

The following query uses the `UNNEST ... WITH OFFSET` parameter to show the zero-based position of each product within its order array.

```
SELECT o.order_id, up.product, up.offset_col
FROM orders o, UNNEST(o.products) WITH OFFSET AS up(product);

 order_id |                                                           product
                                                   | offset_col
----------
+-------------------------------------------------------------------------------------------------
+------------
     1001 | {"product_id":"P456","name":"Monitor","price":299.99,"quantity":1,"specs":
{"size":"27 inch","resolution":"4K"}}             |          0
     1002 | {"product_id":"P567","name":"USB Cable","price":9.99,"quantity":3}
                                                   |          0
```

```
     1002 |
 {"product_id":"P678","name":"Headphones","price":159.99,"quantity":1,"specs":
{"type":"Wireless","battery_life":"20 hours"}} |          1
(3 rows)
```

Since the statement doesn't specify an alias for the offset column, Amazon Redshift defaults to naming it `offset_col`.

Unnesting an array with an explicit OFFSET column

The following query also uses the `UNNEST ... WITH OFFSET` parameter to show the products within their order arrays. The difference in this query compared to the query in the previous example is that it explicitly names the offset column with the alias `idx`.

```
SELECT o.order_id, up.product, up.idx
FROM orders o, UNNEST(o.products) WITH OFFSET AS up(product, idx);

 order_id |                                                            product
                                                       | idx
----------
+----------------------------------------------------------------------------------------------------
+-----
     1001 | {"product_id":"P456","name":"Monitor","price":299.99,"quantity":1,"specs":
{"size":"27 inch","resolution":"4K"}}             |   0
     1002 | {"product_id":"P567","name":"USB Cable","price":9.99,"quantity":3}
                                                       |   0
     1002 |
 {"product_id":"P678","name":"Headphones","price":159.99,"quantity":1,"specs":
{"type":"Wireless","battery_life":"20 hours"}} |   1
(3 rows)
```

WHERE clause

The WHERE clause contains conditions that either join tables or apply predicates to columns in tables. Tables can be inner-joined by using appropriate syntax in either the WHERE clause or the FROM clause. Outer join criteria must be specified in the FROM clause.

Syntax

```
[ WHERE condition ]
```

condition

Any search condition with a Boolean result, such as a join condition or a predicate on a table column. The following examples are valid join conditions:

```
sales.listid=listing.listid
sales.listid<>listing.listid
```

The following examples are valid conditions on columns in tables:

```
catgroup like 'S%'
venueseats between 20000 and 50000
eventname in('Jersey Boys','Spamalot')
year=2008
length(catdesc)>25
date_part(month, caldate)=6
```

Conditions can be simple or complex; for complex conditions, you can use parentheses to isolate logical units. In the following example, the join condition is enclosed by parentheses.

```
where (category.catid=event.catid) and category.catid in(6,7,8)
```

Usage notes

You can use aliases in the WHERE clause to reference select list expressions.

You can't restrict the results of aggregate functions in the WHERE clause; use the HAVING clause for this purpose.

Columns that are restricted in the WHERE clause must derive from table references in the FROM clause.

Example

The following query uses a combination of different WHERE clause restrictions, including a join condition for the SALES and EVENT tables, a predicate on the EVENTNAME column, and two predicates on the STARTTIME column.

```
select eventname, starttime, pricepaid/qtysold as costperticket, qtysold
from sales, event
where sales.eventid = event.eventid
and eventname='Hannah Montana'
```

```
and date_part(quarter, starttime) in(1,2)
and date_part(year, starttime) = 2008
order by 3 desc, 4, 2, 1 limit 10;

eventname    |      starttime      |   costperticket   | qtysold
----------------+---------------------+-------------------+---------
Hannah Montana | 2008-06-07 14:00:00 |     1706.00000000 |       2
Hannah Montana | 2008-05-01 19:00:00 |     1658.00000000 |       2
Hannah Montana | 2008-06-07 14:00:00 |     1479.00000000 |       1
Hannah Montana | 2008-06-07 14:00:00 |     1479.00000000 |       3
Hannah Montana | 2008-06-07 14:00:00 |     1163.00000000 |       1
Hannah Montana | 2008-06-07 14:00:00 |     1163.00000000 |       2
Hannah Montana | 2008-06-07 14:00:00 |     1163.00000000 |       4
Hannah Montana | 2008-05-01 19:00:00 |      497.00000000 |       1
Hannah Montana | 2008-05-01 19:00:00 |      497.00000000 |       2
Hannah Montana | 2008-05-01 19:00:00 |      497.00000000 |       4
(10 rows)
```

Oracle-Style outer joins in the WHERE clause

For Oracle compatibility, Amazon Redshift supports the Oracle outer-join operator (+) in WHERE clause join conditions. This operator is intended for use only in defining outer-join conditions; don't try to use it in other contexts. Other uses of this operator are silently ignored in most cases.

An outer join returns all of the rows that the equivalent inner join would return, plus non-matching rows from one or both tables. In the FROM clause, you can specify left, right, and full outer joins. In the WHERE clause, you can specify left and right outer joins only.

To outer join tables TABLE1 and TABLE2 and return non-matching rows from TABLE1 (a left outer join), specify `TABLE1 LEFT OUTER JOIN TABLE2` in the FROM clause or apply the (+) operator to all joining columns from TABLE2 in the WHERE clause. For all rows in TABLE1 that have no matching rows in TABLE2, the result of the query contains nulls for any select list expressions that contain columns from TABLE2.

To produce the same behavior for all rows in TABLE2 that have no matching rows in TABLE1, specify `TABLE1 RIGHT OUTER JOIN TABLE2` in the FROM clause or apply the (+) operator to all joining columns from TABLE1 in the WHERE clause.

Basic syntax

```
[ WHERE {
[ table1.column1 = table2.column1(+) ]
```

```
[ table1.column1(+) = table2.column1 ]
}
```

The first condition is equivalent to:

```
from table1 left outer join table2
on table1.column1=table2.column1
```

The second condition is equivalent to:

```
from table1 right outer join table2
on table1.column1=table2.column1
```

> **Note**
>
> The syntax shown here covers the simple case of an equijoin over one pair of joining columns. However, other types of comparison conditions and multiple pairs of joining columns are also valid.

For example, the following WHERE clause defines an outer join over two pairs of columns. The (+) operator must be attached to the same table in both conditions:

```
where table1.col1 > table2.col1(+)
and table1.col2 = table2.col2(+)
```

Usage notes

Where possible, use the standard FROM clause OUTER JOIN syntax instead of the (+) operator in the WHERE clause. Queries that contain the (+) operator are subject to the following rules:

- You can only use the (+) operator in the WHERE clause, and only in reference to columns from tables or views.
- You can't apply the (+) operator to expressions. However, an expression can contain columns that use the (+) operator. For example, the following join condition returns a syntax error:

  ```
  event.eventid*10(+)=category.catid
  ```

  However, the following join condition is valid:

```
event.eventid(+)*10=category.catid
```

- You can't use the (+) operator in a query block that also contains FROM clause join syntax.
- If two tables are joined over multiple join conditions, you must use the (+) operator in all or none of these conditions. A join with mixed syntax styles runs as an inner join, without warning.
- The (+) operator doesn't produce an outer join if you join a table in the outer query with a table that results from an inner query.
- To use the (+) operator to outer-join a table to itself, you must define table aliases in the FROM clause and reference them in the join condition:

```
select count(*)
from event a, event b
where a.eventid(+)=b.catid;

count
-------
8798
(1 row)
```

- You can't combine a join condition that contains the (+) operator with an OR condition or an IN condition. For example:

```
select count(*) from sales, listing
where sales.listid(+)=listing.listid or sales.salesid=0;
ERROR:  Outer join operator (+) not allowed in operand of OR or IN.
```

- In a WHERE clause that outer-joins more than two tables, the (+) operator can be applied only once to a given table. In the following example, the SALES table can't be referenced with the (+) operator in two successive joins.

```
select count(*) from sales, listing, event
where sales.listid(+)=listing.listid and sales.dateid(+)=date.dateid;
ERROR:  A table may be outer joined to at most one other table.
```

- If the WHERE clause outer-join condition compares a column from TABLE2 with a constant, apply the (+) operator to the column. If you don't include the operator, the outer-joined rows from TABLE1, which contain nulls for the restricted column, are eliminated. See the Examples section below.

Examples

The following join query specifies a left outer join of the SALES and LISTING tables over their LISTID columns:

```
select count(*)
from sales, listing
where sales.listid = listing.listid(+);

count
--------
172456
(1 row)
```

The following equivalent query produces the same result but uses FROM clause join syntax:

```
select count(*)
from sales left outer join listing on sales.listid = listing.listid;

count
--------
172456
(1 row)
```

The SALES table doesn't contain records for all listings in the LISTING table because not all listings result in sales. The following query outer-joins SALES and LISTING and returns rows from LISTING even when the SALES table reports no sales for a given list ID. The PRICE and COMM columns, derived from the SALES table, contain nulls in the result set for those non-matching rows.

```
select listing.listid, sum(pricepaid) as price,
sum(commission) as comm
from listing, sales
where sales.listid(+) = listing.listid and listing.listid between 1 and 5
group by 1 order by 1;

listid | price  |  comm
--------+--------+--------
1 | 728.00 | 109.20
2 |        |
3 |        |
4 |  76.00 |  11.40
5 | 525.00 |  78.75
```

```
(5 rows)
```

Note that when the WHERE clause join operator is used, the order of the tables in the FROM clause doesn't matter.

An example of a more complex outer join condition in the WHERE clause is the case where the condition consists of a comparison between two table columns *and* a comparison with a constant:

```
where category.catid=event.catid(+) and eventid(+)=796;
```

Note that the (+) operator is used in two places: first in the equality comparison between the tables and second in the comparison condition for the EVENTID column. The result of this syntax is the preservation of the outer-joined rows when the restriction on EVENTID is evaluated. If you remove the (+) operator from the EVENTID restriction, the query treats this restriction as a filter, not as part of the outer-join condition. In turn, the outer-joined rows that contain nulls for EVENTID are eliminated from the result set.

Here is a complete query that illustrates this behavior:

```
select catname, catgroup, eventid
from category, event
where category.catid=event.catid(+) and eventid(+)=796;

catname | catgroup | eventid
-----------+----------+---------
Classical | Concerts |
Jazz | Concerts |
MLB | Sports   |
MLS | Sports   |
Musicals | Shows    | 796
NBA | Sports   |
NFL | Sports   |
NHL | Sports   |
Opera | Shows    |
Plays | Shows    |
Pop | Concerts |
(11 rows)
```

The equivalent query using FROM clause syntax is as follows:

```
select catname, catgroup, eventid
```

```
from category left join event
on category.catid=event.catid and eventid=796;
```

If you remove the second (+) operator from the WHERE clause version of this query, it returns only 1 row (the row where `eventid=796`).

```
select catname, catgroup, eventid
from category, event
where category.catid=event.catid(+) and eventid=796;

catname | catgroup | eventid
-----------+----------+---------
Musicals | Shows    | 796
(1 row)
```

GROUP BY clause

The GROUP BY clause identifies the grouping columns for the query. It is used to group together those rows in a table that have the same values in all the columns listed. The order in which the columns are listed does not matter. The outcome is to combine each set of rows having common values into one group row that represents all rows in the group. Use a GROUP BY to eliminate redundancy in the output and to compute aggregates that apply to the groups. Grouping columns must be declared when the query computes aggregates with standard functions such as SUM, AVG, and COUNT. For more information, see Aggregate functions.

Syntax

```
[ GROUP BY  expression [, ...] | ALL | aggregation_extension  ]
```

where *aggregation_extension* is one of the following:

```
GROUPING SETS ( () | aggregation_extension [, ...] ) |
ROLLUP ( expr [, ...] ) |
CUBE ( expr [, ...] )
```

Parameters

expression

The list of columns or expressions must match the list of non-aggregate expressions in the select list of the query. For example, consider the following simple query.

```
select listid, eventid, sum(pricepaid) as revenue,
count(qtysold) as numtix
from sales
group by listid, eventid
order by 3, 4, 2, 1
limit 5;

listid | eventid | revenue | numtix
-------+---------+---------+--------
89397  |      47 |   20.00 |      1
106590 |      76 |   20.00 |      1
124683 |     393 |   20.00 |      1
103037 |     403 |   20.00 |      1
147685 |     429 |   20.00 |      1
(5 rows)
```

In this query, the select list consists of two aggregate expressions. The first uses the SUM function and the second uses the COUNT function. The remaining two columns, LISTID and EVENTID, must be declared as grouping columns.

Expressions in the GROUP BY clause can also reference the select list by using ordinal numbers. For example, the previous example could be abbreviated as follows.

```
select listid, eventid, sum(pricepaid) as revenue,
count(qtysold) as numtix
from sales
group by 1,2
order by 3, 4, 2, 1
limit 5;

listid | eventid | revenue | numtix
-------+---------+---------+--------
89397  |      47 |   20.00 |      1
106590 |      76 |   20.00 |      1
124683 |     393 |   20.00 |      1
103037 |     403 |   20.00 |      1
147685 |     429 |   20.00 |      1
(5 rows)
```

ALL

ALL indicates to group by all columns specified in the SELECT list except those that are aggregated. For example, consider the following query which groups by `col1` and `col2` without having to specify them individually in the GROUP BY clause. The column `col3` is the argument of the `SUM` function and thus not grouped.

```
SELECT col1, col2 sum(col3) FROM testtable GROUP BY ALL
```

If you EXCLUDE a column in the SELECT list, the GROUP BY ALL clause does not group the results based on that specific column.

```
SELECT * EXCLUDE col3 FROM testtable GROUP BY ALL
```

aggregation_extension

You can use the aggregation extensions GROUPING SETS, ROLLUP, and CUBE to perform the work of multiple GROUP BY operations in a single statement. For more information on aggregation extensions and related functions, see Aggregation extensions.

Examples

The following examples use the SALES table that contains columns: salesid, listid, sellerid, buyerid, eventid, dateid, qtysold, pricepaid, commission, and saletime. For more information about the SALES table, see Sample database.

The following example query groups by `salesid` and `listid` without having to specify them individually in the GROUP BY clause. The column `qtysold` is the argument of the `SUM` function and thus not grouped.

```
SELECT salesid, listid, sum(qtysold) FROM sales GROUP BY ALL;

salesid | listid  | sum
--------+---------+------
33095   | 36572   | 2
88268   | 100813  | 4
110917  | 127048  | 1
...
```

The following example query excludes several columns in the SELECT list, so GROUP BY ALL only groups salesid and listid.

```
SELECT * EXCLUDE sellerid, buyerid, eventid, dateid, qtysold, pricepaid, commission,
 saletime
FROM sales GROUP BY ALL;

salesid | listid
--------+---------
33095   | 36572
88268   | 100813
110917  | 127048
...
```

Aggregation extensions

Amazon Redshift supports aggregation extensions to do the work of multiple GROUP BY operations in a single statement.

The examples for aggregation extensions use the `orders` table, which holds sales data for an electronics company. You can create `orders` with the following.

```
CREATE TABLE ORDERS (
    ID INT,
    PRODUCT CHAR(20),
    CATEGORY CHAR(20),
    PRE_OWNED CHAR(1),
    COST DECIMAL
);

INSERT INTO ORDERS VALUES
    (0, 'laptop',       'computers',    'T', 1000),
    (1, 'smartphone',   'cellphones',   'T', 800),
    (2, 'smartphone',   'cellphones',   'T', 810),
    (3, 'laptop',       'computers',    'F', 1050),
    (4, 'mouse',        'computers',    'F', 50);
```

GROUPING SETS

Computes one or more grouping sets in a single statement. A grouping set is the set of a single GROUP BY clause, a set of 0 or more columns by which you can group a query's result set. GROUP

BY GROUPING SETS is equivalent to running a UNION ALL query on one result set grouped by different columns. For example, GROUP BY GROUPING SETS((a), (b)) is equivalent to GROUP BY a UNION ALL GROUP BY b.

The following example returns the cost of the order table's products grouped according to both the products' categories and the kind of products sold.

```
SELECT category, product, sum(cost) as total
FROM orders
GROUP BY GROUPING SETS(category, product);

       category       |       product        | total
----------------------+----------------------+-------
 computers            |                      |  2100
 cellphones           |                      |  1610
                      | laptop               |  2050
                      | smartphone           |  1610
                      | mouse                |    50

(5 rows)
```

ROLLUP

Assumes a hierarchy where preceding columns are considered the parents of subsequent columns. ROLLUP groups data by the provided columns, returning extra subtotal rows representing the totals throughout all levels of grouping columns, in addition to the grouped rows. For example, you can use GROUP BY ROLLUP((a), (b)) to return a result set grouped first by a, then by b while assuming that b is a subsection of a. ROLLUP also returns a row with the whole result set without grouping columns.

GROUP BY ROLLUP((a), (b)) is equivalent to GROUP BY GROUPING SETS((a,b), (a), ()).

The following example returns the cost of the order table's products grouped first by category and then product, with product as a subdivision of category.

```
SELECT category, product, sum(cost) as total
FROM orders
GROUP BY ROLLUP(category, product) ORDER BY 1,2;

       category       |       product        | total
```

```
----------------------+----------------------+-------
 cellphones           | smartphone           |  1610
 cellphones           |                      |  1610
 computers            | laptop               |  2050
 computers            | mouse                |    50
 computers            |                      |  2100
                      |                      |  3710
(6 rows)
```

CUBE

Groups data by the provided columns, returning extra subtotal rows representing the totals throughout all levels of grouping columns, in addition to the grouped rows. CUBE returns the same rows as ROLLUP, while adding additional subtotal rows for every combination of grouping column not covered by ROLLUP. For example, you can use GROUP BY CUBE ((a), (b)) to return a result set grouped first by a, then by b while assuming that b is a subsection of a, then by b alone. CUBE also returns a row with the whole result set without grouping columns.

GROUP BY CUBE((a), (b)) is equivalent to GROUP BY GROUPING SETS((a, b), (a), (b), ()).

The following example returns the cost of the order table's products grouped first by category and then product, with product as a subdivision of category. Unlike the preceding example for ROLLUP, the statement returns results for every combination of grouping column.

```
SELECT category, product, sum(cost) as total
FROM orders
GROUP BY CUBE(category, product) ORDER BY 1,2;

       category       |       product        | total
----------------------+----------------------+-------
 cellphones           | smartphone           |  1610
 cellphones           |                      |  1610
 computers            | laptop               |  2050
 computers            | mouse                |    50
 computers            |                      |  2100
                      | laptop               |  2050
                      | mouse                |    50
                      | smartphone           |  1610
                      |                      |  3710
(9 rows)
```

GROUPING/GROUPING_ID functions

ROLLUP and CUBE add NULL values to the result set to indicate subtotal rows. For example, GROUP BY ROLLUP((a), (b)) returns one or more rows that have a value of NULL in the b grouping column to indicate they are subtotals of fields in the a grouping column. These NULL values serve only to satisfy the format of returning tuples.

When you run GROUP BY operations with ROLLUP and CUBE on relations that store NULL values themselves, this can produce result sets with rows that appear to have identical grouping columns. Returning to the previous example, if the b grouping column contains a stored NULL value, GROUP BY ROLLUP((a), (b)) returns a row with a value of NULL in the b grouping column that isn't a subtotal.

To distinguish between NULL values created by ROLLUP and CUBE, and the NULL values stored in the tables themselves, you can use the GROUPING function, or its alias GROUPING_ID. GROUPING takes a single grouping set as its argument, and for each row in the result set returns a 0 or 1 bit value corresponding to the grouping column in that position, and then converts that value into an integer. If the value in that position is a NULL value created by an aggregation extension, GROUPING returns 1. It returns 0 for all other values, including stored NULL values.

For example, GROUPING(category, product) can return the following values for a given row, depending on the grouping column values for that row. For the purposes of this example, all NULL values in the table are NULL values created by an aggregation extension.

category column	product column	GROUPING function bit value	Decimal value
not NULL	not NULL	00	0
not NULL	NULL	01	1
NULL	not NULL	10	2
NULL	NULL	11	3

GROUPING functions appear in the SELECT list portion of the query in the following format.

```
SELECT ... [GROUPING( expr )...] ...
```

```
GROUP BY ... {CUBE | ROLLUP| GROUPING SETS} ( expr ) ...
```

The following example is the same as the preceding example for CUBE, but with the addition of GROUPING functions for its grouping sets.

```
SELECT category, product,
       GROUPING(category) as grouping0,
       GROUPING(product) as grouping1,
       GROUPING(category, product) as grouping2,
       sum(cost) as total
FROM orders
GROUP BY CUBE(category, product) ORDER BY 3,1,2;

       category       |       product        | grouping0 | grouping1 | grouping2 |
 total
----------------------+----------------------+-----------+-----------+-----------
+-------
 cellphones           | smartphone           |         0 |         0 |         0 |
 1610
 cellphones           |                      |         0 |         1 |         1 |
 1610
 computers            | laptop               |         0 |         0 |         0 |
 2050
 computers            | mouse                |         0 |         0 |         0 |
 50
 computers            |                      |         0 |         1 |         1 |
 2100
                      | laptop               |         1 |         0 |         2 |
 2050
                      | mouse                |         1 |         0 |         2 |
 50
                      | smartphone           |         1 |         0 |         2 |
 1610
                      |                      |         1 |         1 |         3 |
 3710
(9 rows)
```

Partial ROLLUP and CUBE

You can run ROLLUP and CUBE operations with only a portion of the subtotals.

The syntax for partial ROLLUP and CUBE operations is as follows.

```
GROUP BY expr1, { ROLLUP | CUBE }(expr2, [, ...])
```

Here, the GROUP BY clause only creates subtotal rows at the level of *expr2* and onwards.

The following examples show partial ROLLUP and CUBE operations on the orders table, grouping first by whether a product is pre-owned and then running ROLLUP and CUBE on the category and product columns.

```
SELECT pre_owned, category, product,
       GROUPING(category, product, pre_owned) as group_id,
       sum(cost) as total
FROM orders
GROUP BY pre_owned, ROLLUP(category, product) ORDER BY 4,1,2,3;

 pre_owned |       category       |       product        | group_id | total
-----------+----------------------+----------------------+----------+-------
 F         | computers            | laptop               |        0 |  1050
 F         | computers            | mouse                |        0 |    50
 T         | cellphones           | smartphone           |        0 |  1610
 T         | computers            | laptop               |        0 |  1000
 F         | computers            |                      |        2 |  1100
 T         | cellphones           |                      |        2 |  1610
 T         | computers            |                      |        2 |  1000
 F         |                      |                      |        6 |  1100
 T         |                      |                      |        6 |  2610
(9 rows)

SELECT pre_owned, category, product,
       GROUPING(category, product, pre_owned) as group_id,
       sum(cost) as total
FROM orders
GROUP BY pre_owned, CUBE(category, product) ORDER BY 4,1,2,3;

 pre_owned |       category       |       product        | group_id | total
-----------+----------------------+----------------------+----------+-------
 F         | computers            | laptop               |        0 |  1050
 F         | computers            | mouse                |        0 |    50
 T         | cellphones           | smartphone           |        0 |  1610
 T         | computers            | laptop               |        0 |  1000
 F         | computers            |                      |        2 |  1100
 T         | cellphones           |                      |        2 |  1610
 T         | computers            |                      |        2 |  1000
 F         |                      | laptop               |        4 |  1050
```

```
 F          |                      | mouse                |        4 |    50
 T          |                      | laptop               |        4 |  1000
 T          |                      | smartphone           |        4 |  1610
 F          |                      |                      |        6 |  1100
 T          |                      |                      |        6 |  2610
(13 rows)
```

Since the pre-owned column isn't included in the ROLLUP and CUBE operations, there's no grand total row that includes all other rows.

Concatenated grouping

You can concatenate multiple GROUPING SETS/ROLLUP/CUBE clauses to calculate different levels of subtotals. Concatenated groupings return the Cartesian product of the provided grouping sets.

The syntax for concatenating GROUPING SETS/ROLLUP/CUBE clauses is as follows.

```
GROUP BY {ROLLUP|CUBE|GROUPING SETS}(expr1[, ...]),
         {ROLLUP|CUBE|GROUPING SETS}(expr1[, ...])[, ...]
```

Consider the following example to see how a small concatenated grouping can produce a large final result set.

```
SELECT pre_owned, category, product,
       GROUPING(category, product, pre_owned) as group_id,
       sum(cost) as total
FROM orders
GROUP BY CUBE(category, product), GROUPING SETS(pre_owned, ())
ORDER BY 4,1,2,3;

 pre_owned |       category       |       product        | group_id | total
-----------+----------------------+----------------------+----------+-------
 F          | computers            | laptop               |        0 |  1050
 F          | computers            | mouse                |        0 |    50
 T          | cellphones           | smartphone           |        0 |  1610
 T          | computers            | laptop               |        0 |  1000
            | cellphones           | smartphone           |        1 |  1610
            | computers            | laptop               |        1 |  2050
            | computers            | mouse                |        1 |    50
 F          | computers            |                      |        2 |  1100
 T          | cellphones           |                      |        2 |  1610
 T          | computers            |                      |        2 |  1000
```

```
            | cellphones           |                      |          3 |  1610
            | computers            |                      |          3 |  2100
 F          |                      | laptop               |          4 |  1050
 F          |                      | mouse                |          4 |    50
 T          |                      | laptop               |          4 |  1000
 T          |                      | smartphone           |          4 |  1610
            |                      | laptop               |          5 |  2050
            |                      | mouse                |          5 |    50
            |                      | smartphone           |          5 |  1610
 F          |                      |                      |          6 |  1100
 T          |                      |                      |          6 |  2610
            |                      |                      |          7 |  3710
(22 rows)
```

Nested grouping

You can use GROUPING SETS/ROLLUP/CUBE operations as your GROUPING SETS *expr* to form a nested grouping. The sub grouping inside nested GROUPING SETS is flattened.

The syntax for nested grouping is as follows.

```
GROUP BY GROUPING SETS({ROLLUP|CUBE|GROUPING SETS}(expr[, ...])[, ...])
```

Consider the following example.

```
SELECT category, product, pre_owned,
       GROUPING(category, product, pre_owned) as group_id,
       sum(cost) as total
FROM orders
GROUP BY GROUPING SETS(ROLLUP(category), CUBE(product, pre_owned))
ORDER BY 4,1,2,3;

       category       |       product        | pre_owned | group_id | total
----------------------+----------------------+-----------+----------+-------
 cellphones           |                      |           |        3 |  1610
 computers            |                      |           |        3 |  2100
                      | laptop               | F         |        4 |  1050
                      | laptop               | T         |        4 |  1000
                      | mouse                | F         |        4 |    50
                      | smartphone           | T         |        4 |  1610
                      | laptop               |           |        5 |  2050
                      | mouse                |           |        5 |    50
                      | smartphone           |           |        5 |  1610
```

```
                        |                       | F           |         6 |  1100
                        |                       | T           |         6 |  2610
                        |                       |             |         7 |  3710
                        |                       |             |         7 |  3710
(13 rows)
```

Note that because both ROLLUP(category) and CUBE(product, pre_owned) contain the grouping set (), the row representing the grand total is duplicated.

Usage notes

- The GROUP BY clause supports up to 64 grouping sets. In the case of ROLLUP and CUBE, or some combination of GROUPING SETS, ROLLUP, and CUBE, this limitation applies to the implied number of grouping sets. For example, GROUP BY CUBE((a), (b)) counts as 4 grouping sets, not 2.
- You can't use constants as grouping columns when using aggregation extensions.
- You can't make a grouping set that contains duplicate columns.

HAVING clause

The HAVING clause applies a condition to the intermediate grouped result set that a query returns.

Syntax

```
[ HAVING condition ]
```

For example, you can restrict the results of a SUM function:

```
having sum(pricepaid) >10000
```

The HAVING condition is applied after all WHERE clause conditions are applied and GROUP BY operations are completed.

The condition itself takes the same form as any WHERE clause condition.

Usage notes

- Any column that is referenced in a HAVING clause condition must be either a grouping column or a column that refers to the result of an aggregate function.
- In a HAVING clause, you can't specify:

- An ordinal number that refers to a select list item. Only the GROUP BY and ORDER BY clauses accept ordinal numbers.

Examples

The following query calculates total ticket sales for all events by name, then eliminates events where the total sales were less than $800,000. The HAVING condition is applied to the results of the aggregate function in the select list: `sum(pricepaid)`.

```
select eventname, sum(pricepaid)
from sales join event on sales.eventid = event.eventid
group by 1
having sum(pricepaid) > 800000
order by 2 desc, 1;

eventname        |    sum
-----------------+-----------
Mamma Mia!       | 1135454.00
Spring Awakening |  972855.00
The Country Girl |  910563.00
Macbeth          |  862580.00
Jersey Boys      |  811877.00
Legally Blonde   |  804583.00
```

The following query calculates a similar result set. In this case, however, the HAVING condition is applied to an aggregate that isn't specified in the select list: `sum(qtysold)`. Events that did not sell more than 2,000 tickets are eliminated from the final result.

```
select eventname, sum(pricepaid)
from sales join event on sales.eventid = event.eventid
group by 1
having sum(qtysold) >2000
order by 2 desc, 1;

eventname        |    sum
-----------------+-----------
Mamma Mia!       | 1135454.00
Spring Awakening |  972855.00
The Country Girl |  910563.00
Macbeth          |  862580.00
Jersey Boys      |  811877.00
```

```
Legally Blonde    |   804583.00
Chicago           |   790993.00
Spamalot          |   714307.00
```

The following query calculates total ticket sales for all events by name, then eliminates events where the total sales were less than $800,000. The HAVING condition is applied to the results of the aggregate function in the select list using the alias pp for `sum(pricepaid)`.

```
select eventname, sum(pricepaid) as pp
from sales join event on sales.eventid = event.eventid
group by 1
having pp > 800000
order by 2 desc, 1;

eventname         |    pp
------------------+-----------
Mamma Mia!        | 1135454.00
Spring Awakening  |  972855.00
The Country Girl  |  910563.00
Macbeth           |  862580.00
Jersey Boys       |  811877.00
Legally Blonde    |  804583.00
```

QUALIFY clause

The QUALIFY clause filters results of a previously computed window function according to user-specified search conditions. You can use the clause to apply filtering conditions to the result of a window function without using a subquery.

It is similar to the HAVING clause, which applies a condition to further filter rows from a WHERE clause. The difference between QUALIFY and HAVING is that filtered results from the QUALIFY clause could be based on the result of running window functions on the data. You can use both the QUALIFY and HAVING clauses in one query.

Syntax

```
QUALIFY condition
```

Note

If you're using the QUALIFY clause directly after the FROM clause, the FROM relation name must have an alias specified before the QUALIFY clause.

Examples

The examples in this section use the sample data below.

```
create table store_sales (ss_sold_date date, ss_sold_time time,
               ss_item text, ss_sales_price float);
insert into store_sales values ('2022-01-01', '09:00:00', 'Product 1', 100.0),
                               ('2022-01-01', '11:00:00', 'Product 2', 500.0),
                               ('2022-01-01', '15:00:00', 'Product 3', 20.0),
                               ('2022-01-01', '17:00:00', 'Product 4', 1000.0),
                               ('2022-01-01', '18:00:00', 'Product 5', 30.0),
                               ('2022-01-02', '10:00:00', 'Product 6', 5000.0),
                               ('2022-01-02', '16:00:00', 'Product 7', 5.0);
```

The following example demonstrates how to find the two most expensive items sold after 12:00 each day.

```
SELECT *
FROM store_sales ss
WHERE ss_sold_time > time '12:00:00'
QUALIFY row_number()
OVER (PARTITION BY ss_sold_date ORDER BY ss_sales_price DESC) <= 2


 ss_sold_date | ss_sold_time |  ss_item  | ss_sales_price
--------------+--------------+-----------+----------------
 2022-01-01   | 17:00:00     | Product 4 |           1000
 2022-01-01   | 18:00:00     | Product 5 |             30
 2022-01-02   | 16:00:00     | Product 7 |              5
```

You can then find the last item sold each day.

```
SELECT *
FROM store_sales ss
QUALIFY last_value(ss_item)
OVER (PARTITION BY ss_sold_date ORDER BY ss_sold_time ASC
```

```
      ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING) = ss_item;

ss_sold_date | ss_sold_time |  ss_item   | ss_sales_price
--------------+--------------+-----------+----------------
 2022-01-01   | 18:00:00     | Product 5 |             30
 2022-01-02   | 16:00:00     | Product 7 |              5
```

The following example returns the same records as the previous query, the last item sold each day, but it doesn't use the QUALIFY clause.

```
SELECT * FROM (
  SELECT *,
  last_value(ss_item)
  OVER (PARTITION BY ss_sold_date ORDER BY ss_sold_time ASC
        ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING) ss_last_item
  FROM store_sales ss
)
WHERE ss_last_item = ss_item;

 ss_sold_date | ss_sold_time |  ss_item   | ss_sales_price | ss_last_item
--------------+--------------+-----------+----------------+--------------
 2022-01-02   | 16:00:00     | Product 7 |              5 | Product 7
 2022-01-01   | 18:00:00     | Product 5 |             30 | Product 5
```

UNION, INTERSECT, and EXCEPT

Topics

- Syntax
- Parameters
- Order of evaluation for set operators
- Usage notes
- Example UNION queries
- Example UNION ALL query
- Example INTERSECT queries
- Example EXCEPT query

The UNION, INTERSECT, and EXCEPT *set operators* are used to compare and merge the results of two separate query expressions. For example, if you want to know which users of a website are both buyers and sellers but their user names are stored in separate columns or tables, you can find the *intersection* of these two types of users. If you want to know which website users are buyers but not sellers, you can use the EXCEPT operator to find the *difference* between the two lists of users. If you want to build a list of all users, regardless of role, you can use the UNION operator.

Syntax

```
query
{ UNION [ ALL ] | INTERSECT | EXCEPT | MINUS }
query
```

Parameters

query

A query expression that corresponds, in the form of its select list, to a second query expression that follows the UNION, INTERSECT, or EXCEPT operator. The two expressions must contain the same number of output columns with compatible data types; otherwise, the two result sets can't be compared and merged. Set operations don't allow implicit conversion between different categories of data types; for more information, see Type compatibility and conversion.

You can build queries that contain an unlimited number of query expressions and link them with UNION, INTERSECT, and EXCEPT operators in any combination. For example, the following query structure is valid, assuming that the tables T1, T2, and T3 contain compatible sets of columns:

```
select * from t1
union
select * from t2
except
select * from t3
order by c1;
```

UNION

Set operation that returns rows from two query expressions, regardless of whether the rows derive from one or both expressions.

INTERSECT

Set operation that returns rows that derive from two query expressions. Rows that aren't returned by both expressions are discarded.

EXCEPT | MINUS

Set operation that returns rows that derive from one of two query expressions. To qualify for the result, rows must exist in the first result table but not the second. MINUS and EXCEPT are exact synonyms.

ALL

The ALL keyword retains any duplicate rows that are produced by UNION. The default behavior when the ALL keyword isn't used is to discard these duplicates. INTERSECT ALL, EXCEPT ALL, and MINUS ALL aren't supported.

Order of evaluation for set operators

The UNION and EXCEPT set operators are left-associative. If parentheses aren't specified to influence the order of precedence, a combination of these set operators is evaluated from left to right. For example, in the following query, the UNION of T1 and T2 is evaluated first, then the EXCEPT operation is performed on the UNION result:

```
select * from t1
union
select * from t2
except
select * from t3
order by c1;
```

The INTERSECT operator takes precedence over the UNION and EXCEPT operators when a combination of operators is used in the same query. For example, the following query evaluates the intersection of T2 and T3, then union the result with T1:

```
select * from t1
union
select * from t2
intersect
select * from t3
order by c1;
```

By adding parentheses, you can enforce a different order of evaluation. In the following case, the result of the union of T1 and T2 is intersected with T3, and the query is likely to produce a different result.

```
(select * from t1
union
select * from t2)
intersect
(select * from t3)
order by c1;
```

Usage notes

- The column names returned in the result of a set operation query are the column names (or aliases) from the tables in the first query expression. Because these column names are potentially misleading, in that the values in the column derive from tables on either side of the set operator, you might want to provide meaningful aliases for the result set.
- A query expression that precedes a set operator should not contain an ORDER BY clause. An ORDER BY clause produces meaningful sorted results only when it is used at the end of a query that contains set operators. In this case, the ORDER BY clause applies to the final results of all of the set operations. The outermost query can also contain standard LIMIT and OFFSET clauses.
- When set operator queries return decimal results, the corresponding result columns are promoted to return the same precision and scale. For example, in the following query, where T1.REVENUE is a DECIMAL(10,2) column and T2.REVENUE is a DECIMAL(8,4) column, the decimal result is promoted to DECIMAL(12,4):

  ```
  select t1.revenue union select t2.revenue;
  ```

  The scale is 4 because that is the maximum scale of the two columns. The precision is 12 because T1.REVENUE requires 8 digits to the left of the decimal point (12 - 4 = 8). This type promotion ensures that all values from both sides of the UNION fit in the result. For 64-bit values, the maximum result precision is 19 and the maximum result scale is 18. For 128-bit values, the maximum result precision is 38 and the maximum result scale is 37.

  If the resulting data type exceeds Amazon Redshift precision and scale limits, the query returns an error.
- For set operations, two rows are treated as identical if, for each corresponding pair of columns, the two data values are either *equal* or *both NULL*. For example, if tables T1 and T2 both contain

one column and one row, and that row is NULL in both tables, an INTERSECT operation over those tables returns that row.

Example UNION queries

In the following UNION query, rows in the SALES table are merged with rows in the LISTING table. Three compatible columns are selected from each table; in this case, the corresponding columns have the same names and data types.

The final result set is ordered by the first column in the LISTING table and limited to the 5 rows with the highest LISTID value.

```
select listid, sellerid, eventid from listing
union select listid, sellerid, eventid from sales
order by listid, sellerid, eventid desc limit 5;

listid | sellerid | eventid
--------+----------+---------
1 |    36861 |    7872
2 |    16002 |    4806
3 |    21461 |    4256
4 |     8117 |    4337
5 |     1616 |    8647
(5 rows)
```

The following example shows how you can add a literal value to the output of a UNION query so you can see which query expression produced each row in the result set. The query identifies rows from the first query expression as "B" (for buyers) and rows from the second query expression as "S" (for sellers).

The query identifies buyers and sellers for ticket transactions that cost $10,000 or more. The only difference between the two query expressions on either side of the UNION operator is the joining column for the SALES table.

```
select listid, lastname, firstname, username,
pricepaid as price, 'S' as buyorsell
from sales, users
where sales.sellerid=users.userid
and pricepaid >=10000
union
select listid, lastname, firstname, username, pricepaid,
```

```
'B' as buyorsell
from sales, users
where sales.buyerid=users.userid
and pricepaid >=10000
order by 1, 2, 3, 4, 5;

listid | lastname | firstname | username |   price   | buyorsell
--------+----------+-----------+----------+-----------+-----------
209658 | Lamb     | Colette   | VOR15LYI |  10000.00 | B
209658 | West     | Kato      | ELU81XAA |  10000.00 | S
212395 | Greer    | Harlan    | GXO71KOC |  12624.00 | S
212395 | Perry    | Cora      | YWR73YNZ |  12624.00 | B
215156 | Banks    | Patrick   | ZNQ69CLT |  10000.00 | S
215156 | Hayden   | Malachi   | BBG56AKU |  10000.00 | B
(6 rows)
```

The following example uses a UNION ALL operator because duplicate rows, if found, need to be retained in the result. For a specific series of event IDs, the query returns 0 or more rows for each sale associated with each event, and 0 or 1 row for each listing of that event. Event IDs are unique to each row in the LISTING and EVENT tables, but there might be multiple sales for the same combination of event and listing IDs in the SALES table.

The third column in the result set identifies the source of the row. If it comes from the SALES table, it is marked "Yes" in the SALESROW column. (SALESROW is an alias for SALES.LISTID.) If the row comes from the LISTING table, it is marked "No" in the SALESROW column.

In this case, the result set consists of three sales rows for listing 500, event 7787. In other words, three different transactions took place for this listing and event combination. The other two listings, 501 and 502, did not produce any sales, so the only row that the query produces for these list IDs comes from the LISTING table (SALESROW = 'No').

```
select eventid, listid, 'Yes' as salesrow
from sales
where listid in(500,501,502)
union all
select eventid, listid, 'No'
from listing
where listid in(500,501,502)
order by listid asc;

eventid | listid | salesrow
---------+--------+----------
```

```
7787 |    500 | No
7787 |    500 | Yes
7787 |    500 | Yes
7787 |    500 | Yes
6473 |    501 | No
5108 |    502 | No
(6 rows)
```

If you run the same query without the ALL keyword, the result retains only one of the sales transactions.

```
select eventid, listid, 'Yes' as salesrow
from sales
where listid in(500,501,502)
union
select eventid, listid, 'No'
from listing
where listid in(500,501,502)
order by listid asc;

eventid | listid | salesrow
---------+--------+----------
7787 |    500 | No
7787 |    500 | Yes
6473 |    501 | No
5108 |    502 | No
(4 rows)
```

Example UNION ALL query

The following example uses a UNION ALL operator because duplicate rows, if found, need to be retained in the result. For a specific series of event IDs, the query returns 0 or more rows for each sale associated with each event, and 0 or 1 row for each listing of that event. Event IDs are unique to each row in the LISTING and EVENT tables, but there might be multiple sales for the same combination of event and listing IDs in the SALES table.

The third column in the result set identifies the source of the row. If it comes from the SALES table, it is marked "Yes" in the SALESROW column. (SALESROW is an alias for SALES.LISTID.) If the row comes from the LISTING table, it is marked "No" in the SALESROW column.

In this case, the result set consists of three sales rows for listing 500, event 7787. In other words, three different transactions took place for this listing and event combination. The other two listings, 501 and 502, did not produce any sales, so the only row that the query produces for these list IDs comes from the LISTING table (SALESROW = 'No').

```
select eventid, listid, 'Yes' as salesrow
from sales
where listid in(500,501,502)
union all
select eventid, listid, 'No'
from listing
where listid in(500,501,502)
order by listid asc;

eventid | listid | salesrow
---------+--------+----------
7787 |    500 | No
7787 |    500 | Yes
7787 |    500 | Yes
7787 |    500 | Yes
6473 |    501 | No
5108 |    502 | No
(6 rows)
```

If you run the same query without the ALL keyword, the result retains only one of the sales transactions.

```
select eventid, listid, 'Yes' as salesrow
from sales
where listid in(500,501,502)
union
select eventid, listid, 'No'
from listing
where listid in(500,501,502)
order by listid asc;

eventid | listid | salesrow
---------+--------+----------
7787 |    500 | No
7787 |    500 | Yes
6473 |    501 | No
5108 |    502 | No
(4 rows)
```

Example INTERSECT queries

Compare the following example with the first UNION example. The only difference between the two examples is the set operator that is used, but the results are very different. Only one of the rows is the same:

```
235494 |    23875 |    8771
```

This is the only row in the limited result of 5 rows that was found in both tables.

```
select listid, sellerid, eventid from listing
intersect
select listid, sellerid, eventid from sales
order by listid desc, sellerid, eventid
limit 5;

listid | sellerid | eventid
--------+----------+---------
235494 |    23875 |    8771
235482 |     1067 |    2667
235479 |     1589 |    7303
235476 |    15550 |     793
235475 |    22306 |    7848
(5 rows)
```

The following query finds events (for which tickets were sold) that occurred at venues in both New York City and Los Angeles in March. The difference between the two query expressions is the constraint on the VENUECITY column.

```
select distinct eventname from event, sales, venue
where event.eventid=sales.eventid and event.venueid=venue.venueid
and date_part(month,starttime)=3 and venuecity='Los Angeles'
intersect
select distinct eventname from event, sales, venue
where event.eventid=sales.eventid and event.venueid=venue.venueid
and date_part(month,starttime)=3 and venuecity='New York City'
order by eventname asc;

eventname
----------------------------
A Streetcar Named Desire
Dirty Dancing
```

```
Electra
Running with Annalise
Hairspray
Mary Poppins
November
Oliver!
Return To Forever
Rhinoceros
South Pacific
The 39 Steps
The Bacchae
The Caucasian Chalk Circle
The Country Girl
Wicked
Woyzeck
(16 rows)
```

Example EXCEPT query

The CATEGORY table in the TICKIT database contains the following 11 rows:

```
 catid | catgroup |  catname  |                  catdesc
-------+----------+-----------+--------------------------------------------
   1   | Sports   | MLB       | Major League Baseball
   2   | Sports   | NHL       | National Hockey League
   3   | Sports   | NFL       | National Football League
   4   | Sports   | NBA       | National Basketball Association
   5   | Sports   | MLS       | Major League Soccer
   6   | Shows    | Musicals  | Musical theatre
   7   | Shows    | Plays     | All non-musical theatre
   8   | Shows    | Opera     | All opera and light opera
   9   | Concerts | Pop       | All rock and pop music concerts
  10   | Concerts | Jazz      | All jazz singers and bands
  11   | Concerts | Classical | All symphony, concerto, and choir concerts
(11 rows)
```

Assume that a CATEGORY_STAGE table (a staging table) contains one additional row:

```
 catid | catgroup |  catname  |                  catdesc
-------+----------+-----------+--------------------------------------------
1 | Sports   | MLB       | Major League Baseball
2 | Sports   | NHL       | National Hockey League
3 | Sports   | NFL       | National Football League
```

```
4 | Sports    | NBA       | National Basketball Association
5 | Sports    | MLS       | Major League Soccer
6 | Shows     | Musicals  | Musical theatre
7 | Shows     | Plays     | All non-musical theatre
8 | Shows     | Opera     | All opera and light opera
9 | Concerts | Pop        | All rock and pop music concerts
10 | Concerts | Jazz       | All jazz singers and bands
11 | Concerts | Classical | All symphony, concerto, and choir concerts
12 | Concerts | Comedy     | All stand up comedy performances
(12 rows)
```

Return the difference between the two tables. In other words, return rows that are in the CATEGORY_STAGE table but not in the CATEGORY table:

```
select * from category_stage
except
select * from category;

catid | catgroup | catname |             catdesc
-------+----------+---------+----------------------------------
12 | Concerts | Comedy   | All stand up comedy performances
(1 row)
```

The following equivalent query uses the synonym MINUS.

```
select * from category_stage
minus
select * from category;

catid | catgroup | catname |             catdesc
-------+----------+---------+----------------------------------
12 | Concerts | Comedy   | All stand up comedy performances
(1 row)
```

If you reverse the order of the SELECT expressions, the query returns no rows.

ORDER BY clause

Topics

- Usage notes
- Examples with ORDER BY

The ORDER BY clause sorts the result set of a query.

Syntax

```
[ ORDER BY expression [ ASC | DESC ] ]
[ NULLS FIRST | NULLS LAST ]
[ LIMIT { count | ALL } ]
[ OFFSET start ]
```

Parameters

expression

Expression that defines the sort order of the query result set, typically by specifying one or more columns in the select list. Results are returned based on binary UTF-8 ordering. You can also specify the following:

- Columns that aren't in the select list
- Expressions formed from one or more columns that exist in the tables referenced by the query
- Ordinal numbers that represent the position of select list entries (or the position of columns in the table if no select list exists)
- Aliases that define select list entries

When the ORDER BY clause contains multiple expressions, the result set is sorted according to the first expression, then the second expression is applied to rows that have matching values from the first expression, and so on.

ASC | DESC

Option that defines the sort order for the expression, as follows:

- ASC: ascending (for example, low to high for numeric values and 'A' to 'Z' for character strings). If no option is specified, data is sorted in ascending order by default.
- DESC: descending (high to low for numeric values; 'Z' to 'A' for strings).

NULLS FIRST | NULLS LAST

Option that specifies whether NULL values should be ordered first, before non-null values, or last, after non-null values. By default, NULL values are sorted and ranked last in ASC ordering, and sorted and ranked first in DESC ordering.

LIMIT *number* | ALL

Option that controls the number of sorted rows that the query returns. The LIMIT number must be a positive integer; the maximum value is `2147483647`.

LIMIT 0 returns no rows. You can use this syntax for testing purposes: to check that a query runs (without displaying any rows) or to return a column list from a table. An ORDER BY clause is redundant if you are using LIMIT 0 to return a column list. The default is LIMIT ALL.

OFFSET *start*

Option that specifies to skip the number of rows before *start* before beginning to return rows. The OFFSET number must be a positive integer; the maximum value is `2147483647`. When used with the LIMIT option, OFFSET rows are skipped before starting to count the LIMIT rows that are returned. If the LIMIT option isn't used, the number of rows in the result set is reduced by the number of rows that are skipped. The rows skipped by an OFFSET clause still have to be scanned, so it might be inefficient to use a large OFFSET value.

Usage notes

Note the following expected behavior with ORDER BY clauses:

- NULL values are considered "higher" than all other values. With the default ascending sort order, NULL values sort at the end. To change this behavior, use the NULLS FIRST option.
- When a query doesn't contain an ORDER BY clause, the system returns result sets with no predictable ordering of the rows. The same query run twice might return the result set in a different order.
- The LIMIT and OFFSET options can be used without an ORDER BY clause; however, to return a consistent set of rows, use these options in conjunction with ORDER BY.
- In any parallel system like Amazon Redshift, when ORDER BY doesn't produce a unique ordering, the order of the rows is nondeterministic. That is, if the ORDER BY expression produces duplicate values, the return order of those rows might vary from other systems or from one run of Amazon Redshift to the next.

- Amazon Redshift doesn't support string literals in ORDER BY clauses.

Examples with ORDER BY

Return all 11 rows from the CATEGORY table, ordered by the second column, CATGROUP. For results that have the same CATGROUP value, order the CATDESC column values by the length of the character string. Then order by columns CATID and CATNAME.

```
select * from category order by 2, length(catdesc), 1, 3;

catid | catgroup |  catname  |                  catdesc
------+----------+-----------+----------------------------------------
10    | Concerts | Jazz      | All jazz singers and bands
9     | Concerts | Pop       | All rock and pop music concerts
11    | Concerts | Classical | All symphony, concerto, and choir conce
6     | Shows    | Musicals  | Musical theatre
7     | Shows    | Plays     | All non-musical theatre
8     | Shows    | Opera     | All opera and light opera
5     | Sports   | MLS       | Major League Soccer
1     | Sports   | MLB       | Major League Baseball
2     | Sports   | NHL       | National Hockey League
3     | Sports   | NFL       | National Football League
4     | Sports   | NBA       | National Basketball Association
(11 rows)
```

Return selected columns from the SALES table, ordered by the highest QTYSOLD values. Limit the result to the top 10 rows:

```
select salesid, qtysold, pricepaid, commission, saletime from sales
order by qtysold, pricepaid, commission, salesid, saletime desc
limit 10;

salesid | qtysold | pricepaid | commission |      saletime
--------+---------+-----------+------------+---------------------
15401   |       8 |    272.00 |      40.80 | 2008-03-18 06:54:56
61683   |       8 |    296.00 |      44.40 | 2008-11-26 04:00:23
90528   |       8 |    328.00 |      49.20 | 2008-06-11 02:38:09
74549   |       8 |    336.00 |      50.40 | 2008-01-19 12:01:21
130232  |       8 |    352.00 |      52.80 | 2008-05-02 05:52:31
55243   |       8 |    384.00 |      57.60 | 2008-07-12 02:19:53
16004   |       8 |    440.00 |      66.00 | 2008-11-04 07:22:31
489     |       8 |    496.00 |      74.40 | 2008-08-03 05:48:55
```

```
4197     |        8 |     512.00 |       76.80 | 2008-03-23 11:35:33
16929    |        8 |     568.00 |       85.20 | 2008-12-19 02:59:33
(10 rows)
```

Return a column list and no rows by using LIMIT 0 syntax:

```
select * from venue limit 0;
venueid | venuename | venuecity | venuestate | venueseats
---------+-----------+-----------+------------+------------
(0 rows)
```

CONNECT BY clause

The CONNECT BY clause specifies the relationship between rows in a hierarchy. You can use CONNECT BY to select rows in a hierarchical order by joining the table to itself and processing the hierarchical data. For example, you can use it to recursively loop through an organization chart and list data.

Hierarchical queries process in the following order:

1. If the FROM clause has a join, it is processed first.
2. The CONNECT BY clause is evaluated.
3. The WHERE clause is evaluated.

Syntax

```
[START WITH start_with_conditions]
CONNECT BY connect_by_conditions
```

> **Note**
>
> While START and CONNECT are not reserved words, use delimited identifiers (double quotation marks) or AS if you're using START and CONNECT as table aliases in your query to avoid failure at runtime.

```
SELECT COUNT(*)
FROM Employee "start"
CONNECT BY PRIOR id = manager_id
```

```
START WITH name = 'John'
```

```
SELECT COUNT(*)
FROM Employee AS start
CONNECT BY PRIOR id = manager_id
START WITH name = 'John'
```

Parameters

start_with_conditions

Conditions that specify the root row(s) of the hierarchy

connect_by_conditions

Conditions that specify the relationship between parent rows and child rows of the hierarchy. At least one condition must be qualified with the unary operator used to refer to the parent row.

```
PRIOR column = expression
-- or
expression > PRIOR column
```

Operators

You can use the following operators in a CONNECT BY query.

LEVEL

Pseudocolumn that returns the current row level in the hierarchy. Returns 1 for the root row, 2 for the child of the root row, and so on.

PRIOR

Unary operator that evaluates the expression for the parent row of the current row in the hierarchy.

Examples

The following example is a CONNECT BY query that returns the number of employees that report directly or indirectly to John, no deeper than 4 levels.

```
SELECT id, name, manager_id
```

```
FROM employee
WHERE LEVEL < 4
START WITH name = 'John'
CONNECT BY PRIOR id = manager_id;
```

Following is the result of the query.

```
id      name      manager_id
------+----------+--------------
  101     John        100
  102     Jorge       101
  103     Kwaku       101
  110     Liu         101
  201     Sofía       102
  106     Mateo       102
  110     Nikki       103
  104     Paulo       103
  105     Richard     103
  120     Saanvi      104
  200     Shirley     104
  205     Zhang       104
```

Table definition for this example:

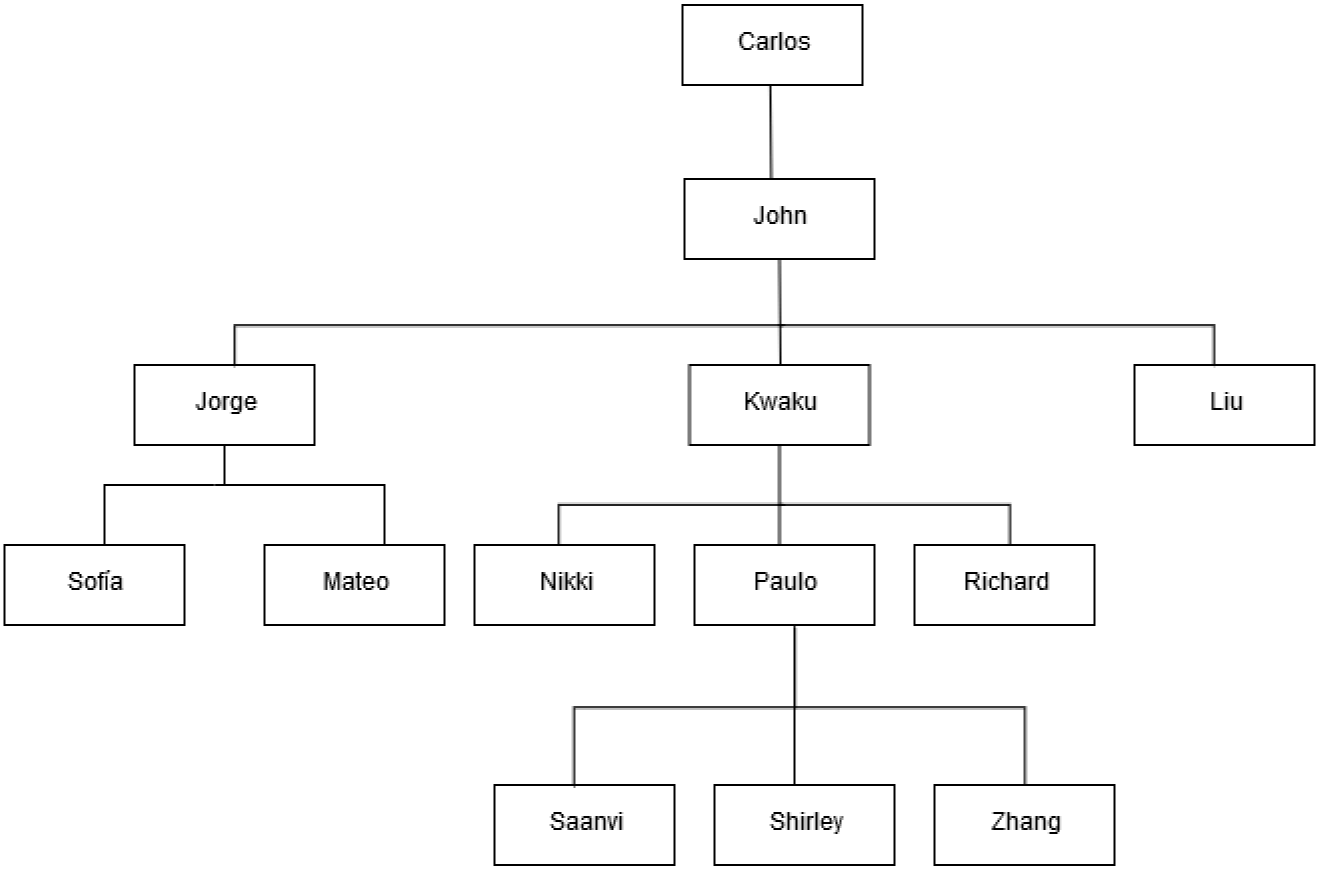
```
CREATE TABLE employee (
   id INT,
   name VARCHAR(20),
   manager_id INT
   );
```

Following are the rows inserted into the table.

```
INSERT INTO employee(id, name, manager_id)  VALUES
(100, 'Carlos', null),
(101, 'John', 100),
(102, 'Jorge', 101),
(103, 'Kwaku', 101),
(110, 'Liu', 101),
(106, 'Mateo', 102),
(110, 'Nikki', 103),
(104, 'Paulo', 103),
(105, 'Richard', 103),
```

```
(120, 'Saanvi', 104),
(200, 'Shirley', 104),
(201, 'Sofía', 102),
(205, 'Zhang', 104);
```

Following is an organization chart for John's department.



Subquery examples

The following examples show different ways in which subqueries fit into SELECT queries. See JOIN examples for another example of the use of subqueries.

SELECT list subquery

The following example contains a subquery in the SELECT list. This subquery is *scalar*: it returns only one column and one value, which is repeated in the result for each row that is returned from the outer query. The query compares the Q1SALES value that the subquery computes with sales values for two other quarters (2 and 3) in 2008, as defined by the outer query.

```
select qtr, sum(pricepaid) as qtrsales,
(select sum(pricepaid)
```

```
from sales join date on sales.dateid=date.dateid
where qtr='1' and year=2008) as q1sales
from sales join date on sales.dateid=date.dateid
where qtr in('2','3') and year=2008
group by qtr
order by qtr;

qtr  |  qtrsales   |   q1sales
-------+-------------+-------------
2     | 30560050.00 | 24742065.00
3     | 31170237.00 | 24742065.00
(2 rows)
```

WHERE clause subquery

The following example contains a table subquery in the WHERE clause. This subquery produces multiple rows. In this case, the rows contain only one column, but table subqueries can contain multiple columns and rows, just like any other table.

The query finds the top 10 sellers in terms of maximum tickets sold. The top 10 list is restricted by the subquery, which removes users who live in cities where there are ticket venues. This query can be written in different ways; for example, the subquery could be rewritten as a join within the main query.

```
select firstname, lastname, city, max(qtysold) as maxsold
from users join sales on users.userid=sales.sellerid
where users.city not in(select venuecity from venue)
group by firstname, lastname, city
order by maxsold desc, city desc
limit 10;

firstname | lastname  |      city      | maxsold
-----------+-----------+----------------+---------
Noah       | Guerrero | Worcester      |       8
Isadora    | Moss     | Winooski       |       8
Kieran     | Harrison | Westminster    |       8
Heidi      | Davis    | Warwick        |       8
Sara       | Anthony  | Waco           |       8
Bree       | Buck     | Valdez         |       8
Evangeline | Sampson  | Trenton        |       8
Kendall    | Keith    | Stillwater     |       8
Bertha     | Bishop   | Stevens Point  |       8
Patricia   | Anderson | South Portland |       8
```

```
(10 rows)
```

WITH clause subqueries

See WITH clause.

Correlated subqueries

The following example contains a *correlated subquery* in the WHERE clause; this kind of subquery contains one or more correlations between its columns and the columns produced by the outer query. In this case, the correlation is `where s.listid=l.listid`. For each row that the outer query produces, the subquery is run to qualify or disqualify the row.

```
select salesid, listid, sum(pricepaid) from sales s
where qtysold=
(select max(numtickets) from listing l
where s.listid=l.listid)
group by 1,2
order by 1,2
limit 5;

salesid | listid |   sum
--------+--------+----------
 27     |     28 | 111.00
 81     |    103 | 181.00
 142    |    149 | 240.00
 146    |    152 | 231.00
 194    |    210 | 144.00
(5 rows)
```

Correlated subquery patterns that are not supported

The query planner uses a query rewrite method called subquery decorrelation to optimize several patterns of correlated subqueries for execution in an MPP environment. A few types of correlated subqueries follow patterns that Amazon Redshift can't decorrelate and doesn't support. Queries that contain the following correlation references return errors:

- Correlation references that skip a query block, also known as "skip-level correlation references." For example, in the following query, the block containing the correlation reference and the skipped block are connected by a NOT EXISTS predicate:

```
select event.eventname from event
```

```
where not exists
(select * from listing
where not exists
(select * from sales where event.eventid=sales.eventid));
```

The skipped block in this case is the subquery against the LISTING table. The correlation reference correlates the EVENT and SALES tables.

- Correlation references from a subquery that is part of an ON clause in an outer query:

```
select * from category
left join event
on category.catid=event.catid and eventid =
(select max(eventid) from sales where sales.eventid=event.eventid);
```

The ON clause contains a correlation reference from SALES in the subquery to EVENT in the outer query.

- Null-sensitive correlation references to an Amazon Redshift system table. For example:

```
select attrelid
from stv_locks sl, pg_attribute
where sl.table_id=pg_attribute.attrelid and 1 not in
(select 1 from pg_opclass where sl.lock_owner = opcowner);
```

- Correlation references from within a subquery that contains a window function.

```
select listid, qtysold
from sales s
where qtysold not in
(select sum(numtickets) over() from listing l where s.listid=l.listid);
```

- References in a GROUP BY column to the results of a correlated subquery. For example:

```
select listing.listid,
(select count (sales.listid) from sales where sales.listid=listing.listid) as list
from listing
group by list, listing.listid;
```

- Correlation references from a subquery with an aggregate function and a GROUP BY clause, connected to the outer query by an IN predicate. (This restriction doesn't apply to MIN and MAX aggregate functions.) For example:

```
select * from listing where listid in
(select sum(qtysold)
from sales
where numtickets>4
group by salesid);
```

SELECT INTO

Selects rows defined by any query and inserts them into a new table. You can specify whether to create a temporary or a persistent table.

Syntax

```
[ WITH with_subquery [, ...] ]
SELECT
[ TOP number | [ ALL | DISTINCT ]
* | expression [ AS output_name ] [, ...] ]
[ EXCLUDE column_list ]
INTO [ TEMPORARY | TEMP ] [ TABLE ] new_table
[ FROM table_reference [, ...] ]
[ WHERE condition ]
[ [ START WITH expression ] CONNECT BY expression ]
[ GROUP BY ALL | expression [, ...] ]
[ HAVING condition ]
[ QUALIFY condition ]
[ { UNION | ALL | INTERSECT | EXCEPT | MINUS } query ]
[ ORDER BY expression [ ASC | DESC ] ]
[ LIMIT { number | ALL } ]
[ OFFSET start ]
```

For details about the parameters of this command, see SELECT.

Examples

Select all of the rows from the EVENT table and create a NEWEVENT table:

```
select * into newevent from event;
```

Select the result of an aggregate query into a temporary table called PROFITS:

```
select username, lastname, sum(pricepaid-commission) as profit
into temp table profits
from sales, users
where sales.sellerid=users.userid
group by 1, 2
order by 3 desc;
```

SET

Sets the value of a server configuration parameter. Use the SET command to override a setting for the duration of the current session or transaction only.

Use the RESET command to return a parameter to its default value.

You can change the server configuration parameters in several ways. For more information, see Modifying the server configuration.

Syntax

```
SET { [ SESSION | LOCAL ]
{ SEED | parameter_name } { TO | = }
{ value | 'value' | DEFAULT } |
SEED TO value }
```

The following statement sets the value of a session context variable.

```
SET { [ SESSION | LOCAL ]
variable_name { TO | = }
{ value | 'value'  }
```

Parameters

SESSION

Specifies that the setting is valid for the current session. Default value.

variable_name

Specifies the name of the context variable set for the session.

The naming convention is a two-part name separated by a dot, for example *identifier.identifier*. Only one dot separator is allowed. Use an *identifier* that follows the standard identifier rules for

Amazon Redshift For more information, see Names and identifiers. Delimited identifiers aren't allowed.

LOCAL

Specifies that the setting is valid for the current transaction.

SEED TO *value*

Sets an internal seed to be used by the RANDOM function for random number generation.

SET SEED takes a numeric *value* between 0 and 1, and multiplies this number by (2^{31}-1) for use with the RANDOM function function. If you use SET SEED before making multiple RANDOM calls, RANDOM generates numbers in a predictable sequence.

parameter_name

Name of the parameter to set. See Modifying the server configuration for information about parameters.

value

New parameter value. Use single quotation marks to set the value to a specific string. If using SET SEED, this parameter contains the SEED value.

DEFAULT

Sets the parameter to the default value.

Examples

Changing a parameter for the current session

The following example sets the datestyle:

```
set datestyle to 'SQL,DMY';
```

Setting a query group for workload management

If query groups are listed in a queue definition as part of the cluster's WLM configuration, you can set the QUERY_GROUP parameter to a listed query group name. Subsequent queries are assigned to the associated query queue. The QUERY_GROUP setting remains in effect for the duration of the session or until a RESET QUERY_GROUP command is encountered.

This example runs two queries as part of the query group 'priority', then resets the query group.

```
set query_group to 'priority';
select tbl, count(*)from stv_blocklist;
select query, elapsed, substring from svl_qlog order by query desc limit 5;
reset query_group;
```

For more information, see Workload management.

Change the default identity namespace for the session

A database user can set `default_identity_namespace`. This sample shows how to use `SET SESSION` to override the setting for the duration of the current session and then show the new identity provider value. This is used most commonly when you are using an identity provider with Redshift and IAM Identity Center. For more information about using an identity provider with Redshift, see Connect Redshift with IAM Identity Center to give users a single sign-on experience.

```
SET SESSION default_identity_namespace = 'MYCO';

SHOW default_identity_namespace;
```

After running the command, you can run a GRANT statement or a CREATE statement like the following:

```
GRANT SELECT ON TABLE mytable TO alice;

GRANT UPDATE ON TABLE mytable TO salesrole;

CREATE USER bob password 'md50c983d1a624280812631c5389e60d48c';
```

In this instance, the effect of setting the default identity namespace is equivalent to prefixing each identity with the namespace. In this example, `alice` is replaced with `MYCO:alice`. For more information about settings that pertain to Redshift configuration with IAM Identity Center, see ALTER SYSTEM and ALTER IDENTITY PROVIDER.

Setting a label for a group of queries

The QUERY_GROUP parameter defines a label for one or more queries that are run in the same session after a SET command. In turn, this label is logged when queries are run and can be used to constrain results returned from the STL_QUERY and STV_INFLIGHT system tables and the SVL_QLOG view.

```
show query_group;
query_group
-------------
unset
(1 row)

set query_group to '6 p.m.';


show query_group;
query_group
-------------
6 p.m.
(1 row)

select * from sales where salesid=500;
salesid | listid | sellerid | buyerid | eventid | dateid | ...
---------+--------+----------+---------+---------+--------+-----
500 |    504 |     3858 |    2123 |    5871 |   2052 | ...
(1 row)

reset query_group;

select query, trim(label) querygroup, pid, trim(querytxt) sql
from stl_query
where label ='6 p.m.';
query | querygroup |  pid  |                  sql
-------+------------+-------+----------------------------------------
57 | 6 p.m.     | 30711 | select * from sales where salesid=500;
(1 row)
```

Query group labels are a useful mechanism for isolating individual queries or groups of queries that are run as part of scripts. You don't need to identify and track queries by their IDs; you can track them by their labels.

Setting a seed value for random number generation

The following example uses the SEED option with SET to cause the RANDOM function to generate numbers in a predictable sequence.

First, return three RANDOM integers without setting the SEED value first:

```
select cast (random() * 100 as int);
```

```
int4
------
6
(1 row)

select cast (random() * 100 as int);
int4
------
68
(1 row)

select cast (random() * 100 as int);
int4
------
56
(1 row)
```

Now, set the SEED value to `.25`, and return three more RANDOM numbers:

```
set seed to .25;

select cast (random() * 100 as int);
int4
------
21
(1 row)

select cast (random() * 100 as int);
int4
------
79
(1 row)

select cast (random() * 100 as int);
int4
------
12
(1 row)
```

Finally, reset the SEED value to `.25`, and verify that RANDOM returns the same results as the previous three calls:

```
set seed to .25;
```

```
select cast (random() * 100 as int);
int4
------
21
(1 row)

select cast (random() * 100 as int);
int4
------
79
(1 row)

select cast (random() * 100 as int);
int4
------
12
(1 row)
```

The following example sets a customized context variable.

```
SET app_context.user_id TO 123;
SET app_context.user_id TO 'sample_variable_value';
```

SET SESSION AUTHORIZATION

Sets the user name for the current session.

You can use the SET SESSION AUTHORIZATION command, for example, to test database access by temporarily running a session or transaction as an unprivileged user. You must be a database superuser to run this command.

Syntax

```
SET [ LOCAL ] SESSION AUTHORIZATION { user_name | DEFAULT }
```

Parameters

LOCAL

Specifies that the setting is valid for the current transaction. Omitting this parameter specifies that the setting is valid for the current session.

user_name

Name of the user to set. The user name may be written as an identifier or a string literal.

DEFAULT

Sets the session user name to the default value.

Examples

The following example sets the user name for the current session to `dwuser`:

```
SET SESSION AUTHORIZATION 'dwuser';
```

The following example sets the user name for the current transaction to `dwuser`:

```
SET LOCAL SESSION AUTHORIZATION 'dwuser';
```

This example sets the user name for the current session to the default user name:

```
SET SESSION AUTHORIZATION DEFAULT;
```

SET SESSION CHARACTERISTICS

This command is deprecated.

SHOW

Displays the current value of a server configuration parameter. This value may be specific to the current session if a SET command is in effect. For a list of configuration parameters, see Configuration reference.

Syntax

```
SHOW { parameter_name | ALL }
```

The following statement displays the current value of a session context variable. If the variable doesn't exist, Amazon Redshift throws an error.

```
SHOW variable_name
```

Parameters

parameter_name

Displays the current value of the specified parameter.

ALL

Displays the current values of all of the parameters.

variable_name

Displays the current value of the specified variable.

Examples

The following example displays the value for the query_group parameter:

```
show query_group;

query_group

unset
(1 row)
```

The following example displays a list of all parameters and their values:

```
show all;
name        |   setting
--------------------+--------------
datestyle          | ISO, MDY
extra_float_digits | 0
query_group        | unset
search_path        | $user,public
statement_timeout  | 0
```

The following example displays the current value of the specified variable.

```
SHOW app_context.user_id;
```

SHOW COLUMNS

Shows a list of columns in a table, along with some column attributes.

Each output row consists of a comma-separated list of database name, schema name, table name, column name, ordinal position, column default, is nullable, data type, character maximum length, numeric precision, and remarks. For more information about these attributes, see [SVV_ALL_COLUMNS](#).

If more than 10,000 columns would result from the SHOW COLUMNS command, then an error is returned.

Required permissions

To view a column in an Amazon Redshift table, the current user must satisfy one of the following criteria:

- Be a superuser.
- Be the owner of the table.
- Granted USAGE privilege on the parent schema and granted SELECT privilege on the table or granted SELECT privilege on the column.

Syntax

```
SHOW COLUMNS FROM TABLE database_name.schema_name.table_name [LIKE 'filter_pattern']
 [LIMIT row_limit ]
```

Parameters

database_name

The name of the database that contains the tables to list.

To show tables in an AWS Glue Data Catalog, specify (`awsdatacatalog`) as the database name, and ensure the system configuration `data_catalog_auto_mount` is set to `true`. For more information, see [ALTER SYSTEM](#).

schema_name

The name of the schema that contains the tables to list.

To show AWS Glue Data Catalog tables, provide the AWS Glue database name as the schema name.

table_name

The name of the table that contains the columns to list.

filter_pattern

A valid UTF-8 character expression with a pattern to match table names. The LIKE option performs a case-sensitive match that supports the following pattern-matching metacharacters:

Metacharacter	Description
%	Matches any sequence of zero or more characters.
_	Matches any single character.

If *filter_pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

row_limit

The maximum number of rows to return. The *row_limit* can be 0–10,000.

Examples

Following example shows the columns in the Amazon Redshift database named `sample_data_dev` that are in schema `tickit` and table `event`.

```
SHOW COLUMNS FROM TABLE sample_data_dev.tickit.event;

 database_name     | schema_name | table_name | column_name | ordinal_position |
 column_default | is_nullable | data_type                    | character_maximum_length
 | numeric_precision | numeric_scale | remarks
-------------------+-------------+------------+-------------+------------------
+----------------+-------------+------------------------------
+--------------------------+------------------+-----------------------
 sample_data_dev   | tickit      | event      | eventid     |                1 | NULL
        | NO          | integer                      | NULL                      |
          32 | 0             | NULL
 sample_data_dev   | tickit      | event      | eventid     |                2 | NULL
        | NO          | smallint                     | NULL                      |
          16 | 0             | NULL
```

```
 sample_data_dev   | tickit      | event      | eventid     |                3 | NULL
        | NO           | smallint                    | NULL                    |
          16 | 0              | NULL
 sample_data_dev   | tickit      | event      | eventid     |                4 | NULL
        | NO           | smallint                    | NULL                    |
          16 | 0              | NULL
 sample_data_dev   | tickit      | event      | eventid     |                5 | NULL
        | YES          | character varying           | 200                     |
        NULL | NULL           | NULL
 sample_data_dev   | tickit      | event      | eventid     |                6 | NULL
        | YES          | timestamp without time zo... | NULL                    |
        NULL | NULL           | NULL
```

Following example shows the tables in the AWS Glue Data Catalog database named `awsdatacatalog` that are in schema `batman` and table `nation`. Output is limited to 2 rows.

```
SHOW COLUMNS FROM TABLE awsdatacatalog.batman.nation LIMIT 2;

 database_name  | schema_name | table_name | column_name | ordinal_position
 | column_default | is_nullable | data_type | character_maximum_length |
 numeric_precision | remarks
----------------+-------------+------------+-------------+------------------
+----------------+-------------+-----------+-------------------------
+-------------------+---------
 awsdatacatalog | batman      | nation     | n_nationkey |                1 |
      |             | integer   |                          |                    |
 awsdatacatalog | batman      | nation     | n_name      |                2 |
      |             | character |                          |                    |
```

SHOW EXTERNAL TABLE

Shows the definition of an external table, including table attributes and column attributes. You can use the output of the SHOW EXTERNAL TABLE statement to recreate the table.

For more information about external table creation, see CREATE EXTERNAL TABLE.

Syntax

```
SHOW EXTERNAL TABLE [external_database].external_schema.table_name [ PARTITION ]
```

Parameters

external_database

The name of the associated external database. This parameter is optional.

external_schema

The name of the associated external schema.

table_name

The name of the table to show.

PARTITION

Displays ALTER TABLE statements to add partitions to the table definition.

Examples

The following examples are based on an external table defined as follows:

```
CREATE EXTERNAL TABLE my_schema.alldatatypes_parquet_test_partitioned (
     csmallint smallint,
     cint int,
     cbigint bigint,
     cfloat float4,
     cdouble float8,
     cchar char(10),
     cvarchar varchar(255),
     cdecimal_small decimal(18,9),
     cdecimal_big decimal(30,15),
     ctimestamp TIMESTAMP,
     cboolean boolean,
     cstring varchar(16383)
)
PARTITIONED BY (cdate date, ctime TIMESTAMP)
STORED AS PARQUET
LOCATION 's3://amzn-s3-demo-bucket/alldatatypes_parquet_partitioned';
```

Following is an example of the SHOW EXTERNAL TABLE command and output for the table `my_schema.alldatatypes_parquet_test_partitioned`.

```
SHOW EXTERNAL TABLE my_schema.alldatatypes_parquet_test_partitioned;
```

```
"CREATE EXTERNAL TABLE my_schema.alldatatypes_parquet_test_partitioned (
    csmallint smallint,
    cint int,
    cbigint bigint,
    cfloat float4,
    cdouble float8,
    cchar char(10),
    cvarchar varchar(255),
    cdecimal_small decimal(18,9),
    cdecimal_big decimal(30,15),
    ctimestamp timestamp,
    cboolean boolean,
    cstring varchar(16383)
)
PARTITIONED BY (cdate date, ctime timestamp)
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS INPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
LOCATION 's3://amzn-s3-demo-bucket/alldatatypes_parquet_partitioned';"
```

Following is an example of the SHOW EXTERNAL TABLE command and output for the same table, but with the database also specified in the parameter.

```
SHOW EXTERNAL TABLE my_database.my_schema.alldatatypes_parquet_test_partitioned;
```

```
"CREATE EXTERNAL TABLE my_database.my_schema.alldatatypes_parquet_test_partitioned (
    csmallint smallint,
    cint int,
    cbigint bigint,
    cfloat float4,
    cdouble float8,
    cchar char(10),
    cvarchar varchar(255),
    cdecimal_small decimal(18,9),
    cdecimal_big decimal(30,15),
    ctimestamp timestamp,
    cboolean boolean,
    cstring varchar(16383)
)
```

```
PARTITIONED BY (cdate date, ctime timestamp)
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS INPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
LOCATION 's3://amzn-s3-demo-bucket/alldatatypes_parquet_partitioned';"
```

Following is an example of the SHOW EXTERNAL TABLE command and output when using the `PARTITION` parameter. The output contains ALTER TABLE statements to add partitions to the table definition.

```
SHOW EXTERNAL TABLE my_schema.alldatatypes_parquet_test_partitioned PARTITION;
```

```
"CREATE EXTERNAL TABLE my_schema.alldatatypes_parquet_test_partitioned (
    csmallint smallint,
    cint int,
    cbigint bigint,
    cfloat float4,
    cdouble float8,
    cchar char(10),
    cvarchar varchar(255),
    cdecimal_small decimal(18,9),
    cdecimal_big decimal(30,15),
    ctimestamp timestamp,
    cboolean boolean,
    cstring varchar(16383)
)
PARTITIONED BY (cdate date)
ROW FORMAT SERDE 'org.apache.hadoop.hive.ql.io.parquet.serde.ParquetHiveSerDe'
STORED AS INPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.parquet.MapredParquetOutputFormat'
LOCATION 's3://amzn-s3-demo-bucket/alldatatypes_parquet_partitioned';
ALTER TABLE my_schema.alldatatypes_parquet_test_partitioned ADD IF NOT
 EXISTS PARTITION (cdate='2021-01-01') LOCATION 's3://amzn-s3-demo-bucket/
alldatatypes_parquet_partitioned2/cdate=2021-01-01';
ALTER TABLE my_schema.alldatatypes_parquet_test_partitioned ADD IF NOT
 EXISTS PARTITION (cdate='2021-01-02') LOCATION 's3://amzn-s3-demo-bucket/
alldatatypes_parquet_partitioned2/cdate=2021-01-02';"
```

SHOW DATABASES

Displays databases from a Data Catalog or an Amazon Redshift data warehouse. SHOW DATABASES lists all accessible databases, such as, within the data warehouse, AWS Glue Data Catalog databases (awsdatacatalog), data sharing databases, and Lake Formation databases.

Required permissions

All databases are visible to users except:

- For databases created from a datashare with permissions to be visible, the current user must be granted USAGE permission on the database.

Syntax

To show databases from an Amazon Redshift data warehouse:

```
SHOW DATABASES
[ LIKE '<expression>' ]
[ LIMIT row_limit ]
```

To show databases from a Data Catalog:

```
SHOW DATABASES FROM DATA CATALOG
[ ACCOUNT  '<id1>', '<id2>', ... ]
[ LIKE '<expression>' ]
[ IAM_ROLE default | 'SESSION' | 'arn:aws:iam::<account-id>:role/<role-name>' ]
[ LIMIT row_limit ]
```

Parameters

ACCOUNT '<id1>', '<id2>', ...

The AWS Glue Data Catalog accounts from which to list databases. Omitting this parameter indicates that Amazon Redshift should show the databases from the account that owns the cluster.

LIKE '<expression>'

Filters the list of databases to those that match the expression that you specify. This parameter supports patterns that use the wildcard characters % (percent) and _ (underscore).

IAM_ROLE default | 'SESSION' | 'arn:aws:iam::<account-id>:role/<role-name>'

If you specify an IAM role that is associated with the cluster when running the SHOW DATABASES command, Amazon Redshift will use the role's credentials when you run queries on the database.

Specifying the `default` keyword means to use the IAM role that's set as the default and associated with the cluster.

Use `'SESSION'` if you connect to your Amazon Redshift cluster using a federated identity and access the tables from the external database created using the the section called "CREATE DATABASE" command. For an example of using a federated identity, see Using a federated identity to manage Amazon Redshift access to local resources and Amazon Redshift Spectrum external tables, which explains how to configure federated identity.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. As a minimum, the IAM role must have permission to perform a LIST operation on the Amazon S3 bucket to be accessed and a GET operation on the Amazon S3 objects the bucket contains. To learn more about databases created from the AWS Glue Data Catalog for datashares and using IAM_ROLE, see Working with Lake Formation-managed datashares as a consumer.

The following shows the syntax for the IAM_ROLE parameter string for a single ARN.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-name>'
```

You can chain roles so that your cluster can assume another IAM role, possibly belonging to another account. You can chain up to 10 roles. For more information, see Chaining IAM roles in Amazon Redshift Spectrum.

To this IAM role, attach an IAM permissions policy similar to the following.

JSON

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
```

```
            "Sid": "AccessSecret",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetResourcePolicy",
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret",
                "secretsmanager:ListSecretVersionIds"
            ],
            "Resource": "arn:aws:secretsmanager:us-west-2:123456789012:secret:my-rds-secret-VNenFy"
        },
        {
            "Sid": "VisualEditor1",
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetRandomPassword",
                "secretsmanager:ListSecrets"
            ],
            "Resource": "*"
        }
    ]
}
```

For the steps to create an IAM role to use with federated query, see Creating a secret and an IAM role to use federated queries.

Note

Don't include spaces in the list of chained roles.

The following shows the syntax for chaining three roles.

```
IAM_ROLE 'arn:aws:iam::<aws-account-id>:role/<role-1-name>,arn:aws:iam::<aws-account-id>:role/<role-2-name>,arn:aws:iam::<aws-account-id>:role/<role-3-name>'
```

LIMIT *row_limit*

Clause to LIMIT the number of rows returned. Where *row_limit* is the maximum number of rows to return. The *row_limit* can be 0–10,000.

Examples

The following example displays all of the Data Catalog databases from the account ID 123456789012.

```
SHOW DATABASES FROM DATA CATALOG ACCOUNT '123456789012'

  catalog_id  | database_name |                        database_arn
 |     type     |                                             target_database
                             | location | parameters
--------------+---------------+----------------------------------------------------------
+--------------
+---------------------------------------------------------------------------------------
+----------+------------
 123456789012 |   database1   | arn:aws:glue:us-east-1:123456789012:database/database1
 | Data Catalog |
                             |          |
 123456789012 |   database2   | arn:aws:glue:us-east-1:123456789012:database/database2
 | Data Catalog | arn:aws:redshift:us-
east-1:123456789012:datashare:035c45ea-61ce-86f0-8b75-19ac6102c3b7/database2 |
 |
```

The following are examples that demonstrate how to display all of the Data Catalog databases from the account ID 123456789012 while using an IAM role's credentials.

```
SHOW DATABASES FROM DATA CATALOG ACCOUNT '123456789012' IAM_ROLE default;
```

```
SHOW DATABASES FROM DATA CATALOG ACCOUNT '123456789012' IAM_ROLE <iam-role-arn>;
```

The following example displays all of the databases in the connected Amazon Redshift data warehouse.

```
SHOW DATABASES

database_name  | database_owner | database_type        | database_acl | parameters |
 database_isolation_level
---------------+----------------+----------------------+--------------+------------
+--------------------
```

```
awsdatacatalog | 1               | auto mounted catalog | NULL          | UNKNOWN     |
 UNKNOWN
dev            | 1               | local                | NULL          | NULL        |
 Snapshot Isolation
```

SHOW GRANTS

Displays grants for a user, role, or object. The object can be a database, a schema, a table, or a function. When you specify an object, such as a table or function, you need to qualify it with two-part or three-part notation. For example, `schema_name.table_name` or `database_name.schema_name.table_name`.

Syntax

The following is the syntax for showing grants on an object. Note that the second way of specifying a function is only valid for external schemas and databases created from a datashare.

```
SHOW GRANTS ON
{
 DATABASE database_name |
 FUNCTION {database_name.schema_name.function_name | schema_name.function_name }
 ( [ [ argname ] argtype [, ...] ] ) |
 FUNCTION {database_name.schema_name.function_name | schema_name.function_name } |
 SCHEMA {database_name.schema_name | schema_name} |
 { TABLE {database_name.schema_name.table_name | schema_name.table_name} | table_name }
}
[FOR {username | ROLE role_name | PUBLIC}]
[LIMIT row_limit]
```

The following is the syntax for showing grants for a user or role.

```
SHOW GRANTS FOR
{username | ROLE role_name}
[LIMIT row_limit]
```

Parameters

database_name

The name of the database to show grants on.

function_name

The name of the function to show grants on.

schema_name

The name of the schema to show grants on.

table_name

The name of the table to show grants on.

FOR *username*

Indicates showing grants for a user.

FOR ROLE *role_name*

Indicates showing grants for a role.

FOR PUBLIC

Indicates showing grants for PUBLIC.

row_limit

The maximum number of rows to return. The *row_limit* can be 0–10,000.

Examples

The following example displays all grants on a database named dev.

```
SHOW GRANTS ON DATABASE dev;

 database_name | privilege_type | identity_id | identity_name | identity_type | 
 admin_option | privilege_scope
---------------+----------------+-------------+---------------+---------------
+--------------+-----------------
 dev           | TRUNCATE       |         101 | alice         | user          | f
      | TABLES
 dev           | DROP           |         101 | alice         | user          | f
      | TABLES
 dev           | INSERT         |         101 | alice         | user          | f
      | TABLES
 dev           | ALTER          |         101 | alice         | user          | f
      | TABLES
```

```
 dev           | TEMP            |           0 | public        | public        | f
      | DATABASE
 dev           | DELETE          |         101 | alice         | user          | f
      | TABLES
 dev           | SELECT          |         101 | alice         | user          | f
      | TABLES
 dev           | UPDATE          |         101 | alice         | user          | f
      | TABLES
 dev           | REFERENCES      |         101 | alice         | user          | f
      | TABLES
(9 rows)
```

The following command shows all grants on a schema named demo.

```
SHOW GRANTS ON SCHEMA demo;

 schema_name | object_name | object_type | privilege_type | identity_id | identity_name
 | identity_type | admin_option | privilege_scope
-------------+-------------+-------------+----------------+-------------
+---------------+--------------+-----------------+-----------------
 demo        | demo        | SCHEMA      | ALTER          |         101 | alice
 | user          | f            | SCHEMA
 demo        | demo        | SCHEMA      | DROP           |         101 | alice
 | user          | f            | SCHEMA
 demo        | demo        | SCHEMA      | USAGE          |         101 | alice
 | user          | f            | SCHEMA
 demo        | demo        | SCHEMA      | CREATE         |         101 | alice
 | user          | f            | SCHEMA
(4 rows)
```

The following command shows all grants for a user named `alice`.

```
SHOW GRANTS FOR alice;

 database_name | schema_name | object_name | object_type | privilege_type | identity_id
 | identity_name | identity_type | privilege_scope
---------------+-------------+-------------+-------------+----------------
+-------------+---------------+---------------+-----------------
 dev           |             |             | DATABASE    | INSERT         |         101
 | alice         | user          | TABLES
 dev           |             |             | DATABASE    | SELECT         |         101
 | alice         | user          | TABLES
```

```
 dev           |              |              | DATABASE    | UPDATE         |           101
 | alice          | user          | TABLES
 dev           |              |              | DATABASE    | DELETE         |           101
 | alice          | user          | TABLES
 dev           |              |              | DATABASE    | REFERENCES     |           101
 | alice          | user          | TABLES
 dev           |              |              | DATABASE    | DROP           |           101
 | alice          | user          | TABLES
 dev           |              |              | DATABASE    | TRUNCATE       |           101
 | alice          | user          | TABLES
 dev           |              |              | DATABASE    | ALTER          |           101
 | alice          | user          | TABLES
 dev           | public       | t1           | TABLE       | INSERT         |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | SELECT         |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | UPDATE         |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | DELETE         |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | REFERENCES     |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | DROP           |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | TRUNCATE       |           101
 | alice          | user          | TABLE
 dev           | public       | t1           | TABLE       | ALTER          |           101
 | alice          | user          | TABLE
 dev           | demo         |              | SCHEMA      | USAGE          |           101
 | alice          | user          | SCHEMA
 dev           | demo         |              | SCHEMA      | CREATE         |           101
 | alice          | user          | SCHEMA
 dev           | demo         |              | SCHEMA      | DROP           |           101
 | alice          | user          | SCHEMA
 dev           | demo         |              | SCHEMA      | ALTER          |           101
 | alice          | user          | SCHEMA
(20 rows)
```

The following command shows all grants on a table named `t3` for a user named `alice`. Note that you can either use two-part or three-part notation to specify the table name.

```
SHOW GRANTS ON TABLE demo_db.demo_schema.t3 FOR alice;
```

```
 schema_name | object_name | object_type | privilege_type | identity_id | identity_name
 | identity_type | admin_option | privilege_scope
-------------+-------------+-------------+----------------+-------------
+---------------+---------------+--------------+-----------------
 demo_schema | t3          | TABLE       | ALTER          |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | TRUNCATE       |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | DROP           |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | SELECT         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | INSERT         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | UPDATE         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | DELETE         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | REFERENCES     |         100 | alice
 | user          | f             | TABLE
(8 rows)

SHOW GRANTS ON TABLE demo_schema.t3 FOR alice;
 schema_name | object_name | object_type | privilege_type | identity_id | identity_name
 | identity_type | admin_option | privilege_scope
-------------+-------------+-------------+----------------+-------------
+---------------+---------------+--------------+-----------------
 demo_schema | t3          | TABLE       | ALTER          |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | TRUNCATE       |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | DROP           |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | SELECT         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | INSERT         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | UPDATE         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | DELETE         |         100 | alice
 | user          | f             | TABLE
 demo_schema | t3          | TABLE       | REFERENCES     |         100 | alice
 | user          | f             | TABLE
```

```
(8 rows)
```

The following example shows all grants on a table named `t4`. Note the different ways that you can specify the table name.

```
SHOW GRANTS ON t4;
 schema_name | object_name | object_type | privilege_type | identity_id | identity_name
 | identity_type | admin_option | privilege_scope
-------------+-------------+-------------+----------------+-------------
+---------------+--------------+-------------+-----------------
 public      | t4          | TABLE       | ALTER          |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | TRUNCATE       |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | DROP           |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | SELECT         |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | INSERT         |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | UPDATE         |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | DELETE         |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | REFERENCES     |         100 | alice
 | user          | f            | TABLE
(8 rows)

SHOW GRANTS ON TABLE public.t4;
 schema_name | object_name | object_type | privilege_type | identity_id | identity_name
 | identity_type | admin_option | privilege_scope
-------------+-------------+-------------+----------------+-------------
+---------------+--------------+-------------+-----------------
 public      | t4          | TABLE       | ALTER          |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | TRUNCATE       |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | DROP           |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | SELECT         |         100 | alice
 | user          | f            | TABLE
 public      | t4          | TABLE       | INSERT         |         100 | alice
 | user          | f            | TABLE
```

```
 public      | t4          | TABLE       | UPDATE        |          100 | alice
 | user          | f             | TABLE
 public      | t4          | TABLE       | DELETE        |          100 | alice
 | user          | f             | TABLE
 public      | t4          | TABLE       | REFERENCES    |          100 | alice
 | user          | f             | TABLE
(8 rows)
```

SHOW MODEL

Shows useful information about a machine learning model, including its status, the parameters used to create it and the prediction function with its input argument types. You can use the information from the SHOW MODEL to recreate the model. If base tables have changed, running CREATE MODEL with the same SQL statement results in a different model. The information returned by the SHOW MODEL is different for the model owner and a user with the EXECUTE privilege. SHOW MODEL shows different outputs when a model is trained from Amazon Redshift or when the model is a BYOM model.

Syntax

```
SHOW MODEL ( ALL | model_name )
```

Parameters

ALL

Returns all the models that the user can use and their schemas.

model_name

The name of the model. The model name in a schema must be unique.

Usage notes

The SHOW MODEL command returns the following:

- The model name.
- The schema where the model was created.
- The owner of the model.

- The model creation time.
- The status of the model, such as READY, TRAINING, or FAILED.
- The reason message for a failed model.
- The validation error if model has finished training.
- The estimated cost needed to derive the model for a non-BYOM approach. Only the owner of the model can view this information.
- A list of user-specified parameters and their values, specifically the following:
  - The specified TARGET column.
  - The model type, AUTO or XGBoost.
  - The problem type, such as REGRESSION, BINARY_CLASSIFICATION, MULTICLASS_CLASSIFICATION. This parameter is specific to AUTO.
  - The name of the Amazon SageMaker AI training job or the Amazon SageMaker AI Autopilot job that created the model. You can use this job name to find more information about the model on Amazon SageMaker AI.
  - The objective, such as MSE, F1, Accuracy. This parameter is specific to AUTO.
  - The name of the created function.
  - The type of inference, local or remote.
  - The prediction function input arguments.
  - The prediction function input argument types for models that aren't bring your own model (BYOM).
  - The return type of the prediction function. This parameter is specific to BYOM.
  - The name of the Amazon SageMaker AI endpoint for a BYOM model with remote inference.
  - The IAM role. Only the owner of the model can see this.
  - The S3 bucket used. Only the owner of the model can see this.
  - The AWS KMS key, if one was provided. Only the owner of the model can see this.
  - The maximum time that the model can run.
- If the model type is not AUTO, then Amazon Redshift also shows the list of hyperparameters provided and their values.

You can also view some of the information provided by SHOW MODEL in other catalog tables, such as pg_proc. Amazon Redshift returns information about the prediction function that is registered in pg_proc catalog table. This information includes the input argument names and their types for the prediction function. Amazon Redshift returns the same information in the SHOW MODEL command.

```
SELECT * FROM pg_proc WHERE proname ILIKE '%<function_name>%';
```

Examples

The following example shows the show model output.

```
SHOW MODEL ALL;

Schema Name |  Model Name
------------+---------------
 public     | customer_churn
```

The owner of the customer_churn can see the following output. A user with only the EXECUTE privilege can't see the IAM role, the Amazon S3 bucket, and the estimated cost of the mode.

```
SHOW MODEL customer_churn;

       Key                   |           Value
----------------------------+-----------------------------------
 Model Name                  | customer_churn
 Schema Name                 | public
 Owner                       | 'owner'
 Creation Time               | Sat, 15.01.2000 14:45:20
 Model State                 | READY
 validation:F1               | 0.855
 Estimated Cost              | 5.7
                             |
 TRAINING DATA:              |
 Table                       | customer_data
 Target Column               | CHURN
                             |
 PARAMETERS:                 |
 Model Type                  | auto
 Problem Type                | binary_classification
 Objective                   | f1
 Function Name               | predict_churn
 Function Parameters         | age zip average_daily_spend average_daily_cases
 Function Parameter Types    | int int float float
 IAM Role                    | 'iam_role'
```

```
 KMS Key                    | 'kms_key'
 Max Runtime                | 36000
```

SHOW DATASHARES

Displays the inbound and outbound shares in a cluster either from the same account or across accounts. If you don't specify a datashare name, then Amazon Redshift displays all datashares in all databases in the cluster. Users who have the ALTER and SHARE privileges can see the shares that they have privileges for.

Syntax

```
SHOW DATASHARES [ LIKE 'namepattern' ]
```

Parameters

LIKE

An optional clause that compares the specified name pattern to the description of the datashare. When this clause is used, Amazon Redshift displays only the datashares with names that match the specified name pattern.

namepattern

The name of the datashare requested or part of the name to be matched using wildcard characters.

Examples

The following example displays the inbound and outbound shares in a cluster.

```
SHOW DATASHARES;
SHOW DATASHARES LIKE 'sales%';

share_name   | share_owner | source_database | consumer_database | share_type |
 createdate          | is_publicaccessible | share_acl | producer_account |
 producer_namespace
-------------+-------------+-----------------+-------------------+------------
+---------------------+---------------------+-----------+------------------
+--------------------------------------
```

```
'salesshare' | 100         | dev             |                     | outbound
 | 2020-12-09 01:22:54.| False             |            |   123456789012   |
 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
```

SHOW PROCEDURE

Shows the definition of a given stored procedure, including its signature. You can use the output of a SHOW PROCEDURE to recreate the stored procedure.

Syntax

```
SHOW PROCEDURE sp_name [( [ [ argname ] [ argmode ] argtype [, ...] ] )]
```

Parameters

sp_name

The name of the procedure to show.

[argname] [argmode] argtype

Input argument types to identify the stored procedure. Optionally, you can include the full argument data types, including OUT arguments. This part is optional if the name of the stored procedure is unique (that is, not overloaded).

Examples

The following example shows the definition of the procedure `test_spl2`.

```
show procedure test_sp2(int, varchar);
                                        Stored Procedure Definition
------------------------------------------------------------------------------------------------------------
CREATE OR REPLACE PROCEDURE public.test_sp2(f1 integer, INOUT f2 character varying, OUT
 character varying)
LANGUAGE plpgsql
AS $_$
DECLARE
out_var alias for $3;
loop_var int;
BEGIN
```

```
IF f1 is null OR f2 is null THEN
RAISE EXCEPTION 'input cannot be null';
END IF;
CREATE TEMP TABLE etl(a int, b varchar);
FOR loop_var IN 1..f1 LOOP
insert into etl values (loop_var, f2);
f2 := f2 || '+' || f2;
END LOOP;
SELECT INTO out_var count(*) from etl;
END;
$_$

(1 row)
```

SHOW SCHEMAS

Shows a list of schemas in a database, along with some schema attributes.

Each output row consists of database name, schema name, schema owner, schema type, schema ACL, source database, and schema option. For more information about these attributes, see SVV_ALL_SCHEMAS.

If more than 10,000 schemas can result from the SHOW SCHEMAS command, then an error is returned.

Required permissions

To view a schema in an Amazon Redshift table, the current user must satisfy one of the following criteria:

- Be a superuser.
- Be the owner of the schema.
- Granted USAGE privilege on the schema.

Syntax

```
SHOW SCHEMAS FROM DATABASE database_name [LIKE 'filter_pattern'] [LIMIT row_limit ]
```

Parameters

database_name

The name of the database that contains the tables to list.

To show tables in an AWS Glue Data Catalog, specify (`awsdatacatalog`) as the database name, and ensure the system configuration `data_catalog_auto_mount` is set to `true`. For more information, see ALTER SYSTEM.

filter_pattern

A valid UTF-8 character expression with a pattern to match schema names. The LIKE option performs a case-sensitive match that supports the following pattern-matching metacharacters:

Metacharacter	Description
`%`	Matches any sequence of zero or more characters.
`_`	Matches any single character.

If *filter_pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

row_limit

The maximum number of rows to return. The *row_limit* can be 0–10,000.

Examples

Following example shows the schemas from the Amazon Redshift database named `dev` .

```
SHOW SCHEMAS FROM DATABASE dev;

 database_name |     schema_name        | schema_owner | schema_type |          schema_acl
          | source_database | schema_option
---------------+----------------------+--------------+-------------
+----------------------------+-----------------+---------------
 dev           | pg_automv            |            1 | local       |
          |                  |
```

```
 dev           | pg_catalog             |             1 | local        | jpuser=UC/
jpuser~=U/jpuser  |                  |
 dev           | public                 |             1 | local        | jpuser=UC/
jpuser~=UC/jpuser |                  |
 dev           | information_schema     |             1 | local        | jpuser=UC/
jpuser~=U/jpuser  |                  |
 dev           | schemad79cd6d93bf043 |             1 | local        |
          |                  |
```

Following example shows the schemas in the AWS Glue Data Catalog database named `awsdatacatalog`. The maximum number of output rows is 5.

```
SHOW SCHEMAS FROM DATABASE awsdatacatalog LIMIT 5;

 database_name  |     schema_name      | schema_owner | schema_type | schema_acl |
 source_database | schema_option
----------------+----------------------+--------------+-------------+------------
+-----------------+---------------
 awsdatacatalog | 000_too_many_glue_db |              | EXTERNAL    |            |
           |
 awsdatacatalog | 123_default          |              | EXTERNAL    |            |
           |
 awsdatacatalog | adhoc                |              | EXTERNAL    |            |
           |
 awsdatacatalog | all_shapes_10mb      |              | EXTERNAL    |            |
           |
 awsdatacatalog | all_shapes_1g        |              | EXTERNAL    |            |
           |
```

SHOW TABLE

Shows the definition of a table, including table attributes, table constraints, column attributes, and column constraints. You can use the output of the SHOW TABLE statement to recreate the table.

For more information on table creation, see CREATE TABLE.

Syntax

```
SHOW TABLE [schema_name.]table_name
```

Parameters

schema_name

(Optional) The name of the related schema.

table_name

The name of the table to show.

Examples

Following is an example of the SHOW TABLE output for the table `sales`.

```
show table sales;
```

```
CREATE TABLE public.sales (
salesid integer NOT NULL ENCODE az64,
listid integer NOT NULL ENCODE az64 distkey,
sellerid integer NOT NULL ENCODE az64,
buyerid integer NOT NULL ENCODE az64,
eventid integer NOT NULL ENCODE az64,
dateid smallint NOT NULL,
qtysold smallint NOT NULL ENCODE az64,
pricepaid numeric(8,2) ENCODE az64,
commission numeric(8,2) ENCODE az64,
saletime timestamp without time zone ENCODE az64
)
DISTSTYLE KEY SORTKEY ( dateid );
```

Following is an example of the SHOW TABLE output for the table `category` in the schema `public`.

```
show table public.category;
```

```
CREATE TABLE public.category (
catid smallint NOT NULL distkey,
catgroup character varying(10) ENCODE lzo,
catname character varying(10) ENCODE lzo,
catdesc character varying(50) ENCODE lzo
```

```
) DISTSTYLE KEY SORTKEY ( catid );
```

The following example creates table `foo` with a primary key.

```
create table foo(a int PRIMARY KEY, b int);
```

The SHOW TABLE results display the create statement with all properties of the `foo` table.

```
show table foo;
```

```
CREATE TABLE public.foo ( a integer NOT NULL ENCODE az64, b integer ENCODE az64,
 PRIMARY KEY (a) ) DISTSTYLE AUTO;
```

SHOW TABLES

Shows a list of tables in a schema, along with some table attributes.

Each output row consists of database name, schema name, table name, table type, table ACL, and remarks. For more information about these attributes, see SVV_ALL_TABLES.

If more than 10,000 tables would result from the SHOW TABLES command, then an error is returned.

Required permissions

To view a table in an Amazon Redshift schema, the current user must satisfy one of the following criteria:

- Be a superuser.
- Be the owner of the table.
- Granted USAGE privilege on the parent schema and granted SELECT privilege on the table or granted SELECT privilege on any column in the table.

Syntax

```
SHOW TABLES FROM SCHEMA database_name.schema_name [LIKE 'filter_pattern']
 [LIMIT row_limit ]
```

Parameters

database_name

The name of the database that contains the tables to list.

To show tables in an AWS Glue Data Catalog, specify (`awsdatacatalog`) as the database name, and ensure the system configuration `data_catalog_auto_mount` is set to `true`. For more information, see ALTER SYSTEM.

schema_name

The name of the schema that contains the tables to list.

To show AWS Glue Data Catalog tables, provide the AWS Glue database name as the schema name.

filter_pattern

A valid UTF-8 character expression with a pattern to match table names. The LIKE option performs a case-sensitive match that supports the following pattern-matching metacharacters:

Metacharacter	Description
`%`	Matches any sequence of zero or more characters.
`_`	Matches any single character.

If *filter_pattern* does not contain metacharacters, then the pattern only represents the string itself; in that case LIKE acts the same as the equals operator.

row_limit

The maximum number of rows to return. The *row_limit* can be 0–10,000.

Examples

Following example shows the tables in the Amazon Redshift database named `dev` that are in schema `public`.

```
SHOW TABLES FROM SCHEMA dev.public;
```

```
 database_name | schema_name | table_name | table_type | table_acl | remarks
---------------+-------------+------------+------------+-----------+---------
 dev           | public      | tb         | TABLE      |           |
 dev           | public      | tb2        | TABLE      |           |
 dev           | public      | tb3        | TABLE      |           |
```

Following example shows the tables in the AWS Glue Data Catalog database named `awsdatacatalog` that are in schema `batman`.

```
SHOW TABLES FROM SCHEMA awsdatacatalog.batman;

 database_name  | schema_name |    table_name    | table_type | table_acl | remarks
----------------+-------------+------------------+------------+-----------+---------
 awsdatacatalog | batman      | nation           | EXTERNAL   |           |
 awsdatacatalog | batman      | part             | EXTERNAL   |           |
 awsdatacatalog | batman      | partsupp         | EXTERNAL   |           |
 awsdatacatalog | batman      | region           | EXTERNAL   |           |
 awsdatacatalog | batman      | supplier         | EXTERNAL   |           |
 awsdatacatalog | batman      | automount_nation | EXTERNAL   |           |
```

SHOW VIEW

Shows the definition of a view, including for materialized views and late-binding views. You can use the output of the SHOW VIEW statement to recreate the view.

Syntax

```
SHOW VIEW [schema_name.]view_name
```

Parameters

schema_name

(Optional) The name of the related schema.

view_name

The name of the view to show.

Examples

Following is the view definition for the view `LA_Venues_v`.

```
create view LA_Venues_v as select * from venue where venuecity='Los Angeles';
```

Following is an example of the SHOW VIEW command and output for the view defined preceding.

```
show view LA_Venues_v;
```

```
SELECT venue.venueid,
venue.venuename,
venue.venuecity,
venue.venuestate,
venue.venueseats
FROM venue WHERE ((venue.venuecity)::text = 'Los Angeles'::text);
```

Following is the view definition for the view `public.Sports_v` in the schema `public`.

```
create view public.Sports_v as select * from category where catgroup='Sports';
```

Following is an example of the SHOW VIEW command and output for the view defined preceding.

```
show view public.Sports_v;
```

```
SELECT category.catid,
category.catgroup,
category.catname,
category.catdesc
FROM category WHERE ((category.catgroup)::text = 'Sports'::text);
```

START TRANSACTION

Synonym of the BEGIN function.

See BEGIN.

TRUNCATE

Deletes all of the rows from a table without doing a table scan: this operation is a faster alternative to an unqualified DELETE operation. To run a TRUNCATE command, you must have the TRUNCATE permission for the table, be the owner of the table, or be a superuser. To grant permissions to truncate a table, use the GRANT command.

TRUNCATE is much more efficient than DELETE and doesn't require a VACUUM and ANALYZE. However, be aware that TRUNCATE commits the transaction in which it is run.

Syntax

```
TRUNCATE [ TABLE ] table_name
```

The command also works on a materialized view.

```
TRUNCATE materialized_view_name
```

Parameters

TABLE

Optional keyword.

table_name

A temporary or persistent table. Only the owner of the table or a superuser may truncate it.

You can truncate any table, including tables that are referenced in foreign-key constraints.

You don't need to vacuum a table after truncating it.

materialized_view_name

A materialized view.

You can truncate a materialized view that is used for Streaming ingestion to a materialized view.

Usage notes

- The TRUNCATE command commits the transaction in which it is run; therefore, you can't roll back a TRUNCATE operation, and a TRUNCATE command may commit other operations when it commits itself.

- TRUNCATE operations hold exclusive locks when run on Amazon Redshift streaming materialized views connected to any of the following:
  - An Amazon Kinesis data stream
  - An Amazon Managed Streaming for Apache Kafka topic
  - A supported external stream, such as a Confluent Cloud Kafka topic

  For more information, see Streaming ingestion to a materialized view.

Examples

Use the TRUNCATE command to delete all of the rows from the CATEGORY table:

```
truncate category;
```

Attempt to roll back a TRUNCATE operation:

```
begin;

truncate date;

rollback;

select count(*) from date;
count
-------
0
(1 row)
```

The DATE table remains empty after the ROLLBACK command because the TRUNCATE command committed automatically.

The following example uses the TRUNCATE command to delete all of the rows from a materialized view.

```
truncate my_materialized_view;
```

It deletes all records in the materialized view and leaves the materialized view and its schema intact. In the query, the materialized view name is a sample.

UNLOAD

Client-side encryption for COPY and UNLOAD commands will no longer be open to new customers starting April 30, 2025. If you used client-side encryption with COPY and UNLOAD commands in the 12 months before April 30, 2025, you can continue to use client side encryption with COPY or UNLOAD commands until April 30, 2026. After April 30, 2026, you won't be able to use client-side encryption for COPY and UNLOAD. We recommend that you switch to using server-side encryption for COPY and UNLOAD as soon as possible. If you're already using server-side encryption for COPY and UNLOAD, there's no change and you can continue to use it without altering your queries. For more information on encryption for COPY and UNLOAD, see the ENCRYPTED parameter below.

Unloads the result of a query to one or more text, JSON, or Apache Parquet files on Amazon S3, using Amazon S3 server-side encryption (SSE-S3). You can also specify server-side encryption with an AWS Key Management Service key (SSE-KMS).

By default, the format of the unloaded file is pipe-delimited (**|**) text.

You can manage the size of files on Amazon S3, and by extension the number of files, by setting the MAXFILESIZE parameter. Ensure that the S3 IP ranges are added to your allow list. To learn more about the required S3 IP ranges, see [Network isolation](#).

You can unload the result of an Amazon Redshift query to your Amazon S3 data lake in Apache Parquet, an efficient open columnar storage format for analytics. Parquet format is up to 2x faster to unload and consumes up to 6x less storage in Amazon S3, compared with text formats. This enables you to save data transformation and enrichment you have done in Amazon S3 into your Amazon S3 data lake in an open format. You can then analyze your data with Redshift Spectrum and other AWS services such as Amazon Athena, Amazon EMR, and Amazon SageMaker AI.

For more information and example scenarios about using the UNLOAD command, see [Unloading data in Amazon Redshift](#).

Required privileges and permissions

For the UNLOAD command to succeed, at least SELECT privilege on the data in the database is needed, along with permission to write to the Amazon S3 location. For information about permissions to access AWS resources for the UNLOAD command, see [Permissions to access other AWS Resources](#).

To apply least-privilege permissions, follow these recommendations to only grant permissions, as needed, to the user running the command.

- The user must have SELECT privilege on the data. For information about how to limit database privileges, see GRANT.
- The user needs permission to assume the IAM role to write to the Amazon S3 bucket in your AWS account. To restrict access for a database user to assume a role, see Restricting access to IAM roles in the *Amazon Redshift Management Guide*.
- The user needs access to the Amazon S3 bucket. To restrict permission using an Amazon S3 bucket policy, see Bucket policies for Amazon S3 in the *Amazon Simple Storage Service User Guide*.

Syntax

```
UNLOAD ('select-statement')
TO 's3://object-path/name-prefix'
authorization
[ option, ...]

where authorization is
IAM_ROLE { default | 'arn:aws:iam::<AWS account-id-1>:role/<role-
name>[,arn:aws:iam::<AWS account-id-2>:role/<role-name>][,...]' }

where option is
| [ FORMAT [ AS ] ] CSV | PARQUET | JSON
| PARTITION BY ( column_name [, ... ] ) [ INCLUDE ]
| MANIFEST [ VERBOSE ]
| HEADER
| DELIMITER [ AS ] 'delimiter-char'
| FIXEDWIDTH [ AS ] 'fixedwidth-spec'
| ENCRYPTED [ AUTO ]
| BZIP2
| GZIP
| ZSTD
| ADDQUOTES
| NULL [ AS ] 'null-string'
| ESCAPE
| ALLOWOVERWRITE
| CLEANPATH
| PARALLEL [ { ON | TRUE } | { OFF | FALSE } ]
```

```
| MAXFILESIZE [AS] max-size [ MB | GB ]
| ROWGROUPSIZE [AS] size [ MB | GB ]
| REGION [AS] 'aws-region' }
| EXTENSION 'extension-name'
```

Parameters

('*select-statement*')

A SELECT query. The results of the query are unloaded. In most cases, it is worthwhile to unload data in sorted order by specifying an ORDER BY clause in the query. This approach saves the time required to sort the data when it is reloaded.

The query must be enclosed in single quotation marks as shown following:

```
('select * from venue order by venueid')
```

> **Note**
>
> If your query contains quotation marks (for example to enclose literal values), put the literal between two sets of single quotation marks—you must also enclose the query between single quotation marks:
>
> ```
> ('select * from venue where venuestate=''NV''')
> ```

TO 's3://*object-path/name-prefix*'

The full path, including bucket name, to the location on Amazon S3 where Amazon Redshift writes the output file objects, including the manifest file if MANIFEST is specified. The object names are prefixed with *name-prefix*. If you use `PARTITION BY`, a forward slash (/) is automatically added to the end of the *name-prefix* value if needed. For added security, UNLOAD connects to Amazon S3 using an HTTPS connection. By default, UNLOAD writes one or more files per slice. UNLOAD appends a slice number and part number to the specified name prefix as follows:

`<object-path>/<name-prefix><slice-number>_part_<part-number>`.

If MANIFEST is specified, the manifest file is written as follows:

<object_path>/*<name_prefix>*`manifest`.

If PARALLEL is specified OFF, the data files are written as follows:

<object_path>/*<name_prefix><part-number>*.

UNLOAD automatically creates encrypted files using Amazon S3 server-side encryption (SSE), including the manifest file if MANIFEST is used. The COPY command automatically reads server-side encrypted files during the load operation. You can transparently download server-side encrypted files from your bucket using either the Amazon S3 console or API. For more information, see Protecting Data Using Server-Side Encryption.

> **Important**
>
> REGION is required when the Amazon S3 bucket isn't in the same AWS Region as the Amazon Redshift database.

authorization

The UNLOAD command needs authorization to write data to Amazon S3. The UNLOAD command uses the same parameters the COPY command uses for authorization. For more information, see Authorization parameters in the COPY command syntax reference.

IAM_ROLE { default | 'arn:aws:iam::*<AWS account-id-1>*:role/*<role-name>*'

Use the default keyword to have Amazon Redshift use the IAM role that is set as default and associated with the cluster when the UNLOAD command runs.

Use the Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization. If you specify IAM_ROLE, you can't use ACCESS_KEY_ID and SECRET_ACCESS_KEY, SESSION_TOKEN, or CREDENTIALS. The IAM_ROLE can be chained. For more information, see Chaining IAM roles in the *Amazon Redshift Management Guide*.

[FORMAT [AS]] CSV | PARQUET | JSON

Keywords to specify the unload format to override the default format.

When CSV, unloads to a text file in CSV format using a comma (,) character as the default delimiter. If a field contains delimiters, double quotation marks, newline characters, or carriage returns, then the field in the unloaded file is enclosed in double quotation marks. A double quotation mark within a data field is escaped by an additional double quotation mark. When zero rows are unloaded, Amazon Redshift might write empty Amazon S3 objects.

When PARQUET, unloads to a file in Apache Parquet version 1.0 format. By default, each row group is compressed using SNAPPY compression. For more information about Apache Parquet format, see Parquet.

When JSON, unloads to a JSON file with each line containing a JSON object, representing a full record in the query result. Amazon Redshift supports writing nested JSON when the query result contains SUPER columns. To create a valid JSON object, the name of each column in the query must be unique. In the JSON file, boolean values are unloaded as `t` or `f`, and NULL values are unloaded as `null`. When zero rows are unloaded, Amazon Redshift does not write Amazon S3 objects.

The FORMAT and AS keywords are optional. You can't use CSV with ESCAPE, FIXEDWIDTH, or ADDQUOTES. You can't use PARQUET with DELIMITER, FIXEDWIDTH, ADDQUOTES, ESCAPE, NULL AS, HEADER, GZIP, BZIP2, or ZSTD. PARQUET with ENCRYPTED is only supported with server-side encryption with an AWS Key Management Service key (SSE-KMS). You can't use JSON with DELIMITER, HEADER, FIXEDWIDTH, ADDQUOTES, ESCAPE, or NULL AS.

PARTITION BY (*column_name* [, ...]) [INCLUDE]

Specifies the partition keys for the unload operation. UNLOAD automatically partitions output files into partition folders based on the partition key values, following the Apache Hive convention. For example, a Parquet file that belongs to the partition year 2019 and the month September has the following prefix: `s3://amzn-s3-demo-bucket/my_prefix/year=2019/month=September/000.parquet`.

The value for *column_name* must be a column in the query results being unloaded.

If you specify PARTITION BY with the INCLUDE option, partition columns aren't removed from the unloaded files.

Amazon Redshift doesn't support string literals in PARTITION BY clauses.

MANIFEST [VERBOSE]

Creates a manifest file that explicitly lists details for the data files that are created by the UNLOAD process. The manifest is a text file in JSON format that lists the URL of each file that was written to Amazon S3.

If MANIFEST is specified with the VERBOSE option, the manifest includes the following details:

- The column names and data types, and for CHAR, VARCHAR, or NUMERIC data types, dimensions for each column. For CHAR and VARCHAR data types, the dimension is the length. For a DECIMAL or NUMERIC data type, the dimensions are precision and scale.
- The row count unloaded to each file. If the HEADER option is specified, the row count includes the header line.
- The total file size of all files unloaded and the total row count unloaded to all files. If the HEADER option is specified, the row count includes the header lines.
- The author. Author is always "Amazon Redshift".

You can specify VERBOSE only following MANIFEST.

The manifest file is written to the same Amazon S3 path prefix as the unload files in the format <object_path_prefix>manifest. For example, if UNLOAD specifies the Amazon S3 path prefix '`s3://amzn-s3-demo-bucket/venue_`', the manifest file location is '`s3://amzn-s3-demo-bucket/venue_manifest`'.

HEADER

Adds a header line containing column names at the top of each output file. Text transformation options, such as CSV, DELIMITER, ADDQUOTES, and ESCAPE, also apply to the header line. You can't use HEADER with FIXEDWIDTH.

DELIMITER AS '*delimiter_character*'

Specifies a single ASCII character that is used to separate fields in the output file, such as a pipe character (|), a comma (,), or a tab (\t). The default delimiter for text files is a pipe character. The default delimiter for CSV files is a comma character. The AS keyword is optional. You can't use DELIMITER with FIXEDWIDTH. If the data contains the delimiter character, you need to specify the ESCAPE option to escape the delimiter, or use ADDQUOTES to enclose the data in double quotation marks. Alternatively, specify a delimiter that isn't contained in the data.

FIXEDWIDTH '*fixedwidth_spec*'

Unloads the data to a file where each column width is a fixed length, rather than separated by a delimiter. The *fixedwidth_spec* is a string that specifies the number of columns and the width of the columns. The AS keyword is optional. Because FIXEDWIDTH doesn't truncate data, the specification for each column in the UNLOAD statement needs to be at least as long as the length of the longest entry for that column. The format for *fixedwidth_spec* is shown below:

```
'colID1:colWidth1,colID2:colWidth2, ...'
```

You can't use FIXEDWIDTH with DELIMITER or HEADER.

ENCRYPTED [AUTO]

Specifies that the output files on Amazon S3 are encrypted using Amazon S3 server-side encryption. If MANIFEST is specified, the manifest file is also encrypted. For more information, see Unloading encrypted data files. If you don't specify the ENCRYPTED parameter, UNLOAD automatically creates encrypted files using Amazon S3 server-side encryption with AWS-managed encryption keys (SSE-S3).

For ENCRYPTED, you might want to unload to Amazon S3 using server-side encryption with an AWS KMS key (SSE-KMS). If so, use the KMS_KEY_ID parameter to provide the key ID. You can't use the the section called “Using CREDENTIALS” parameter with the KMS_KEY_ID parameter. If you run an UNLOAD command for data using KMS_KEY_ID, you can then do a COPY operation for the same data without specifying a key.

If ENCRYPTED AUTO is used, the UNLOAD command fetches the default AWS KMS encryption key on the target Amazon S3 bucket property and encrypts the files written to Amazon S3 with the AWS KMS key. If the bucket doesn't have the default AWS KMS encryption key, UNLOAD automatically creates encrypted files using Amazon Redshift server-side encryption with AWS-managed encryption keys (SSE-S3). You can't use this option with KMS_KEY_ID, MASTER_SYMMETRIC_KEY, or CREDENTIALS that contains master_symmetric_key.

KMS_KEY_ID '*key-id*'

Specifies the key ID for an AWS Key Management Service (AWS KMS) key to be used to encrypt data files on Amazon S3. For more information, see What is AWS Key Management Service? If you specify KMS_KEY_ID, you must specify the ENCRYPTED parameter also. If you specify KMS_KEY_ID, you can't authenticate using the CREDENTIALS parameter. Instead, use either the section called “Using IAM_ROLE” or the section called “Using ACCESS_KEY_ID and SECRET_ACCESS_KEY”.

BZIP2

Unloads data to one or more bzip2-compressed files per slice. Each resulting file is appended with a `.bz2` extension.

GZIP

Unloads data to one or more gzip-compressed files per slice. Each resulting file is appended with a `.gz` extension.

ZSTD

Unloads data to one or more Zstandard-compressed files per slice. Each resulting file is appended with a `.zst` extension.

ADDQUOTES

Places quotation marks around each unloaded data field, so that Amazon Redshift can unload data values that contain the delimiter itself. For example, if the delimiter is a comma, you could unload and reload the following data successfully:

```
"1","Hello, World"
```

Without the added quotation marks, the string `Hello, World` would be parsed as two separate fields.

Some output formats do not support ADDQUOTES.

If you use ADDQUOTES, you must specify REMOVEQUOTES in the COPY if you reload the data.

NULL AS '*null-string*'

Specifies a string that represents a null value in unload files. If this option is used, all output files contain the specified string in place of any null values found in the selected data. If this option isn't specified, null values are unloaded as:

- Zero-length strings for delimited output
- Whitespace strings for fixed-width output

If a null string is specified for a fixed-width unload and the width of an output column is less than the width of the null string, the following behavior occurs:

- An empty field is output for non-character columns
- An error is reported for character columns

Unlike other data types where a user-defined string represents a null value, Amazon Redshift exports the SUPER data columns using the JSON format and represents it as null as determined by the JSON format. As a result, SUPER data columns ignore the NULL [AS] option used in UNLOAD commands.

ESCAPE

For CHAR and VARCHAR columns in delimited unload files, an escape character (\) is placed before every occurrence of the following characters:

- Linefeed: `\n`
- Carriage return: `\r`
- The delimiter character specified for the unloaded data.
- The escape character: `\`
- A quotation mark character: `"` or `'` (if both ESCAPE and ADDQUOTES are specified in the UNLOAD command).

> **Important**
>
> If you loaded your data using a COPY with the ESCAPE option, you must also specify the ESCAPE option with your UNLOAD command to generate the reciprocal output file. Similarly, if you UNLOAD using the ESCAPE option, you need to use ESCAPE when you COPY the same data.

ALLOWOVERWRITE

By default, UNLOAD fails if it finds files that it would possibly overwrite. If ALLOWOVERWRITE is specified, UNLOAD overwrites existing files, including the manifest file.

CLEANPATH

The CLEANPATH option removes existing files located in the Amazon S3 path specified in the TO clause before unloading files to the specified location.

If you include the PARTITION BY clause, existing files are removed only from the partition folders to receive new files generated by the UNLOAD operation.

You must have the `s3:DeleteObject` permission on the Amazon S3 bucket. For information, see Policies and Permissions in Amazon S3 in the *Amazon Simple Storage Service User Guide*. Files that you remove by using the CLEANPATH option are permanently deleted and can't be recovered. If the target Amazon S3 bucket has versioning enabled, UNLOAD with the CLEANPATH option does not remove previous versions of the files.

You can't specify the CLEANPATH option if you specify the ALLOWOVERWRITE option.

PARALLEL

By default, UNLOAD writes data in parallel to multiple files, according to the number of slices in the cluster. The default option is ON or TRUE. If PARALLEL is OFF or FALSE, UNLOAD writes to one or more data files serially, sorted absolutely according to the ORDER BY clause, if one is used. The maximum size for a data file is 6.2 GB. So, for example, if you unload 13.4 GB of data, UNLOAD creates the following three files.

```
s3://amzn-s3-demo-bucket/key000    6.2 GB
s3://amzn-s3-demo-bucket/key001    6.2 GB
s3://amzn-s3-demo-bucket/key002    1.0 GB
```

> **Note**
>
> The UNLOAD command is designed to use parallel processing. We recommend leaving PARALLEL enabled for most cases, especially if the files are used to load tables using a COPY command.

MAXFILESIZE [AS] max-size [MB | GB]

Specifies the maximum size of files that UNLOAD creates in Amazon S3. Specify a decimal value between 5 MB and 6.2 GB. The AS keyword is optional. The default unit is MB. If MAXFILESIZE isn't specified, the default maximum file size is 6.2 GB. The size of the manifest file, if one is used, isn't affected by MAXFILESIZE.

ROWGROUPSIZE [AS] size [MB | GB]

Specifies the size of row groups. Choosing a larger size can reduce the number of row groups, reducing the amount of network communication. Specify an integer value between 32 MB and 128 MB. The AS keyword is optional. The default unit is MB.

If ROWGROUPSIZE isn't specified, the default size is 32 MB. To use this parameter, the storage format must be Parquet and the node type must be ra3.4xlarge, ra3.16xlarge, or dc2.8xlarge.

REGION [AS] '*aws-region*'

Specifies the AWS Region where the target Amazon S3 bucket is located. REGION is required for UNLOAD to an Amazon S3 bucket that isn't in the same AWS Region as the Amazon Redshift database.

The value for *aws_region* must match an AWS Region listed in the [Amazon Redshift regions and endpoints](#) table in the *AWS General Reference*.

By default, UNLOAD assumes that the target Amazon S3 bucket is located in the same AWS Region as the Amazon Redshift database.

EXTENSION '*extension-name*'

Specifies the file extension to append to the names of the unloaded files. Amazon Redshift doesn't run any validation, so you must verify that the specified file extension is correct. If you specify a compression method without providing an extension, Amazon Redshift only adds the compression method's extension to the filename. If you don't provide any extension and don't specify a compression method, Amazon Redshift doesn't add anything to the filename.

Usage notes

Using ESCAPE for all delimited text UNLOAD operations

When you UNLOAD using a delimiter, your data can include that delimiter or any of the characters listed in the ESCAPE option description. In this case, you must use the ESCAPE option with the UNLOAD statement. If you don't use the ESCAPE option with the UNLOAD, subsequent COPY operations using the unloaded data might fail.

Important

We strongly recommend that you always use ESCAPE with both UNLOAD and COPY statements. The exception is if you are certain that your data doesn't contain any delimiters or other characters that might need to be escaped.

Loss of floating-point precision

You might encounter loss of precision for floating-point data that is successively unloaded and reloaded.

Limit clause

The SELECT query can't use a LIMIT clause in the outer SELECT. For example, the following UNLOAD statement fails.

```
unload ('select * from venue limit 10')
to 's3://amzn-s3-demo-bucket/venue_pipe_' iam_role 'arn:aws:iam::0123456789012:role/
MyRedshiftRole';
```

Instead, use a nested LIMIT clause, as in the following example.

```
unload ('select * from venue where venueid in
(select venueid from venue order by venueid desc limit 10)')
to 's3://amzn-s3-demo-bucket/venue_pipe_' iam_role 'arn:aws:iam::0123456789012:role/
MyRedshiftRole';
```

You can also populate a table using SELECT…INTO or CREATE TABLE AS using a LIMIT clause, then unload from that table.

Unloading a column of the GEOMETRY data type

You can only unload GEOMETRY columns to text or CSV format. You can't unload GEOMETRY data with the `FIXEDWIDTH` option. The data is unloaded in the hexadecimal form of the extended well-known binary (EWKB) format. If the size of the EWKB data is more than 4 MB, then a warning occurs because the data can't later be loaded into a table.

Unloading the HLLSKETCH data type

You can only unload HLLSKETCH columns to text or CSV format. You can't unload HLLSKETCH data with the `FIXEDWIDTH` option. The data is unloaded in the Base64 format for dense HyperLogLog sketches or in the JSON format for sparse HyperLogLog sketches. For more information, see [HyperLogLog functions](#).

The following example exports a table containing HLLSKETCH columns into a file.

```
CREATE TABLE a_table(an_int INT, b_int INT);
INSERT INTO a_table VALUES (1,1), (2,1), (3,1), (4,1), (1,2), (2,2), (3,2), (4,2),
 (5,2), (6,2);

CREATE TABLE hll_table (sketch HLLSKETCH);
INSERT INTO hll_table select hll_create_sketch(an_int) from a_table group by b_int;

UNLOAD ('select * from hll_table') TO 's3://amzn-s3-demo-bucket/unload/'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole' NULL AS 'null' ALLOWOVERWRITE
 CSV;
```

Unloading a column of the VARBYTE data type

You can only unload VARBYTE columns to text or CSV format. The data is unloaded in the hexadecimal form. You can't unload VARBYTE data with the `FIXEDWIDTH` option. The `ADDQUOTES` option of UNLOAD to a CSV is not supported. A VARBYTE column can't be a PARTITIONED BY column.

FORMAT AS PARQUET clause

Be aware of these considerations when using FORMAT AS PARQUET:

- Unload to Parquet doesn't use file level compression. Each row group is compressed with SNAPPY.
- If MAXFILESIZE isn't specified, the default maximum file size is 6.2 GB. You can use MAXFILESIZE to specify a file size of 5 MB–6.2 GB. The actual file size is approximated when the file is being written, so it might not be exactly equal to the number you specify.

  To maximize scan performance, Amazon Redshift tries to create Parquet files that contain equally sized 32-MB row groups. The MAXFILESIZE value that you specify is automatically rounded down to the nearest multiple of 32 MB. For example, if you specify MAXFILESIZE 200 MB, then each Parquet file unloaded is approximately 192 MB (32 MB row group x 6 = 192 MB).
- If a column uses TIMESTAMPTZ data format, only the timestamp values are unloaded. The time zone information isn't unloaded.
- Don't specify file name prefixes that begin with underscore (_) or period (.) characters. Redshift Spectrum treats files that begin with these characters as hidden files and ignores them.

PARTITION BY clause

Be aware of these considerations when using PARTITION BY:

- Partition columns aren't included in the output file.
- Make sure to include partition columns in the SELECT query used in the UNLOAD statement. You can specify any number of partition columns in the UNLOAD command. However, there is a limitation that there should be at least one nonpartition column to be part of the file.
- If the partition key value is null, Amazon Redshift automatically unloads that data into a default partition called `partition_column=__HIVE_DEFAULT_PARTITION__`.
- The UNLOAD command doesn't make any calls to an external catalog. To register your new partitions to be part of your existing external table, use a separate ALTER TABLE ... ADD PARTITION ... command. Or you can run a CREATE EXTERNAL TABLE command to register the unloaded data as a new external table. You can also use an AWS Glue crawler to populate your Data Catalog. For more information, see [Defining Crawlers](#) in the *AWS Glue Developer Guide*.
- If you use the MANIFEST option, Amazon Redshift generates only one manifest file in the root Amazon S3 folder.

- The column data types that you can use as the partition key are SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, BOOLEAN, CHAR, VARCHAR, DATE, and TIMESTAMP.

Using the ASSUMEROLE privilege to grant access to an IAM role for UNLOAD operations

To provide access for specific users and groups to an IAM role for UNLOAD operations, a superuser can grant the ASSUMEROLE privilege on an IAM role to users and groups. For information, see GRANT.

UNLOAD doesn't support Amazon S3 access point aliases

You can't use Amazon S3 access point aliases with the UNLOAD command.

Examples

For examples that show how to use the UNLOAD command, see UNLOAD examples.

UNLOAD examples

These examples demonstrate various parameters of the UNLOAD command. The TICKIT sample data is used in many of the examples. For more information, see Sample database.

> **Note**
>
> These examples contain line breaks for readability. Do not include line breaks or spaces in your *credentials-args* string.

Unload VENUE to a pipe-delimited file (default delimiter)

The following example unloads the VENUE table and writes the data to `s3://amzn-s3-demo-bucket/unload/`:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

By default, UNLOAD writes one or more files per slice. Assuming a two-node cluster with two slices per node, the previous example creates these files in `amzn-s3-demo-bucket`:

```
unload/0000_part_00
unload/0001_part_00
unload/0002_part_00
unload/0003_part_00
```

To better differentiate the output files, you can include a prefix in the location. The following example unloads the VENUE table and writes the data to `s3://amzn-s3-demo-bucket/unload/venue_pipe_`:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The result is these four files in the `unload` folder, again assuming four slices.

```
venue_pipe_0000_part_00
venue_pipe_0001_part_00
venue_pipe_0002_part_00
venue_pipe_0003_part_00
```

Unload LINEITEM table to partitioned Parquet files

The following example unloads the LINEITEM table in Parquet format, partitioned by the `l_shipdate` column.

```
unload ('select * from lineitem')
to 's3://amzn-s3-demo-bucket/lineitem/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
PARQUET
PARTITION BY (l_shipdate);
```

Assuming four slices, the resulting Parquet files are dynamically partitioned into various folders.

```

s3://amzn-s3-demo-bucket/lineitem/l_shipdate=1992-01-02/0000_part_00.parquet
                                                        0001_part_00.parquet
                                                        0002_part_00.parquet
                                                        0003_part_00.parquet
s3://amzn-s3-demo-bucket/lineitem/l_shipdate=1992-01-03/0000_part_00.parquet
                                                        0001_part_00.parquet
```

```
                                                            0002_part_00.parquet
                                                            0003_part_00.parquet
s3://amzn-s3-demo-bucket/lineitem/l_shipdate=1992-01-04/0000_part_00.parquet
                                                            0001_part_00.parquet
                                                            0002_part_00.parquet
                                                            0003_part_00.parquet
...
```

Note

In some cases, the UNLOAD command used the INCLUDE option as shown in the following SQL statement.

```
unload ('select * from lineitem')
to 's3://amzn-s3-demo-bucket/lineitem/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
PARQUET
PARTITION BY (l_shipdate) INCLUDE;
```

In these cases, the `l_shipdate` column is also in the data in the Parquet files. Otherwise, the `l_shipdate` column data isn't in the Parquet files.

Unload the VENUE table to a JSON file

The following example unloads the VENUE table and writes the data in JSON format to `s3://amzn-s3-demo-bucket/unload/`.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
JSON;
```

Following are sample rows from the VENUE table.

```
venueid | venuename                  | venuecity        | venuestate | venueseats
--------+----------------------------+------------------+------------+-----------
      1 | Pinewood Racetrack         | Akron            | OH         | 0
      2 | Columbus "Crew" Stadium    | Columbus         | OH         | 0
      4 | Community, Ballpark, Arena | Kansas City      | KS         | 0
```

After unloading to JSON, the format of the file is similar to the following.

```
{"venueid":1,"venuename":"Pinewood
 Racetrack","venuecity":"Akron","venuestate":"OH","venueseats":0}
{"venueid":2,"venuename":"Columbus \"Crew\" Stadium
 ","venuecity":"Columbus","venuestate":"OH","venueseats":0}
{"venueid":4,"venuename":"Community, Ballpark, Arena","venuecity":"Kansas
 City","venuestate":"KS","venueseats":0}
```

Unload VENUE to a CSV file

The following example unloads the VENUE table and writes the data in CSV format to `s3://amzn-s3-demo-bucket/unload/`.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
CSV;
```

Suppose that the VENUE table contains the following rows.

```

venueid | venuename                    | venuecity       | venuestate | venueseats
--------+----------------------------+-----------------+------------+-----------
      1 | Pinewood Racetrack         | Akron           | OH         | 0
      2 | Columbus "Crew" Stadium    | Columbus        | OH         | 0
      4 | Community, Ballpark, Arena | Kansas City     | KS         | 0

```

The unload file looks similar to the following.

```
1,Pinewood Racetrack,Akron,OH,0
2,"Columbus ""Crew"" Stadium",Columbus,OH,0
4,"Community, Ballpark, Arena",Kansas City,KS,0
```

Unload VENUE to a CSV file using a delimiter

The following example unloads the VENUE table and writes the data in CSV format using the pipe character (|) as the delimiter. The unloaded file is written to `s3://amzn-s3-demo-bucket/unload/`. The VENUE table in this example contains the pipe character in the value of the first row (`Pinewood Race|track`). It does this to show that the value in the result is enclosed in double quotation marks. A double quotation mark is escaped by a double quotation mark, and the entire field is enclosed in double quotation marks.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
CSV DELIMITER AS '|';
```

Suppose that the VENUE table contains the following rows.

```

venueid | venuename                   | venuecity         | venuestate | venueseats
--------+-----------------------------+------------------+------------+-------------
      1 | Pinewood Race|track        | Akron             | OH         | 0
      2 | Columbus "Crew" Stadium    | Columbus          | OH         | 0
      4 | Community, Ballpark, Arena | Kansas City       | KS         | 0
```

The unload file looks similar to the following.

```
1|"Pinewood Race|track"|Akron|OH|0
2|"Columbus ""Crew"" Stadium"|Columbus|OH|0
4|Community, Ballpark, Arena|Kansas City|KS|0
```

Unload VENUE with a manifest file

To create a manifest file, include the MANIFEST option. The following example unloads the VENUE table and writes a manifest file along with the data files to s3://amzn-s3-demo-bucket/venue_pipe_:

> **Important**
>
> If you unload files with the MANIFEST option, you should use the MANIFEST option with the COPY command when you load the files. If you use the same prefix to load the files and don't specify the MANIFEST option, COPY fails because it assumes the manifest file is a data file.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_pipe_' iam_role 'arn:aws:iam::0123456789012:role/
MyRedshiftRole'
```

```
manifest;
```

The result is these five files:

```
s3://amzn-s3-demo-bucket/venue_pipe_0000_part_00
s3://amzn-s3-demo-bucket/venue_pipe_0001_part_00
s3://amzn-s3-demo-bucket/venue_pipe_0002_part_00
s3://amzn-s3-demo-bucket/venue_pipe_0003_part_00
s3://amzn-s3-demo-bucket/venue_pipe_manifest
```

The following shows the contents of the manifest file.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0000_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0001_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0002_part_00"},
    {"url":"s3://amzn-s3-demo-bucket/tickit/venue_0003_part_00"}
  ]
}
```

Unload VENUE with MANIFEST VERBOSE

When you specify the MANIFEST VERBOSE option, the manifest file includes the following sections:

- The `entries` section lists Amazon S3 path, file size, and row count for each file.
- The `schema` section lists the column names, data types, and dimension for each column.
- The `meta` section shows the total file size and row count for all files.

The following example unloads the VENUE table using the MANIFEST VERBOSE option.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload_venue_folder/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest verbose;
```

The following shows the contents of the manifest file.

```
{
```

```
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/venue_pipe_0000_part_00", "meta":
 { "content_length": 32295, "record_count": 10 }},
    {"url":"s3://amzn-s3-demo-bucket/venue_pipe_0001_part_00", "meta":
 { "content_length": 32771, "record_count": 20 }},
    {"url":"s3://amzn-s3-demo-bucket/venue_pipe_0002_part_00", "meta":
 { "content_length": 32302, "record_count": 10 }},
    {"url":"s3://amzn-s3-demo-bucket/venue_pipe_0003_part_00", "meta":
 { "content_length": 31810, "record_count": 15 }}
  ],
  "schema": {
    "elements": [
      {"name": "venueid", "type": { "base": "integer" }},
      {"name": "venuename", "type": { "base": "character varying", 25 }},
      {"name": "venuecity", "type": { "base": "character varying", 25 }},
      {"name": "venuestate", "type": { "base": "character varying", 25 }},
      {"name": "venueseats", "type": { "base": "character varying", 25 }}
    ]
  },
  "meta": {
    "content_length": 129178,
    "record_count": 55
  },
  "author": {
    "name": "Amazon Redshift",
    "version": "1.0.0"
  }
}
```

Unload VENUE with a header

The following example unloads VENUE with a header row.

```
unload ('select * from venue where venueseats > 75000')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
header
parallel off;
```

The following shows the contents of the output file with a header row.

```
venueid|venuename|venuecity|venuestate|venueseats
6|New York Giants Stadium|East Rutherford|NJ|80242
```

```
78|INVESCO Field|Denver|CO|76125
83|FedExField|Landover|MD|91704
79|Arrowhead Stadium|Kansas City|MO|79451
```

Unload VENUE to smaller files

By default, the maximum file size is 6.2 GB. If the unload data is larger than 6.2 GB, UNLOAD creates a new file for each 6.2 GB data segment. To create smaller files, include the MAXFILESIZE parameter. Assuming the size of the data in the previous example was 20 GB, the following UNLOAD command creates 20 files, each 1 GB in size.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
maxfilesize 1 gb;
```

Unload VENUE serially

To unload serially, specify PARALLEL OFF. UNLOAD then writes one file at a time, up to a maximum of 6.2 GB per file.

The following example unloads the VENUE table and writes the data serially to `s3://amzn-s3-demo-bucket/unload/`.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/venue_serial_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
parallel off;
```

The result is one file named venue_serial_000.

If the unload data is larger than 6.2 GB, UNLOAD creates a new file for each 6.2 GB data segment. The following example unloads the LINEORDER table and writes the data serially to `s3://amzn-s3-demo-bucket/unload/`.

```
unload ('select * from lineorder')
to 's3://amzn-s3-demo-bucket/unload/lineorder_serial_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
parallel off gzip;
```

The result is the following series of files.

```
lineorder_serial_0000.gz
lineorder_serial_0001.gz
lineorder_serial_0002.gz
lineorder_serial_0003.gz
```

To better differentiate the output files, you can include a prefix in the location. The following example unloads the VENUE table and writes the data to `s3://amzn-s3-demo-bucket/venue_pipe_`:

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/unload/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The result is these four files in the `unload` folder, again assuming four slices.

```
venue_pipe_0000_part_00
venue_pipe_0001_part_00
venue_pipe_0002_part_00
venue_pipe_0003_part_00
```

Load VENUE from unload files

To load a table from a set of unload files, simply reverse the process by using a COPY command. The following example creates a new table, LOADVENUE, and loads the table from the data files created in the previous example.

```
create table loadvenue (like venue);

copy loadvenue from 's3://amzn-s3-demo-bucket/venue_pipe_' iam_role
 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

If you used the MANIFEST option to create a manifest file with your unload files, you can load the data using the same manifest file. You do so with a COPY command with the MANIFEST option. The following example loads data using a manifest file.

```
copy loadvenue
from 's3://amzn-s3-demo-bucket/venue_pipe_manifest' iam_role
 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
```

```
manifest;
```

Unload VENUE to encrypted files

The following example unloads the VENUE table to a set of encrypted files using an AWS KMS key. If you specify a manifest file with the ENCRYPTED option, the manifest file is also encrypted. For more information, see Unloading encrypted data files.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_encrypt_kms'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
kms_key_id '1234abcd-12ab-34cd-56ef-1234567890ab'
manifest
encrypted;
```

The following example unloads the VENUE table to a set of encrypted files using a root symmetric key.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_encrypt_cmk'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key 'EXAMPLEMASTERKEYtkbjk/OpCwtYSx/M4/t7DMCDIK722'
encrypted;
```

Load VENUE from encrypted files

To load tables from a set of files that were created by using UNLOAD with the ENCRYPT option, reverse the process by using a COPY command. With that command, use the ENCRYPTED option and specify the same root symmetric key that was used for the UNLOAD command. The following example loads the LOADVENUE table from the encrypted data files created in the previous example.

```
create table loadvenue (like venue);

copy loadvenue
from 's3://amzn-s3-demo-bucket/venue_encrypt_manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key 'EXAMPLEMASTERKEYtkbjk/OpCwtYSx/M4/t7DMCDIK722'
manifest
encrypted;
```

Unload VENUE data to a tab-delimited file

```
unload ('select venueid, venuename, venueseats from venue')
to 's3://amzn-s3-demo-bucket/venue_tab_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter as '\t';
```

The output data files look like this:

```
1 Toyota Park Bridgeview IL 0
2 Columbus Crew Stadium Columbus OH 0
3 RFK Stadium Washington DC 0
4 CommunityAmerica Ballpark Kansas City KS 0
5 Gillette Stadium Foxborough MA 68756
...
```

Unload VENUE to a fixed-width data file

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_fw_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
fixedwidth as 'venueid:3,venuename:39,venuecity:16,venuestate:2,venueseats:6';
```

The output data files look like the following.

```
1  Toyota Park              Bridgeview  IL0
2  Columbus Crew Stadium    Columbus    OH0
3  RFK Stadium              Washington  DC0
4  CommunityAmerica BallparkKansas City KS0
5  Gillette Stadium         Foxborough  MA68756
...
```

Unload VENUE to a set of tab-delimited GZIP-compressed files

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_tab_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter as '\t'
gzip;
```

Unload VENUE to a GZIP-compressed text file

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_tab_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
extension 'txt.gz'
gzip;
```

Unload data that contains a delimiter

This example uses the ADDQUOTES option to unload comma-delimited data where some of the actual data fields contain a comma.

First, create a table that contains quotation marks.

```
create table location (id int, location char(64));

insert into location values (1,'Phoenix, AZ'),(2,'San Diego, CA'),(3,'Chicago, IL');
```

Then, unload the data using the ADDQUOTES option.

```
unload ('select id, location from location')
to 's3://amzn-s3-demo-bucket/location_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter ',' addquotes;
```

The unloaded data files look like this:

```
1,"Phoenix, AZ"
2,"San Diego, CA"
3,"Chicago, IL"
...
```

Unload the results of a join query

The following example unloads the results of a join query that contains a window function.

```
unload ('select venuecity, venuestate, caldate, pricepaid,
sum(pricepaid) over(partition by venuecity, venuestate
order by caldate rows between 3 preceding and 3 following) as winsum
from sales join date on sales.dateid=date.dateid
join event on event.eventid=sales.eventid
```

```
join venue on event.venueid=venue.venueid
order by 1,2')
to 's3://amzn-s3-demo-bucket/tickit/winsum'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The output files look like this:

```
Atlanta|GA|2008-01-04|363.00|1362.00
Atlanta|GA|2008-01-05|233.00|2030.00
Atlanta|GA|2008-01-06|310.00|3135.00
Atlanta|GA|2008-01-08|166.00|8338.00
Atlanta|GA|2008-01-11|268.00|7630.00
...
```

Unload using NULL AS

UNLOAD outputs null values as empty strings by default. The following examples show how to use NULL AS to substitute a text string for nulls.

For these examples, we add some null values to the VENUE table.

```
update venue set venuestate = NULL
where venuecity = 'Cleveland';
```

Select from VENUE where VENUESTATE is null to verify that the columns contain NULL.

```
select * from venue where venuestate is null;

 venueid |         venuename          | venuecity | venuestate | venueseats
---------+--------------------------+-----------+------------+------------
      22 | Quicken Loans Arena      | Cleveland |            |          0
     101 | Progressive Field        | Cleveland |            |      43345
      72 | Cleveland Browns Stadium | Cleveland |            |      73200
```

Now, UNLOAD the VENUE table using the NULL AS option to replace null values with the character string 'fred'.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
null as 'fred';
```

The following sample from the unload file shows that null values were replaced with `fred`. It turns out that some values for VENUESEATS were also null and were replaced with `fred`. Even though the data type for VENUESEATS is integer, UNLOAD converts the values to text in the unload files, and then COPY converts them back to integer. If you are unloading to a fixed-width file, the NULL AS string must not be larger than the field width.

```
248|Charles Playhouse|Boston|MA|0
251|Paris Hotel|Las Vegas|NV|fred
258|Tropicana Hotel|Las Vegas|NV|fred
300|Kennedy Center Opera House|Washington|DC|0
306|Lyric Opera House|Baltimore|MD|0
308|Metropolitan Opera|New York City|NY|0
  5|Gillette Stadium|Foxborough|MA|5
 22|Quicken Loans Arena|Cleveland|fred|0
101|Progressive Field|Cleveland|fred|43345
...
```

To load a table from the unload files, use a COPY command with the same NULL AS option.

> **Note**
>
> If you attempt to load nulls into a column defined as NOT NULL, the COPY command fails.

```
create table loadvenuenulls (like venue);

copy loadvenuenulls from 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
null as 'fred';
```

To verify that the columns contain null, not just empty strings, select from LOADVENUENULLS and filter for null.

```
select * from loadvenuenulls where venuestate is null or venueseats is null;

 venueid |        venuename         | venuecity | venuestate | venueseats
---------+--------------------------+-----------+------------+------------
      72 | Cleveland Browns Stadium | Cleveland |            |      73200
     253 | Mirage Hotel             | Las Vegas | NV         |
     255 | Venetian Hotel           | Las Vegas | NV         |
```

```
      22 | Quicken Loans Arena       | Cleveland |            |          0
     101 | Progressive Field         | Cleveland |            |      43345
     251 | Paris Hotel               | Las Vegas | NV         |

...
```

You can UNLOAD a table that contains nulls using the default NULL AS behavior and then COPY the data back into a table using the default NULL AS behavior; however, any non-numeric fields in the target table contain empty strings, not nulls. By default UNLOAD converts nulls to empty strings (white space or zero-length). COPY converts empty strings to NULL for numeric columns, but inserts empty strings into non-numeric columns. The following example shows how to perform an UNLOAD followed by a COPY using the default NULL AS behavior.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' allowoverwrite;

truncate loadvenuenulls;
copy loadvenuenulls from 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

In this case, when you filter for nulls, only the rows where VENUESEATS contained nulls. Where VENUESTATE contained nulls in the table (VENUE), VENUESTATE in the target table (LOADVENUENULLS) contains empty strings.

```
select * from loadvenuenulls where venuestate is null or venueseats is null;

 venueid |        venuename          | venuecity | venuestate | venueseats
---------+---------------------------+-----------+------------+------------
     253 | Mirage Hotel              | Las Vegas | NV         |
     255 | Venetian Hotel            | Las Vegas | NV         |
     251 | Paris Hotel               | Las Vegas | NV         |
...
```

To load empty strings to non-numeric columns as NULL, include the EMPTYASNULL or BLANKSASNULL options. It's OK to use both.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' allowoverwrite;
```

```
truncate loadvenuenulls;
copy loadvenuenulls from 's3://amzn-s3-demo-bucket/nulls/'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' EMPTYASNULL;
```

To verify that the columns contain NULL, not just whitespace or empty strings, select from LOADVENUENULLS and filter for null.

```
select * from loadvenuenulls where venuestate is null or venueseats is null;

 venueid |        venuename          | venuecity | venuestate | venueseats
---------+--------------------------+-----------+------------+------------
      72 | Cleveland Browns Stadium | Cleveland |            |      73200
     253 | Mirage Hotel             | Las Vegas | NV         |
     255 | Venetian Hotel           | Las Vegas | NV         |
      22 | Quicken Loans Arena      | Cleveland |            |          0
     101 | Progressive Field        | Cleveland |            |      43345
     251 | Paris Hotel              | Las Vegas | NV         |
     ...
```

Unload using ALLOWOVERWRITE parameter

By default, UNLOAD doesn't overwrite existing files in the destination bucket. For example, if you run the same UNLOAD statement twice without modifying the files in the destination bucket, the second UNLOAD fails. To overwrite the existing files, including the manifest file, specify the ALLOWOVERWRITE option.

```
unload ('select * from venue')
to 's3://amzn-s3-demo-bucket/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest allowoverwrite;
```

Unload EVENT table using PARALLEL and MANIFEST parameters

You can UNLOAD a table in parallel and generate a manifest file. The Amazon S3 data files are all created at the same level and names are suffixed with the pattern `0000_part_00`. The manifest file is at the same folder level as the data files and suffixed with the text `manifest`. The following SQL unloads the EVENT table and creates files with the base name `parallel`

```
unload ('select * from mytickit1.event')
to 's3://amzn-s3-demo-bucket/parallel'
```

```
iam_role 'arn:aws:iam::123456789012:role/MyRedshiftRole'
parallel on
manifest;
```

The Amazon S3 files listing is similar to the following.

```
Name                        Last modified                        Size
parallel0000_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 52.1 KB
parallel0001_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 53.4 KB
parallel0002_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 52.1 KB
parallel0003_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 51.1 KB
parallel0004_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 54.6 KB
parallel0005_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 53.4 KB
parallel0006_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 54.1 KB
parallel0007_part_00 -   August 2, 2023, 14:54:39 (UTC-07:00) 55.9 KB
parallelmanifest       -   August 2, 2023, 14:54:39 (UTC-07:00) 886.0 B
```

The `parallelmanifest` file content is similar to the following.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/parallel0000_part_00", "meta": { "content_length":
 53316 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0001_part_00", "meta": { "content_length":
 54704 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0002_part_00", "meta": { "content_length":
 53326 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0003_part_00", "meta": { "content_length":
 52356 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0004_part_00", "meta": { "content_length":
 55933 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0005_part_00", "meta": { "content_length":
 54648 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0006_part_00", "meta": { "content_length":
 55436 }},
    {"url":"s3://amzn-s3-demo-bucket/parallel0007_part_00", "meta": { "content_length":
 57272 }}
  ]
}
```

Unload EVENT table using PARALLEL OFF and MANIFEST parameters

You can UNLOAD a table serially (PARALLEL OFF) and generate a manifest file. The Amazon S3 data files are all created at the same level and names are suffixed with the pattern `0000`. The manifest file is at the same folder level as the data files and suffixed with the text `manifest`.

```
unload ('select * from mytickit1.event')
to 's3://amzn-s3-demo-bucket/serial'
iam_role 'arn:aws:iam::123456789012:role/MyRedshiftRole'
parallel off
manifest;
```

The Amazon S3 files listing is similar to the following.

```
Name                       Last modified                           Size
serial0000             -   August 2, 2023, 15:54:39 (UTC-07:00) 426.7 KB
serialmanifest         -   August 2, 2023, 15:54:39 (UTC-07:00) 120.0 B
```

The `serialmanifest` file content is similar to the following.

```
{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/serial000", "meta": { "content_length": 436991 }}
  ]
}
```

Unload EVENT table using PARTITION BY and MANIFEST parameters

You can UNLOAD a table by partition and generate a manifest file. A new folder is created in Amazon S3 with child partition folders, and the data files in the child folders with a name pattern similar to `0000_par_00`. The manifest file is at the same folder level as the child folders with the name `manifest`.

```
unload ('select * from mytickit1.event')
to 's3://amzn-s3-demo-bucket/partition'
iam_role 'arn:aws:iam::123456789012:role/MyRedshiftRole'
partition by (eventname)
manifest;
```

The Amazon S3 files listing is similar to the following.

```
Name                      Type     Last modified                             Size

partition               Folder
```

In the `partition` folder are child folders with the partition name and the manifest file. Shown following is the bottom of the list of folders in the `partition` folder, similar to the following.

```
Name                      Type      Last modified                             Size

...
eventname=Zucchero/     Folder
eventname=Zumanity/     Folder
eventname=ZZ Top/       Folder
manifest                -      August 2, 2023, 15:54:39 (UTC-07:00) 467.6 KB
```

In the `eventname=Zucchero/` folder are the data files similar to the following.

```
Name                  Last modified                            Size
0000_part_00 -   August 2, 2023, 15:59:19 (UTC-07:00) 70.0 B
0001_part_00 -   August 2, 2023, 15:59:16 (UTC-07:00) 106.0 B
0002_part_00 -   August 2, 2023, 15:59:15 (UTC-07:00) 70.0 B
0004_part_00 -   August 2, 2023, 15:59:17 (UTC-07:00) 141.0 B
0006_part_00 -   August 2, 2023, 15:59:16 (UTC-07:00) 35.0 B
0007_part_00 -   August 2, 2023, 15:59:19 (UTC-07:00) 108.0 B
```

The bottom of the `manifest` file content is similar to the following.

```
{
  "entries": [
    ...
    {"url":"s3://amzn-s3-demo-bucket/partition/eventname=Zucchero/007_part_00", "meta":
 { "content_length": 108 }},
    {"url":"s3://amzn-s3-demo-bucket/partition/eventname=Zumanity/007_part_00", "meta":
 { "content_length": 72 }}
  ]
```

```
}
```

Unload EVENT table using MAXFILESIZE, ROWGROUPSIZE, and MANIFEST parameters

You can UNLOAD a table in parallel and generate a manifest file. The Amazon S3 data files are all created at the same level and names are suffixed with the pattern `0000_part_00`. The generated Parquet data files are limited to 256 MB and row group size 128 MB. The manifest file is at the same folder level as the data files and suffixed with `manifest`.

```
unload ('select * from mytickit1.event')
to 's3://amzn-s3-demo-bucket/eventsize'
iam_role 'arn:aws:iam::123456789012:role/MyRedshiftRole'
maxfilesize 256 MB
rowgroupsize 128 MB
parallel on
parquet
manifest;
```

The Amazon S3 files listing is similar to the following.

```

 Name                            Type     Last modified                             Size
 eventsize0000_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 24.5 KB
 eventsize0001_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 24.8 KB
 eventsize0002_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 24.4 KB
 eventsize0003_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 24.0 KB
 eventsize0004_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 25.3 KB
 eventsize0005_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 24.8 KB
 eventsize0006_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 25.0 KB
 eventsize0007_part_00.parquet parquet August 2, 2023, 17:35:21 (UTC-07:00) 25.6 KB
 eventsizemanifest                 -       August 2, 2023, 17:35:21 (UTC-07:00) 958.0 B

```

The `eventsizemanifest` file content is similar to the following.

```

{
  "entries": [
    {"url":"s3://amzn-s3-demo-bucket/eventsize0000_part_00.parquet", "meta":
 { "content_length": 25130 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0001_part_00.parquet", "meta":
 { "content_length": 25428 }},
```

```
    {"url":"s3://amzn-s3-demo-bucket/eventsize0002_part_00.parquet", "meta":
 { "content_length": 25025 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0003_part_00.parquet", "meta":
 { "content_length": 24554 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0004_part_00.parquet", "meta":
 { "content_length": 25918 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0005_part_00.parquet", "meta":
 { "content_length": 25362 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0006_part_00.parquet", "meta":
 { "content_length": 25647 }},
    {"url":"s3://amzn-s3-demo-bucket/eventsize0007_part_00.parquet", "meta":
 { "content_length": 26256 }}
  ]
}
```

UPDATE

Topics

- Syntax
- Parameters
- Usage notes
- Examples of UPDATE statements

Updates values in one or more table columns when a condition is satisfied.

> **Note**
>
> The maximum size for a single SQL statement is 16 MB.

Syntax

```
[ WITH [RECURSIVE] common_table_expression [, common_table_expression , ...] ]
            UPDATE table_name [ [ AS ] alias ] SET column = { expression | DEFAULT }
 [,...]

[ FROM fromlist ]
[ WHERE condition ]
```

Parameters

WITH clause

Optional clause that specifies one or more *common-table-expressions*. See WITH clause.

table_name

A temporary or persistent table. Only the owner of the table or a user with UPDATE privilege on the table may update rows. If you use the FROM clause or select from tables in an expression or condition, you must have SELECT privilege on those tables. You can't give the table an alias here; however, you can specify an alias in the FROM clause.

> **Note**
>
> Amazon Redshift Spectrum external tables are read-only. You can't UPDATE an external table.

alias

Temporary alternative name for a target table. Aliases are optional. The AS keyword is always optional.

SET *column* =

One or more columns that you want to modify. Columns that aren't listed retain their current values. Do not include the table name in the specification of a target column. For example, `UPDATE tab SET tab.col = 1` is invalid.

expression

An expression that defines the new value for the specified column.

DEFAULT

Updates the column with the default value that was assigned to the column in the CREATE TABLE statement.

FROM *tablelist*

You can update a table by referencing information in other tables. List these other tables in the FROM clause or use a subquery as part of the WHERE condition. Tables listed in the FROM clause can have aliases. If you need to include the target table of the UPDATE statement in the list, use an alias.

WHERE *condition*

Optional clause that restricts updates to rows that match a condition. When the condition returns `true`, the specified SET columns are updated. The condition can be a simple predicate on a column or a condition based on the result of a subquery.

You can name any table in the subquery, including the target table for the UPDATE.

Usage notes

After updating a large number of rows in a table:

- Vacuum the table to reclaim storage space and re-sort rows.
- Analyze the table to update statistics for the query planner.

Left, right, and full outer joins aren't supported in the FROM clause of an UPDATE statement; they return the following error:

```
ERROR: Target table must be part of an equijoin predicate
```

If you need to specify an outer join, use a subquery in the WHERE clause of the UPDATE statement.

If your UPDATE statement requires a self-join to the target table, you need to specify the join condition, as well as the WHERE clause criteria that qualify rows for the update operation. In general, when the target table is joined to itself or another table, a best practice is to use a subquery that clearly separates the join conditions from the criteria that qualify rows for updates.

UPDATE queries with multiple matches per row throw an error when the configuration parameter `error_on_nondeterministic_update` is set to *true*. For more information, see error_on_nondeterministic_update.

You can update a GENERATED BY DEFAULT AS IDENTITY column. Columns defined as GENERATED BY DEFAULT AS IDENTITY can be updated with values you supply. For more information, see GENERATED BY DEFAULT AS IDENTITY.

Examples of UPDATE statements

For more information about the tables used in the following examples, see Sample database.

The CATEGORY table in the TICKIT database contains the following rows:

```
+-------+----------+-----------+-----------------------------------------+
| catid | catgroup |  catname  |                 catdesc                 |
+-------+----------+-----------+-----------------------------------------+
| 5     | Sports   | MLS       | Major League Soccer                     |
| 11    | Concerts | Classical | All symphony, concerto, and choir concerts |
| 1     | Sports   | MLB       | Major League Baseball                   |
| 6     | Shows    | Musicals  | Musical theatre                         |
| 3     | Sports   | NFL       | National Football League                |
| 8     | Shows    | Opera     | All opera and light opera               |
| 2     | Sports   | NHL       | National Hockey League                  |
| 9     | Concerts | Pop       | All rock and pop music concerts         |
| 4     | Sports   | NBA       | National Basketball Association         |
| 7     | Shows    | Plays     | All non-musical theatre                 |
| 10    | Concerts | Jazz      | All jazz singers and bands              |
+-------+----------+-----------+-----------------------------------------+
```

Updating a table based on a range of values

Update the CATGROUP column based on a range of values in the CATID column.

```
UPDATE category
SET catgroup='Theatre'
WHERE catid BETWEEN 6 AND 8;

SELECT * FROM category
WHERE catid BETWEEN 6 AND 8;

+-------+----------+----------+-------------------------+
| catid | catgroup | catname  |         catdesc         |
+-------+----------+----------+-------------------------+
| 6     | Theatre  | Musicals | Musical theatre         |
| 7     | Theatre  | Plays    | All non-musical theatre |
| 8     | Theatre  | Opera    | All opera and light opera |
+-------+----------+----------+-------------------------+
```

Updating a table based on a current value

Update the CATNAME and CATDESC columns based on their current CATGROUP value:

```
UPDATE category
SET catdesc=default, catname='Shows'
WHERE catgroup='Theatre';

SELECT * FROM category
WHERE catname='Shows';

+-------+----------+---------+---------+
| catid | catgroup | catname | catdesc |
+-------+----------+---------+---------+
| 6     | Theatre  | Shows   | NULL    |
| 7     | Theatre  | Shows   | NULL    |
| 8     | Theatre  | Shows   | NULL    |
+-------+----------+---------+---------+)
```

In this case, the CATDESC column was set to null because no default value was defined when the table was created.

Run the following commands to set the CATEGORY table data back to the original values:

```
TRUNCATE category;

COPY category
FROM 's3://redshift-downloads/tickit/category_pipe.txt'
DELIMITER '|'
IGNOREHEADER 1
REGION 'us-east-1'
IAM_ROLE default;
```

Updating a table based on the result of a WHERE clause subquery

Update the CATEGORY table based on the result of a subquery in the WHERE clause:

```
UPDATE category
SET catdesc='Broadway Musical'
WHERE category.catid IN
(SELECT category.catid FROM category
JOIN event ON category.catid = event.catid
JOIN venue ON venue.venueid = event.venueid
JOIN sales ON sales.eventid = event.eventid
```

```
WHERE venuecity='New York City' AND catname='Musicals');
```

View the updated table:

```
SELECT * FROM category ORDER BY catid;

+-------+----------+-----------+-----------------------------------------+
| catid | catgroup |  catname  |                 catdesc                 |
+-------+----------+-----------+-----------------------------------------+
| 2     | Sports   | NHL       | National Hockey League                  |
| 3     | Sports   | NFL       | National Football League                |
| 4     | Sports   | NBA       | National Basketball Association         |
| 5     | Sports   | MLS       | Major League Soccer                     |
| 6     | Shows    | Musicals  | Broadway Musical                        |
| 7     | Shows    | Plays     | All non-musical theatre                 |
| 8     | Shows    | Opera     | All opera and light opera               |
| 9     | Concerts | Pop       | All rock and pop music concerts         |
| 10    | Concerts | Jazz      | All jazz singers and bands              |
| 11    | Concerts | Classical | All symphony, concerto, and choir concerts |
+-------+----------+-----------+-----------------------------------------+
```

Updating a table based on the result of a WITH clause subquery

To update the CATEGORY table based on the result of a subquery using the WITH clause, use the following example.

```
WITH u1 as (SELECT catid FROM event ORDER BY catid DESC LIMIT 1)
UPDATE category SET catid='200' FROM u1 WHERE u1.catid=category.catid;

SELECT * FROM category ORDER BY catid DESC LIMIT 1;

+-------+----------+---------+---------------------------------+
| catid | catgroup | catname |             catdesc             |
+-------+----------+---------+---------------------------------+
| 200   | Concerts | Pop     | All rock and pop music concerts |
+-------+----------+---------+---------------------------------+
```

Updating a table based on the result of a join condition

Update the original 11 rows in the CATEGORY table based on matching CATID rows in the EVENT table:

```
UPDATE category SET catid=100
FROM event
WHERE event.catid=category.catid;

SELECT * FROM category ORDER BY catid;

+-------+----------+-----------+--------------------------------------------+
| catid | catgroup |  catname  |                   catdesc                  |
+-------+----------+-----------+--------------------------------------------+
| 2     | Sports   | NHL       | National Hockey League                     |
| 3     | Sports   | NFL       | National Football League                   |
| 4     | Sports   | NBA       | National Basketball Association            |
| 5     | Sports   | MLS       | Major League Soccer                        |
| 10    | Concerts | Jazz      | All jazz singers and bands                 |
| 11    | Concerts | Classical | All symphony, concerto, and choir concerts |
| 100   | Concerts | Pop       | All rock and pop music concerts            |
| 100   | Shows    | Plays     | All non-musical theatre                    |
| 100   | Shows    | Opera     | All opera and light opera                  |
| 100   | Shows    | Musicals  | Broadway Musical                           |
+-------+----------+-----------+--------------------------------------------+
```

Note that the EVENT table is listed in the FROM clause and the join condition to the target table is defined in the WHERE clause. Only four rows qualified for the update. These four rows are the rows whose CATID values were originally 6, 7, 8, and 9; only those four categories are represented in the EVENT table:

```
SELECT DISTINCT catid FROM event;

+-------+
| catid |
+-------+
| 6     |
| 7     |
| 8     |
| 9     |
+-------+
```

Update the original 11 rows in the CATEGORY table by extending the previous example and adding another condition to the WHERE clause. Because of the restriction on the CATGROUP column, only one row qualifies for the update (although four rows qualify for the join).

```
UPDATE category SET catid=100
FROM event
WHERE event.catid=category.catid
AND catgroup='Concerts';

SELECT * FROM category WHERE catid=100;

+-------+----------+---------+---------------------------------+
| catid | catgroup | catname |             catdesc             |
+-------+----------+---------+---------------------------------+
| 100   | Concerts | Pop     | All rock and pop music concerts |
+-------+----------+---------+---------------------------------+
```

An alternative way to write this example is as follows:

```
UPDATE category SET catid=100
FROM event JOIN category cat ON event.catid=cat.catid
WHERE cat.catgroup='Concerts';
```

The advantage to this approach is that the join criteria are clearly separated from any other criteria that qualify rows for the update. Note the use of the alias CAT for the CATEGORY table in the FROM clause.

Updates with outer joins in the FROM clause

The previous example showed an inner join specified in the FROM clause of an UPDATE statement. The following example returns an error because the FROM clause does not support outer joins to the target table:

```
UPDATE category SET catid=100
FROM event LEFT JOIN category cat ON event.catid=cat.catid
WHERE cat.catgroup='Concerts';
ERROR:  Target table must be part of an equijoin predicate
```

If the outer join is required for the UPDATE statement, you can move the outer join syntax into a subquery:

```
UPDATE category SET catid=100
FROM
(SELECT event.catid FROM event LEFT JOIN category cat ON event.catid=cat.catid)
 eventcat
```

```
WHERE category.catid=eventcat.catid
AND catgroup='Concerts';
```

Updates with columns from another table in the SET clause

To update the listing table in the TICKIT sample database with values from the sales table, use the following example.

```
SELECT listid, numtickets FROM listing WHERE sellerid = 1 ORDER BY 1 ASC LIMIT 5;

+--------+------------+
| listid | numtickets |
+--------+------------+
| 100423 | 4          |
| 108334 | 24         |
| 117150 | 4          |
| 135915 | 20         |
| 205927 | 6          |
+--------+------------+

UPDATE listing
SET numtickets = sales.sellerid
FROM sales
WHERE sales.sellerid = 1 AND listing.sellerid = sales.sellerid;

SELECT listid, numtickets FROM listing WHERE sellerid = 1 ORDER BY 1 ASC LIMIT 5;

+--------+------------+
| listid | numtickets |
+--------+------------+
| 100423 | 1          |
| 108334 | 1          |
| 117150 | 1          |
| 135915 | 1          |
| 205927 | 1          |
+--------+------------+
```

USE

Changes the database on which queries run. SHOW USE points to the database that most recently is used with the USE command. RESET USE resets the used database. This means that if the database is not specified in the SQL, the objects are searched in the current database.

Syntax

```
USE database
```

Examples

Suppose there are three databases, dev and pdb, and pdb2. Let there be two tables t in the public schemas of each of the databases. First, insert data into tables across different databases:

```
dev=# insert into dev.public.t values (1);
INSERT 0 1
dev=# insert into pdb.public.t values (2);
INSERT 0 1
```

Without explicitly setting a database, the system uses your connected database. Check your current database context:

```
dev=# show use;
Use Database

(1 row)
dev=> show search_path;
search_path
$user, public
(1 row)
```

When querying table t without specifying a database, the system uses the table in your current database:

```
dev=# select * from t;
c
----
1
(1 row)
```

Use the use command to switch databases without changing your connection:

```
dev=# use pdb;
USE
dev=# show use;
```

```
 Use Database
--------------
 pdb
(1 row)
dev=# select * from t;
id
----
2
(1 row)
```

You can also explicitly specify the schema:

```
dev=# select * from public.t;
id
----
2
(1 row)
```

You can now create tables in different schemas within your current database:

```
dev=# create table s1.t(id int);
CREATE TABLE
dev=# insert into pdb.s1.t values (3);
INSERT 0 1
```

The search path determines which schema's objects are accessed when you don't specify a schema:

```
dev=# set search_path to public, s1;
SET
dev=# select * from t;
 id
----
  2
(1 row)
```

Change the order of schemas to access different tables:

```
dev=# set search_path to s1, public;
SET
dev=# show search_path;
 search_path
-------------
```

```
 s1, public
(1 row)
dev=# select * from t;
 id
----
  3
(1 row)
```

Switch to another database while maintaining your original connection:

```
dev=# show use;
 Use Database
--------------
 pdb
(1 row)
dev=# use pdb2;
USE
dev=# show use;
 Use Database
--------------
 pdb2
(1 row)
```

When switching databases, the search path resets to default:

```
dev=# show search_path;
  search_path
---------------
 $user, public
(1 row)
```

Create a table and insert data in your current database:

```
dev=# create table pdb2.public.t(id int);
CREATE TABLE
dev=# insert into pdb2.public.t values (4);
INSERT 0 1
dev=# select * from t;
 id
----
  4
(1 row)
```

In transactions, you can write to the current database and read from any database using three-part notation. This also includes the connected database:

```
dev=# show use;
 Use Database
--------------
 pdb2
(1 row)

dev=# BEGIN;
BEGIN
dev=# select * from t;
 id
----
  4
(1 row)

dev=# insert into t values (5);
INSERT 0 1
dev=# select * from t;
 id
----
  4
  5
(2 rows)

dev=# select * from pdb.public.t;
 id
----
  2
(1 row)

dev=# select * from dev.public.t;
 id
----
  1
(1 row)
```

Reset to your connected database. Note that this does not only revert to the previously used database pdb, but resets to the connected database. The search path also changes to the default one:

```
dev=# RESET USE;
RESET
dev=# select * from t;
c
----
1
(1 row)
dev=# show use;
 Use Database
--------------

(1 row)

dev=# show search_path;
  search_path
---------------
 $user, public
(1 row)
```

You can change databases at the start of a transaction, but not after running queries:

```
dev=# BEGIN;
BEGIN
dev=# use pdb;
USE
dev=# use pdb2;
USE
dev=# use pdb;
USE
dev=# select * from t;
 id
----
  2
(1 row)
dev=# use pdb2;
ERROR:  USEd Database cannot be set or reset inside a transaction after another
 command.
dev=# rollback;
ROLLBACK
(1 row)
```

Data Catalog example

First, create tables in different schemas and catalogs to demonstrate cross-catalog queries. Start by creating tables in the connected database.

```
dev=# CREATE TABLE dev.public.t (col INT);
dev=# INSERT INTO dev.public.t VALUES (1);
dev=# CREATE SCHEMA write_schema;
dev=# CREATE TABLE dev.write_schema.t (state char (2));
dev=# INSERT INTO dev.write_schema.t VALUES ('WA');
```

Now, create similar tables in a different catalog. This demonstrates how to work with cross-catalog databases.

```
dev=# CREATE TABLE my_db@my_catalog.public.t (col INT);
dev=# INSERT INTO my_db@my_catalog.public.t VALUES (100);
dev=# CREATE SCHEMA my_db@my_catalog.write_schema;
dev=# CREATE TABLE my_db@my_catalog.write_schema.t (state char (2));
dev=# INSERT INTO my_db@my_catalog.write_schema.t VALUES ('CA');
```

Check the current database context. Without explicitly setting a database, the system uses the connected database.

```
dev=# SHOW USE;
 Use Database
--------------

(1 row)

dev=# SHOW search_path;
  search_path
---------------
 $user, public
(1 row)

dev=# SELECT * FROM t;
```

```
 col
-----
   1
(1 row)
```

Set the USEd database to query the tables in a different catalog.

```
dev=# USE my_db@my_catalog;

dev=# SHOW USE;
            Use Database
-------------------------------------
 my_db@my_catalog
(1 row)

dev=# SHOW search_path;
  search_path
---------------
 $user, public
(1 row)
```

When querying table t, results come from the cross-catalog database.

```
dev=# SELECT * FROM t;
 col
-----
 100
(1 row)

dev=# SELECT * FROM public.t;
 col
-----
 100
(1 row)

dev=# SELECT * FROM my_db@my_catalog.public.t;
 col
-----
 100
(1 row)
```

Change the search path to access tables in different schemas within the USEd database.

```
dev=# SET search_path to write_schema;

dev=# SHOW search_path;
 search_path
--------------
 write_schema
(1 row)

dev=# SELECT * FROM t;
 state
-------
 CA
(1 row)

dev=# SELECT * FROM write_schema.t;
 state
-------
 CA
(1 row)

dev=# SELECT * FROM my_db@my_catalog.write_schema.t;
 state
-------
 CA
(1 row)
```

Even though USE is set to a cross-catalog database, it's still possible to explicitly query the original database.

```
dev=# SELECT * FROM dev.write_schema.t;
 state
-------
 WA
(1 row)
```

Reset the USEd database to again refer to objects in the connected database.

```
dev=# RESET USE;

dev=# SHOW USE;
 Use Database
--------------

(1 row)
```

Note that the search_path gets reset when USE is reset.

```
dev=# SHOW search_path;
  search_path
---------------
 $user, public
(1 row)
```

After resetting, queries now refer to the original connected database.

```
dev=# SELECT * FROM t;
 col
-----
   1
(1 row)

dev=# SELECT * FROM public.t;
 col
-----
   1
(1 row)

dev=# SELECT * FROM dev.public.t;
 col
-----
   1
(1 row)
```

You can modify the search path in the original database to access different schemas.

```
dev=# SET search_path to write_schema;

dev=# SHOW search_path;
 search_path
--------------
 write_schema
(1 row)

dev=# SELECT * FROM t;
 state
-------
 WA
(1 row)

dev=# SELECT * FROM write_schema.t;
 state
-------
 WA
(1 row)

dev=# SELECT * FROM dev.write_schema.t;
 state
-------
 WA
(1 row)
```

VACUUM

Re-sorts rows and reclaims space in either a specified table or all tables in the current database.

> **Note**
>
> Only users with the necessary table permissions can effectively vacuum a table. If VACUUM is run without the necessary table permissions, the operation completes successfully but has no effect. For a list of valid table permissions to effectively run VACUUM, see the following Required privileges section.

Amazon Redshift automatically sorts data and runs VACUUM DELETE in the background. This lessens the need to run the VACUUM command. For more information, see Vacuuming tables.

By default, VACUUM skips the sort phase for any table where more than 95 percent of the table's rows are already sorted. Skipping the sort phase can significantly improve VACUUM performance. To change the default sort or delete threshold for a single table, include the table name and the TO *threshold* PERCENT parameter when you run VACUUM.

Users can access tables while they are being vacuumed. You can perform queries and write operations while a table is being vacuumed, but when data manipulation language (DML) commands and a vacuum run concurrently, both might take longer. If you run UPDATE and DELETE statements during a vacuum, system performance might be reduced. VACUUM DELETE temporarily blocks update and delete operations.

Amazon Redshift automatically performs a DELETE ONLY vacuum in the background. Automatic vacuum operation pauses when users run data definition language (DDL) operations, such as ALTER TABLE.

> **Note**
>
> The Amazon Redshift VACUUM command syntax and behavior are substantially different from the PostgreSQL VACUUM operation. For example, the default VACUUM operation in Amazon Redshift is VACUUM FULL, which reclaims disk space and re-sorts all rows. In contrast, the default VACUUM operation in PostgreSQL simply reclaims space and makes it available for reuse.

For more information, see Vacuuming tables.

Required privileges

Following are required privileges for VACUUM:

- Superuser
- Users with the VACUUM privilege
- Table owner
- Database owner whom the table is shared to

Syntax

```
VACUUM [ FULL | SORT ONLY | DELETE ONLY | REINDEX | RECLUSTER ]
[ [ table_name ] [ TO threshold PERCENT ] [ BOOST ] ]
```

Parameters

FULL

Sorts the specified table (or all tables in the current database) and reclaims disk space occupied by rows that were marked for deletion by previous UPDATE and DELETE operations. VACUUM FULL is the default.

A full vacuum doesn't perform a reindex for interleaved tables. To reindex interleaved tables followed by a full vacuum, use the VACUUM REINDEX option.

By default, VACUUM FULL skips the sort phase for any table that is already at least 95 percent sorted. If VACUUM is able to skip the sort phase, it performs a DELETE ONLY and reclaims space in the delete phase such that at least 95 percent of the remaining rows aren't marked for deletion.

If the sort threshold isn't met (for example, if 90 percent of rows are sorted) and VACUUM performs a full sort, then it also performs a complete delete operation, recovering space from 100 percent of deleted rows.

You can change the default vacuum threshold only for a single table. To change the default vacuum threshold for a single table, include the table name and the TO *threshold* PERCENT parameter.

SORT ONLY

Sorts the specified table (or all tables in the current database) without reclaiming space freed by deleted rows. This option is useful when reclaiming disk space isn't important but re-sorting new rows is important. A SORT ONLY vacuum reduces the elapsed time for vacuum operations when the unsorted region doesn't contain a large number of deleted rows and doesn't span the entire sorted region. Applications that don't have disk space constraints but do depend on query optimizations associated with keeping table rows sorted can benefit from this kind of vacuum.

By default, VACUUM SORT ONLY skips any table that is already at least 95 percent sorted. To change the default sort threshold for a single table, include the table name and the TO *threshold* PERCENT parameter when you run VACUUM.

DELETE ONLY

Amazon Redshift automatically performs a DELETE ONLY vacuum in the background, so you rarely, if ever, need to run a DELETE ONLY vacuum.

A VACUUM DELETE reclaims disk space occupied by rows that were marked for deletion by previous UPDATE and DELETE operations, and compacts the table to free up the consumed space. A DELETE ONLY vacuum operation doesn't sort table data.

This option reduces the elapsed time for vacuum operations when reclaiming disk space is important but re-sorting new rows isn't important. This option can also be useful when your query performance is already optimal, and re-sorting rows to optimize query performance isn't a requirement.

By default, VACUUM DELETE ONLY reclaims space such that at least 95 percent of the remaining rows aren't marked for deletion. To change the default delete threshold for a single table, include the table name and the TO *threshold* PERCENT parameter when you run VACUUM.

Some operations, such as `ALTER TABLE APPEND`, can cause tables to be fragmented. When you use the `DELETE ONLY` clause the vacuum operation reclaims space from fragmented tables. The same threshold value of 95 percent applies to the defragmentation operation.

REINDEX

Analyzes the distribution of the values in interleaved sort key columns, then performs a full VACUUM operation. If REINDEX is used, a table name is required.

VACUUM REINDEX takes significantly longer than VACUUM FULL because it makes an additional pass to analyze the interleaved sort keys. The sort and merge operation can take longer for interleaved tables because the interleaved sort might need to rearrange more rows than a compound sort.

If a VACUUM REINDEX operation terminates before it completes, the next VACUUM resumes the reindex operation before performing the full vacuum operation.

VACUUM REINDEX isn't supported with TO *threshold* PERCENT.

RECLUSTER

Sorts the portions of the table that are unsorted. Portions of the table that are already sorted by automatic table sort are left intact. This command doesn't merge the newly sorted data with the sorted region. It also doesn't reclaim all space that is marked for deletion. When this command completes, the table might not appear fully sorted, as indicated by the `unsorted` field in SVV_TABLE_INFO.

We recommend that you use VACUUM RECLUSTER for large tables with frequent ingestion and queries that access only the most recent data.

VACUUM RECLUSTER isn't supported with TO threshold PERCENT. If RECLUSTER is used, a table name is required.

VACUUM RECLUSTER isn't supported on tables with interleaved sort keys and tables with ALL distribution style.

table_name

The name of a table to vacuum. If you don't specify a table name, the vacuum operation applies to all tables in the current database. You can specify any permanent or temporary user-created table. The command isn't meaningful for other objects, such as views and system tables.

If you include the TO *threshold* PERCENT parameter, a table name is required.

TO *threshold* PERCENT

A clause that specifies the threshold above which VACUUM skips the sort phase and the target threshold for reclaiming space in the delete phase. The *sort threshold* is the percentage of total rows that are already in sort order for the specified table prior to vacuuming. The *delete threshold* is the minimum percentage of total rows not marked for deletion after vacuuming.

Because VACUUM re-sorts the rows only when the percent of sorted rows in a table is less than the sort threshold, Amazon Redshift can often reduce VACUUM times significantly. Similarly, when VACUUM isn't constrained to reclaim space from 100 percent of rows marked for deletion, it is often able to skip rewriting blocks that contain only a few deleted rows.

For example, if you specify 75 for *threshold*, VACUUM skips the sort phase if 75 percent or more of the table's rows are already in sort order. For the delete phase, VACUUMS sets a target of reclaiming disk space such that at least 75 percent of the table's rows aren't marked for deletion following the vacuum. The *threshold* value must be an integer between 0 and 100. The default is 95. If you specify a value of 100, VACUUM always sorts the table unless it's already fully sorted and reclaims space from all rows marked for deletion. If you specify a value of 0, VACUUM never sorts the table and never reclaims space.

If you include the TO *threshold* PERCENT parameter, you must also specify a table name. If a table name is omitted, VACUUM fails.

You can't use the TO *threshold* PERCENT parameter with REINDEX.

BOOST

Runs the VACUUM command with additional resources, such as memory and disk space, as they're available. With the BOOST option, VACUUM operates in one window and blocks concurrent deletes and updates for the duration of the VACUUM operation. Running with the BOOST option contends for system resources, which might affect query performance. Run the VACUUM BOOST when the load on the system is light, such as during maintenance operations.

Consider the following when using the BOOST option:

- When BOOST is specified, the *table_name* value is required.
- BOOST isn't supported with REINDEX.
- BOOST is ignored with DELETE ONLY.

Usage notes

For most Amazon Redshift applications, a full vacuum is recommended. For more information, see [Vacuuming tables](#).

Before running a vacuum operation, note the following behavior:

- You can't run VACUUM within a transaction block (BEGIN ... END). For more information about transactions, see [Serializable isolation](#).
- Some amount of table growth might occur when tables are vacuumed. This behavior is expected when there are no deleted rows to reclaim or the new sort order of the table results in a lower ratio of data compression.
- During vacuum operations, some degree of query performance degradation is expected. Normal performance resumes as soon as the vacuum operation is complete.
- Concurrent write operations proceed during vacuum operations, but we don’t recommend performing write operations while vacuuming. It's more efficient to complete write operations before running the vacuum. Also, any data that is written after a vacuum operation has been

started can't be vacuumed by that operation. In this case, a second vacuum operation is necessary.

- A vacuum operation might not be able to start if a load or insert operation is already in progress. Vacuum operations temporarily require exclusive access to tables in order to start. This exclusive access is required briefly, so vacuum operations don't block concurrent loads and inserts for any significant period of time.
- Vacuum operations are skipped when there is no work to do for a particular table; however, there is some overhead associated with discovering that the operation can be skipped. If you know that a table is pristine or doesn't meet the vacuum threshold, don't run a vacuum operation against it.
- A DELETE ONLY vacuum operation on a small table might not reduce the number of blocks used to store the data, especially when the table has a large number of columns or the cluster uses a large number of slices per node. These vacuum operations add one block per column per slice to account for concurrent inserts into the table, and there is potential for this overhead to outweigh the reduction in block count from the reclaimed disk space. For example, if a 10-column table on an 8-node cluster occupies 1000 blocks before a vacuum, the vacuum doesn't reduce the actual block count unless more than 80 blocks of disk space are reclaimed because of deleted rows. (Each data block uses 1 MB.)

Automatic vacuum operations pause if any of the following conditions are met:

- A user runs a data definition language (DDL) operation, such as ALTER TABLE, that requires an exclusive lock on a table that automatic vacuum is currently working on.
- A period of high cluster load.

Support for concurrent VACUUM

Amazon Redshift supports running multiple vacuum transactions concurrently across different sessions in a cluster or workgroup. This means you can issue different and multiple instances of all vacuum modes at once, with each vacuum transaction on a unique table. Two vacuum operations can't work on a single table at the same time.

Guidelines for running concurrent vacuum

- When running concurrent vacuum transactions across different sessions, you should monitor system resources, and avoid running too many vacuum operations concurrently.

- The recommended concurrency level depends on the amount of space to be reclaimed, both the number and width of the rows to be sorted, the size of the warehouse, and the size of your workload running alongside the VACUUM operations.
- Depending on the mode of the vacuum transaction, start with two concurrent vacuum operations, and add more depending on their run time and system load. Just like other heavy queries issued by users, vacuum operations may begin queueing if you run too many concurrently when Amazon Redshift reaches system resource limits.
- Run multiple Vacuum BOOST operations carefully. Running Vacuum with the BOOST option contends for system resources, which might affect query performance. Run the VACUUM BOOST when the load on the system is light, such as during maintenance operations.
- If you don't specify a table name, the vacuum operation applies to all tables in the current database. These vacuum opearations still run sequentially.

Examples

Reclaim space and database and re-sort rows in all tables based on the default 95 percent vacuum threshold.

```
vacuum;
```

Reclaim space and re-sort rows in the SALES table based on the default 95 percent threshold.

```
vacuum sales;
```

Always reclaim space and re-sort rows in the SALES table.

```
vacuum sales to 100 percent;
```

Re-sort rows in the SALES table only if fewer than 75 percent of rows are already sorted.

```
 vacuum sort only sales to 75 percent;
```

Reclaim space in the SALES table such that at least 75 percent of the remaining rows aren't marked for deletion following the vacuum.

```
vacuum delete only sales to 75 percent;
```

Reindex and then vacuum the LISTING table.

```
vacuum reindex listing;
```

The following command returns an error.

```
vacuum reindex listing to 75 percent;
```

Recluster and then vacuum the LISTING table.

```
vacuum recluster listing;
```

Recluster and then vacuum the LISTING table with the BOOST option.

```
vacuum recluster listing boost;
```

SQL functions reference

Topics

- Spatial functions
- String functions
- SUPER type information functions
- VARBYTE functions and operators
- Window functions
- System administration functions
- System information functions

Amazon Redshift supports a number of functions that are extensions to the SQL standard, as well as standard aggregate functions, scalar functions, and window functions.

> **Note**
>
> Amazon Redshift is based on PostgreSQL. Amazon Redshift and PostgreSQL have a number of very important differences that you must be aware of as you design and develop your data warehouse applications. For more information about how Amazon Redshift SQL differs from PostgreSQL, see Amazon Redshift and PostgreSQL.

Leader node–only functions

Some Amazon Redshift queries are distributed and run on the compute nodes; other queries run exclusively on the leader node.

The leader node distributes SQL to the compute nodes when a query references user-created tables or system tables (tables with an STL or STV prefix and system views with an SVL or SVV prefix). A query that references only catalog tables (tables with a PG prefix, such as PG_TABLE_DEF) or that does not reference any tables, runs exclusively on the leader node.

Some Amazon Redshift SQL functions are supported only on the leader node and are not supported on the compute nodes. A query that uses a leader-node function must run exclusively on the leader node, not on the compute nodes, or it will return an error.

The documentation for each leader-node only function includes a note stating that the function will return an error if it references user-defined tables or Amazon Redshift system tables.

For more information, see SQL functions supported on the leader node.

The following SQL functions are leader-node only functions and are not supported on the compute nodes:

System information functions

- CURRENT_SCHEMA
- CURRENT_SCHEMAS
- HAS_DATABASE_PRIVILEGE
- HAS_SCHEMA_PRIVILEGE
- HAS_TABLE_PRIVILEGE

String functions

- SUBSTR

Math functions

- FACTORIAL
- LOG

The following leader-node only functions are deprecated and are no longer supported:

Date functions

- AGE
- CURRENT_TIME
- CURRENT_TIMESTAMP
- LOCALTIME
- ISFINITE
- NOW

String functions

- GETBIT
- GET_BYTE

- SET_BIT
- SET_BYTE
- TO_ASCII

Aggregate functions

Topics

Aggregate functions compute a single result value from a set of input values.

SELECT statements using aggregate functions can include two optional clauses: GROUP BY and HAVING. The syntax for these clauses is as follows (using the COUNT function as an example):

```
SELECT count (*) expression FROM table_reference
WHERE condition [GROUP BY expression ] [ HAVING condition]
```

The GROUP BY clause aggregates and groups results by the unique values in a specified column or columns. The HAVING clause restricts the results returned to rows where a particular aggregate condition is true, such as count (*) > 1. The HAVING clause is used in the same way as WHERE to restrict rows based on the value of a column. For an example of these additional clauses, see the COUNT.

Aggregate functions don't accept nested aggregate functions or window functions as arguments.

ANY_VALUE function

The ANY_VALUE function returns any value from the input expression values nondeterministically. This function returns `NULL` if the input expression doesn't result in any rows being returned. The function can also return `NULL` if there are `NULL` values in the input expression. If the input contains `NULL` values mixed with non-`NULL` values, `NULL` might be returned. If all values are `NULL`, `NULL` is returned. If no rows match the condition, `NULL` is returned.

Syntax

```
ANY_VALUE( [ DISTINCT | ALL ] expression )
```

Arguments

DISTINCT | ALL

Specify either DISTINCT or ALL to return any value from the input expression values. The DISTINCT argument has no effect and is ignored.

expression

The target column or expression on which the function operates. The *expression* is one of the following data types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- REAL
- DOUBLE PRECISON
- BOOLEAN
- CHAR
- VARCHAR
- DATE
- TIMESTAMP

- TIMESTAMPTZ
- TIME
- TIMETZ
- INTERVAL YEAR TO MONTH
- INTERVAL DAY TO SECOND
- VARBYTE
- SUPER
- HLLSKETCH
- GEOMETRY
- GEOGRAPHY

Returns

Returns the same data type as *expression*.

Usage notes

If a statement that specifies the ANY_VALUE function for a column also includes a second column reference, the second column must appear in a GROUP BY clause or be included in an aggregate function.

Examples

The examples use the event table that is created in [Step 4: Load sample data from Amazon S3](#) in the *Amazon Redshift Getting Started Guide*. The following example returns an instance of any dateid where the eventname is Eagles.

```
select any_value(dateid) as dateid, eventname from event where eventname ='Eagles'
 group by eventname;
```

Following are the results.

```
dateid | eventname
-------+---------------
 1878  | Eagles
```

The following example returns an instance of any dateid where the eventname is Eagles or Cold War Kids.

```
select any_value(dateid) as dateid, eventname from event where eventname in('Eagles',
 'Cold War Kids') group by eventname;
```

Following are the results.

```
dateid | eventname
-------+---------------
 1922  | Cold War Kids
 1878  | Eagles
```

APPROXIMATE PERCENTILE_DISC function

APPROXIMATE PERCENTILE_DISC is an inverse distribution function that assumes a discrete distribution model. It takes a percentile value and a sort specification and returns an element from the given set. Approximation enables the function to run much faster, with a low relative error of around 0.5 percent.

For a given *percentile* value, APPROXIMATE PERCENTILE_DISC uses a quantile summary algorithm to approximate the discrete percentile of the expression in the ORDER BY clause. APPROXIMATE PERCENTILE_DISC returns the value with the smallest cumulative distribution value (with respect to the same sort specification) that is greater than or equal to *percentile*.

Syntax

```
APPROXIMATE  PERCENTILE_DISC ( percentile )
WITHIN GROUP (ORDER BY expr)
```

Arguments

percentile

Numeric constant between 0 and 1. Nulls are ignored in the calculation.

WITHIN GROUP (ORDER BY *expr*)

Clause that specifies numeric or date/time values to sort and compute the percentile over.

Returns

The same data type as the ORDER BY expression in the WITHIN GROUP clause.

Usage notes

If the APPROXIMATE PERCENTILE_DISC statement includes a GROUP BY clause, the result set is limited. The limit varies based on node type and the number of nodes. If the limit is exceeded, the function fails and returns the following error.

```
GROUP BY limit for approximate percentile_disc exceeded.
```

If you need to evaluate more groups than the limit permits, consider using PERCENTILE_CONT function.

Examples

The following example returns the number of sales, total sales, and fiftieth percentile value for the top 10 dates.

```
select top 10 date.caldate,
count(totalprice), sum(totalprice),
approximate percentile_disc(0.5)
within group (order by totalprice)
from listing
join date on listing.dateid = date.dateid
group by date.caldate
order by 3 desc;

caldate    | count | sum        | percentile_disc
-----------+-------+------------+----------------
2008-01-07 |   658 | 2081400.00 |         2020.00
2008-01-02 |   614 | 2064840.00 |         2178.00
2008-07-22 |   593 | 1994256.00 |         2214.00
2008-01-26 |   595 | 1993188.00 |         2272.00
2008-02-24 |   655 | 1975345.00 |         2070.00
2008-02-04 |   616 | 1972491.00 |         1995.00
2008-02-14 |   628 | 1971759.00 |         2184.00
2008-09-01 |   600 | 1944976.00 |         2100.00
2008-07-29 |   597 | 1944488.00 |         2106.00
2008-07-23 |   592 | 1943265.00 |         1974.00
```

AVG function

The AVG function returns the average (arithmetic mean) of the input expression values. The AVG function works with numeric values and ignores NULL values.

Syntax

```
AVG ( [ DISTINCT | ALL ] expression )
```

Arguments

expression

The target column or expression that the function operates on. The *expression* is one of the following data types:

- SMALLINT
- INTEGER
- BIGINT
- NUMERIC
- DECIMAL
- REAL
- DOUBLE PRECISON
- SUPER

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values from the specified expression before calculating the average. With the argument ALL, the function retains all duplicate values from the expression for calculating the average. ALL is the default.

Data types

The argument types supported by the AVG function are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, DOUBLE PRECISION, and SUPER.

The return types supported by the AVG function are:

- BIGINT for any integer type argument

- DOUBLE PRECISION for a floating point argument
- Returns the same data type as expression for any other argument type.

The default precision for an AVG function result with a NUMERIC or DECIMAL argument is 38. The scale of the result is the same as the scale of the argument. For example, an AVG of a DEC(5,2) column returns a DEC(38,2) data type.

Examples

Find the average quantity sold per transaction from the SALES table:

```
select avg(qtysold)from sales;

avg
-----
2
(1 row)
```

Find the average total price listed for all listings:

```
select avg(numtickets*priceperticket) as avg_total_price from listing;

avg_total_price
-----------------
3034.41
(1 row)
```

Find the average price paid, grouped by month in descending order:

```
select avg(pricepaid) as avg_price, month
from sales, date
where sales.dateid = date.dateid
group by month
order by avg_price desc;

avg_price | month
-----------+-------
659.34 | MAR
655.06 | APR
645.82 | JAN
643.10 | MAY
```

```
642.72 | JUN
642.37 | SEP
640.72 | OCT
640.57 | DEC
635.34 | JUL
635.24 | FEB
634.24 | NOV
632.78 | AUG
(12 rows)
```

COUNT function

The COUNT function counts the rows defined by the expression.

The COUNT function has the following variations.

- COUNT (*) counts all the rows in the target table whether they include nulls or not.
- COUNT (*expression*) computes the number of rows with non-NULL values in a specific column or expression.
- COUNT (DISTINCT *expression*) computes the number of distinct non-NULL values in a column or expression.
- APPROXIMATE COUNT DISTINCT approximates the number of distinct non-NULL values in a column or expression.

Syntax

```
COUNT( * | expression )
```

```
COUNT ( [ DISTINCT | ALL ] expression )
```

```
APPROXIMATE COUNT ( DISTINCT expression )
```

Arguments

expression

The target column or expression that the function operates on. The COUNT function supports all argument data types.

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values from the specified expression before doing the count. With the argument ALL, the function retains all duplicate values from the expression for counting. ALL is the default.

APPROXIMATE

When used with APPROXIMATE, a COUNT DISTINCT function uses a HyperLogLog algorithm to approximate the number of distinct non-NULL values in a column or expression. Queries that use the APPROXIMATE keyword run much faster, with a low relative error of around 2%. Approximation is warranted for queries that return a large number of distinct values, in the millions or more per query, or per group, if there is a group by clause. For smaller sets of distinct values, in the thousands, approximation might be slower than a precise count. APPROXIMATE can only be used with COUNT DISTINCT.

Return type

The COUNT function returns BIGINT.

Examples

Count all of the users from the state of Florida:

```
select count(*) from users where state='FL';

count
-------
510
```

Count all of the event names from the EVENT table:

```
select count(eventname) from event;

count
-------
8798
```

Count all of the event names from the EVENT table:

```
select count(all eventname) from event;
```

```
count
-------
8798
```

Count all of the unique venue IDs from the EVENT table:

```
select count(distinct venueid) as venues from event;

venues
--------
204
```

Count the number of times each seller listed batches of more than four tickets for sale. Group the results by seller ID:

```
select count(*), sellerid from listing
where numtickets > 4
group by sellerid
order by 1 desc, 2;

count | sellerid
------+----------
12    |    6386
11    |    17304
11    |    20123
11    |    25428
...
```

The following examples compare the return values and execution times for COUNT and APPROXIMATE COUNT.

```
select  count(distinct pricepaid) from sales;

count
-------
  4528


Time: 48.048 ms


select approximate count(distinct pricepaid) from sales;
```

```
count
-------
  4553


Time: 21.728 ms
```

LISTAGG function

For each group in a query, the LISTAGG aggregate function orders the rows for that group according to the ORDER BY expression, then concatenates the values into a single string.

Syntax

```
LISTAGG( [DISTINCT] aggregate_expression [, 'delimiter' ] )
[ WITHIN GROUP (ORDER BY order_list) ]
```

Arguments

DISTINCT

A clause that eliminates duplicate values from the specified expression before concatenating. Trailing spaces are ignored. For example, the strings `'a'` and `'a  '` are treated as duplicates. LISTAGG uses the first value encountered. For more information, see Significance of trailing blanks.

aggregate_expression

Any valid expression, such as a column name, that provides the values to aggregate. NULL values and empty strings are ignored.

delimiter

The string constant to separate the concatenated values. The default is NULL.

WITHIN GROUP (ORDER BY order_list)

A clause that specifies the sort order of the aggregated values.

Returns

VARCHAR(MAX). If the result set is larger than the maximum VARCHAR size, LISTAGG returns the following error:

```
Invalid operation: Result size exceeds LISTAGG limit
```

Usage notes

- If a statement includes multiple LISTAGG functions that use WITHIN GROUP clauses, each WITHIN GROUP clause must use the same ORDER BY values.

  For example, the following statement returns an error.

  ```
  SELECT LISTAGG(sellerid)
  WITHIN GROUP (ORDER BY dateid) AS sellers,
  LISTAGG(dateid)
  WITHIN GROUP (ORDER BY sellerid) AS dates
  FROM sales;
  ```

  The following statements runs successfully.

  ```
  SELECT LISTAGG(sellerid)
  WITHIN GROUP (ORDER BY dateid) AS sellers,
  LISTAGG(dateid)
  WITHIN GROUP (ORDER BY dateid) AS dates
  FROM sales;

  SELECT LISTAGG(sellerid)
  WITHIN GROUP (ORDER BY dateid) AS sellers,
  LISTAGG(dateid) AS dates
  FROM sales;
  ```

- You can't use the LISTAGG, PERCENTILE_CONT, and MEDIAN aggregate functions with other distinct aggregate functions.

Examples

The following example aggregates seller IDs, ordered by seller ID.

```
SELECT LISTAGG(sellerid, ', ')
WITHIN GROUP (ORDER BY sellerid)
FROM sales
WHERE eventid = 4337;
```

```
listagg

-----------------------------------------------------------------------------------------------------------
380, 380, 1178, 1178, 1178, 2731, 8117, 12905, 32043, 32043, 32043, 32432, 32432,
 38669, 38750, 41498, 45676, 46324, 47188, 47188, 48294
```

The following example uses DISTINCT to return a list of unique seller IDs.

```
SELECT LISTAGG(DISTINCT sellerid, ', ')
WITHIN GROUP (ORDER BY sellerid)
FROM sales
WHERE eventid = 4337;

listagg

-------------------------------------------------------------------------------------------
380, 1178, 2731, 8117, 12905, 32043, 32432, 38669, 38750, 41498, 45676, 46324, 47188,
 48294
```

The following example aggregates seller IDs in date order.

```
SELECT LISTAGG(sellerid, ', ')
WITHIN GROUP (ORDER BY dateid)
FROM sales
WHERE eventid = 4337;

   listagg
-----------------------------------------------------------------------------------------------------------
 41498, 47188, 47188, 1178, 1178, 1178, 380, 45676, 46324, 48294, 32043, 32043, 32432,
 12905, 8117, 38750, 2731, 32432, 32043, 380, 38669
```

The following example returns a pipe-separated list of sales dates for the buyer with an ID of 660.

```
SELECT LISTAGG(
    (SELECT caldate FROM date WHERE date.dateid=sales.dateid), ' | '
)
WITHIN GROUP (ORDER BY sellerid DESC, salesid ASC)
FROM sales
WHERE buyerid = 660;

             listagg
-------------------------------------------------
```

```
2008-07-16 | 2008-07-09 | 2008-01-01 | 2008-10-26
```

The following example returns a comma-separated list of sales IDs for the buyer IDs 660, 661, and 662.

```
SELECT buyerid,
LISTAGG(salesid,', ')
WITHIN GROUP (ORDER BY salesid) AS sales_id
FROM sales
WHERE buyerid BETWEEN 660 AND 662
GROUP BY buyerid
ORDER BY buyerid;

buyerid |                sales_id
--------+-----------------------------------------------------
660     | 32872, 33095, 33514, 34548
661     | 19951, 20517, 21695, 21931
662     | 3318, 3823, 4215, 51980, 53202, 55908, 57832, 171603
```

MAX function

The MAX function returns the maximum value in a set of rows. DISTINCT or ALL might be used but do not affect the result.

Syntax

```
MAX ( [ DISTINCT | ALL ] expression )
```

Arguments

expression

The target column or expression that the function operates on. The *expression* is one of the following data types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- REAL

- DOUBLE PRECISON
- CHAR
- VARCHAR
- DATE
- TIMESTAMP
- TIMESTAMPTZ
- TIME
- TIMETZ
- VARBYTE
- SUPER

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values from the specified expression before calculating the maximum. With the argument ALL, the function retains all duplicate values from the expression for calculating the maximum. ALL is the default.

Data types

Returns the same data type as *expression*. The Boolean equivalent of the MIN function is the BOOL_AND function, and the Boolean equivalent of MAX is the BOOL_OR function.

Examples

Find the highest price paid from all sales:

```
select max(pricepaid) from sales;

max
----------
12624.00
(1 row)
```

Find the highest price paid per ticket from all sales:

```
select max(pricepaid/qtysold) as max_ticket_price
```

```
from sales;

max_ticket_price
-----------------
2500.00000000
(1 row)
```

MEDIAN function

Calculates the median value for the range of values. NULL values in the range are ignored.

MEDIAN is an inverse distribution function that assumes a continuous distribution model.

MEDIAN is a special case of PERCENTILE_CONT.

Syntax

```
MEDIAN(median_expression)
```

Arguments

median_expression

The target column or expression that the function operates on.

Data types

The return type is determined by the data type of *median_expression*. The following table shows the return type for each *median_expression* data type.

Input type	Return type
INT2, INT4, INT8, NUMERIC, DECIMAL	DECIMAL
FLOAT, DOUBLE	DOUBLE
DATE	DATE
TIMESTAMP	TIMESTAMP

Input type	Return type
TIMESTAMPTZ	TIMESTAMPTZ

Usage notes

If the *median_expression* argument is a DECIMAL data type defined with the maximum precision of 38 digits, it is possible that MEDIAN will return either an inaccurate result or an error. If the return value of the MEDIAN function exceeds 38 digits, the result is truncated to fit, which causes a loss of precision. If, during interpolation, an intermediate result exceeds the maximum precision, a numeric overflow occurs and the function returns an error. To avoid these conditions, we recommend either using a data type with lower precision or casting the *median_expression* argument to a lower precision.

If a statement includes multiple calls to sort-based aggregate functions (LISTAGG, PERCENTILE_CONT, or MEDIAN), they must all use the same ORDER BY values. Note that MEDIAN applies an implicit order by on the expression value.

For example, the following statement returns an error.

```
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(pricepaid)
FROM sales
GROUP BY salesid, pricepaid;

An error occurred when executing the SQL command:
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(pricepaid)
FROM sales
GROUP BY salesid, pricepaid;

ERROR: within group ORDER BY clauses for aggregate functions must be the same
```

The following statement runs successfully.

```
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(salesid)
```

```
FROM sales
GROUP BY salesid, pricepaid;
```

Examples

The following examples use the TICKIT sample database. For more information, see Sample database.

The following example shows that MEDIAN produces the same results as PERCENTILE_CONT(0.5).

```
SELECT TOP 10 DISTINCT sellerid, qtysold,
PERCENTILE_CONT(0.5) WITHIN GROUP(ORDER BY qtysold),
MEDIAN(qtysold)
FROM sales
GROUP BY sellerid, qtysold;

+----------+---------+-----------------+--------+
| sellerid | qtysold | percentile_cont | median |
+----------+---------+-----------------+--------+
|        2 |       2 |               2 |      2 |
|       26 |       1 |               1 |      1 |
|       33 |       1 |               1 |      1 |
|       38 |       1 |               1 |      1 |
|       43 |       1 |               1 |      1 |
|       48 |       2 |               2 |      2 |
|       48 |       3 |               3 |      3 |
|       77 |       4 |               4 |      4 |
|       85 |       4 |               4 |      4 |
|       95 |       2 |               2 |      2 |
+----------+---------+-----------------+--------+
```

The following example finds the median quantity sold for each sellerid.

```
SELECT sellerid,
MEDIAN(qtysold)
FROM sales
GROUP BY sellerid
ORDER BY sellerid
LIMIT 10;

+----------+--------+
| sellerid | median |
```

```
+----------+--------+
|        1 |    1.5 |
|        2 |      2 |
|        3 |      2 |
|        4 |      2 |
|        5 |      1 |
|        6 |      1 |
|        7 |    1.5 |
|        8 |      1 |
|        9 |      4 |
|       12 |      2 |
+----------+--------+
```

To verify the results of the previous query for the first sellerid, use the following example.

```
SELECT qtysold
FROM sales
WHERE sellerid=1;

+---------+
| qtysold |
+---------+
|       2 |
|       1 |
+---------+
```

MIN function

The MIN function returns the minimum value in a set of rows. DISTINCT or ALL might be used but do not affect the result.

Syntax

```
MIN ( [ DISTINCT | ALL ] expression )
```

Arguments

expression

The target column or expression that the function operates on. The *expression* is one of the following data types:

- SMALLINT
- INTEGER
- BIGINT
- DECIMAL
- REAL
- DOUBLE PRECISON
- CHAR
- VARCHAR
- DATE
- TIMESTAMP
- TIMESTAMPTZ
- TIME
- TIMETZ
- VARBYTE
- SUPER

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values from the specified expression before calculating the minimum. With the argument ALL, the function retains all duplicate values from the expression for calculating the minimum. ALL is the default.

Data types

Returns the same data type as *expression*. The Boolean equivalent of the MIN function is BOOL_AND function, and the Boolean equivalent of MAX is BOOL_OR function.

Examples

Find the lowest price paid from all sales:

```
select min(pricepaid) from sales;

min
-------
```

```
20.00
(1 row)
```

Find the lowest price paid per ticket from all sales:

```
select min(pricepaid/qtysold)as min_ticket_price
from sales;

min_ticket_price
------------------
20.00000000
(1 row)
```

PERCENTILE_CONT function

PERCENTILE_CONT is an inverse distribution function that assumes a continuous distribution model. It takes a percentile value and a sort specification, and returns an interpolated value that would fall into the given percentile value with respect to the sort specification.

PERCENTILE_CONT computes a linear interpolation between values after ordering them. Using the percentile value `(P)` and the number of not null rows `(N)` in the aggregation group, the function computes the row number after ordering the rows according to the sort specification. This row number `(RN)` is computed according to the formula `RN = (1+ (P*(N-1))`. The final result of the aggregate function is computed by linear interpolation between the values from rows at row numbers `CRN = CEILING(RN)` and `FRN = FLOOR(RN)`.

The final result will be as follows.

If `(CRN = FRN = RN)` then the result is `(value of expression from row at RN)`

Otherwise the result is as follows:

`(CRN - RN) * (value of expression for row at FRN) + (RN - FRN) * (value of expression for row at CRN)`.

Syntax

```
PERCENTILE_CONT(percentile)
WITHIN GROUP(ORDER BY expr)
```

Arguments

percentile

Numeric constant between 0 and 1. NULL values are ignored in the calculation.

expr

Specifies numeric or date/time values to sort and compute the percentile over.

Returns

The return type is determined by the data type of the ORDER BY expression in the WITHIN GROUP clause. The following table shows the return type for each ORDER BY expression data type.

Input type	Return type
INT2, INT4, INT8, NUMERIC, DECIMAL	DECIMAL
FLOAT, DOUBLE	DOUBLE
DATE	DATE
TIMESTAMP	TIMESTAMP
TIMESTAMPTZ	TIMESTAMPTZ

Usage notes

If the ORDER BY expression is a DECIMAL data type defined with the maximum precision of 38 digits, it is possible that PERCENTILE_CONT will return either an inaccurate result or an error. If the return value of the PERCENTILE_CONT function exceeds 38 digits, the result is truncated to fit, which causes a loss of precision.. If, during interpolation, an intermediate result exceeds the maximum precision, a numeric overflow occurs and the function returns an error. To avoid these conditions, we recommend either using a data type with lower precision or casting the ORDER BY expression to a lower precision.

If a statement includes multiple calls to sort-based aggregate functions (LISTAGG, PERCENTILE_CONT, or MEDIAN), they must all use the same ORDER BY values. Note that MEDIAN applies an implicit order by on the expression value.

For example, the following statement returns an error.

```
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(pricepaid)
FROM sales
GROUP BY salesid, pricepaid;

An error occurred when executing the SQL command:
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(pricepaid)
FROM sales
GROUP BY salesid, pricepaid;

ERROR: within group ORDER BY clauses for aggregate functions must be the same
```

The following statement runs successfully.

```
SELECT TOP 10 salesid, SUM(pricepaid),
PERCENTILE_CONT(0.6) WITHIN GROUP(ORDER BY salesid),
MEDIAN(salesid)
FROM sales
GROUP BY salesid, pricepaid;
```

Examples

The following examples use the TICKIT sample database. For more information, see Sample database.

The following example shows that PERCENTILE_CONT(0.5) produces the same results as MEDIAN.

```
SELECT TOP 10 DISTINCT sellerid, qtysold,
PERCENTILE_CONT(0.5) WITHIN GROUP(ORDER BY qtysold),
MEDIAN(qtysold)
FROM sales
GROUP BY sellerid, qtysold;

+----------+---------+-----------------+--------+
| sellerid | qtysold | percentile_cont | median |
+----------+---------+-----------------+--------+
|        2 |       2 |               2 |      2 |
```

```
|       26 |       1 |                 1 |        1 |
|       33 |       1 |                 1 |        1 |
|       38 |       1 |                 1 |        1 |
|       43 |       1 |                 1 |        1 |
|       48 |       2 |                 2 |        2 |
|       48 |       3 |                 3 |        3 |
|       77 |       4 |                 4 |        4 |
|       85 |       4 |                 4 |        4 |
|       95 |       2 |                 2 |        2 |
+----------+---------+-----------------+--------+
```

The following example finds PERCENTILE_CONT(0.5) and PERCENTILE_CONT(0.75) for the quantity sold for each sellerid in the SALES table.

```
SELECT sellerid,
PERCENTILE_CONT(0.5) WITHIN GROUP(ORDER BY qtysold) as pct_50,
PERCENTILE_CONT(0.75) WITHIN GROUP(ORDER BY qtysold) as pct_75
FROM sales
GROUP BY sellerid
ORDER BY sellerid
LIMIT 10;

+----------+--------+---------+
| sellerid | pct_50 | pct_75 |
+----------+--------+---------+
|        1 |    1.5 |    1.75 |
|        2 |      2 |    2.25 |
|        3 |      2 |       3 |
|        4 |      2 |       2 |
|        5 |      1 |     1.5 |
|        6 |      1 |       1 |
|        7 |    1.5 |    1.75 |
|        8 |      1 |       1 |
|        9 |      4 |       4 |
|       12 |      2 |    3.25 |
+----------+--------+---------+
```

To verify the results of the previous query for the first sellerid, use the following example.

```
SELECT qtysold
FROM sales
WHERE sellerid=1;
```

```
+---------+
| qtysold |
+---------+
|       2 |
|       1 |
+---------+
```

STDDEV_SAMP and STDDEV_POP functions

The STDDEV_SAMP and STDDEV_POP functions return the sample and population standard deviation of a set of numeric values (integer, decimal, or floating-point). The result of the STDDEV_SAMP function is equivalent to the square root of the sample variance of the same set of values.

STDDEV_SAMP and STDDEV are synonyms for the same function.

Syntax

```
STDDEV_SAMP | STDDEV ( [ DISTINCT | ALL ] expression)
STDDEV_POP ( [ DISTINCT | ALL ] expression)
```

The expression must have an integer, decimal, or floating point data type. Regardless of the data type of the expression, the return type of this function is a double precision number.

> **Note**
>
> Standard deviation is calculated using floating point arithmetic, which might result in slight imprecision.

Usage notes

When the sample standard deviation (STDDEV or STDDEV_SAMP) is calculated for an expression that consists of a single value, the result of the function is NULL not 0.

Examples

The following query returns the average of the values in the VENUESEATS column of the VENUE table, followed by the sample standard deviation and population standard deviation of the same set of values. VENUESEATS is an INTEGER column. The scale of the result is reduced to 2 digits.

```
select avg(venueseats),
cast(stddev_samp(venueseats) as dec(14,2)) stddevsamp,
cast(stddev_pop(venueseats) as dec(14,2)) stddevpop
from venue;

avg  | stddevsamp | stddevpop
-------+------------+-----------
17503 |   27847.76 |  27773.20
(1 row)
```

The following query returns the sample standard deviation for the COMMISSION column in the SALES table. COMMISSION is a DECIMAL column. The scale of the result is reduced to 10 digits.

```
select cast(stddev(commission) as dec(18,10))
from sales;

stddev
----------------
130.3912659086
(1 row)
```

The following query casts the sample standard deviation for the COMMISSION column as an integer.

```
select cast(stddev(commission) as integer)
from sales;

stddev
--------
130
(1 row)
```

The following query returns both the sample standard deviation and the square root of the sample variance for the COMMISSION column. The results of these calculations are the same.

```
select
cast(stddev_samp(commission) as dec(18,10)) stddevsamp,
cast(sqrt(var_samp(commission)) as dec(18,10)) sqrtvarsamp
from sales;

stddevsamp   |  sqrtvarsamp
```

```
----------------+----------------
130.3912659086 | 130.3912659086
(1 row)
```

SUM function

The SUM function returns the sum of the input column or expression values. The SUM function works with numeric values and ignores NULL values.

Syntax

```
SUM ( [ DISTINCT | ALL ] expression )
```

Arguments

expression

The target column or expression that the function operates on. The *expression* is one of the following data types:

- SMALLINT
- INTEGER
- BIGINT
- NUMERIC
- DECIMAL
- REAL
- DOUBLE PRECISON
- SUPER

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values from the specified expression before calculating the sum. With the argument ALL, the function retains all duplicate values from the expression for calculating the sum. ALL is the default.

Data types

The argument types supported by the SUM function are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, DOUBLE PRECISION, and SUPER.

The return types supported by the SUM function are

- BIGINT for BIGINT, SMALLINT, and INTEGER arguments
- NUMERIC for NUMERIC arguments
- DOUBLE PRECISION for floating point arguments
- Returns the same data type as expression for any other argument type.

The default precision for a SUM function result with a NUMERIC or DECIMAL argument is 38. The scale of the result is the same as the scale of the argument. For example, a SUM of a DEC(5,2) column returns a DEC(38,2) data type.

Examples

Find the sum of all commissions paid from the SALES table:

```
select sum(commission) from sales;

sum
-------------
16614814.65
(1 row)
```

Find the number of seats in all venues in the state of Florida:

```
select sum(venueseats) from venue
where venuestate = 'FL';

sum
--------
250411
(1 row)
```

Find the number of seats sold in May:

```
select sum(qtysold) from sales, date
where sales.dateid = date.dateid and date.month = 'MAY';

sum
-------
```

```
32291
(1 row)
```

VAR_SAMP and VAR_POP functions

The VAR_SAMP and VAR_POP functions return the sample and population variance of a set of numeric values (integer, decimal, or floating-point). The result of the VAR_SAMP function is equivalent to the squared sample standard deviation of the same set of values.

VAR_SAMP and VARIANCE are synonyms for the same function.

Syntax

```
VAR_SAMP | VARIANCE ( [ DISTINCT | ALL ] expression)
VAR_POP ( [ DISTINCT | ALL ] expression)
```

The expression must have an integer, decimal, or floating-point data type. Regardless of the data type of the expression, the return type of this function is a double precision number.

> **Note**
>
> The results of these functions might vary across data warehouse clusters, depending on the configuration of the cluster in each case.

Usage notes

When the sample variance (VARIANCE or VAR_SAMP) is calculated for an expression that consists of a single value, the result of the function is NULL not 0.

Examples

The following query returns the rounded sample and population variance of the NUMTICKETS column in the LISTING table.

```
select avg(numtickets),
round(var_samp(numtickets)) varsamp,
round(var_pop(numtickets)) varpop
from listing;
```

```
avg | varsamp | varpop
-----+---------+--------
10 |      54 |     54
(1 row)
```

The following query runs the same calculations but casts the results to decimal values.

```
select avg(numtickets),
cast(var_samp(numtickets) as dec(10,4)) varsamp,
cast(var_pop(numtickets) as dec(10,4)) varpop
from listing;

avg | varsamp | varpop
-----+---------+---------
10 | 53.6291 | 53.6288
(1 row)
```

Array functions

Following, you can find a description for the array functions for SQL that Amazon Redshift supports to access and manipulate arrays.

Topics

array function

Creates an array of the SUPER data type.

Syntax

```
ARRAY( [ expr1 ] [ , expr2 [ , ... ] ] )
```

Argument

expr1, expr2

Expressions of any Amazon Redshift data type except date and time types, since Amazon Redshift doesn't cast the date and time types to the SUPER data type. The arguments don't need to be of the same data type.

Return type

The array function returns the SUPER data type.

Example

The following examples show an array of numeric values and an array of different data types.

```
--an array of numeric values
select array(1,50,null,100);
      array
------------------
 [1,50,null,100]
(1 row)

--an array of different data types
select array(1,'abc',true,3.14);
        array
-----------------------
 [1,"abc",true,3.14]
(1 row)
```

array_concat function

The array_concat function concatenates two arrays to create an array that contains all the elements in the first array followed by all the elements in the second array. The two arguments must be valid arrays.

Syntax

```
array_concat( super_expr1,  super_expr2 )
```

Arguments

super_expr1

The value that specifies the first of the two arrays to concatenate.

super_expr2

The value that specifies the second of the two arrays to concatenate.

Return type

The array_concat function returns a SUPER data value.

Example

The following examples shows concatenation of two arrays of the same type and concatenation of two arrays of different types.

```
-- concatenating two arrays
SELECT ARRAY_CONCAT(ARRAY(10001,10002),ARRAY(10003,10004));
              array_concat
------------------------------------
 [10001,10002,10003,10004]
(1 row)

-- concatenating two arrays of different types
SELECT ARRAY_CONCAT(ARRAY(10001,10002),ARRAY('ab','cd'));
          array_concat
------------------------------
 [10001,10002,"ab","cd"]
(1 row)
```

array_flatten function

Merges multiple arrays into a single array of SUPER type.

Syntax

```
array_flatten( super_expr1,super_expr2,.. )
```

Arguments

super_expr1,*super_expr2*

A valid SUPER expression of array form.

Return type

The array_flatten function returns a SUPER data value.

Example

The following example shows an array_flatten function.

```
SELECT ARRAY_FLATTEN(ARRAY(ARRAY(1,2,3,4),ARRAY(5,6,7,8),ARRAY(9,10)));
     array_flatten
------------------------
 [1,2,3,4,5,6,7,8,9,10]
(1 row)
```

get_array_length function

Returns the length of the specified array. The GET_ARRAY_LENGTH function returns the length of a SUPER array given an object or array path.

Syntax

```
get_array_length( super_expr )
```

Arguments

super_expr

A valid SUPER expression of array form.

Return type

The get_array_length function returns a BIGINT.

Example

The following example shows a get_array_length function.

```
SELECT GET_ARRAY_LENGTH(ARRAY(1,2,3,4,5,6,7,8,9,10));
 get_array_length
----------------------
            10
(1 row)
```

split_to_array function

Uses a delimiter as an optional parameter. If no delimiter is present, then the default is a comma.

Syntax

```
split_to_array( string,delimiter )
```

Arguments

string

The input string to be split.

delimiter

An optional value on which the input string will be split. The default is a comma.

Return type

The split_to_array function returns a SUPER data value.

Example

The following example show a split_to_array function.

```
SELECT SPLIT_TO_ARRAY('12|345|6789', '|');
     split_to_array
-------------------------
 ["12","345","6789"]
(1 row)
```

subarray function

Manipulates arrays to return a subset of the input arrays.

Syntax

```
SUBARRAY( super_expr, start_position, length )
```

Arguments

super_expr

A valid SUPER expression in array form.

start_position

The position within the array to begin the extraction, starting at index position 0. A negative position counts backward from the end of the array.

length

The number of elements to extract (the length of the substring).

Return type

The subarray function returns a SUPER data value.

Examples

The following is an example of a subarray function.

```
 SELECT SUBARRAY(ARRAY('a', 'b', 'c', 'd', 'e', 'f'), 2, 3);
   subarray
---------------
 ["c","d","e"]
(1 row)
```

Bit-wise aggregate functions

Bit-wise aggregate functions compute bit operations to perform aggregation of integer columns and columns that can be converted or rounded to integer values.

Topics

- Using NULLs in bit-wise aggregations
- DISTINCT support for bit-wise aggregations

Using NULLs in bit-wise aggregations

When you apply a bit-wise function to a column that is nullable, any NULL values are eliminated before the function result is calculated. If no rows qualify for aggregation, the bit-wise function returns NULL. The same behavior applies to regular aggregate functions. Following is an example.

```
select sum(venueseats), bit_and(venueseats) from venue
where venueseats is null;

sum  | bit_and
------+---------
null |    null
(1 row)
```

DISTINCT support for bit-wise aggregations

As other aggregate functions do, bit-wise functions support the DISTINCT keyword.

However, using DISTINCT with these functions has no impact on the results. The first instance of a value is sufficient to satisfy bit-wise AND or OR operations. It makes no difference if duplicate values are present in the expression being evaluated.

Because the DISTINCT processing is likely to incur some query execution overhead, we recommend that you don't use DISTINCT with bit-wise functions.

Overview examples for bit-wise functions

Following, you can find some overview examples demonstrating how to work with the bit-wise functions. You can also find specific code examples with each function description.

Examples for the bit-wise functions are based on the TICKIT sample database. The USERS table in the TICKIT sample database contains several Boolean columns that indicate whether each user is known to like different types of events, such as sports, theatre, opera, and so on. An example follows.

```
select userid, username, lastname, city, state,
likesports, liketheatre
from users limit 10;

userid | username | lastname  |      city      | state | likesports | liketheatre
-------+----------+-----------+----------------+-------+------------+-------------
1 | JSG99FHE | Taylor    | Kent          | WA    | t          | t
9 | MSD36KVR | Watkins   | Port Orford   | MD    | t          | f
```

Assume that a new version of the USERS table is built in a different way. In this new version, a single integer column that defines (in binary form) eight types of events that each user likes or dislikes. In this design, each bit position represents a type of event. A user who likes all eight types has all eight bits set to 1 (as in the first row of the following table). A user who doesn't like any of these events has all eight bits set to 0 (see the second row). A user who likes only sports and jazz is represented in the third row following.

USER	SPORTS	THEATRE	JAZZ	OPERA	ROCK	VEGAS	BROADW.	CLASSICAL
User 1	1	1	1	1	1	1	1	1
User 2	0	0	0	0	0	0	0	0
User 3	1	0	1	0	0	0	0	0

In the database table, these binary values can be stored in a single LIKES column as integers, as shown following.

User	Binary value	Stored value (integer)
User 1	11111111	255
User 2	00000000	0
User 3	10100000	160

BIT_AND function

The BIT_AND function runs bit-wise AND operations on all of the values in a single integer column or expression. This function aggregates each bit of each binary value that corresponds to each integer value in the expression.

The BIT_AND function returns a result of `0` if none of the bits is set to 1 across all of the values. If one or more bits is set to 1 across all values, the function returns an integer value. This integer is the number that corresponds to the binary value for the those bits.

For example, a table contains four integer values in a column: 3, 7, 10, and 22. These integers are represented in binary form as follows:

Integer	Binary value
3	11
7	111
10	1010
22	10110

A BIT_AND operation on this dataset finds that all bits are set to 1 in the second-to-last position only. The result is a binary value of `00000010`, which represents the integer value 2. Therefore, the BIT_AND function returns 2.

Syntax

```
BIT_AND ( [DISTINCT | ALL] expression )
```

Arguments

expression

The target column or expression that the function operates on. This expression must have an INT, INT2, or INT8 data type. The function returns an equivalent INT, INT2, or INT8 data type.

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values for the specified expression before calculating the result. With the argument ALL, the function retains all duplicate values. ALL is the default. For more information, see DISTINCT support for bit-wise aggregations.

Examples

Given that meaningful business information is stored in integer columns, you can use bit-wise functions to extract and aggregate that information. The following query applies the BIT_AND function to the LIKES column in a table called USERLIKES and groups the results by the CITY column.

```
select city, bit_and(likes) from userlikes group by city
order by city;
city          | bit_and
--------------+---------
Los Angeles   |       0
Sacramento    |       0
San Francisco |       0
San Jose      |      64
Santa Barbara |     192
(5 rows)
```

You can interpret these results as follows:

- The integer value 192 for Santa Barbara translates to the binary value 11000000. In other words, all users in this city like sports and theatre, but not all users like any other type of event.
- The integer 64 translates to 01000000. So, for users in San Jose, the only type of event that they all like is theatre.
- The values of 0 for the other three cities indicate that no "likes" are shared by all users in those cities.

BIT_OR function

The BIT_OR function runs bit-wise OR operations on all of the values in a single integer column or expression. This function aggregates each bit of each binary value that corresponds to each integer value in the expression.

For example, suppose that your table contains four integer values in a column: 3, 7, 10, and 22. These integers are represented in binary form as follows.

Integer	Binary value
3	11
7	111
10	1010
22	10110

If you apply the BIT_OR function to the set of integer values, the operation looks for any value in which a 1 is found in each position. In this case, a 1 exists in the last five positions for at least one of the values, yielding a binary result of `00011111`; therefore, the function returns 31 (or `16 + 8 + 4 + 2 + 1`).

Syntax

```
BIT_OR ( [DISTINCT | ALL] expression )
```

Arguments

expression

The target column or expression that the function operates on. This expression must have an INT, INT2, or INT8 data type. The function returns an equivalent INT, INT2, or INT8 data type.

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values for the specified expression before calculating the result. With the argument ALL, the function retains all duplicate values. ALL is the default. For more information, see DISTINCT support for bit-wise aggregations.

Example

The following query applies the BIT_OR function to the LIKES column in a table called USERLIKES and groups the results by the CITY column.

```
select city, bit_or(likes) from userlikes group by city
order by city;
city          | bit_or
--------------+--------
Los Angeles   |    127
Sacramento    |    255
San Francisco |    255
San Jose      |    255
Santa Barbara |    255
(5 rows)
```

For four of the cities listed, all of the event types are liked by at least one user (`255=11111111`). For Los Angeles, all of the event types except sports are liked by at least one user (`127=01111111`).

BOOL_AND function

The BOOL_AND function operates on a single Boolean or integer column or expression. This function applies similar logic to the BIT_AND and BIT_OR functions. For this function, the return type is a Boolean value (`true` or `false`).

If all values in a set are true, the BOOL_AND function returns `true` (`t`). If any value is false, the function returns `false` (`f`).

Syntax

```
BOOL_AND ( [DISTINCT | ALL] expression )
```

Arguments

expression

The target column or expression that the function operates on. This expression must have a BOOLEAN or integer data type. The return type of the function is BOOLEAN.

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values for the specified expression before calculating the result. With the argument ALL, the function retains all duplicate values. ALL is the default. For more information, see DISTINCT support for bit-wise aggregations.

Examples

You can use the Boolean functions against either Boolean expressions or integer expressions. For example, the following query return results from the standard USERS table in the TICKIT database, which has several Boolean columns.

The BOOL_AND function returns `false` for all five rows. Not all users in each of those states likes sports.

```
select state, bool_and(likesports) from users
group by state order by state limit 5;

state | bool_and
------+---------
AB    | f
AK    | f
AL    | f
AZ    | f
BC    | f
(5 rows)
```

BOOL_OR function

The BOOL_OR function operates on a single Boolean or integer column or expression. This function applies similar logic to the BIT_AND and BIT_OR functions. For this function, the return type is a Boolean value (`true`, `false`, or `NULL`).

If one or more values in a set is `true`, the BOOL_OR function returns `true` (`t`). If all values in a set are `false`, the function returns `false` (`f`). NULL can be returned if the value is unknown.

Syntax

```
BOOL_OR ( [DISTINCT | ALL] expression )
```

Arguments

expression

The target column or expression that the function operates on. This expression must have a BOOLEAN or integer data type. The return type of the function is BOOLEAN.

DISTINCT | ALL

With the argument DISTINCT, the function eliminates all duplicate values for the specified expression before calculating the result. With the argument ALL, the function retains all duplicate values. ALL is the default. See DISTINCT support for bit-wise aggregations.

Examples

You can use the Boolean functions with either Boolean expressions or integer expressions. For example, the following query return results from the standard USERS table in the TICKIT database, which has several Boolean columns.

The BOOL_OR function returns `true` for all five rows. At least one user in each of those states likes sports.

```
select state, bool_or(likesports) from users
group by state order by state limit 5;

state | bool_or
------+--------
AB    | t
AK    | t
AL    | t
AZ    | t
BC    | t
(5 rows)
```

The following example returns NULL.

```
SELECT BOOL_OR(NULL = '123')
               bool_or
------
NULL
```

Conditional expressions

Topics

- CASE conditional expression
- DECODE function
- GREATEST and LEAST functions

- NVL and COALESCE functions
- NVL2 function
- NULLIF function

Amazon Redshift supports some conditional expressions that are extensions to the SQL standard.

CASE conditional expression

The CASE expression is a conditional expression, similar to if/then/else statements found in other languages. CASE is used to specify a result when there are multiple conditions. Use CASE where a SQL expression is valid, such as in a SELECT command.

There are two types of CASE expressions: simple and searched.

- In simple CASE expressions, an expression is compared with a value. When a match is found, the specified action in the THEN clause is applied. If no match is found, the action in the ELSE clause is applied.
- In searched CASE expressions, each CASE is evaluated based on a Boolean expression, and the CASE statement returns the first matching CASE. If no match is found among the WHEN clauses, the action in the ELSE clause is returned.

Syntax

Simple CASE statement used to match conditions:

```
CASE expression
  WHEN value THEN result
  [WHEN...]
  [ELSE result]
END
```

Searched CASE statement used to evaluate each condition:

```
CASE
  WHEN condition THEN result
  [WHEN ...]
  [ELSE result]
END
```

Arguments

expression

A column name or any valid expression.

value

Value that the expression is compared with, such as a numeric constant or a character string.

result

The target value or expression that is returned when an expression or Boolean condition is evaluated. The data types of all the result expressions must be convertible to a single output type.

condition

A Boolean expression that evaluates to true or false. If *condition* is true, the value of the CASE expression is the result that follows the condition, and the remainder of the CASE expression is not processed. If *condition* is false, any subsequent WHEN clauses are evaluated. If no WHEN condition results are true, the value of the CASE expression is the result of the ELSE clause. If the ELSE clause is omitted and no condition is true, the result is null.

Examples

The following examples use the VENUE table and SALES table from the sample TICKIT data. For more information, see [Sample database](#).

Use a simple CASE expression to replace `New York City` with `Big Apple` in a query against the VENUE table. Replace all other city names with `other`.

```
select venuecity,
  case venuecity
    when 'New York City'
    then 'Big Apple' else 'other'
  end
from venue
order by venueid desc;

venuecity        |   case
-----------------+-----------
Los Angeles      | other
New York City    | Big Apple
```

```
San Francisco    | other
Baltimore        | other
...
```

Use a searched CASE expression to assign group numbers based on the PRICEPAID value for individual ticket sales:

```
select pricepaid,
  case when pricepaid <10000 then 'group 1'
    when pricepaid >10000 then 'group 2'
    else 'group 3'
  end
from sales
order by 1 desc;

pricepaid |  case
----------+---------
12624     | group 2
10000     | group 3
10000     | group 3
9996      | group 1
9988      | group 1
...
```

DECODE function

A DECODE expression replaces a specific value with either another specific value or a default value, depending on the result of an equality condition. This operation is equivalent to the operation of a simple CASE expression or an IF-THEN-ELSE statement.

Syntax

```
DECODE ( expression, search, result [, search, result ]... [ ,default ] )
```

This type of expression is useful for replacing abbreviations or codes that are stored in tables with meaningful business values that are needed for reports.

Parameters

expression

The source of the value that you want to compare, such as a column in a table.

search

The target value that is compared against the source expression, such as a numeric value or a character string. The search expression must evaluate to a single fixed value. You cannot specify an expression that evaluates to a range of values, such as `age between 20 and 29`; you need to specify separate search/result pairs for each value that you want to replace.

The data type of all instances of the search expression must be the same or compatible. The *expression* and *search* parameters must also be compatible.

result

The replacement value that query returns when the expression matches the search value. You must include at least one search/result pair in the DECODE expression.

The data types of all instances of the result expression must be the same or compatible. The *result* and *default* parameters must also be compatible.

default

An optional default value that is used for cases when the search condition fails. If you do not specify a default value, the DECODE expression returns NULL.

Usage notes

If the *expression* value and the *search* value are both NULL, the DECODE result is the corresponding *result* value. For an illustration of this use of the function, see the Examples section.

When used this way, DECODE is similar to NVL2 function, but there are some differences. For a description of these differences, see the NVL2 usage notes.

Examples

When the value `2008-06-01` exists in the caldate column of datetable, the following example replaces it with `June 1st, 2008`. The example replaces all other caldate values with NULL.

```
select decode(caldate, '2008-06-01', 'June 1st, 2008')
from datetable where month='JUN' order by caldate;

case
----------------
June 1st, 2008
```

```
...
(30 rows)
```

The following example uses a DECODE expression to convert the five abbreviated CATNAME columns in the CATEGORY table to full names and convert other values in the column to Unknown.

```
select catid, decode(catname,
'NHL', 'National Hockey League',
'MLB', 'Major League Baseball',
'MLS', 'Major League Soccer',
'NFL', 'National Football League',
'NBA', 'National Basketball Association',
'Unknown')
from category
order by catid;

catid  | case
-------+---------------------------------
1      | Major League Baseball
2      | National Hockey League
3      | National Football League
4      | National Basketball Association
5      | Major League Soccer
6      | Unknown
7      | Unknown
8      | Unknown
9      | Unknown
10     | Unknown
11     | Unknown
(11 rows)
```

Use a DECODE expression to find venues in Colorado and Nevada with NULL in the VENUESEATS column; convert the NULLs to zeroes. If the VENUESEATS column is not NULL, return 1 as the result.

```
select venuename, venuestate, decode(venueseats,null,0,1)
from venue
where venuestate in('NV','CO')
order by 2,3,1;

venuename                 | venuestate     | case
------------------------------+----------------+-----------
```

```
Coors Field                    | CO        |   1
Dick's Sporting Goods Park     | CO        |   1
Ellie Caulkins Opera House     | CO        |   1
INVESCO Field         | CO        |   1
Pepsi Center         | CO        |   1
Ballys Hotel         | NV        |   0
Bellagio Hotel                 | NV        |   0
Caesars Palace                 | NV        |   0
Harrahs Hotel                  | NV        |   0
Hilton Hotel                   | NV        |   0
...
(20 rows)
```

GREATEST and LEAST functions

Returns the largest or smallest value from a list of any number of expressions.

Syntax

```
GREATEST (value [, ...])
LEAST (value [, ...])
```

Parameters

expression_list

A comma-separated list of expressions, such as column names. The expressions must all be convertible to a common data type. NULL values in the list are ignored. If all of the expressions evaluate to NULL, the result is NULL.

Returns

Returns the greatest (for GREATEST) or least (for LEAST) value from the provided list of expressions.

Example

The following example returns the highest value alphabetically for `firstname` or `lastname`.

```
select firstname, lastname, greatest(firstname,lastname) from users
where userid < 10
```

```
order by 3;

 firstname | lastname  | greatest
-----------+-----------+-----------
 Lars      | Ratliff   | Ratliff
 Reagan    | Hodge     | Reagan
 Colton    | Roy       | Roy
 Barry     | Roy       | Roy
 Tamekah   | Juarez    | Tamekah
 Rafael    | Taylor    | Taylor
 Victor    | Hernandez | Victor
 Vladimir  | Humphrey  | Vladimir
 Mufutau   | Watkins   | Watkins
(9 rows)
```

NVL and COALESCE functions

Returns the value of the first expression that isn't null in a series of expressions. When a non-null value is found, the remaining expressions in the list aren't evaluated.

NVL is identical to COALESCE. They are synonyms. This topic explains the syntax and contains examples for both.

Syntax

```
NVL( expression, expression, ... )
```

The syntax for COALESCE is the same:

```
COALESCE( expression, expression, ... )
```

If all expressions are null, the result is null.

These functions are useful when you want to return a secondary value when a primary value is missing or null. For example, a query might return the first of three available phone numbers: cell, home, or work. The order of the expressions in the function determines the order of evaluation.

Arguments

expression

An expression, such as a column name, to be evaluated for null status.

Return type

Amazon Redshift determines the data type of the returned value based on the input expressions. If the data types of the input expressions don't have a common type, then an error is returned.

Examples

If the list contains integer expressions, the function returns an integer.

```
SELECT COALESCE(NULL, 12, NULL);

coalesce
--------------
12
```

This example, which is the same as the previous example, except that it uses NVL, returns the same result.

```
SELECT NVL(NULL, 12, NULL);

coalesce
--------------
12
```

The following example returns a string type.

```
SELECT COALESCE(NULL, 'Amazon Redshift', NULL);

coalesce
--------------
Amazon Redshift
```

The following example results in an error because the data types vary in the expression list. In this case, there is both a string type and a number type in the list.

```
SELECT COALESCE(NULL, 'Amazon Redshift', 12);
ERROR: invalid input syntax for integer: "Amazon Redshift"
```

For this example, you create a table with START_DATE and END_DATE columns, insert rows that include null values, then apply an NVL expression to the two columns.

```
create table datetable (start_date date, end_date date);
insert into datetable values ('2008-06-01','2008-12-31');
insert into datetable values (null,'2008-12-31');
insert into datetable values ('2008-12-31',null);
```

```
select nvl(start_date, end_date)
from datetable
order by 1;

coalesce
------------
2008-06-01
2008-12-31
2008-12-31
```

The default column name for an NVL expression is COALESCE. The following query returns the same results:

```
select coalesce(start_date, end_date)
from datetable
order by 1;
```

For the following example queries, you create a table with sample hotel-booking information and insert several rows. Some records contain null values.

```
create table booking_info (booking_id int, booking_code character(8), check_in date,
 check_out date, funds_collected numeric(12,2));
```

Insert the following sample data. Some records don't have a `check_out` date or `funds_collected` amount.

```
insert into booking_info values (1, 'OCEAN_WV', '2023-02-01','2023-02-03',100.00);
insert into booking_info values (2, 'OCEAN_WV', '2023-04-22','2023-04-26',120.00);
insert into booking_info values (3, 'DSRT_SUN', '2023-03-13','2023-03-16',125.00);
insert into booking_info values (4, 'DSRT_SUN', '2023-06-01','2023-06-03',140.00);
insert into booking_info values (5, 'DSRT_SUN', '2023-07-10',null,null);
insert into booking_info values (6, 'OCEAN_WV', '2023-08-15',null,null);
```

The following query returns a list of dates. If the `check_out` date isn't available, it lists the `check_in` date.

```
select coalesce(check_out, check_in)
from booking_info
order by booking_id;
```

The results are the following. Note that the last two records show the `check_in` date.

```
coalesce
------------
2023-02-03
2023-04-26
2023-03-16
2023-06-03
2023-07-10
2023-08-15
```

If you expect a query to return null values for certain functions or columns, you can use an NVL expression to replace the nulls with some other value. For example, aggregate functions, such as SUM, return null values instead of zeroes when they have no rows to evaluate. You can use an NVL expression to replace these null values with `700.0`. Instead of `485`, the result of summing the `funds_collected` is `1885` because two rows that have null are replaced with `700`.

```
select sum(nvl(funds_collected, 700.0)) as sumresult from booking_info;

sumresult
------
 1885
```

NVL2 function

Returns one of two values based on whether a specified expression evaluates to NULL or NOT NULL.

Syntax

```
NVL2 ( expression, not_null_return_value, null_return_value )
```

Arguments

expression

An expression, such as a column name, to be evaluated for null status.

not_null_return_value

The value returned if *expression* evaluates to NOT NULL. The *not_null_return_value* value must either have the same data type as *expression* or be implicitly convertible to that data type.

null_return_value

The value returned if *expression* evaluates to NULL. The *null_return_value* value must either have the same data type as *expression* or be implicitly convertible to that data type.

Return type

The NVL2 return type is determined as follows:

- If either *not_null_return_value* or *null_return_value* is null, the data type of the not-null expression is returned.

If both *not_null_return_value* and *null_return_value* are not null:

- If *not_null_return_value* and *null_return_value* have the same data type, that data type is returned.
- If *not_null_return_value* and *null_return_value* have different numeric data types, the smallest compatible numeric data type is returned.
- If *not_null_return_value* and *null_return_value* have different datetime data types, a timestamp data type is returned.
- If *not_null_return_value* and *null_return_value* have different character data types, the data type of *not_null_return_value* is returned.
- If *not_null_return_value* and *null_return_value* have mixed numeric and non-numeric data types, the data type of *not_null_return_value* is returned.

> **Important**
>
> In the last two cases where the data type of *not_null_return_value* is returned, *null_return_value* is implicitly cast to that data type. If the data types are incompatible, the function fails.

Usage notes

DECODE function can be used in a similar way to NVL2 when the *expression* and *search* parameters are both null. The difference is that for DECODE, the return will have both the value and the data type of the *result* parameter. In contrast, for NVL2, the return will have the value of either the *not_null_return_value* or *null_return_value* parameter, whichever is selected by the function, but will have the data type of *not_null_return_value*.

For example, assuming column1 is NULL, the following queries will return the same value. However, the DECODE return value data type will be INTEGER and the NVL2 return value data type will be VARCHAR.

```
select decode(column1, null, 1234, '2345');
select nvl2(column1, '2345', 1234);
```

Example

The following example modifies some sample data, then evaluates two fields to provide appropriate contact information for users:

```
update users set email = null where firstname = 'Aphrodite' and lastname = 'Acevedo';

select (firstname + ' ' + lastname) as name,
nvl2(email, email, phone) AS contact_info
from users
where state = 'WA'
and lastname  like 'A%'
order by lastname, firstname;

name        contact_info
--------------------+-------------------------------------------
Aphrodite Acevedo (906) 632-4407
Caldwell Acevedo  Nunc.sollicitudin@Duisac.ca
Quinn Adams    vel@adipiscingligulaAenean.com
Kamal Aguilar  quis@vulputaterisusa.com
Samson Alexander  hendrerit.neque@indolorFusce.ca
Hall Alford    ac.mattis@vitaediamProin.edu
Lane Allen     et.netus@risusDonec.org
Xander Allison    ac.facilisis.facilisis@Infaucibus.com
Amaya Alvarado    dui.nec.tempus@eudui.edu
Vera Alvarez   at.arcu.Vestibulum@pellentesque.edu
Yetta Anthony  enim.sit@risus.org
```

```
Violet Arnold  ad.litora@at.com
August Ashley  consectetuer.euismod@Phasellus.com
Karyn Austin   ipsum.primis.in@Maurisblanditenim.org
Lucas Ayers    at@elitpretiumet.com
```

NULLIF function

Syntax

The NULLIF expression compares two arguments and returns null if the arguments are equal. If they are not equal, the first argument is returned. This expression is the inverse of the NVL or COALESCE expression.

```
NULLIF ( expression1, expression2 )
```

Arguments

expression1, expression2

The target columns or expressions that are compared. The return type is the same as the type of the first expression. The default column name of the NULLIF result is the column name of the first expression.

Examples

In the following example, the query returns the string `first` because the arguments are not equal.

```
SELECT NULLIF('first', 'second');

case
-------
first
```

In the following example, the query returns `NULL` because the string literal arguments are equal.

```
SELECT NULLIF('first', 'first');

case
-------
NULL
```

In the following example, the query returns 1 because the integer arguments are not equal.

```
SELECT NULLIF(1, 2);

case
-------
1
```

In the following example, the query returns NULL because the integer arguments are equal.

```
SELECT NULLIF(1, 1);

case
-------
NULL
```

In the following example, the query returns null when the LISTID and SALESID values match:

```
select nullif(listid,salesid), salesid
from sales where salesid<10 order by 1, 2 desc;

listid  | salesid
--------+---------
     4  |       2
     5  |       4
     5  |       3
     6  |       5
     10 |       9
     10 |       8
     10 |       7
     10 |       6
        |       1
(9 rows)
```

You can use NULLIF to ensure that empty strings are always returned as nulls. In the example below, the NULLIF expression returns either a null value or a string that contains at least one character.

```
insert into category
values(0,'','Special','Special');
```

```
select nullif(catgroup,'') from category
where catdesc='Special';

catgroup
----------
null
(1 row)
```

NULLIF ignores trailing blanks. If a string is not empty but contains blanks, NULLIF still returns null:

```
create table nulliftest(c1 char(2), c2 char(2));

insert into nulliftest values ('a','a ');

insert into nulliftest values ('b','b');


select nullif(c1,c2) from nulliftest;
c1
------
null
null
(2 rows)
```

Data type formatting functions

Topics

Data type formatting functions provide an easy way to convert values from one data type to another. For each of these functions, the first argument is always the value to be formatted and the second argument contains the template for the new format. Amazon Redshift supports several data type formatting functions.

CAST function

The CAST function converts one data type to another compatible data type. For instance, you can convert a string to a date, or a numeric type to a string. CAST performs a runtime conversion, which means that the conversion doesn't change a value's data type in a source table. It's changed only in the context of the query.

The CAST function is very similar to the section called “CONVERT”, in that they both convert one data type to another, but they are called differently.

Certain data types require an explicit conversion to other data types using the CAST or CONVERT function. Other data types can be converted implicitly, as part of another command, without using CAST or CONVERT. See Type compatibility and conversion.

Syntax

Use either of these two equivalent syntax forms to cast expressions from one data type to another.

```
CAST ( expression AS type )
expression :: type
```

Arguments

expression

An expression that evaluates to one or more values, such as a column name or a literal. Converting null values returns nulls. The expression cannot contain blank or empty strings.

type

One of the supported Data types.

Return type

CAST returns the data type specified by the *type* argument.

Note

Amazon Redshift returns an error if you try to perform a problematic conversion, such as a DECIMAL conversion that loses precision, like the following:

```
select 123.456::decimal(2,1);
```

or an INTEGER conversion that causes an overflow:

```
select 12345678::smallint;
```

Examples

Some of the examples use the sample TICKIT database. For more information about setting up sample data, see Load data.

The following two queries are equivalent. They both cast a decimal value to an integer:

```
select cast(pricepaid as integer)
from sales where salesid=100;

pricepaid
-----------
162
(1 row)
```

```
select pricepaid::integer
from sales where salesid=100;

pricepaid
-----------
162
(1 row)
```

The following produces a similar result. It doesn't require sample data to run:

```
select cast(162.00 as integer) as pricepaid;

pricepaid
```

```
-----------
162
(1 row)
```

In this example, the values in a timestamp column are cast as dates, which results in removing the time from each result:

```
select cast(saletime as date), salesid
from sales order by salesid limit 10;

 saletime  | salesid
-----------+---------
2008-02-18 |       1
2008-06-06 |       2
2008-06-06 |       3
2008-06-09 |       4
2008-08-31 |       5
2008-07-16 |       6
2008-06-26 |       7
2008-07-10 |       8
2008-07-22 |       9
2008-08-06 |      10
(10 rows)
```

If you didn't use CAST as illustrated in the previous sample, the results would include the time: *2008-02-18 02:36:48*.

The following query casts variable character data to a date. It doesn't require sample data to run.

```
select cast('2008-02-18 02:36:48' as date) as mysaletime;

mysaletime
--------------------
2008-02-18
(1 row)
```

In this example, the values in a date column are cast as timestamps:

```
select cast(caldate as timestamp), dateid
from date order by dateid limit 10;

      caldate       | dateid
```

```
--------------------+--------
2008-01-01 00:00:00 |   1827
2008-01-02 00:00:00 |   1828
2008-01-03 00:00:00 |   1829
2008-01-04 00:00:00 |   1830
2008-01-05 00:00:00 |   1831
2008-01-06 00:00:00 |   1832
2008-01-07 00:00:00 |   1833
2008-01-08 00:00:00 |   1834
2008-01-09 00:00:00 |   1835
2008-01-10 00:00:00 |   1836
(10 rows)
```

In a case like the previous sample, you can gain additional control over output formatting by using TO_CHAR.

In this example, an integer is cast as a character string:

```
select cast(2008 as char(4));

bpchar
--------
2008
```

In this example, a DECIMAL(6,3) value is cast as a DECIMAL(4,1) value:

```
select cast(109.652 as decimal(4,1));

numeric
---------
109.7
```

This example shows a more complex expression. The PRICEPAID column (a DECIMAL(8,2) column) in the SALES table is converted to a DECIMAL(38,2) column and the values are multiplied by 100000000000000000000:

```
select salesid, pricepaid::decimal(38,2)*100000000000000000000
as value from sales where salesid<10 order by salesid;


 salesid |           value
---------+----------------------------
```

```
        1 | 7280000000000000000000000.00
        2 |  760000000000000000000000.00
        3 | 3500000000000000000000000.00
        4 | 1750000000000000000000000.00
        5 | 1540000000000000000000000.00
        6 | 3940000000000000000000000.00
        7 | 7880000000000000000000000.00
        8 | 1970000000000000000000000.00
        9 | 5910000000000000000000000.00
(9 rows)
```

> **Note**
>
> You can't perform a CAST or CONVERT operation on the GEOMETRY data type to change it to another data type. However, you can provide a hexadecimal representation of a string literal in extended well-known binary (EWKB) format as input to functions that accept a GEOMETRY argument. For example, the ST_AsText function following expects a GEOMETRY data type.
>
> ```
> SELECT ST_AsText('01010000000000000000000000001C400000000000002040');
> ```
>
> ```
> st_astext
> ------------
>  POINT(7 8)
> ```
>
> You can also explicitly specify the GEOMETRY data type.
>
> ```
> SELECT ST_AsText('010100000000000000000000000014400000000000001840'::geometry);
> ```
>
> ```
> st_astext
> ------------
>  POINT(5 6)
> ```

CONVERT function

Like the CAST function, the CONVERT function converts one data type to another compatible data type. For instance, you can convert a string to a date, or a numeric type to a string. CONVERT performs a runtime conversion, which means that the conversion doesn't change a value's data type in a source table. It's changed only in the context of the query.

Certain data types require an explicit conversion to other data types using the CONVERT function. Other data types can be converted implicitly, as part of another command, without using CAST or CONVERT. See Type compatibility and conversion.

Syntax

```
CONVERT ( type, expression )
```

Arguments

type

One of the supported Data types.

expression

An expression that evaluates to one or more values, such as a column name or a literal. Converting null values returns nulls. The expression cannot contain blank or empty strings.

Return type

CONVERT returns the data type specified by the *type* argument.

Note

Amazon Redshift returns an error if you try to perform a problematic conversion, such as a DECIMAL conversion that loses precision, like the following:

```
SELECT CONVERT(decimal(2,1), 123.456);
```

or an INTEGER conversion that causes an overflow:

```
SELECT CONVERT(smallint, 12345678);
```

Examples

Some of the examples use the sample TICKIT database. For more information about setting up sample data, see Load data.

The following query uses the CONVERT function to convert a column of decimals into integers

```
SELECT CONVERT(integer, pricepaid)
FROM sales WHERE salesid=100;
```

This example converts an integer into a character string.

```
SELECT CONVERT(char(4), 2008);
```

In this example, the current date and time is converted to a variable character data type:

```
SELECT CONVERT(VARCHAR(30), GETDATE());

getdate
---------
2023-02-02 04:31:16
```

This example converts the saletime column into just the time, removing the dates from each row.

```
SELECT CONVERT(time, saletime), salesid
FROM sales order by salesid limit 10;
```

For information about converting a timestamp from one time zone to another, see the CONVERT_TIMEZONE function. For additional date and time functions, see Date and time functions.

The following example converts variable character data into a datetime object.

```
SELECT CONVERT(datetime, '2008-02-18 02:36:48') as mysaletime;
```

Note

You can't perform a CAST or CONVERT operation on the GEOMETRY data type to change it to another data type. However, you can provide a hexadecimal representation of a string literal in extended well-known binary (EWKB) format as input to functions that accept a

GEOMETRY argument. For example, the ST_AsText function following expects a GEOMETRY data type.

```
SELECT ST_AsText('01010000000000000000001C400000000000002040');
```

```
st_astext
------------
 POINT(7 8)
```

You can also explicitly specify the GEOMETRY data type.

```
SELECT ST_AsText('010100000000000000000014400000000000001840'::geometry);
```

```
st_astext
------------
 POINT(5 6)
```

TEXT_TO_INT_ALT

TEXT_TO_INT_ALT converts a character string to an integer using Teradata-style formatting. Fraction digits in the result are truncated.

Syntax

```
TEXT_TO_INT_ALT (expression [ , 'format'])
```

Arguments

expression

An expression that results in one or more CHAR or VARCHAR values, such as a column name or literal string. Converting null values returns nulls. The function converts blank or empty strings to 0.

format

A string literal that defines the format of the input expression. For more information about the formatting characters you can specify, see Teradata-style formatting characters for numeric data.

Return type

TEXT_TO_INT_ALT returns an INTEGER value.

The fractional portion of the cast result is truncated.

Amazon Redshift returns an error if the conversion to the *format* phrase that you specify isn't successful.

Examples

The following example converts the input *expression* string '123-' to the integer -123.

```
select text_to_int_alt('123-');
```

```
text_to_int_alt
----------
      -123
```

The following example converts the input *expression* string '2147483647+' to the integer 2147483647.

```
select text_to_int_alt('2147483647+');
```

```
text_to_int_alt
----------
2147483647
```

The following example converts the exponential input *expression* string '-123E-2' to the integer -1.

```
select text_to_int_alt('-123E-2');
```

```
text_to_int_alt
----------
        -1
```

The following example converts the input *expression* string '2147483647+' to the integer 2147483647.

```
select text_to_int_alt('2147483647+');
```

```
text_to_int_alt
----------
2147483647
```

The following example converts the input *expression* string '123{' with the *format* phrase '999S' to the integer 1230. The S character indicates a Signed Zoned Decimal. For more information, see Teradata-style formatting characters for numeric data.

```
select text_to_int_alt('123{', '999S');
```

```
text_to_int_alt
----------
      1230
```

The following example converts the input *expression* string 'USD123' with the *format* phrase 'C9(I)' to the integer 123. See Teradata-style formatting characters for numeric data.

```
select text_to_int_alt('USD123', 'C9(I)');
```

```
text_to_int_alt
----------
       123
```

The following example specifies a table column as the input *expression*.

```
select text_to_int_alt(a), text_to_int_alt(b) from t_text2int order by 1;
```

```
 text_to_int_alt | text_to_int_alt
-----------------+-----------------
            -123 |            -123
            -123 |            -123
             123 |             123
             123 |             123
```

Following is the table definition and the insert statement for this example.

```
create table t_text2int (a varchar(200), b char(200));
```

```
insert into t_text2int VALUES('123', '123'),('123.123', '123.123'), ('-123', '-123'),
 ('123-', '123-');
```

TEXT_TO_NUMERIC_ALT

TEXT_TO_NUMERIC_ALT performs a Teradata-style cast operation to convert a character string to a numeric data format.

Syntax

```
TEXT_TO_NUMERIC_ALT (expression [, 'format'] [, precision, scale])
```

Arguments

expression

An expression that evaluates to one or more CHAR or VARCHAR values, such as a column name or a literal. Converting null values returns nulls. Blank or empty strings are converted to 0.

format

A string literal that defines the format of the input expression. For more information, see Teradata-style formatting characters for numeric data.

precision

The number of digits in the numeric result. The default is 38.

scale

The number of digits to the right of the decimal point in the numeric result. The default is 0.

Return type

TEXT_TO_NUMERIC_ALT returns a DECIMAL number.

Amazon Redshift returns an error if the conversion to the *format* phrase that you specify isn't successful.

Amazon Redshift casts the input *expression* string to the numeric type with the highest precision that you specify for that type in the *precision* option. If the length of the numeric value exceeds the value that you specify for *precision*, Amazon Redshift rounds the numeric value according to the following rules:

- If the length of the cast result exceeds the length that you specify in the *format* phrase, Amazon Redshift returns an error.
- If the result is cast to a numeric value, the result is rounded to the closest value. If the fractional portion is exactly midway between the upper and lower cast result, the result is rounded to the nearest even value.

Examples

The following example converts the input *expression* string '1.5' to the numeric value '2'. Because the statement doesn't specify *scale*, the *scale* defaults to 0 and the cast result doesn't include a fraction result. Because .5 is midway between 1 and 2, the cast result is rounded to the even value of 2.

```
select text_to_numeric_alt('1.5');
```

```
 text_to_numeric_alt
---------------------
                   2
```

The following example converts the input *expression* string '2.51' to the numeric value 3. Because the statement doesn't specify a *scale* value, the *scale* defaults to 0 and the cast result doesn't include a fraction result. Because .51 is closer to 3 than 2, the cast result is rounded to the value of 3.

```
select text_to_numeric_alt('2.51');
```

```
 text_to_numeric_alt
---------------------
                   3
```

The following example converts the input *expression* string 123.52501 with a *precision* of 10 and a *scale* of 2 to the numeric value 123.53.

```
select text_to_numeric_alt('123.52501', 10, 2);
```

```
 text_to_numeric_alt
---------------------
              123.53
```

The following example converts the input *expression* string '123{' with the *format* phrase '999S' to the numeric 1230. The S character indicates a Signed Zoned Decimal. For more information, see Teradata-style formatting characters for numeric data.

```
select text_to_numeric_alt('123{', '999S');
```

```
text_to_int_alt
----------
      1230
```

The following example converts the input *expression* string 'USD123' with the *format* phrase 'C9(I)' to the numeric 124. See Teradata-style formatting characters for numeric data.

```
select text_to_numeric_alt('USD123.9', 'C9(I)');
```

```
text_to_numeric_alt
----------
       124
```

The following example specifies a table column as the input *expression*.

```
select text_to_numeric_alt(a), text_to_numeric_alt(b) from t_text2numeric order by 1;
```

```
           text_to_numeric_alt           |           text_to_numeric_alt
-----------------------------------------+-----------------------------------------
 -99999999999999999999999999999999999999 | -99999999999999999999999999999999999999
                                  -12300 |                                   -12300
                                     123 |                                      123
                                     123 |                                      123
  99999999999999999999999999999999999999 |  99999999999999999999999999999999999999
```

Following is the table definition and the insert statement for this example.

```
create table  t_text2numeric (a varchar(200), b char(200));
```

```
insert into  t_text2numeric values
('123', '123'),
('+123.456', '+123.456'),
('-' || repeat('9', 38), '-' || repeat('9', 38)),
(repeat('9', 38) || '+', repeat('9', 38) || '+'),
('-123E2', '-123E2');
```

TO_CHAR

TO_CHAR converts a timestamp or numeric expression to a character-string data format.

Syntax

```
TO_CHAR (timestamp_expression | numeric_expression , 'format')
```

Arguments

timestamp_expression

An expression that results in a TIMESTAMP or TIMESTAMPTZ type value or a value that can implicitly be coerced to a timestamp.

numeric_expression

An expression that results in a numeric data type value or a value that can implicitly be coerced to a numeric type. For more information, see Numeric types. TO_CHAR inserts a space to the left of the numeral string.

> **Note**
>
> TO_CHAR does not support 128-bit DECIMAL values.

format

The format for the new value. For valid formats, see Datetime format strings and Numeric format strings.

Return type

VARCHAR

Examples

The following example converts a timestamp to a value with the date and time in a format with the name of the month padded to nine characters, the name of the day of the week, and the day number of the month.

```
select to_char(timestamp '2009-12-31 23:15:59', 'MONTH-DY-DD-YYYY HH12:MIPM');

to_char
-------------------------
DECEMBER -THU-31-2009 11:15PM
```

The following example converts a timestamp to a value with day number of the year.

```
select to_char(timestamp '2009-12-31 23:15:59', 'DDD');

to_char
-------------------------
365
```

The following example converts a timestamp to an ISO day number of the week.

```
select to_char(timestamp '2022-05-16 23:15:59', 'ID');

to_char
-------------------------
1
```

The following example extracts the month name from a date.

```
select to_char(date '2009-12-31', 'MONTH');

to_char
-------------------------
DECEMBER
```

The following example converts each STARTTIME value in the EVENT table to a string that consists of hours, minutes, and seconds.

```
select to_char(starttime, 'HH12:MI:SS')
from event where eventid between 1 and 5
order by eventid;

to_char
----------
02:30:00
08:00:00
02:30:00
02:30:00
07:00:00
```

The following example converts an entire timestamp value into a different format.

```
select starttime, to_char(starttime, 'MON-DD-YYYY HH12:MIPM')
from event where eventid=1;

      starttime      |       to_char
---------------------+---------------------
 2008-01-25 14:30:00 | JAN-25-2008 02:30PM
```

The following example converts a timestamp literal to a character string.

```
select to_char(timestamp '2009-12-31 23:15:59','HH24:MI:SS');

to_char
----------
23:15:59
```

The following example converts a decimal number to a character string.

```
select to_char(125.8, '999.99');

to_char
---------
125.80
```

The following example converts a decimal number to a character string.

```
select to_char(125.8, '999D99');
```

```
to_char
---------
125.80
```

The following example converts a number to a character string with a leading zero.

```
select to_char(125.8, '0999D99');

to_char
---------
0125.80
```

The following example converts a number to a character string with the negative sign at the end.

```
select to_char(-125.8, '999D99S');

to_char
---------
125.80-
```

The following example converts a number to a character string with the positive or negative sign at the specified position.

```
select to_char(125.8, '999D99SG');

to_char
---------
125.80+
```

The following example converts a number to a character string with the positive sign at the specified position.

```
select to_char(125.8, 'PL999D99');

to_char
---------
+ 125.80
```

The following example converts a number to a character string with the currency symbol.

```
select to_char(-125.88, '$S999D99');

to_char
---------
$-125.88
```

The following example converts a number to a character string with the currency symbol in the specified position.

```
select to_char(-125.88, 'S999D99L');

to_char
---------
-125.88$
```

The following example converts a number to a character string using a thousands (comma) separator.

```
select to_char(1125.8, '9,999.99');

to_char
---------
1,125.80
```

The following example converts a number to a character string using angle brackets for negative numbers.

```
select to_char(-125.88, '$999D99PR');

to_char
---------
$<125.88>
```

The following example converts a number to a Roman numeral string.

```
select to_char(125, 'RN');

to_char
---------
   CXXV
```

The following example converts a date to a century code.

```
select to_char(date '2020-12-31', 'CC');

to_char
---------
21
```

The following example displays the day of the week.

```
SELECT to_char(current_timestamp, 'FMDay, FMDD HH12:MI:SS');

to_char
-----------------------
Wednesday, 31 09:34:26
```

The following example displays the ordinal number suffix for a number.

```
SELECT to_char(482, '999th');

to_char
-----------------------
 482nd
```

The following example subtracts the commission from the price paid in the sales table. The difference is then rounded up and converted to a roman numeral, shown in the to_char column:

```
select salesid, pricepaid, commission, (pricepaid - commission)
as difference, to_char(pricepaid - commission, 'rn') from sales
group by sales.pricepaid, sales.commission, salesid
order by salesid limit 10;

 salesid | pricepaid | commission | difference |     to_char
---------+-----------+------------+------------+-----------------
       1 |    728.00 |     109.20 |     618.80 |           dcxix
       2 |     76.00 |      11.40 |      64.60 |             lxv
       3 |    350.00 |      52.50 |     297.50 |        ccxcviii
       4 |    175.00 |      26.25 |     148.75 |           cxlix
       5 |    154.00 |      23.10 |     130.90 |           cxxxi
       6 |    394.00 |      59.10 |     334.90 |         cccxxxv
       7 |    788.00 |     118.20 |     669.80 |           dclxx
```

```
       8 |    197.00 |       29.55 |     167.45 |          clxvii
       9 |    591.00 |       88.65 |     502.35 |             dii
      10 |     65.00 |        9.75 |      55.25 |              lv
```

The following example adds the currency symbol to the difference values shown in the to_char column:

```
select salesid, pricepaid, commission, (pricepaid - commission)
as difference, to_char(pricepaid - commission, 'l99999D99') from sales
group by sales.pricepaid, sales.commission, salesid
order by salesid limit 10;

salesid | pricepaid | commission | difference |  to_char
--------+-----------+------------+------------+------------
      1 |    728.00 |     109.20 |     618.80 | $   618.80
      2 |     76.00 |      11.40 |      64.60 | $    64.60
      3 |    350.00 |      52.50 |     297.50 | $   297.50
      4 |    175.00 |      26.25 |     148.75 | $   148.75
      5 |    154.00 |      23.10 |     130.90 | $   130.90
      6 |    394.00 |      59.10 |     334.90 | $   334.90
      7 |    788.00 |     118.20 |     669.80 | $   669.80
      8 |    197.00 |      29.55 |     167.45 | $   167.45
      9 |    591.00 |      88.65 |     502.35 | $   502.35
     10 |     65.00 |       9.75 |      55.25 | $    55.25
```

The following example lists the century in which each sale was made.

```
select salesid, saletime, to_char(saletime, 'cc') from sales
order by salesid limit 10;

 salesid |      saletime       | to_char
---------+---------------------+---------
       1 | 2008-02-18 02:36:48 | 21
       2 | 2008-06-06 05:00:16 | 21
       3 | 2008-06-06 08:26:17 | 21
       4 | 2008-06-09 08:38:52 | 21
       5 | 2008-08-31 09:17:02 | 21
       6 | 2008-07-16 11:59:24 | 21
       7 | 2008-06-26 12:56:06 | 21
       8 | 2008-07-10 02:12:36 | 21
       9 | 2008-07-22 02:23:17 | 21
      10 | 2008-08-06 02:51:55 | 21
```

The following example converts each STARTTIME value in the EVENT table to a string that consists of hours, minutes, seconds, and time zone.

```
select to_char(starttime, 'HH12:MI:SS TZ')
from event where eventid between 1 and 5
order by eventid;

to_char
----------
02:30:00 UTC
08:00:00 UTC
02:30:00 UTC
02:30:00 UTC
07:00:00 UTC
```

The following example shows formatting for seconds, milliseconds, and microseconds.

```
select sysdate,
to_char(sysdate, 'HH24:MI:SS') as seconds,
to_char(sysdate, 'HH24:MI:SS.MS') as milliseconds,
to_char(sysdate, 'HH24:MI:SS:US') as microseconds;

timestamp           | seconds  | milliseconds | microseconds
--------------------+----------+--------------+----------------
2015-04-10 18:45:09 | 18:45:09 | 18:45:09.325 | 18:45:09:325143
```

TO_DATE function

TO_DATE converts a date represented by a character string to a DATE data type.

Note

TO_DATE doesn't support format strings with Q (Quarter number).

Syntax

```
TO_DATE(string, format)
```

```
TO_DATE(string, format, is_strict)
```

Arguments

string

A string to be converted.

format

A string literal that defines the format of the input *string*, in terms of its date parts. For a list of valid day, month, and year formats, see Datetime format strings.

is_strict

An optional Boolean value that specifies whether an error is returned if an input date value is out of range. When *is_strict* is set to TRUE, an error is returned if there is an out of range value. When *is_strict* is set to FALSE, which is the default, then overflow values are accepted.

Return type

TO_DATE returns a DATE, depending on the *format* value.

If the conversion to *format* fails, then an error is returned.

Examples

The following SQL statement converts the date `02 Oct 2001` into a date data type.

```
select to_date('02 Oct 2001', 'DD Mon YYYY');

to_date
------------
2001-10-02
(1 row)
```

The following SQL statement converts the string `20010631` to a date.

```
select to_date('20010631', 'YYYYMMDD', FALSE);
```

The result is July 1, 2001, because there are only 30 days in June.

```
to_date
------------
2001-07-01
```

The following SQL statement converts the string 20010631 to a date:

```
to_date('20010631', 'YYYYMMDD', TRUE);
```

The result is an error because there are only 30 days in June.

```
ERROR:  date/time field date value out of range: 2001-6-31
```

TO_NUMBER

TO_NUMBER converts a string to a numeric (decimal) value.

> **Note**
>
> We recommend that you use FM in your format string to suppress padding blanks and zeroes. For a list of valid formats, see Numeric format strings.

Syntax

```
to_number(string, format)
```

Arguments

string

String to be converted. The format must be a literal value.

format

The second argument is a format string that indicates how the character string should be parsed to create the numeric value. For example, the format 'FM99D999' specifies that the string to be converted consists of five digits with the decimal point in the third position. For example, to_number('12.345','FM99D999') returns 12.345 as a numeric value. For a list of valid formats, see Numeric format strings.

Return type

TO_NUMBER returns a DECIMAL number.

If the conversion to *format* fails, then an error is returned.

Examples

The following example converts the string `12,454.8-` to a number:

```
select to_number('12,454.8-', 'FM99G999D9S');

to_number
-----------
-12454.8
```

The following example converts the string `$ 12,454.88` to a number:

```
select to_number('$ 12,454.88', 'FML99G999D99');

to_number
-----------
12454.88
```

The following example converts the string `$ 2,012,454.88` to a number:

```
select to_number('$ 2,012,454.88', 'FML9,999,999.99');

to_number
-----------
2012454.88
```

TRY_CAST function

Compared to the CAST function, TRY_CAST first attempts to cast the expression to the specified type. If casting fails because of conversion errors, the operation returns null. If a conversion isn’t explicitly permitted, the operation returns an error. You can find the list of possible conversions in the usage notes below. For example, attempting to convert a boolean to a timestamp isn't permitted.

Syntax

```
TRY_CAST(expression AS type)
```

Arguments

expression

An expression that evaluates to one or more values, such as a column name or a literal. Converting null values returns nulls. The expression cannot contain blank or empty strings.

type

One of the supported data types. For a full list of data types, see Data types. For the list of supported source data type and target data type pairs, see the usage notes below.

Return type

TRY_CAST returns a value of the data type specified by the *type* argument. If the conversion fails, the operation returns null.

Usage notes

Following is the list of source data type and target data type pairs that Amazon Redshift supports for TRY_CAST.

BOOL

SMALLINT, INT, BIGINT, SUPER

SMALLINT

BOOL, INT, BIGINT, DECIMAL, REAL, FLOAT, BPCHAR, TEXT, VARCHAR, SUPER

INT

BOOL, SMALLINT, BIGINT, DECIMAL, REAL, FLOAT, BPCHAR, TEXT, VARCHAR, SUPER

BIGINT

BOOL, SMALLINT, INT, DECIMAL, REAL, FLOAT, BPCHAR, TEXT, VARCHAR, SUPER

DECIMAL

SMALLINT, INT, BIGINT, REAL, FLOAT, BPCHAR, TEXT, VARCHAR, SUPER

REAL

SMALLINT, INT, BIGINT, DECIMAL, FLOAT, BPCHAR, TEXT, VARCHAR, SUPER

FLOAT

SMALLINT, INT, BIGINT, DECIMAL, REAL, BPCHAR, TEXT, VARCHAR, SUPER

BPCHAR

SMALLINT, INT, BIGINT, DECIMAL, REAL, FLOAT, TEXT, VARCHAR, TIMESTAMP, TIMESTAMPTZ, DATE, TIME, TIMETZ, SUPER

TEXT

SMALLINT, INT, BIGINT, DECIMAL, REAL, FLOAT, BPCHAR, VARCHAR, TIMESTAMP, TIMESTAMPTZ, DATE, TIME, TIMETZ, SUPER

VARCHAR

SMALLINT, INT, BIGINT, DECIMAL, REAL, FLOAT, BPCHAR, TEXT, TIMESTAMP, TIMESTAMPTZ, DATE, TIME, TIMETZ, SUPER

TIMESTAMP

BPCHAR, TEXT, VARCHAR, TIMESTAMPTZ, DATE, TIME

TIMESTAMPTZ

BPCHAR, TEXT, VARCHAR, TIMESTAMP, DATE, TIME, TIMETZ

DATE

BPCHAR, TEXT, VARCHAR, TIMESTAMP, TIMESTAMPTZ

TIME

BPCHAR, TEXT, VARCHAR

TIMETZ

BPCHAR, TEXT, VARCHAR

SUPER

SUPER can be converted into any other data type, with the exception of DATE, TIME, TIMETZ, TIMESTAMP, and TIMESTAMPTZ.

Examples

The following example casts a STRING into an INTEGER.

```
SELECT TRY_CAST('123' AS INT);
```

```
int
----
123
```

The following example returns null. Converting a STRING to an INTEGER is permitted so TRY_CAST doesn't return an error, but 'foo' isn't an integer so the function returns null.

```
SELECT TRY_CAST('foo' AS INT)
```

The following example returns an error, because converting a BOOLEAN to a TIMESTAMP isn't permitted.

```
SELECT TRY_CAST(true as timestamp);
```

Because TRY_CAST returns null instead of immediately returning an error if conversion fails, you can use TRY_CAST to filter out invalid data. Consider the following example, where an invalid row is filtered out because of a conversion failure in the age column for Akua Mansa.

```
CREATE TABLE IF NOT EXISTS student_data(
name VARCHAR(100) NOT NULL,
age VARCHAR(3) NOT NULL,
enrollment_date DATE NOT NULL);

INSERT INTO student_data (name, age, enrollment_date)
VALUES
('Alejandro Rosalez', '10', '01/01/2000'),
('Akua Mansa', 'Ten', '01/01/2000');

SELECT * FROM student_data WHERE TRY_CAST(age AS INT) IS NOT NULL;

--Akua is not returned.
 name              | age | enrollment_date
-------------------+-----+-----------------
 Alejandro Rosalez | 10  | 01/01/2000
```

Datetime format strings

You can find a reference for datetime format strings following.

The following format strings apply to functions such as TO_CHAR. These strings can contain datetime separators (such as '`-`', '`/`', or '`:`') and the following "dateparts" and "timeparts".

Datepart or timepart	Meaning
BC or B.C., AD or A.D., b.c. or bc, ad or a.d.	Upper and lowercase era indicators
CC	Two-digit century number
YYYY, YYY, YY, Y	4-digit, 3-digit, 2-digit, 1-digit year number
Y,YYY	4-digit year number with comma
IYYY, IYY, IY, I	4-digit, 3-digit, 2-digit, 1-digit International Organization for Standardization (ISO) year number
Q	Quarter number (1 to 4)
MONTH, Month, month	Month name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)
MON, Mon, mon	Abbreviated month name (uppercase, mixed-case, lowercase, blank-padded to 3 characters)
MM	Month number (01-12)
RM, rm	Month number in Roman numerals (I–XII, with I being January, uppercase or lowercase)
W	Week of month (1–5; the first week starts on the first day of the month.)
WW	Week number of year (1–53; the first week starts on the first day of the year.)
IW	ISO week number of year (the first Thursday of the new year is in week 1.)

Datepart or timepart	Meaning
DAY, Day, day	Day name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)
DY, Dy, dy	Abbreviated day name (uppercase, mixed-case, lowercase, blank-padded to 3 characters)
DDD	Day of year (001–366)
IDDD	Day of ISO 8601 week-numbering year (001-371; day 1 of the year is Monday of the first ISO week)
DD	Day of month as a number (01–31)
D	Day of week (1–7; Sunday is 1) **Note** The D datepart behaves differently from the day of week (DOW) datepart used for the datetime functions DATE_PART and EXTRACT. DOW is based on integers 0–6, where Sunday is 0. For more information, see Date parts for date or timestamp functions.
ID	ISO 8601 day of the week, Monday (1) to Sunday (7)
J	Julian day (days since January 1, 4712 BC)
HH24	Hour (24-hour clock, 00–23)
HH or HH12	Hour (12-hour clock, 01–12)
MI	Minutes (00–59)

Datepart or timepart	Meaning
SS	Seconds (00–59)
MS	Milliseconds (.000)
US	Microseconds (.000000)
AM or PM, A.M. or P.M., a.m. or p.m., am or pm	Upper and lowercase meridian indicators (for 12-hour clock)
TZ, tz	Upper and lowercase time zone abbreviation; valid for TIMESTAMPTZ only
OF	Offset from UTC; valid for TIMESTAMPTZ only

Note

You must surround datetime separators (such as '-', '/' or ':') with single quotation marks, but you must surround the "dateparts" and "timeparts" listed in the preceding table with double quotation marks.

Examples

For examples of formatting dates as strings, see TO_CHAR.

Numeric format strings

Following, you can find a reference for numeric format strings.

The following format strings apply to functions such as TO_NUMBER and TO_CHAR.

- For examples of formatting strings as numbers, see TO_NUMBER.
- For examples of formatting numbers as strings, see TO_CHAR.

Format	Description
9	Numeric value with the specified number of digits.
0	Numeric value with leading zeros.
. (period), D	Decimal point.
, (comma)	Thousands separator.
CC	Century code. For example, the 21st century started on 2001-01-01 (supported for TO_CHAR only).
FM	Fill mode. Suppress padding blanks and zeroes.
PR	Negative value in angle brackets.
S	Sign anchored to a number.
L	Currency symbol in the specified position.
G	Group separator.
MI	Minus sign in the specified position for numbers that are less than 0.
PL	Plus sign in the specified position for numbers that are greater than 0.
SG	Plus or minus sign in the specified position.
RN	Roman numeral between 1 and 3999 (supported for TO_CHAR only).
TH or th	Ordinal number suffix. Does not convert fractional numbers or values that are less than zero.

Teradata-style formatting characters for numeric data

Following, you can find how the TEXT_TO_INT_ALT and TEXT_TO_NUMERIC_ALT functions interpret the characters in the input *expression* string. You can also find a list of the characters that you can specify in the *format* phrase. In addition, you can find a description of the differences between Teradata-style formatting and Amazon Redshift for the *format* option.

Format	Description
G	Not supported as a group separator in the input *expression* string. You can't specify this character in the *format* phrase.
D	Radix symbol. You can specify this character in the *format* phrase. This character is equivalent to the . (period). The Radix symbol can't appear in a *format* phrase that contains any of the following characters: • . (period) • S (uppercase 's') • V (uppercase 'v')
/ , : %	Insertion characters / (forward slash), comma (,), : (colon), and % (percent sign). You can't include these characters in the *format* phrase. Amazon Redshift ignores these characters in the input *expression* string.
.	Period as a radix character, that is a decimal point. This character can't appear in a *format* phrase that contains any of the following characters:

Format	Description
	• D (uppercase 'd') • S (uppercase 's') • V (uppercase 'v')
B	You can't include the blank space character (B) in the *format* phrase. In the input *expression* string, leading and trailing spaces are ignored and spaces between digits aren't allowed.
+ -	You can't include the plus sign (+) or minus sign (-) in the *format* phrase. However, the plus sign (+) and minus sign (-) are parsed implicitly as part of numeric value if they appear in the input *expression* string.
V	Decimal point position indicator. This character can't appear in a *format* phrase that contains any of the following characters: • D (uppercase 'd') • . (period)
Z	Zero-suppressed decimal digit. Amazon Redshift trims leading zeros. The Z character can't follow a 9 character. The Z character must be to the left of the radix character if the fraction part contains the 9 character.
9	Decimal digit.

Format	Description
CHAR(*n*)	For this format, you can specify the following: • CHAR consists of Z or 9 characters. Amazon Redshift doesn't support a + (plus) or - (minus) in the CHAR value. • *n* is an integer constant, I, or F. For I, this is the number of characters necessary to display the integer portion of numeric or integer data. For F, this is the number of characters necessary to display the fractiona l portion of numeric data.
-	Hyphen (-) character. You can't include this character in the *format* phrase. Amazon Redshift ignores this character in the input *expression* string.

Format	Description
S	Signed Zoned Decimal. The S character must follow the last decimal digit in the *format* phrase. The last character of the input *expression* string and the correspon ding numeric conversion are listed in [Data formatting characters for Signed Zone Decimal, Teradata–style numeric data formatting](). The S character can't appear in a *format* phrase that contains any of the following characters: • + (plus sign) • . (period) • D (uppercase 'd') • Z (uppercase 'z') • F (uppercase 'f') • E (uppercase 'e')
E	Exponential notation. The input *expression* string can include the exponent character. You can't specify E as an exponent character in *format* phrase.
FN9	Not supported in Amazon Redshift.
FNE	Not supported in Amazon Redshift.

Format	Description
$, USD, US Dollars	Dollar sign ($), ISO currency symbol (USD), and the currency name US Dollars. The ISO currency symbol USD and the currency name US Dollars are case-sensitive. Amazon Redshift supports only the USD currency. The input *expression* string can include spaces between the USD currency symbol and the numeric value, for example ‘$ 123E2’ or ‘123E2 $’.
L	Currency symbol. This currency symbol character can only appear once in the *format* phrase. You can't specify repeated currency symbol characters.
C	ISO currency symbol. This currency symbol character can only appear once in the *format* phrase. You can't specify repeated currency symbol characters.
N	Full currency name. This currency symbol character can only appear once in the *format* phrase. You can't specify repeated currency symbol characters.
O	Dual currency symbol. You can't specify this character in the *format* phrase.
U	Dual ISO currency symbol. You can't specify this character in the *format* phrase.
A	Full dual currency name. You can't specify this character in the *format* phrase.

Data formatting characters for Signed Zone Decimal, Teradata–style numeric data formatting

You can use the following characters in the *format* phrase of the TEXT_TO_INT_ALT and TEXT_TO_NUMERIC_ALT functions for a signed zoned decimal value.

Last character of the input string	Numeric conversion
{ or 0	*n* … 0
A or 1	*n* … 1
B or 2	*n* … 2
C or 3	*n* … 3
D or 4	*n* … 4
E or 5	*n* … 5
F or 6	*n* … 6
G or 7	*n* … 7
H or 8	*n* … 8
I or 9	*n* … 9
}	-*n* … 0
J	-*n* … 1
K	-*n* … 2
L	-*n* … 3
M	-*n* … 4
N	-*n* … 5
O	-*n* … 6
P	-*n* … 7

Last character of the input string	Numeric conversion
Q	-*n* … 8
R	-*n* … 9

Date and time functions

In this section, you can find information about the date and time scalar functions that Amazon Redshift supports.

Topics

- MONTHS_BETWEEN function
- NEXT_DAY function
- SYSDATE function
- TIMEOFDAY function
- TIMESTAMP_CMP function
- TIMESTAMP_CMP_DATE function
- TIMESTAMP_CMP_TIMESTAMPTZ function
- TIMESTAMPTZ_CMP function
- TIMESTAMPTZ_CMP_DATE function
- TIMESTAMPTZ_CMP_TIMESTAMP function
- TIMEZONE function
- TO_TIMESTAMP function
- TRUNC function
- Date parts for date or timestamp functions

Summary of date and time functions

Function	Syntax	Returns
+ (Concatenation) operator Concatenates a date to a time on either side of the + symbol and returns a TIMESTAMP or TIMESTAMPTZ.	*date + time*	`TIMESTAMP` or `TIMESTAMPTZ`
ADD_MONTHS Adds the specified number of months to a date or timestamp.	ADD_MONTHS ({*date*|*timestamp*}, *integer*)	`TIMESTAMP`
AT TIME ZONE Specifies which time zone to use with a TIMESTAMP or TIMESTAMPTZ expression.	AT TIME ZONE '*timezone*'	`TIMESTAMP` or `TIMESTAMPTZ`

Function	Syntax	Returns
[CONVERT_TIMEZONE](#) Converts a timestamp from one time zone to another.	CONVERT_TIMEZONE (['*timezone*',] '*timezone*', *timestamp*)	`TIMESTAMP`
[CURRENT_DATE](#) Returns a date in the current session time zone (UTC by default) for the start of the current transaction.	CURRENT_DATE	`DATE`
[DATE_CMP](#) Compares two dates and returns `0` if the dates are identical, `1` if *date1* is greater, and `-1` if *date2* is greater.	DATE_CMP (*date1*, *date2*)	`INTEGER`
[DATE_CMP_TIMESTAMP](#) Compares a date to a time and returns `0` if the values are identical, `1` if *date* is greater and `-1` if *timestamp* is greater.	DATE_CMP_TIMESTAMP (*date*, *timestamp*)	`INTEGER`
[DATE_CMP_TIMESTAMPTZ](#) Compares a date and a timestamp with time zone and returns `0` if the values are identical , `1` if *date* is greater and `-1` if *timestamptz* is greater.	DATE_CMP_TIMESTAMPTZ (*date*, *timestamptz*)	`INTEGER`
[DATE_PART_YEAR](#) Extracts the year from a date.	DATE_PART_YEAR (*date*)	`INTEGER`
[DATEADD](#) Increments a date or time by a specified interval.	DATEADD (*datepart*, *interval*, {*date*|*time*|*timetz*|*timestamp*})	`TIMESTAMP` or `TIME` or `TIMETZ`

Function	Syntax	Returns
DATEDIFF Returns the difference between two dates or times for a given date part, such as a day or month.	DATEDIFF (*datepart*, {*date*|*time*|*timetz*|*timestamp* }, {*date*|*time*|*timetz*|*timestamp*})	`BIGINT`
DATE_PART Extracts a date part value from a date or time.	DATE_PART (*datepart*, {*date*|*timestamp*})	`DOUBLE`
DATE_TRUNC Truncates a timestamp based on a date part.	DATE_TRUNC ('*datepart*', *timestamp*)	`TIMESTAMP`
EXTRACT Extracts a date or time part from a timestamp, timestamptz, time, or timetz.	EXTRACT (*datepart* FROM *source*)	`INTEGER or DOUBLE`
GETDATE Returns the current date and time in the current session time zone (UTC by default). The parentheses are required.	GETDATE()	`TIMESTAMP`
INTERVAL_CMP Compares two intervals and returns `0` if the intervals are equal, `1` if *interval1* is greater, and `-1` if *interval2* is greater.	INTERVAL_CMP (*interval1*, *interval2*)	`INTEGER`
LAST_DAY Returns the date of the last day of the month that contains *date*.	LAST_DAY(*date*)	`DATE`

Function	Syntax	Returns
MONTHS_BETWEEN Returns the number of months between two dates.	MONTHS_BETWEEN (*date*, *date*)	`FLOAT8`
NEXT_DAY Returns the date of the first instance of *day* that is later than *date*.	NEXT_DAY (*date*, *day*)	`DATE`
SYSDATE Returns the date and time in UTC for the start of the current transaction.	SYSDATE	`TIMESTAMP`
TIMEOFDAY Returns the current weekday, date, and time in the current session time zone (UTC by default) as a string value.	TIMEOFDAY()	`VARCHAR`
TIMESTAMP_CMP Compares two timestamps and returns `0` if the timestamps are equal, `1` if *timestamp1* is greater, and `-1` if *timestamp2* is greater.	TIMESTAMP_CMP (*timestamp 1*, *timestamp2*)	`INTEGER`
TIMESTAMP_CMP_DATE Compares a timestamp to a date and returns `0` if the values are identical, `1` if *timestamp* is greater, and `-1` if *date* is greater.	TIMESTAMP_CMP_DATE (*timestamp*, *date*)	`INTEGER`

Function	Syntax	Returns
[TIMESTAMP_CMP_TIMESTAMPTZ] Compares a timestamp with a timestamp with time zone and returns `0` if the values are equal, `1` if *timestamp* is greater, and `-1` if *timestamptz* is greater.	TIMESTAMP_CMP_TIMESTAMPTZ (*timestamp*, *timestamptz*)	`INTEGER`
[TIMESTAMPTZ_CMP] Compares two timestamp with time zone values and returns `0` if the values are equal, `1` if *timestamptz1* is greater, and `-1` if *timestamptz2* is greater.	TIMESTAMPTZ_CMP (*timestamptz1*, *timestamptz2*)	`INTEGER`
[TIMESTAMPTZ_CMP_DATE] Compares the value of a timestamp with time zone and a date and returns `0` if the values are equal, `1` if *timestamptz* is greater, and `-1` if *date* is greater.	TIMESTAMPTZ_CMP_DATE (*timestamptz*, *date*)	`INTEGER`
[TIMESTAMPTZ_CMP_TIMESTAMP] Compares a timestamp with time zone with a timestamp and returns `0` if the values are equal, `1` if *timestamptz* is greater, and `-1` if *timestamp* is greater.	TIMESTAMPTZ_CMP_TIMESTAMP (*timestamptz*, *timestamp*)	`INTEGER`
[TIMEZONE] Returns a timestamp for the specified time zone and timestamp value.	TIMEZONE ('*timezone*' { *timestamp* | *timestamptz*)	`TIMESTAMP` or `TIMESTAMPTZ`
[TO_TIMESTAMP] Returns a timestamp with time zone for the specified timestamp and time zone format.	TO_TIMESTAMP ('*timestamp*', '*format*')	`TIMESTAMPTZ`

Function	Syntax	Returns
TRUNC Truncates a timestamp and returns a date.	TRUNC(*timestamp*)	DATE

> **Note**
>
> Leap seconds are not considered in elapsed-time calculations.

Date and time functions in transactions

When you run the following functions within a transaction block (BEGIN … END), the function returns the start date or time of the current transaction, not the start of the current statement.

- SYSDATE
- TIMESTAMP
- CURRENT_DATE

The following functions always return the start date or time of the current statement, even when they are within a transaction block.

- GETDATE
- TIMEOFDAY

Deprecated leader node-only functions

The following date functions are deprecated because they run only on the leader node. For more information, see Leader node–only functions.

- AGE. Use DATEDIFF function instead.
- CURRENT_TIME. Use GETDATE function or SYSDATE instead.
- CURRENT_TIMESTAMP. Use GETDATE function or SYSDATE instead.
- LOCALTIME. Use GETDATE function or SYSDATE instead.
- LOCALTIMESTAMP. Use GETDATE function or SYSDATE instead.

- ISFINITE
- NOW. Use GETDATE function or SYSDATE instead. If you use the NOW function within a materialized view, it sets to the timestamp of the creation of the materialized view, instead of the current timestamp.

+ (Concatenation) operator

Concatenates a DATE to a TIME or TIMETZ on either side of the + symbol and returns a TIMESTAMP or TIMESTAMPTZ.

Syntax

```
date + {time | timetz}
```

The order of the arguments can be reversed. For example, *time* + *date*.

Arguments

date

A column of data type `DATE` or an expression that implicitly evaluates to a `DATE` type.

time

A column of data type `TIME` or an expression that implicitly evaluates to a `TIME` type.

timetz

A column of data type `TIMETZ` or an expression that implicitly evaluates to a `TIMETZ` type.

Return type

TIMESTAMP if input is *date* + *time*.

TIMESTAMPTZ if input is *date* + *timetz*.

Examples

Example setup

To set up the TIME_TEST and TIMETZ_TEST tables used in the examples, use the following command.

```
create table time_test(time_val time);

insert into time_test values
('20:00:00'),
('00:00:00.5550'),
('00:58:00');

create table timetz_test(timetz_val timetz);

insert into timetz_test values
('04:00:00+00'),
('00:00:00.5550+00'),
('05:58:00+00');
```

Examples with a time column

The following example table TIME_TEST has a column TIME_VAL (type TIME) with three values inserted.

```
select time_val from time_test;

time_val
---------------------
20:00:00
00:00:00.5550
00:58:00
```

The following example concatenates a date literal and a TIME_VAL column.

```
select date '2000-01-02' + time_val as ts from time_test;

ts
---------------------
2000-01-02 20:00:00
2000-01-02 00:00:00.5550
2000-01-02 00:58:00
```

The following example concatenates a date literal and a time literal.

```
select date '2000-01-01' + time '20:00:00' as ts;

         ts
```

```
---------------------
 2000-01-01 20:00:00
```

The following example concatenates a time literal and a date literal.

```
select time '20:00:00' + date '2000-01-01' as ts;

         ts
---------------------
 2000-01-01 20:00:00
```

Examples with a TIMETZ column

The following example table TIMETZ_TEST has a column TIMETZ_VAL (type TIMETZ) with three values inserted.

```
select timetz_val from timetz_test;

timetz_val
------------------
04:00:00+00
00:00:00.5550+00
05:58:00+00
```

The following example concatenates a date literal and a TIMETZ_VAL column.

```
select date '2000-01-01' + timetz_val as ts from timetz_test;
ts
---------------------
2000-01-01 04:00:00+00
2000-01-01 00:00:00.5550+00
2000-01-01 05:58:00+00
```

The following example concatenates a TIMETZ_VAL column and a date literal.

```
select timetz_val + date '2000-01-01' as ts from timetz_test;
ts
---------------------
2000-01-01 04:00:00+00
2000-01-01 00:00:00.5550+00
2000-01-01 05:58:00+00
```

The following example concatenates a DATE literal and a TIMETZ literal. The example returns a TIMESTAMPTZ which is in the time zone UTC by default. UTC is 8 hours ahead of PST, so the result is 8 hours ahead of the input time.

```
select date '2000-01-01' + timetz '20:00:00 PST' as ts;

           ts
------------------------
 2000-01-02 04:00:00+00
```

ADD_MONTHS function

ADD_MONTHS adds the specified number of months to a date or timestamp value or expression. The DATEADD function provides similar functionality.

Syntax

```
ADD_MONTHS( {date | timestamp}, integer)
```

Arguments

date | *timestamp*

A column of data type DATE or TIMESTAMP or an expression that implicitly evaluates to a DATE or TIMESTAMP type. If the date is the last day of the month, or if the resulting month is shorter, the function returns the last day of the month in the result. For other dates, the result contains the same day number as the date expression.

integer

A value of data type INTEGER. Use a negative number to subtract months from dates.

Return type

TIMESTAMP

Examples

The following query uses the ADD_MONTHS function inside a TRUNC function. The TRUNC function removes the time of day from the result of ADD_MONTHS. The ADD_MONTHS function adds 12 months to each value from the CALDATE column. The values in the CALDATE column are dates.

```
select distinct trunc(add_months(caldate, 12)) as calplus12,
trunc(caldate) as cal
from date
order by 1 asc;

 calplus12  |    cal
------------+------------
 2009-01-01 | 2008-01-01
 2009-01-02 | 2008-01-02
 2009-01-03 | 2008-01-03
...
(365 rows)
```

The following example uses the ADD_MONTHS function to add 1 month to a *timestamp*.

```
select add_months('2008-01-01 05:07:30', 1);

add_months
---------------------
2008-02-01 05:07:30
```

The following examples demonstrate the behavior when the ADD_MONTHS function operates on dates with months that have different numbers of days. This example shows how the function handles adding 1 month to March 31 and adding 1 month to April 30. April has 30 days, so adding 1 month to March 31 results in April 30. May has 31 days, so adding 1 month to April 30 results in May 31.

```
select add_months('2008-03-31',1);

add_months
---------------------
2008-04-30 00:00:00

select add_months('2008-04-30',1);

add_months
---------------------
2008-05-31 00:00:00
```

AT TIME ZONE function

AT TIME ZONE specifies which time zone to use with a TIMESTAMP or TIMESTAMPTZ expression.

Syntax

```
AT TIME ZONE 'timezone'
```

Arguments

timezone

The TIMEZONE for the return value. The time zone can be specified as a time zone name (such as **'Africa/Kampala'** or **'Singapore'**) or as a time zone abbreviation (such as **'UTC'** or **'PDT'**).

To view a list of supported time zone names, run the following command.

```
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, run the following command.

```
select pg_timezone_abbrevs();
```

For more information and examples, see Time zone usage notes.

Return type

TIMESTAMPTZ when used with a TIMESTAMP expression. TIMESTAMP when used with a TIMESTAMPTZ expression.

Examples

The following example converts a timestamp value without time zone and interprets it as MST time (UTC+7 in POSIX). The example returns a value of data type TIMESTAMPTZ for the UTC timezone. If you configure your default timezone to a timezone other than UTC, you might see a different result.

```
SELECT TIMESTAMP '2001-02-16 20:38:40' AT TIME ZONE 'MST';
```

```
timezone
------------------------
2001-02-17 03:38:40+00
```

The following example takes an input timestamp with a time zone value where the specified time zone is EST (UTC+5 in POSIX) and converts it to MST (UTC+7 in POSIX). The example returns a value of data type TIMESTAMP.

```
SELECT TIMESTAMPTZ '2001-02-16 20:38:40-05' AT TIME ZONE 'MST';

timezone
------------------------
2001-02-16 18:38:40
```

CONVERT_TIMEZONE function

CONVERT_TIMEZONE converts a timestamp from one time zone to another. The function automatically adjusts for daylight saving time.

Syntax

```
CONVERT_TIMEZONE( ['source_timezone',] 'target_timezone', 'timestamp')
```

Arguments

source_timezone

(Optional) The time zone of the current timestamp. The default is UTC. For more information, see Time zone usage notes.

target_timezone

The time zone for the new timestamp. For more information, see Time zone usage notes.

timestamp

A timestamp column or an expression that implicitly converts to a timestamp.

Return type

TIMESTAMP

Time zone usage notes

source_timezone or *target_timezone* can be specified as a time zone name (such as 'Africa/Kampala' or 'Singapore') or as a time zone abbreviation (such as 'UTC' or 'PDT'). You don't have to convert time zone names to names or abbreviations to abbreviations. For example, you can choose a timestamp from the source time zone name 'Singapore' and convert it to a timestamp in the time zone abbreviation 'PDT'.

> **Note**
>
> The results of using a time zone name or a time zone abbreviation can be different due to local seasonal time, such as daylight saving time.

Using a time zone name

To view a current and complete list of time zone names, run the following command.

```
select pg_timezone_names();
```

Each row contains a comma-separated string with the time zone name, abbreviation, UTC offset, and indicator if the time zone observes daylight saving time (`t` or `f`). For example, the following snippet shows two resulting rows. The first row is the time zone `Antarctica/South Pole`, abbreviation `NZDT`, with `13:00:00` offset from UTC, and `f` to indicate it doesn't observe daylight saving time. The second row is the time zone `Europe/Paris`, abbreviation `CET`, with `01:00:00` offset from UTC, and `f` to indicate it observes daylight saving time.

```
pg_timezone_names
------------------
(Antarctica/South_Pole,NZDT,13:00:00,t)
(Europe/Paris,CET,01:00:00,f)
```

Run the SQL statement to obtain the entire list and find a time zone name. Approximately 600 rows are returned. Even though some of the returned time zone names are capitalized initialisms or acronyms (for example; GB, PRC, ROK), the CONVERT_TIMEZONE function treats them as time zone names, not time zone abbreviations.

If you specify a time zone using a time zone name, CONVERT_TIMEZONE automatically adjusts for daylight saving time (DST), or any other local seasonal protocol, such as Summer Time, Standard

Time, or Winter Time, that is in force for that time zone during the date and time specified by '*timestamp*'. For example, 'Europe/London' represents UTC in the winter and adds one hour in the summer.

Using a time zone abbreviation

To view a current and complete list of time zone abbreviations, run the following command.

```
select pg_timezone_abbrevs();
```

The results contain a comma-separated string with the time zone abbreviation, UTC offset, and indicator if the time zone observes daylight saving time (`t` or `f`). For example, the following snippet shows two resulting rows. The first row contains the abbreviation for Pacific Daylight Time `PDT`, with a `-07:00:00` offset from UTC, and `t` to indicate it observes daylight saving time. The second row contains the abbreviation for Pacific Standard Time `PST`, with a `-08:00:00` offset from UTC, and `f` to indicate it doesn't observe daylight saving time.

```
pg_timezone_abbrevs
--------------------
(PDT,-07:00:00,t)
(PST,-08:00:00,f)
```

Run the SQL statement to obtain the entire list and find an abbreviation based on its offset and daylight saving time indicator. Approximately 200 rows are returned.

Time zone abbreviations represent a fixed offset from UTC. If you specify a time zone using a time zone abbreviation, CONVERT_TIMEZONE uses the fixed offset from UTC and doesn't adjust for any local seasonal protocol.

Using POSIX-style format

A POSIX-style time zone specification is in the form *STDoffset* or *STDoffsetDST*, where *STD* is a time zone abbreviation, *offset* is the numeric offset in hours west from UTC, and *DST* is an optional daylight saving zone abbreviation. Daylight saving time is assumed to be one hour ahead of the given offset.

POSIX-style time zone formats use positive offsets west of Greenwich, in contrast to the ISO-8601 convention, which uses positive offsets east of Greenwich.

The following are examples of POSIX-style time zones:

- PST8
- PST8PDT
- EST5
- EST5EDT

Note

Amazon Redshift doesn't validate POSIX-style time zone specifications, so it is possible to set the time zone to an invalid value. For example, the following command doesn't return an error, even though it sets the time zone to an invalid value.

```
set timezone to ‘xxx36’;
```

Examples

Many of the examples use the TICKIT sample data set. For more information, see Sample database.

The following example converts the timestamp value from the default UTC time zone to PST.

```
select convert_timezone('PST', '2008-08-21 07:23:54');

 convert_timezone
------------------------
2008-08-20 23:23:54
```

The following example converts the timestamp value in the LISTTIME column from the default UTC time zone to PST. Though the timestamp is within the daylight time period, it's converted to standard time because the target time zone is specified as an abbreviation (PST).

```
select listtime, convert_timezone('PST', listtime) from listing
where listid = 16;

     listtime       |   convert_timezone
--------------------+-------------------
2008-08-24 09:36:12     2008-08-24 01:36:12
```

The following example converts a timestamp LISTTIME column from the default UTC time zone to US/Pacific time zone. The target time zone uses a time zone name, and the timestamp is within the daylight time period, so the function returns the daylight time.

```
select listtime, convert_timezone('US/Pacific', listtime) from listing
where listid = 16;

     listtime       |   convert_timezone
--------------------+--------------------
2008-08-24 09:36:12 | 2008-08-24 02:36:12
```

The following example converts a timestamp string from EST to PST:

```
select convert_timezone('EST', 'PST', '20080305 12:25:29');

 convert_timezone
-------------------
2008-03-05 09:25:29
```

The following example converts a timestamp to US Eastern Standard Time because the target time zone uses a time zone name (America/New_York) and the timestamp is within the standard time period.

```
select convert_timezone('America/New_York', '2013-02-01 08:00:00');

 convert_timezone
---------------------
2013-02-01 03:00:00
(1 row)
```

The following example converts the timestamp to US Eastern Daylight Time because the target time zone uses a time zone name (America/New_York) and the timestamp is within the daylight time period.

```
select convert_timezone('America/New_York', '2013-06-01 08:00:00');

 convert_timezone
---------------------
2013-06-01 04:00:00
(1 row)
```

The following example demonstrates the use of offsets.

```
SELECT CONVERT_TIMEZONE('GMT','NEWZONE +2','2014-05-17 12:00:00') as newzone_plus_2,
CONVERT_TIMEZONE('GMT','NEWZONE-2:15','2014-05-17 12:00:00') as newzone_minus_2_15,
CONVERT_TIMEZONE('GMT','America/Los_Angeles+2','2014-05-17 12:00:00') as la_plus_2,
CONVERT_TIMEZONE('GMT','GMT+2','2014-05-17 12:00:00') as gmt_plus_2;

   newzone_plus_2    | newzone_minus_2_15  |      la_plus_2      |     gmt_plus_2
---------------------+---------------------+---------------------+---------------------
2014-05-17 10:00:00 | 2014-05-17 14:15:00 | 2014-05-17 10:00:00 | 2014-05-17 10:00:00
(1 row)
```

CURRENT_DATE function

CURRENT_DATE returns a date in the current session time zone (UTC by default) in the default format: YYYY-MM-DD.

> **Note**
>
> CURRENT_DATE returns the start date for the current transaction, not for the start of the current statement. Consider the scenario where you start a transaction containing multiple statements on 10/01/08 23:59, and the statement containing CURRENT_DATE runs at 10/02/08 00:00. CURRENT_DATE returns `10/01/08`, not `10/02/08`.

Syntax

```
CURRENT_DATE
```

Return type

DATE

Examples

The following example returns the current date (in the AWS Region where the function runs).

```
select current_date;

   date
------------
```

```
2008-10-01
```

The following example creates a table, inserts a row where the default of column `todays_date` is CURRENT_DATE, and then selects all the rows in the table.

```
CREATE TABLE insert_dates(
    label varchar(128) NOT NULL,
    todays_date DATE DEFAULT CURRENT_DATE);

INSERT INTO insert_dates(label)
VALUES('Date row inserted');

SELECT * FROM insert_dates;


 label             | todays_date
-------------------+-------------
Date row inserted | 2023-05-10
```

DATE_CMP function

DATE_CMP compares two dates. The function returns `0` if the dates are identical, `1` if *date1* is greater, and `-1` if *date2* is greater.

Syntax

```
DATE_CMP(date1, date2)
```

Arguments

date1

A column of data type `DATE` or an expression that evaluates to a `DATE` type.

date2

A column of data type `DATE` or an expression that evaluates to a `DATE` type.

Return type

INTEGER

Examples

The following query compares the DATE values in the CALDATE column to the date January 4, 2008 and returns whether the value in CALDATE is before (-1), equal to (0), or after (1) January 4, 2008:

```
select caldate, '2008-01-04',
date_cmp(caldate,'2008-01-04')
from date
order by dateid
limit 10;

 caldate   |  ?column?  | date_cmp
-----------+------------+----------
2008-01-01 | 2008-01-04 |       -1
2008-01-02 | 2008-01-04 |       -1
2008-01-03 | 2008-01-04 |       -1
2008-01-04 | 2008-01-04 |        0
2008-01-05 | 2008-01-04 |        1
2008-01-06 | 2008-01-04 |        1
2008-01-07 | 2008-01-04 |        1
2008-01-08 | 2008-01-04 |        1
2008-01-09 | 2008-01-04 |        1
2008-01-10 | 2008-01-04 |        1
(10 rows)
```

DATE_CMP_TIMESTAMP function

DATE_CMP_TIMESTAMP compares a date to a timestamp and returns `0` if the values are identical, `1` if *date* is greater chronologically and `-1` if *timestamp* is greater.

Syntax

```
DATE_CMP_TIMESTAMP(date, timestamp)
```

Arguments

date

A column of data type `DATE` or an expression that evaluates to a `DATE` type.

timestamp

A column of data type `TIMESTAMP` or an expression that evaluates to a `TIMESTAMP` type.

Return type

INTEGER

Examples

The following example compares the date 2008-06-18 to LISTTIME. The values of the column LISTTIME are timestamps. Listings made before this date return 1; listings made after this date return -1.

```
select listid, '2008-06-18', listtime,
date_cmp_timestamp('2008-06-18', listtime)
from listing
order by 1, 2, 3, 4
limit 10;

 listid |  ?column?  |      listtime       | date_cmp_timestamp
--------+------------+---------------------+--------------------
      1 | 2008-06-18 | 2008-01-24 06:43:29 |                  1
      2 | 2008-06-18 | 2008-03-05 12:25:29 |                  1
      3 | 2008-06-18 | 2008-11-01 07:35:33 |                 -1
      4 | 2008-06-18 | 2008-05-24 01:18:37 |                  1
      5 | 2008-06-18 | 2008-05-17 02:29:11 |                  1
      6 | 2008-06-18 | 2008-08-15 02:08:13 |                 -1
      7 | 2008-06-18 | 2008-11-15 09:38:15 |                 -1
      8 | 2008-06-18 | 2008-11-09 05:07:30 |                 -1
      9 | 2008-06-18 | 2008-09-09 08:03:36 |                 -1
     10 | 2008-06-18 | 2008-06-17 09:44:54 |                  1
(10 rows)
```

DATE_CMP_TIMESTAMPTZ function

DATE_CMP_TIMESTAMPTZ compares a date to a timestamp with time zone and returns 0 if the values are identical, 1 if *date* is greater chronologically and -1 if *timestamptz* is greater.

Syntax

```
DATE_CMP_TIMESTAMPTZ(date, timestamptz)
```

Arguments

date

A column of data type `DATE` or an expression that implicitly evaluates to a `DATE` type.

timestamptz

A column of data type `TIMESTAMPTZ` or an expression that implicitly evaluates to a `TIMESTAMPTZ` type.

Return type

INTEGER

Examples

The following example compares the date `2008-06-18` to LISTTIME. Listings made before this date return 1; listings made after this date return `-1`.

```
select listid, '2008-06-18', CAST(listtime AS timestamptz),
date_cmp_timestamptz('2008-06-18', CAST(listtime AS timestamptz))
from listing
order by 1, 2, 3, 4
limit 10;

 listid |  ?column?  |      timestamptz       | date_cmp_timestamptz
--------+------------+------------------------+----------------------
      1 | 2008-06-18 | 2008-01-24 06:43:29+00 |                    1
      2 | 2008-06-18 | 2008-03-05 12:25:29+00 |                    1
      3 | 2008-06-18 | 2008-11-01 07:35:33+00 |                   -1
      4 | 2008-06-18 | 2008-05-24 01:18:37+00 |                    1
      5 | 2008-06-18 | 2008-05-17 02:29:11+00 |                    1
      6 | 2008-06-18 | 2008-08-15 02:08:13+00 |                   -1
      7 | 2008-06-18 | 2008-11-15 09:38:15+00 |                   -1
      8 | 2008-06-18 | 2008-11-09 05:07:30+00 |                   -1
      9 | 2008-06-18 | 2008-09-09 08:03:36+00 |                   -1
     10 | 2008-06-18 | 2008-06-17 09:44:54+00 |                    1
(10 rows)
```

DATEADD function

Increments a DATE, TIME, TIMETZ, or TIMESTAMP value by a specified interval.

Syntax

```
DATEADD( datepart, interval, {date|time|timetz|timestamp} )
```

Arguments

datepart

The date part (year, month, day, or hour, for example) that the function operates on. For more information, see [Date parts for date or timestamp functions].

interval

An integer that specified the interval (number of days, for example) to add to the target expression. A negative integer subtracts the interval.

date|time|timetz|timestamp

A DATE, TIME, TIMETZ, or TIMESTAMP column or an expression that implicitly converts to a DATE, TIME, TIMETZ, or TIMESTAMP. The DATE, TIME, TIMETZ, or TIMESTAMP expression must contain the specified date part.

Return type

TIMESTAMP or TIME or TIMETZ depending on the input data type.

Examples with a DATE column

The following example adds 30 days to each date in November that exists in the DATE table.

```
select dateadd(day,30,caldate) as novplus30
from date
where month='NOV'
order by dateid;

novplus30
---------------------
2008-12-01 00:00:00
2008-12-02 00:00:00
2008-12-03 00:00:00
...
(30 rows)
```

The following example adds 18 months to a literal date value.

```
select dateadd(month,18,'2008-02-28');

date_add
---------------------
2009-08-28 00:00:00
(1 row)
```

The default column name for a DATEADD function is DATE_ADD. The default timestamp for a date value is `00:00:00`.

The following example adds 30 minutes to a date value that doesn't specify a timestamp.

```
select dateadd(m,30,'2008-02-28');

date_add
---------------------
2008-02-28 00:30:00
(1 row)
```

You can name date parts in full or abbreviate them. In this case, *m* stands for minutes, not months.

Examples with a TIME column

The following example table TIME_TEST has a column TIME_VAL (type TIME) with three values inserted.

```
select time_val from time_test;

time_val
---------------------
20:00:00
00:00:00.5550
00:58:00
```

The following example adds 5 minutes to each TIME_VAL in the TIME_TEST table.

```
select dateadd(minute,5,time_val) as minplus5 from time_test;
```

```
minplus5
---------------
20:05:00
00:05:00.5550
01:03:00
```

The following example adds 8 hours to a literal time value.

```
select dateadd(hour, 8, time '13:24:55');

date_add
---------------
21:24:55
```

The following example shows when a time goes over 24:00:00 or under 00:00:00.

```
select dateadd(hour, 12, time '13:24:55');

date_add
---------------
01:24:55
```

Examples with a TIMETZ column

The output values in these examples are in UTC which is the default timezone.

The following example table TIMETZ_TEST has a column TIMETZ_VAL (type TIMETZ) with three values inserted.

```
select timetz_val from timetz_test;

timetz_val
------------------
04:00:00+00
00:00:00.5550+00
05:58:00+00
```

The following example adds 5 minutes to each TIMETZ_VAL in TIMETZ_TEST table.

```
select dateadd(minute,5,timetz_val) as minplus5_tz from timetz_test;
```

```
minplus5_tz
---------------
04:05:00+00
00:05:00.5550+00
06:03:00+00
```

The following example adds 2 hours to a literal timetz value.

```
select dateadd(hour, 2, timetz '13:24:55 PST');

date_add
---------------
23:24:55+00
```

Examples with a TIMESTAMP column

The output values in these examples are in UTC which is the default timezone.

The following example table TIMESTAMP_TEST has a column TIMESTAMP_VAL (type TIMESTAMP) with three values inserted.

```
SELECT timestamp_val FROM timestamp_test;

timestamp_val
------------------
1988-05-15 10:23:31
2021-03-18 17:20:41
2023-06-02 18:11:12
```

The following example adds 20 years only to the TIMESTAMP_VAL values in TIMESTAMP_TEST from before the year 2000.

```
SELECT dateadd(year,20,timestamp_val)
FROM timestamp_test
WHERE timestamp_val < to_timestamp('2000-01-01 00:00:00', 'YYYY-MM-DD HH:MI:SS');

date_add
---------------
2008-05-15 10:23:31
```

The following example adds 5 seconds to a literal timestamp value written without a seconds indicator.

```
SELECT dateadd(second, 5, timestamp '2001-06-06');

date_add
---------------
2001-06-06 00:00:05
```

Usage notes

The DATEADD(month, ...) and ADD_MONTHS functions handle dates that fall at the ends of months differently:

- ADD_MONTHS: If the date you are adding to is the last day of the month, the result is always the last day of the result month, regardless of the length of the month. For example, April 30 + 1 month is May 31.

  ```
  select add_months('2008-04-30',1);

  add_months
  ---------------------
  2008-05-31 00:00:00
  (1 row)
  ```

- DATEADD: If there are fewer days in the date you are adding to than in the result month, the result is the corresponding day of the result month, not the last day of that month. For example, April 30 + 1 month is May 30.

  ```
  select dateadd(month,1,'2008-04-30');

  date_add
  ---------------------
  2008-05-30 00:00:00
  (1 row)
  ```

The DATEADD function handles the leap year date 02-29 differently when using dateadd(month, 12,…) or dateadd(year, 1, …).

```
select dateadd(month,12,'2016-02-29');
```

```
date_add
---------------------
2017-02-28 00:00:00

select dateadd(year, 1, '2016-02-29');

date_add
---------------------
2017-03-01 00:00:00
```

DATEDIFF function

DATEDIFF returns the difference between the date parts of two date or time expressions.

Syntax

```
DATEDIFF( datepart, {date|time|timetz|timestamp}, {date|time|timetz|timestamp} )
```

Arguments

datepart

The specific part of the date or time value (year, month, or day, hour, minute, second, millisecond, or microsecond) that the function operates on. For more information, see Date parts for date or timestamp functions.

Specifically, DATEDIFF determines the number of date part boundaries that are crossed between two expressions. For example, suppose that you're calculating the difference in years between two dates, `12-31-2008` and `01-01-2009`. In this case, the function returns 1 year despite the fact that these dates are only one day apart. If you are finding the difference in hours between two timestamps, `01-01-2009 8:30:00` and `01-01-2009 10:00:00`, the result is 2 hours. If you are finding the difference in hours between two timestamps, `8:30:00` and `10:00:00`, the result is 2 hours.

date|*time*|*timetz*|*timestamp*

A DATE, TIME, TIMETZ, or TIMESTAMP column or expressions that implicitly convert to a DATE, TIME, TIMETZ, or TIMESTAMP. The expressions must both contain the specified date or time part. If the second date or time is later than the first date or time, the result is positive. If the second date or time is earlier than the first date or time, the result is negative.

Return type

BIGINT

Examples with a DATE column

The following example finds the difference, in number of weeks, between two literal date values.

```
select datediff(week,'2009-01-01','2009-12-31') as numweeks;

numweeks
----------
52
(1 row)
```

The following example finds the difference, in hours, between two literal date values. When you don't provide the time value for a date, it defaults to 00:00:00.

```
select datediff(hour, '2023-01-01', '2023-01-03 05:04:03');

date_diff
----------
53
(1 row)
```

The following example finds the difference, in days, between two literal TIMESTAMETZ values.

```
Select datediff(days, 'Jun 1,2008  09:59:59 EST', 'Jul 4,2008  09:59:59 EST')

date_diff
----------
33
```

The following example finds the difference, in days, between two dates in the same row of a table.

```
select * from date_table;

start_date |   end_date
-----------+-----------
2009-01-01 | 2009-03-23
```

```
2023-01-04 | 2024-05-04
(2 rows)

select datediff(day, start_date, end_date) as duration from date_table;

duration
---------
      81
     486
(2 rows)
```

The following example finds the difference, in number of quarters, between a literal value in the past and today's date. This example assumes that the current date is June 5, 2008. You can name date parts in full or abbreviate them. The default column name for the DATEDIFF function is DATE_DIFF.

```
select datediff(qtr, '1998-07-01', current_date);

date_diff
-----------
40
(1 row)
```

The following example joins the SALES and LISTING tables to calculate how many days after they were listed any tickets were sold for listings 1000 through 1005. The longest wait for sales of these listings was 15 days, and the shortest was less than one day (0 days).

```
select priceperticket,
datediff(day, listtime, saletime) as wait
from sales, listing where sales.listid = listing.listid
and sales.listid between 1000 and 1005
order by wait desc, priceperticket desc;

priceperticket | wait
---------------+------
 96.00         |   15
 123.00        |   11
 131.00        |    9
 123.00        |    6
 129.00        |    4
 96.00         |    4
 96.00         |    0
```

```
(7 rows)
```

This example calculates the average number of hours sellers waited for all ticket sales.

```
select avg(datediff(hours, listtime, saletime)) as avgwait
from sales, listing
where sales.listid = listing.listid;

avgwait
---------
465
(1 row)
```

Examples with a TIME column

The following example table TIME_TEST has a column TIME_VAL (type TIME) with three values inserted.

```
select time_val from time_test;

time_val
---------------------
20:00:00
00:00:00.5550
00:58:00
```

The following example finds the difference in number of hours between the TIME_VAL column and a time literal.

```
select datediff(hour, time_val, time '15:24:45') from time_test;

 date_diff
-----------
        -5
        15
        15
```

The following example finds the difference in number of minutes between two literal time values.

```
select datediff(minute, time '20:00:00', time '21:00:00') as nummins;
```

```
nummins
----------
60
```

Examples with a TIMETZ column

The following example table TIMETZ_TEST has a column TIMETZ_VAL (type TIMETZ) with three values inserted.

```
select timetz_val from timetz_test;

timetz_val
------------------
04:00:00+00
00:00:00.5550+00
05:58:00+00
```

The following example finds the differences in number of hours, between a TIMETZ literal and timetz_val.

```
select datediff(hours, timetz '20:00:00 PST', timetz_val) as numhours from timetz_test;

numhours
----------
0
-4
1
```

The following example finds the difference in number of hours, between two literal TIMETZ values.

```
select datediff(hours, timetz '20:00:00 PST', timetz '00:58:00 EST') as numhours;

numhours
----------
1
```

DATE_PART function

DATE_PART extracts date part values from an expression. DATE_PART is a synonym of the PGDATE_PART function.

Syntax

```
DATE_PART(datepart, {date|timestamp})
```

Arguments

datepart

An identifier literal or string of the specific part of the date value (for example, year, month, or day) that the function operates on. For more information, see Date parts for date or timestamp functions.

{*date*|*timestamp*}

A date column, timestamp column, or an expression that implicitly converts to a date or timestamp. The column or expression in *date* or *timestamp* must contain the date part specified in *datepart*.

Return type

DOUBLE

Examples

The default column name for the DATE_PART function is `pgdate_part`.

For more information about the data used in some of these examples, see Sample database.

The following example finds the minute from a timestamp literal.

```
SELECT DATE_PART(minute, timestamp '20230104 04:05:06.789');

pgdate_part
-----------
         5
```

The following example finds the week number from a timestamp literal. The week number calculation follows the ISO 8601 standard. For more information, see ISO 8601 in Wikipedia.

```
SELECT DATE_PART(week, timestamp '20220502 04:05:06.789');

pgdate_part
```

```
-----------
         18
```

The following example finds the day of the month from a timestamp literal.

```
SELECT DATE_PART(day, timestamp '20220502 04:05:06.789');

pgdate_part
-----------
         2
```

The following example finds the day of the week from a timestamp literal. The day of week number calculation is an integer from 0-6, starting with Sunday.

```
SELECT DATE_PART(dayofweek, timestamp '20220502 04:05:06.789');

pgdate_part
-----------
         1
```

The following example finds the century from a timestamp literal. The century calculation follows the ISO 8601 standard. For more information, see ISO 8601 in Wikipedia.

```
SELECT DATE_PART(century, timestamp '20220502 04:05:06.789');

pgdate_part
-----------
         21
```

The following example finds the millennium from a timestamp literal. The millennium calculation follows the ISO 8601 standard. For more information, see ISO 8601 in Wikipedia.

```
SELECT DATE_PART(millennium, timestamp '20220502 04:05:06.789');

pgdate_part
-----------
         3
```

The following example finds the microseconds from a timestamp literal. The microseconds calculation follows the ISO 8601 standard. For more information, see ISO 8601 in Wikipedia.

```
SELECT DATE_PART(microsecond, timestamp '20220502 04:05:06.789');

pgdate_part
-----------
    789000
```

The following example finds the month from a date literal.

```
SELECT DATE_PART(month, date '20220502');

pgdate_part
-----------
         5
```

The following example applies the DATE_PART function to a column in a table.

```
SELECT date_part(w, listtime) AS weeks, listtime
FROM listing
WHERE listid=10


weeks |      listtime
------+---------------------
 25   | 2008-06-17 09:44:54
(1 row)
```

You can name date parts in full or abbreviate them; in this case, *w* stands for weeks.

The day of week date part returns an integer from 0-6, starting with Sunday. Use DATE_PART with dow (DAYOFWEEK) to view events on a Saturday.

```
SELECT date_part(dow, starttime) AS dow, starttime
FROM event
WHERE date_part(dow, starttime)=6
ORDER BY 2,1;

 dow |      starttime
-----+---------------------
   6 | 2008-01-05 14:00:00
   6 | 2008-01-05 14:00:00
   6 | 2008-01-05 14:00:00
   6 | 2008-01-05 14:00:00
```

```
...
(1147 rows)
```

DATE_PART_YEAR function

The DATE_PART_YEAR function extracts the year from a date.

Syntax

```
DATE_PART_YEAR(date)
```

Argument

date

A column of data type DATE or an expression that implicitly evaluates to a DATE type.

Return type

INTEGER

Examples

The following example finds the year from a date literal.

```
SELECT DATE_PART_YEAR(date '20220502 04:05:06.789');

date_part_year
---------------
2022
```

The following example extracts the year from the CALDATE column. The values in the CALDATE column are dates. For more information about the data used in this example, see Sample database.

```
select caldate, date_part_year(caldate)
from date
order by
dateid limit 10;

 caldate   | date_part_year
-----------+----------------
2008-01-01 |           2008
```

```
2008-01-02 |            2008
2008-01-03 |            2008
2008-01-04 |            2008
2008-01-05 |            2008
2008-01-06 |            2008
2008-01-07 |            2008
2008-01-08 |            2008
2008-01-09 |            2008
2008-01-10 |            2008
(10 rows)
```

DATE_TRUNC function

The DATE_TRUNC function truncates a timestamp expression or literal based on the date part that you specify, such as hour, day, or month.

Syntax

```
DATE_TRUNC('datepart', timestamp)
```

Arguments

datepart

The date part to which to truncate the timestamp value. The input *timestamp* is truncated to the precision of the input *datepart*. For example, `month` truncates to the first day of the month. Valid formats are as follows:

- microsecond, microseconds
- millisecond, milliseconds
- second, seconds
- minute, minutes
- hour, hours
- day, days
- week, weeks
- month, months
- quarter, quarters
- year, years
- decade, decades

- century, centuries
- millennium, millennia

For more information about abbreviations of some formats, see Date parts for date or timestamp functions

timestamp

A timestamp column or an expression that implicitly converts to a timestamp.

Return type

TIMESTAMP

Examples

Truncate the input timestamp to the second.

```
SELECT DATE_TRUNC('second', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-30 04:05:06
```

Truncate the input timestamp to the minute.

```
SELECT DATE_TRUNC('minute', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-30 04:05:00
```

Truncate the input timestamp to the hour.

```
SELECT DATE_TRUNC('hour', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-30 04:00:00
```

Truncate the input timestamp to the day.

```
SELECT DATE_TRUNC('day', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-30 00:00:00
```

Truncate the input timestamp to the first day of a month.

```
SELECT DATE_TRUNC('month', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-01 00:00:00
```

Truncate the input timestamp to the first day of a quarter.

```
SELECT DATE_TRUNC('quarter', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-04-01 00:00:00
```

Truncate the input timestamp to the first day of a year.

```
SELECT DATE_TRUNC('year', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2020-01-01 00:00:00
```

Truncate the input timestamp to the first day of a century.

```
SELECT DATE_TRUNC('millennium', TIMESTAMP '20200430 04:05:06.789');
date_trunc
2001-01-01 00:00:00
```

Truncate the input timestamp to the Monday of a week.

```
select date_trunc('week', TIMESTAMP '20220430 04:05:06.789');
date_trunc
2022-04-25 00:00:00
```

In the following example, the DATE_TRUNC function uses the 'week' date part to return the date for the Monday of each week.

```
select date_trunc('week', saletime), sum(pricepaid) from sales where
saletime like '2008-09%' group by date_trunc('week', saletime) order by 1;

date_trunc  |    sum
------------+-------------
2008-09-01  | 2474899
2008-09-08  | 2412354
2008-09-15  | 2364707
2008-09-22  | 2359351
```

```
2008-09-29   |   705249
```

EXTRACT function

The EXTRACT function returns a date or time part from a TIMESTAMP, TIMESTAMPTZ, TIME, TIMETZ, INTERVAL YEAR TO MONTH, or INTERVAL DAY TO SECOND value. Examples include a day, month, year, hour, minute, second, millisecond, or microsecond from a timestamp.

Syntax

```
EXTRACT(datepart FROM source)
```

Arguments

datepart

The subfield of a date or time to extract, such as a day, month, year, hour, minute, second, millisecond, or microsecond. For possible values, see [Date parts for date or timestamp functions](#).

source

A column or expression that evaluates to a data type of TIMESTAMP, TIMESTAMPTZ, TIME, TIMETZ, INTERVAL YEAR TO MONTH, or INTERVAL DAY TO SECOND.

Return type

INTEGER if the *source* value evaluates to data type TIMESTAMP, TIME, TIMETZ, INTERVAL YEAR TO MONTH, or INTERVAL DAY TO SECOND.

DOUBLE PRECISION if the *source* value evaluates to data type TIMESTAMPTZ.

Examples with TIMESTAMP

The following example determines the week numbers for sales in which the price paid was $10,000 or more. This example uses the TICKIT data. For more information, see [Sample database](#).

```
select salesid, extract(week from saletime) as weeknum
from sales
where pricepaid > 9999
order by 2;
```

```
salesid | weeknum
--------+---------
 159073 |       6
 160318 |       8
 161723 |      26
```

The following example returns the minute value from a literal timestamp value.

```
select extract(minute from timestamp '2009-09-09 12:08:43');

date_part
-----------
8
```

The following example returns the millisecond value from a literal timestamp value.

```
select extract(ms from timestamp '2009-09-09 12:08:43.101');

date_part
-----------
101
```

Examples with TIMESTAMPTZ

The following example returns the year value from a literal timestamptz value.

```
select extract(year from timestamptz '1.12.1997 07:37:16.00 PST');

date_part
-----------
1997
```

Examples with TIME

The following example table TIME_TEST has a column TIME_VAL (type TIME) with three values inserted.

```
select time_val from time_test;

time_val
---------------------
20:00:00
```

```
00:00:00.5550
00:58:00
```

The following example extracts the minutes from each time_val.

```
select extract(minute from time_val) as minutes from time_test;

minutes
-----------
         0
         0
         58
```

The following example extracts the hours from each time_val.

```
select extract(hour from time_val) as hours from time_test;

hours
-----------
         20
         0
         0
```

The following example extracts milliseconds from a literal value.

```
select extract(ms from time '18:25:33.123456');

 date_part
-----------
     123
```

Examples with TIMETZ

The following example table TIMETZ_TEST has a column TIMETZ_VAL (type TIMETZ) with three values inserted.

```
select timetz_val from timetz_test;

timetz_val
------------------
04:00:00+00
```

```
00:00:00.5550+00
05:58:00+00
```

The following example extracts the hours from each timetz_val.

```
select extract(hour from timetz_val) as hours from time_test;

hours
-----------
         4
         0
         5
```

The following example extracts milliseconds from a literal value. Literals aren't converted to UTC before the extraction is processed.

```
select extract(ms from timetz '18:25:33.123456 EST');

 date_part
-----------
     123
```

The following example returns the timezone offset hour from UTC from a literal timetz value.

```
select extract(timezone_hour from timetz '1.12.1997 07:37:16.00 PDT');

date_part
-----------
-7
```

Examples with INTERVAL YEAR TO MONTH and INTERVAL DAY TO SECOND

The following example extracts the day part of 1 from the INTERVAL DAY TO SECOND that defines 36 hours, which is 1 day 12 hours.

```
select EXTRACT('days' from INTERVAL '36 hours' DAY TO SECOND)

 date_part
------------------
 1
```

The following example extracts the month part of 3 from the YEAR TO MONTH that defines 15 months, which is 1 year 3 months.

```
select EXTRACT('month' from INTERVAL '15 months' YEAR TO MONTH)

 date_part
------------------
 3
```

The following example extracts the month part of 6 from 30 months which is 2 years 6 months.

```
select EXTRACT('month' from INTERVAL '30' MONTH)

 date_part
------------------
 6
```

The following example extracts the hour part of 2 from 50 hours which is 2 days 2 hours.

```
select EXTRACT('hours' from INTERVAL '50' HOUR)

 date_part
------------------
 2
```

The following example extracts the minute part of 11 from 1 hour 11 minutes 11.123 seconds.

```
select EXTRACT('minute' from INTERVAL '70 minutes 70.123 seconds' MINUTE TO SECOND)

 date_part
------------------
 11
```

The following example extracts the seconds part of `1.11` from 1 day 1 hour 1 minute 1.11 seconds.

```
select EXTRACT('seconds' from INTERVAL '1 day 1:1:1.11' DAY TO SECOND)

 date_part
------------------
 1.11
```

The following example extracts the total number of hours in an INTERVAL. Each part is extracted and added to a total.

```
select EXTRACT('days' from INTERVAL '50' HOUR) * 24 + EXTRACT('hours' from INTERVAL
 '50' HOUR)

 ?column?
------------------
 50
```

The following example extracts the total number of seconds in an INTERVAL. Each part is extracted and added to a total.

```
select EXTRACT('days' from INTERVAL '1 day 1:1:1.11' DAY TO SECOND) * 86400 +
       EXTRACT('hours' from INTERVAL '1 day 1:1:1.11' DAY TO SECOND) * 3600 +
       EXTRACT('minutes' from INTERVAL '1 day 1:1:1.11' DAY TO SECOND) * 60 +
       EXTRACT('seconds' from INTERVAL '1 day 1:1:1.11' DAY TO SECOND)

 ?column?
------------------
 90061.11
```

GETDATE function

GETDATE returns the current date and time in the current session time zone (UTC by default). It returns the start date or time of the current statement, even when it is within a transaction block.

Syntax

```
GETDATE()
```

The parentheses are required.

Return type

TIMESTAMP

Examples

The following example uses the GETDATE function to return the full timestamp for the current date.

```
select getdate();

timestamp
---------------------
2008-12-04 16:10:43
```

The following example uses the GETDATE function inside the TRUNC function to return the current date without the time.

```
select trunc(getdate());

trunc
------------
2008-12-04
```

INTERVAL_CMP function

INTERVAL_CMP compares two intervals and returns `1` if the first interval is greater, `-1` if the second interval is greater, and `0` if the intervals are equal. For more information, see Examples of interval literals without qualifier syntax.

Syntax

```
INTERVAL_CMP(interval1, interval2)
```

Arguments

interval1

An interval literal value.

interval2

An interval literal value.

Return type

INTEGER

Examples

The following example compares the value of `3 days` to `1 year`.

```
select interval_cmp('3 days','1 year');

interval_cmp
--------------
-1
```

This example compares the value `7 days` to `1 week`.

```
select interval_cmp('7 days','1 week');

interval_cmp
--------------
0
```

The following example compares the value of `1 year` to `3 days`.

```
select interval_cmp('1 year','3 days');

interval_cmp
--------------
1
```

LAST_DAY function

LAST_DAY returns the date of the last day of the month that contains *date*. The return type is always DATE, regardless of the data type of the *date* argument.

For more information about retrieving specific date parts, see DATE_TRUNC function.

Syntax

```
LAST_DAY( { date | timestamp } )
```

Arguments

date | *timestamp*

A column of data type `DATE` or `TIMESTAMP` or an expression that implicitly evaluates to a `DATE` or `TIMESTAMP` type.

Return type

DATE

Examples

The following example returns the date of the last day in the current month.

```
select last_day(sysdate);

  last_day
------------
 2014-01-31
```

The following example returns the number of tickets sold for each of the last 7 days of the month. The values in the SALETIME column are timestamps.

```
select datediff(day, saletime, last_day(saletime)) as "Days Remaining", sum(qtysold)
from sales
where datediff(day, saletime, last_day(saletime)) < 7
group by 1
order by 1;

days remaining |  sum
---------------+-------
             0 | 10140
             1 | 11187
             2 | 11515
             3 | 11217
             4 | 11446
             5 | 11708
             6 | 10988
(7 rows)
```

MONTHS_BETWEEN function

MONTHS_BETWEEN determines the number of months between two dates.

If the first date is later than the second date, the result is positive; otherwise, the result is negative.

If either argument is null, the result is NULL.

Syntax

```
MONTHS_BETWEEN( date1, date2 )
```

Arguments

date1

A column of data type DATE or an expression that implicitly evaluates to a DATE type.

date2

A column of data type DATE or an expression that implicitly evaluates to a DATE type.

Return type

FLOAT8

The whole number portion of the result is based on the difference between the year and month values of the dates. The fractional portion of the result is calculated from the day and timestamp values of the dates and assumes a 31-day month.

If *date1* and *date2* both contain the same date within a month (for example, 1/15/14 and 2/15/14) or the last day of the month (for example, 8/31/14 and 9/30/14), then the result is a whole number based on the year and month values of the dates, regardless of whether the timestamp portion matches, if present.

Examples

The following example returns the months between 1/18/1969 and 3/18/1969.

```
select months_between('1969-01-18', '1969-03-18')
as months;

months
----------
-2
```

The following example returns the months between 1/18/1969 and 1/18/1969.

```
select months_between('1969-01-18', '1969-01-18')
as months;
```

```
months
----------
0
```

The following example returns the months between the first and last showings of an event.

```
select eventname,
min(starttime) as first_show,
max(starttime) as last_show,
months_between(max(starttime),min(starttime)) as month_diff
from event
group by eventname
order by eventname
limit 5;

eventname         first_show              last_show               month_diff
---------------------------------------------------------------------------
.38 Special       2008-01-21 19:30:00.0  2008-12-25 15:00:00.0  11.12
3 Doors Down      2008-01-03 15:00:00.0  2008-12-01 19:30:00.0  10.94
70s Soul Jam      2008-01-16 19:30:00.0  2008-12-07 14:00:00.0  10.7
A Bronx Tale      2008-01-21 19:00:00.0  2008-12-15 15:00:00.0  10.8
A Catered Affair  2008-01-08 19:30:00.0  2008-12-19 19:00:00.0  11.35
```

NEXT_DAY function

NEXT_DAY returns the date of the first instance of the specified day that is later than the given date.

If the *day* value is the same day of the week as the given date, the next occurrence of that day is returned.

Syntax

```
NEXT_DAY( { date | timestamp }, day )
```

Arguments

date **|** *timestamp*

A column of data type `DATE` or `TIMESTAMP` or an expression that implicitly evaluates to a `DATE` or `TIMESTAMP` type.

day

A string containing the name of any day. Capitalization doesn't matter.

Valid values are as follows.

Day	Values
Sunday	Su, Sun, Sunday
Monday	M, Mo, Mon, Monday
Tuesday	Tu, Tue, Tues, Tuesday
Wednesday	W, We, Wed, Wednesday
Thursday	Th, Thu, Thurs, Thursday
Friday	F, Fr, Fri, Friday
Saturday	Sa, Sat, Saturday

Return type

DATE

Examples

The following example returns the date of the first Tuesday after 8/20/2014.

```
select next_day('2014-08-20','Tuesday');

next_day
-----------
2014-08-26
```

The following example returns the date of the first Tuesday after 1/1/2008 at 5:54:44.

```
select listtime, next_day(listtime, 'Tue') from listing limit 1;

listtime            | next_day
--------------------+-----------
```

```
2008-01-01 05:54:44 | 2008-01-08
```

The following example gets target marketing dates for the third quarter.

```
select username, (firstname ||' '|| lastname) as name,
eventname, caldate, next_day (caldate, 'Monday') as marketing_target
from sales, date, users, event
where sales.buyerid = users.userid
and sales.eventid = event.eventid
and event.dateid = date.dateid
and date.qtr = 3
order by marketing_target, eventname, name;

username  |     name          |     eventname        |    caldate   |
 marketing_target
----------+-------------------+----------------------+--------------
+-------------------
MBO26QSG  |   Callum Atkinson | .38 Special          |  2008-07-06  | 2008-07-07
WCR50YIU  |   Erasmus Alvarez | A Doll's House       |  2008-07-03  | 2008-07-07
CKT70OIE  |   Hadassah Adkins | Ana Gabriel          |  2008-07-06  | 2008-07-07
VVG07OUO  |   Nathan Abbott   | Armando Manzanero    |  2008-07-04  | 2008-07-07
GEW77SII  |   Scarlet Avila   | August: Osage County |  2008-07-06  | 2008-07-07
ECR71CVS  |   Caryn Adkins    | Ben Folds            |  2008-07-03  | 2008-07-07
KUW82CYU  |   Kaden Aguilar   | Bette Midler         |  2008-07-01  | 2008-07-07
WZE78DJZ  |   Kay Avila       | Bette Midler         |  2008-07-01  | 2008-07-07
HXY04NVE  |   Dante Austin    | Britney Spears       |  2008-07-02  | 2008-07-07
URY81YWF  |   Wilma Anthony   | Britney Spears       |  2008-07-02  | 2008-07-07
```

SYSDATE function

SYSDATE returns the current date and time in the current session time zone (UTC by default).

Note

SYSDATE returns the start date and time for the current transaction, not for the start of the current statement.

Syntax

```
SYSDATE
```

This function requires no arguments.

Return type

TIMESTAMP

Examples

The following example uses the SYSDATE function to return the full timestamp for the current date.

```
select sysdate;

timestamp
----------------------------
2008-12-04 16:10:43.976353
```

The following example uses the SYSDATE function inside the TRUNC function to return the current date without the time.

```
select trunc(sysdate);

trunc
------------
2008-12-04
```

The following query returns sales information for dates that fall between the date when the query is issued and whatever date is 120 days earlier.

```
select salesid, pricepaid, trunc(saletime) as saletime, trunc(sysdate) as now
from sales
where saletime between trunc(sysdate)-120 and trunc(sysdate)
order by saletime asc;

 salesid | pricepaid |  saletime  |    now
---------+-----------+------------+------------
91535    |    670.00 | 2008-08-07 | 2008-12-05
91635    |    365.00 | 2008-08-07 | 2008-12-05
91901    |   1002.00 | 2008-08-07 | 2008-12-05
...
```

TIMEOFDAY function

TIMEOFDAY is a special alias used to return the weekday, date, and time as a string value. It returns the time of day string for the current statement, even when it is within a transaction block.

Syntax

```
TIMEOFDAY()
```

Return type

VARCHAR

Examples

The following example returns the current date and time by using the TIMEOFDAY function.

```
select timeofday();

timeofday
------------
Thu Sep 19 22:53:50.333525 2013 UTC
```

TIMESTAMP_CMP function

Compares the value of two timestamps and returns an integer. If the timestamps are identical, the function returns `0`. If the first timestamp is greater, the function returns `1`. If the second timestamp is greater, the function returns `-1`.

Syntax

```
TIMESTAMP_CMP(timestamp1, timestamp2)
```

Arguments

timestamp1

A column of data type `TIMESTAMP` or an expression that implicitly evaluates to a `TIMESTAMP` type.

timestamp2

A column of data type TIMESTAMP or an expression that implicitly evaluates to a TIMESTAMP type.

Return type

INTEGER

Examples

The following example compares timestamps and shows the results of the comparison.

```
SELECT TIMESTAMP_CMP('2008-01-24 06:43:29', '2008-01-24 06:43:29'),
 TIMESTAMP_CMP('2008-01-24 06:43:29', '2008-02-18 02:36:48'), TIMESTAMP_CMP('2008-02-18
 02:36:48', '2008-01-24 06:43:29');

timestamp_cmp  | timestamp_cmp | timestamp_cmp
---------------+---------------+---------------
             0 |            -1 |             1
```

The following example compares the LISTTIME and SALETIME for a listing. The value for TIMESTAMP_CMP is -1 for all listings because the timestamp for the sale is after the timestamp for the listing.

```
select listing.listid, listing.listtime,
sales.saletime, timestamp_cmp(listing.listtime, sales.saletime)
from listing, sales
where listing.listid=sales.listid
order by 1, 2, 3, 4
limit 10;

 listid |      listtime       |      saletime       | timestamp_cmp
--------+---------------------+---------------------+---------------
      1 | 2008-01-24 06:43:29 | 2008-02-18 02:36:48 |            -1
      4 | 2008-05-24 01:18:37 | 2008-06-06 05:00:16 |            -1
      5 | 2008-05-17 02:29:11 | 2008-06-06 08:26:17 |            -1
      5 | 2008-05-17 02:29:11 | 2008-06-09 08:38:52 |            -1
      6 | 2008-08-15 02:08:13 | 2008-08-31 09:17:02 |            -1
     10 | 2008-06-17 09:44:54 | 2008-06-26 12:56:06 |            -1
     10 | 2008-06-17 09:44:54 | 2008-07-10 02:12:36 |            -1
     10 | 2008-06-17 09:44:54 | 2008-07-16 11:59:24 |            -1
```

```
     10 | 2008-06-17 09:44:54 | 2008-07-22 02:23:17 |            -1
     12 | 2008-07-25 01:45:49 | 2008-08-04 03:06:36 |            -1
(10 rows)
```

This example shows that TIMESTAMP_CMP returns a 0 for identical timestamps:

```
select listid, timestamp_cmp(listtime, listtime)
from listing
order by 1 , 2
limit 10;

 listid | timestamp_cmp
--------+---------------
      1 |             0
      2 |             0
      3 |             0
      4 |             0
      5 |             0
      6 |             0
      7 |             0
      8 |             0
      9 |             0
     10 |             0
(10 rows)
```

TIMESTAMP_CMP_DATE function

TIMESTAMP_CMP_DATE compares the value of a timestamp and a date. If the timestamp and date values are identical, the function returns `0`. If the timestamp is greater chronologically, the function returns `1`. If the date is greater, the function returns `-1`.

Syntax

```
TIMESTAMP_CMP_DATE(timestamp, date)
```

Arguments

timestamp

A column of data type `TIMESTAMP` or an expression that implicitly evaluates to a `TIMESTAMP` type.

date

A column of data type DATE or an expression that implicitly evaluates to a DATE type.

Return type

INTEGER

Examples

The following example compares LISTTIME to the date 2008-06-18. Listings made after this date return 1; listings made before this date return -1. LISTTIME values are timestamps.

```
select listid, listtime,
timestamp_cmp_date(listtime, '2008-06-18')
from listing
order by 1, 2, 3
limit 10;


 listid |      listtime       | timestamp_cmp_date
--------+---------------------+--------------------
      1 | 2008-01-24 06:43:29 |              -1
      2 | 2008-03-05 12:25:29 |              -1
      3 | 2008-11-01 07:35:33 |               1
      4 | 2008-05-24 01:18:37 |              -1
      5 | 2008-05-17 02:29:11 |              -1
      6 | 2008-08-15 02:08:13 |               1
      7 | 2008-11-15 09:38:15 |               1
      8 | 2008-11-09 05:07:30 |               1
      9 | 2008-09-09 08:03:36 |               1
     10 | 2008-06-17 09:44:54 |              -1
(10 rows)
```

TIMESTAMP_CMP_TIMESTAMPTZ function

TIMESTAMP_CMP_TIMESTAMPTZ compares the value of a timestamp expression with a timestamp with time zone expression. If the timestamp and timestamp with time zone values are identical, the function returns 0. If the timestamp is greater chronologically, the function returns 1. If the timestamp with time zone is greater, the function returns –1.

Syntax

```
TIMESTAMP_CMP_TIMESTAMPTZ(timestamp, timestamptz)
```

Arguments

timestamp

A column of data type TIMESTAMP or an expression that implicitly evaluates to a TIMESTAMP type.

timestamptz

A column of data type TIMESTAMPTZ or an expression that implicitly evaluates to a TIMESTAMPTZ type.

Return type

INTEGER

Examples

The following example compares timestamps to timestamps with time zones and shows the results of the comparison.

```
SELECT TIMESTAMP_CMP_TIMESTAMPTZ('2008-01-24 06:43:29', '2008-01-24 06:43:29+00'),
 TIMESTAMP_CMP_TIMESTAMPTZ('2008-01-24 06:43:29', '2008-02-18 02:36:48+00'),
 TIMESTAMP_CMP_TIMESTAMPTZ('2008-02-18 02:36:48', '2008-01-24 06:43:29+00');

timestamp_cmp_timestamptz  | timestamp_cmp_timestamptz | timestamp_cmp_timestamptz
---------------------------+---------------------------+--------------------------
             0             |            -1             |             1
```

TIMESTAMPTZ_CMP function

TIMESTAMPTZ_CMP compares the value of two timestamp with time zone values and returns an integer. If the timestamps are identical, the function returns 0. If the first timestamp is greater chronologically, the function returns 1. If the second timestamp is greater, the function returns –1.

Syntax

```
TIMESTAMPTZ_CMP(timestamptz1, timestamptz2)
```

Arguments

timestamptz1

A column of data type TIMESTAMPTZ or an expression that implicitly evaluates to a TIMESTAMPTZ type.

timestamptz2

A column of data type TIMESTAMPTZ or an expression that implicitly evaluates to a TIMESTAMPTZ type.

Return type

INTEGER

Examples

The following example compares timestamps with time zones and shows the results of the comparison.

```
SELECT TIMESTAMPTZ_CMP('2008-01-24 06:43:29+00', '2008-01-24 06:43:29+00'),
 TIMESTAMPTZ_CMP('2008-01-24 06:43:29+00', '2008-02-18 02:36:48+00'),
 TIMESTAMPTZ_CMP('2008-02-18 02:36:48+00', '2008-01-24 06:43:29+00');

timestamptz_cmp  | timestamptz_cmp | timestamptz_cmp
-----------------+-----------------+----------------
        0        |       -1        |       1
```

TIMESTAMPTZ_CMP_DATE function

TIMESTAMPTZ_CMP_DATE compares the value of a timestamp and a date. If the timestamp and date values are identical, the function returns 0. If the timestamp is greater chronologically, the function returns 1. If the date is greater, the function returns –1.

Syntax

```
TIMESTAMPTZ_CMP_DATE(timestamptz, date)
```

Arguments

timestamptz

A column of data type TIMESTAMPTZ or an expression that implicitly evaluates to a TIMESTAMPTZ type.

date

A column of data type DATE or an expression that implicitly evaluates to a DATE type.

Return type

INTEGER

Examples

The following example compares LISTTIME as a timestamp with time zone to the date 2008-06-18. Listings made after this date return 1; listings made before this date return -1.

```
select listid, CAST(listtime as timestamptz) as tstz,
timestamp_cmp_date(tstz, '2008-06-18')
from listing
order by 1, 2, 3
limit 10;


 listid |          tstz          | timestamptz_cmp_date
--------+------------------------+----------------------
      1 | 2008-01-24 06:43:29+00 |           -1
      2 | 2008-03-05 12:25:29+00 |           -1
      3 | 2008-11-01 07:35:33+00 |            1
      4 | 2008-05-24 01:18:37+00 |           -1
      5 | 2008-05-17 02:29:11+00 |           -1
      6 | 2008-08-15 02:08:13+00 |            1
      7 | 2008-11-15 09:38:15+00 |            1
      8 | 2008-11-09 05:07:30+00 |            1
      9 | 2008-09-09 08:03:36+00 |            1
     10 | 2008-06-17 09:44:54+00 |           -1
(10 rows)
```

TIMESTAMPTZ_CMP_TIMESTAMP function

TIMESTAMPTZ_CMP_TIMESTAMP compares the value of a timestamp with time zone expression with a timestamp expression. If the timestamp with time zone and timestamp values are identical, the function returns `0`. If the timestamp with time zone is greater chronologically, the function returns `1`. If the timestamp is greater, the function returns `–1`.

Syntax

```
TIMESTAMPTZ_CMP_TIMESTAMP(timestamptz, timestamp)
```

Arguments

timestamptz

A column of data type `TIMESTAMPTZ` or an expression that implicitly evaluates to a `TIMESTAMPTZ` type.

timestamp

A column of data type `TIMESTAMP` or an expression that implicitly evaluates to a `TIMESTAMP` type.

Return type

INTEGER

Examples

The following example compares timestamps with time zones to timestamps and shows the results of the comparison.

```
SELECT TIMESTAMPTZ_CMP_TIMESTAMP('2008-01-24 06:43:29+00', '2008-01-24 06:43:29'),
 TIMESTAMPTZ_CMP_TIMESTAMP('2008-01-24 06:43:29+00', '2008-02-18 02:36:48'),
 TIMESTAMPTZ_CMP_TIMESTAMP('2008-02-18 02:36:48+00', '2008-01-24 06:43:29');

timestamptz_cmp_timestamp  | timestamptz_cmp_timestamp | timestamptz_cmp_timestamp
---------------------------+---------------------------+---------------------------
             0             |            -1             |             1
```

TIMEZONE function

TIMEZONE returns a timestamp for the specified time zone and timestamp value.

For information and examples about how to set time zone, see timezone.

For information and examples about how to convert time zone, see CONVERT_TIMEZONE.

Syntax

```
TIMEZONE('timezone', { timestamp | timestamptz })
```

Arguments

timezone

The time zone for the return value. The time zone can be specified as a time zone name (such as **'Africa/Kampala'** or **'Singapore'**) or as a time zone abbreviation (such as **'UTC'** or **'PDT'**). To view a list of supported time zone names, run the following command.

```
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, run the following command.

```
select pg_timezone_abbrevs();
```

For more information and examples, see Time zone usage notes.

timestamp | *timestamptz*

An expression that results in a TIMESTAMP or TIMESTAMPTZ type, or a value that can implicitly be coerced to a timestamp or a timestamp with time zone.

Return type

TIMESTAMPTZ when used with a TIMESTAMP expression.

TIMESTAMP when used with a TIMESTAMPTZ expression.

Examples

The following returns a timestamp for the UTC time zone using the timestamp `2008-06-17 09:44:54` from the PST timezone.

```
SELECT TIMEZONE('PST', '2008-06-17 09:44:54');

timezone
-----------------------
2008-06-17 17:44:54+00
```

The following returns a timestamp for the PST time zone using the timestamp with UTC time zone `2008-06-17 09:44:54+00`.

```
SELECT TIMEZONE('PST', timestamptz('2008-06-17 09:44:54+00'));

timezone
-----------------------
2008-06-17 01:44:54
```

TO_TIMESTAMP function

TO_TIMESTAMP converts a TIMESTAMP string to TIMESTAMPTZ. For a list of additional date and time functions for Amazon Redshift, see Date and time functions.

Syntax

```
to_timestamp(timestamp, format)
```

```
to_timestamp (timestamp, format, is_strict)
```

Arguments

timestamp

A string that represents a timestamp value in the format specified by *format*. If this argument is left as empty, the timestamp value defaults to `0001-01-01 00:00:00`.

format

A string literal that defines the format of the *timestamp* value. Formats that include a time zone (**TZ**, **tz**, or **OF**) are not supported as input. For valid timestamp formats, see Datetime format strings.

is_strict

An optional Boolean value that specifies whether an error is returned if an input timestamp value is out of range. When *is_strict* is set to TRUE, an error is returned if there is an out of range value. When *is_strict* is set to FALSE, which is the default, then overflow values are accepted.

Return type

TIMESTAMPTZ

Examples

The following example demonstrates using the TO_TIMESTAMP function to convert a TIMESTAMP string to a TIMESTAMPTZ.

```
select sysdate, to_timestamp(sysdate, 'YYYY-MM-DD HH24:MI:SS') as second;

timestamp                  | second
--------------------------   ----------------------
2021-04-05 19:27:53.281812 | 2021-04-05 19:27:53+00
```

It's possible to pass TO_TIMESTAMP part of a date. The remaining date parts are set to default values. The time is included in the output:

```
SELECT TO_TIMESTAMP('2017','YYYY');

to_timestamp
--------------------------
2017-01-01 00:00:00+00
```

The following SQL statement converts the string '2011-12-18 24:38:15' to a TIMESTAMPTZ. The result is a TIMESTAMPTZ that falls on the next day because the number of hours is more than 24 hours:

```
SELECT TO_TIMESTAMP('2011-12-18 24:38:15', 'YYYY-MM-DD HH24:MI:SS');

to_timestamp
----------------------
```

```
2011-12-19 00:38:15+00
```

The following SQL statement converts the string '2011-12-18 24:38:15' to a TIMESTAMPTZ. The result is an error because the time value in the timestamp is more than 24 hours:

```
SELECT TO_TIMESTAMP('2011-12-18 24:38:15', 'YYYY-MM-DD HH24:MI:SS', TRUE);

ERROR:  date/time field time value out of range: 24:38:15.0
```

TRUNC function

Truncates a `TIMESTAMP` and returns a `DATE`.

This function can also truncate a number. For more information, see TRUNC function.

Syntax

```
TRUNC(timestamp)
```

Arguments

timestamp

A column of data type `TIMESTAMP` or an expression that implicitly evaluates to a `TIMESTAMP` type.

To return a timestamp value with `00:00:00` as the time, cast the function result to a `TIMESTAMP`.

Return type

DATE

Examples

The following example returns the date portion from the result of the SYSDATE function (which returns a timestamp).

```
SELECT SYSDATE;
```

```
+----------------------------+
|         timestamp          |
+----------------------------+
| 2011-07-21 10:32:38.248109 |
+----------------------------+

SELECT TRUNC(SYSDATE);

+------------+
|   trunc    |
+------------+
| 2011-07-21 |
+------------+
```

The following example applies the TRUNC function to a TIMESTAMP column. The return type is a date.

```
SELECT TRUNC(starttime) FROM event
ORDER BY eventid LIMIT 1;

+------------+
|   trunc    |
+------------+
| 2008-01-25 |
+------------+
```

The following example returns a timestamp value with 00:00:00 as the time by casting the TRUNC function result to a TIMESTAMP.

```
SELECT CAST((TRUNC(SYSDATE)) AS TIMESTAMP);

+---------------------+
|        trunc        |
+---------------------+
| 2011-07-21 00:00:00 |
+---------------------+
```

Date parts for date or timestamp functions

The following table identifies the date part and time part names and abbreviations that are accepted as arguments to the following functions:

- DATEADD
- DATEDIFF
- DATE_PART
- EXTRACT

Date part or time part	Abbreviations
millennium, millennia	mil, mils
century, centuries	c, cent, cents
decade, decades	dec, decs
epoch	epoch (supported by the EXTRACT)
year, years	y, yr, yrs
quarter, quarters	qtr, qtrs
month, months	mon, mons
week, weeks	w
day of week	dayofweek, dow, dw, weekday (supported by the DATE_PART and the EXTRACT function) Returns an integer from 0–6, starting with Sunday. **Note** The DOW date part behaves differently from the day of week (D) date part used for datetime format strings. D is based on integers 1–7, where Sunday is 1. For more information, see Datetime format strings.
day of year	dayofyear, doy, dy, yearday (supported by the EXTRACT)
day, days	d

Date part or time part	Abbreviations
hour, hours	h, hr, hrs
minute, minutes	m, min, mins
second, seconds	s, sec, secs
millisecond, milliseconds	ms, msec, msecs, msecond, mseconds, millisec, millisecs, millisecon
microsecond, microseconds	microsec, microsecs, microsecond, usecond, useconds, us, usec, usecs
timezone, timezone_hour, timezone_minute	Supported by the EXTRACT for timestamp with time zone (TIMESTAMPTZ) only.

Variations in results with seconds, milliseconds, and microseconds

Minor differences in query results occur when different date functions specify seconds, milliseconds, or microseconds as date parts:

- The EXTRACT function return integers for the specified date part only, ignoring higher- and lower-level date parts. If the specified date part is seconds, milliseconds and microseconds are not included in the result. If the specified date part is milliseconds, seconds and microseconds are not included. If the specified date part is microseconds, seconds and milliseconds are not included.
- The DATE_PART function returns the complete seconds portion of the timestamp, regardless of the specified date part, returning either a decimal value or an integer as required.

For example, compare the results of the following queries:

```
create table seconds(micro timestamp);

insert into seconds values('2009-09-21 11:10:03.189717');

select extract(sec from micro) from seconds;

date_part
```

```
-----------
3

select date_part(sec, micro) from seconds;

pgdate_part
-------------
3.189717
```

CENTURY, EPOCH, DECADE, and MIL notes

CENTURY or CENTURIES

Amazon Redshift interprets a CENTURY to start with year *###1* and end with year *###0*:

```
select extract (century from timestamp '2000-12-16 12:21:13');
date_part
-----------
20

select extract (century from timestamp '2001-12-16 12:21:13');
date_part
-----------
21
```

EPOCH

The Amazon Redshift implementation of EPOCH is relative to 1970-01-01 00:00:00.000000 independent of the time zone where the cluster resides. You might need to offset the results by the difference in hours depending on the time zone where the cluster is located.

The following example demonstrates the following:

1. Creates a table called EVENT_EXAMPLE based on the EVENT table. This CREATE AS command uses the DATE_PART function to create a date column (called PGDATE_PART by default) to store the epoch value for each event.
2. Selects the column and data type of EVENT_EXAMPLE from PG_TABLE_DEF.
3. Selects EVENTNAME, STARTTIME, and PGDATE_PART from the EVENT_EXAMPLE table to view the different date and time formats.

4. Selects EVENTNAME and STARTTIME from EVENT EXAMPLE as is. Converts epoch values in PGDATE_PART using a 1 second interval to a timestamp without time zone, and returns the results in a column called CONVERTED_TIMESTAMP.

```
create table event_example
as select eventname, starttime, date_part(epoch, starttime) from event;

select "column", type from pg_table_def where tablename='event_example';

     column    |            type
---------------+-----------------------------
 eventname     | character varying(200)
 starttime     | timestamp without time zone
 pgdate_part   | double precision
(3 rows)
```

```
select eventname, starttime, pgdate_part from event_example;

   eventname          |      starttime      | pgdate_part
----------------------+---------------------+-------------
 Mamma Mia!           | 2008-01-01 20:00:00 |  1199217600
 Spring Awakening     | 2008-01-01 15:00:00 |  1199199600
 Nas                  | 2008-01-01 14:30:00 |  1199197800
 Hannah Montana       | 2008-01-01 19:30:00 |  1199215800
 K.D. Lang            | 2008-01-01 15:00:00 |  1199199600
 Spamalot             | 2008-01-02 20:00:00 |  1199304000
 Macbeth              | 2008-01-02 15:00:00 |  1199286000
 The Cherry Orchard   | 2008-01-02 14:30:00 |  1199284200
 Macbeth              | 2008-01-02 19:30:00 |  1199302200
 Demi Lovato          | 2008-01-02 19:30:00 |  1199302200


select eventname,
starttime,
timestamp with time zone 'epoch' + pgdate_part * interval '1 second' AS
 converted_timestamp
from event_example;

       eventname      |      starttime      | converted_timestamp
----------------------+---------------------+---------------------
 Mamma Mia!           | 2008-01-01 20:00:00 | 2008-01-01 20:00:00
 Spring Awakening     | 2008-01-01 15:00:00 | 2008-01-01 15:00:00
 Nas                  | 2008-01-01 14:30:00 | 2008-01-01 14:30:00
```

```
 Hannah Montana        | 2008-01-01 19:30:00 | 2008-01-01 19:30:00
 K.D. Lang             | 2008-01-01 15:00:00 | 2008-01-01 15:00:00
 Spamalot              | 2008-01-02 20:00:00 | 2008-01-02 20:00:00
 Macbeth               | 2008-01-02 15:00:00 | 2008-01-02 15:00:00
 The Cherry Orchard    | 2008-01-02 14:30:00 | 2008-01-02 14:30:00
 Macbeth               | 2008-01-02 19:30:00 | 2008-01-02 19:30:00
 Demi Lovato           | 2008-01-02 19:30:00 | 2008-01-02 19:30:00
 ...
```

DECADE or DECADES

Amazon Redshift interprets the DECADE or DECADES DATEPART based on the common calendar. For example, because the common calendar starts from the year 1, the first decade (decade 1) is 0001-01-01 through 0009-12-31, and the second decade (decade 2) is 0010-01-01 through 0019-12-31. For example, decade 201 spans from 2000-01-01 to 2009-12-31:

```
select extract(decade from timestamp '1999-02-16 20:38:40');
date_part
-----------
200

select extract(decade from timestamp '2000-02-16 20:38:40');
date_part
-----------
201

select extract(decade from timestamp '2010-02-16 20:38:40');
date_part
-----------
202
```

MIL or MILS

Amazon Redshift interprets a MIL to start with the first day of year *#001* and end with the last day of year *#000*:

```
select extract (mil from timestamp '2000-12-16 12:21:13');
date_part
-----------
2
```

```
select extract (mil from timestamp '2001-12-16 12:21:13');
date_part
-----------
3
```

Hash functions

Topics

- CHECKSUM function
- farmFingerprint64 function
- FUNC_SHA1 function
- FNV_HASH function
- MD5 function
- SHA function
- SHA1 function
- SHA2 function
- MURMUR3_32_HASH

A hash function is a mathematical function that converts a numerical input value into another value.

CHECKSUM function

Computes a checksum value for building a hash index.

Syntax

```
CHECKSUM(expression)
```

Argument

expression

The input expression must be a VARCHAR, INTEGER, or DECIMAL data type.

Return type

The CHECKSUM function returns an integer.

Example

The following example computes a checksum value for the COMMISSION column:

```
select checksum(commission)
from sales
order by salesid
limit 10;

checksum
----------
10920
1140
5250
2625
2310
5910
11820
2955
8865
975
(10 rows)
```

farmFingerprint64 function

Computes the farmhash value of the input argument using the `Fingerprint64` function.

Syntax

```
farmFingerprint64(expression)
```

Argument

expression

The input expression must be a `VARCHAR` or `VARBYTE` data type.

Return type

The `farmFingerprint64` function returns a `BIGINT`.

Example

The following example returns the `farmFingerprint64` value of `Amazon Redshift` that is input as a `VARCHAR` data type.

```
SELECT farmFingerprint64('Amazon Redshift');
```

```

  farmfingerprint64
---------------------
 8085098817162212970
```

The following example returns the `farmFingerprint64` value of `Amazon Redshift` that is input as a `VARBYTE` data type.

```
SELECT farmFingerprint64('Amazon Redshift'::varbyte);
```

```

  farmfingerprint64
---------------------
 8085098817162212970
```

FUNC_SHA1 function

Synonym of SHA1 function.

See SHA1 function.

FNV_HASH function

Computes the 64-bit FNV-1a non-cryptographic hash function for all basic data types.

Syntax

```
FNV_HASH(value [, seed])
```

Arguments

value

The input value to be hashed. Amazon Redshift uses the binary representation of the value to hash the input value; for instance, INTEGER values are hashed using 4 bytes and BIGINT values are hashed using 8 bytes. Also, hashing CHAR and VARCHAR inputs does not ignore trailing spaces.

seed

The BIGINT seed of the hash function is optional. If not given, Amazon Redshift uses the default FNV seed. This enables combining the hash of multiple columns without any conversions or concatenations.

Return type

BIGINT

Example

The following examples return the FNV hash of a number, the string 'Amazon Redshift', and the concatenation of the two.

```
select fnv_hash(1);
        fnv_hash
----------------------
 -5968735742475085980
(1 row)
```

```
select fnv_hash('Amazon Redshift');
      fnv_hash
---------------------
 7783490368944507294
(1 row)
```

```
select fnv_hash('Amazon Redshift', fnv_hash(1));
       fnv_hash
----------------------
 -2202602717770968555
```

```
(1 row)
```

Usage notes

- To compute the hash of a table with multiple columns, you can compute the FNV hash of the first column and pass it as a seed to the hash of the second column. Then, it passes the FNV hash of the second column as a seed to the hash of the third column.

  The following example creates seeds to hash a table with multiple columns.

```
select fnv_hash(column_3, fnv_hash(column_2, fnv_hash(column_1))) from sample_table;
```

- The same property can be used to compute the hash of a concatenation of strings.

```
select fnv_hash('abcd');
       fnv_hash
---------------------
 -281581062704388899
(1 row)
```

```
select fnv_hash('cd', fnv_hash('ab'));
      fnv_hash
---------------------
 -281581062704388899
(1 row)
```

- The hash function uses the type of the input to determine the number of bytes to hash. Use casting to enforce a specific type, if necessary.

  The following examples use different types of input to produce different results.

```
select fnv_hash(1::smallint);
      fnv_hash
--------------------
 589727492704079044
(1 row)
```

```
select fnv_hash(1);
       fnv_hash
----------------------
```

```
 -5968735742475085980
(1 row)
```

```
select fnv_hash(1::bigint);
       fnv_hash
----------------------
 -8517097267634966620
(1 row)
```

MD5 function

Uses the MD5 cryptographic hash function to convert a variable-length string into a 32-character string that is a text representation of the hexadecimal value of a 128-bit checksum.

Syntax

```
MD5(string)
```

Arguments

string

A variable-length string.

Return type

The MD5 function returns a 32-character string that is a text representation of the hexadecimal value of a 128-bit checksum.

Examples

The following example shows the 128-bit value for the string 'Amazon Redshift':

```
select md5('Amazon Redshift');
md5
----------------------------------
f7415e33f972c03abd4f3fed36748f7a
(1 row)
```

SHA function

Synonym of SHA1 function.

See SHA1 function.

SHA1 function

The SHA1 function uses the SHA1 cryptographic hash function to convert a variable-length string into a 40-character string that is a text representation of the hexadecimal value of a 160-bit checksum.

Syntax

SHA1 is a synonym of SHA function and FUNC_SHA1 function.

```
SHA1(string)
```

Arguments

string

A variable-length string.

Return type

The SHA1 function returns a 40-character string that is a text representation of the hexadecimal value of a 160-bit checksum.

Example

The following example returns the 160-bit value for the word 'Amazon Redshift':

```
select sha1('Amazon Redshift');
```

SHA2 function

The SHA2 function uses the SHA2 cryptographic hash function to convert a variable-length string into a character string. The character string is a text representation of the hexadecimal value of the checksum with the specified number of bits.

Syntax

```
SHA2(string, bits)
```

Arguments

string

A variable-length string.

integer

The number of bits in the hash functions. Valid values are 0 (same as 256), 224, 256, 384, and 512.

Return type

The SHA2 function returns a character string that is a text representation of the hexadecimal value of the checksum or an empty string if the number of bits is invalid.

Example

The following example returns the 256-bit value for the word 'Amazon Redshift':

```
select sha2('Amazon Redshift', 256);
```

MURMUR3_32_HASH

The MURMUR3_32_HASH function computes the 32-bit Murmur3A non-cryptographic hash for all common data types including numeric and string types.

Syntax

```
MURMUR3_32_HASH(value [, seed])
```

Arguments

value

The input value to hash. Amazon Redshift hashes the binary representation of the input value. This behavior is similar to FNV_HASH function, but the value is converted to the binary representation specified by the Apache Iceberg 32-bit Murmur3 hash specification.

seed

The INT seed of the hash function. This argument is optional. If not given, Amazon Redshift uses the default seed of 0. This enables combining the hash of multiple columns without any conversions or concatenations.

Return type

The function returns an INT.

Example

The following examples return the Murmur3 hash of a number, the string 'Amazon Redshift', and the concatenation of the two.

```
select MURMUR3_32_HASH(1);

    MURMUR3_32_HASH
----------------------
 1392991556
(1 row)
```

```
select MURMUR3_32_HASH('Amazon Redshift');

    MURMUR3_32_HASH
----------------------
 -1563580564
(1 row)
```

```
select MURMUR3_32_HASH('Amazon Redshift', MURMUR3_32_HASH(1));

    MURMUR3_32_HASH
----------------------
 -1346554171
(1 row)
```

Usage notes

To compute the hash of a table with multiple columns, you can compute the Murmur3 hash of the first column and pass it as a seed to the hash of the second column. Then, it passes the Murmur3 hash of the second column as a seed to the hash of the third column.

The following example creates seeds to hash a table with multiple columns.

```
select MURMUR3_32_HASH(column_3, MURMUR3_32_HASH(column_2, MURMUR3_32_HASH(column_1)))
 from sample_table;
```

The same property can be used to compute the hash of a concatenation of strings.

```
select MURMUR3_32_HASH('abcd');

   MURMUR3_32_HASH
---------------------
 1139631978
(1 row)
```

```
select MURMUR3_32_HASH('cd', MURMUR3_32_HASH('ab'));

   MURMUR3_32_HASH
---------------------
 1711522338
(1 row)
```

The hash function uses the type of the input to determine the number of bytes to hash. Use casting to enforce a specific type, if necessary.

The following examples use different input types to produce different results.

```
select MURMUR3_32_HASH(1, MURMUR3_32_HASH(1));

   MURMUR3_32_HASH
--------------------
 -1193428387
(1 row)
```

```
select MURMUR3_32_HASH(1);

   MURMUR3_32_HASH
----------------------
 1392991556
(1 row)
```

```
select MURMUR3_32_HASH(1, MURMUR3_32_HASH(2));

   MURMUR3_32_HASH
----------------------
 1179621905
(1 row)
```

HyperLogLog functions

Following, you can find descriptions for the HyperLogLog functions for SQL that Amazon Redshift supports.

Topics

HLL function

The HLL function returns the HyperLogLog cardinality of the input expression values. The HLL function works with any data types except the HLLSKETCH data type. The HLL function ignores NULL values. When there are no rows in a table or all rows are NULL, the resulting cardinality is 0.

Syntax

```
HLL (aggregate_expression)
```

Argument

aggregate_expression

Any valid expression that provides the value to an aggregate, such as a column name. This function supports any data type as input except HLLSKETCH, GEOMETRY, GEOGRAPHY, and VARBYTE.

Return type

The HLL function returns a BIGINT or INT8 value.

Examples

The following example returns the cardinality of column `an_int` in table `a_table`.

```
CREATE TABLE a_table(an_int INT);
INSERT INTO a_table VALUES (1), (2), (3), (4);

SELECT hll(an_int) AS cardinality FROM a_table;
cardinality
-------------
4
```

HLL_CREATE_SKETCH function

The HLL_CREATE_SKETCH function returns an HLLSKETCH data type that encapsulates the input expression values. The HLL_CREATE_SKETCH function works with any data type and ignores NULL values. When there are no rows in a table or all rows are NULL, the resulting sketch has no index-value pairs such as `{"version":1,"logm":15,"sparse":{"indices":[],"values":[]}}`.

Syntax

```
HLL_CREATE_SKETCH (aggregate_expression)
```

Argument

aggregate_expression

Any valid expression that provides the value to an aggregate, such as a column name. NULL values are ignored. This function supports any data type as input except HLLSKETCH, GEOMETRY, GEOGRAPHY, and VARBYTE.

Return type

The HLL_CREATE_SKETCH function returns an HLLSKETCH value.

Examples

The following example returns the HLLSKETCH type for column an_int in table a_table. A JSON object is used to represent a sparse HyperLogLog sketch when importing, exporting, or printing sketches. A string representation (in Base64 format) is used to represent a dense HyperLogLog sketch.

```
CREATE TABLE a_table(an_int INT);
INSERT INTO a_table VALUES (1), (2), (3), (4);

SELECT hll_create_sketch(an_int) AS sketch FROM a_table;
sketch
-------------------------------------------------------------------------------------
{"version":1,"logm":15,"sparse":{"indices":
[20812342,20850007,22362299,47158030],"values":[1,2,1,1]}}
(1 row)
```

HLL_CARDINALITY function

The HLL_CARDINALITY function returns the cardinality of the input HLLSKETCH data type.

Syntax

```
HLL_CARDINALITY (hllsketch_expression)
```

Argument

hllsketch_expression

Any valid expression that evaluates to an HLLSKETCH type, such as a column name. The input value is the HLLSKETCH data type.

Return type

The HLL_CARDINALITY function returns a BIGINT or INT8 value.

Examples

The following example returns the cardinality of column sketch in table hll_table.

```
CREATE TABLE a_table(an_int INT, b_int INT);
```

```
INSERT INTO a_table VALUES (1,1), (2,1), (3,1), (4,1), (1,2), (2,2), (3,2), (4,2),
 (5,2), (6,2);

CREATE TABLE hll_table (sketch HLLSKETCH);
INSERT INTO hll_table select hll_create_sketch(an_int) from a_table group by b_int;

SELECT hll_cardinality(sketch) AS cardinality FROM hll_table;
cardinality
-------------
6
4
(2 rows)
```

HLL_COMBINE function

The HLL_COMBINE aggregate function returns an HLLSKETCH data type that combines all input HLLSKETCH values.

The combination of two or more HyperLogLog sketches is a new HLLSKETCH that encapsulates information about the union of the distinct values that each input sketch represents. After combining sketches, Amazon Redshift extracts the cardinality of the union of two or more datasets. For more information on how to combine multiple sketches, see Example: Return a HyperLogLog sketch from combining multiple sketches.

Syntax

```
HLL_COMBINE (hllsketch_expression)
```

Argument

hllsketch_expression

Any valid expression that evaluates to an HLLSKETCH type, such as a column name. The input value is the HLLSKETCH data type.

Return type

The HLL_COMBINE function returns an HLLSKETCH type.

Examples

The following example returns the combined HLLSKETCH values in the table `hll_table`.

```
CREATE TABLE a_table(an_int INT, b_int INT);
INSERT INTO a_table VALUES (1,1), (2,1), (3,1), (4,1), (1,2), (2,2), (3,2), (4,2),
 (5,2), (6,2);

CREATE TABLE hll_table (sketch HLLSKETCH);
INSERT INTO hll_table select hll_create_sketch(an_int) from a_table group by b_int;

SELECT hll_combine(sketch) AS sketches FROM hll_table;
sketches
------------------------------------------------------------------------------------------------------
{"version":1,"logm":15,"sparse":{"indices":
[20812342,20850007,22362299,40314817,42650774,47158030],"values":[1,2,1,3,2,1]}}
(1 row)
```

HLL_COMBINE_SKETCHES function

The HLL_COMBINE_SKETCHES is a scalar function that takes as input two HLLSKETCH values and combines them into a single HLLSKETCH.

The combination of two or more HyperLogLog sketches is a new HLLSKETCH that encapsulates information about the union of the distinct values that each input sketch represents.

Syntax

```
HLL_COMBINE_SKETCHES (hllsketch_expression1, hllsketch_expression2)
```

Argument

hllsketch_expression1 and *hllsketch_expression2*

Any valid expression that evaluates to an HLLSKETCH type, such as a column name.

Return type

The HLL_COMBINE_SKETCHES function returns an HLLSKETCH type.

Examples

The following example returns the combined HLLSKETCH values in the table `hll_table`.

```
WITH tbl1(x, y)
     AS (SELECT Hll_create_sketch(1),
```

```
                 Hll_create_sketch(2)
          UNION ALL
          SELECT Hll_create_sketch(3),
                 Hll_create_sketch(4)
          UNION ALL
          SELECT Hll_create_sketch(5),
                 Hll_create_sketch(6)
          UNION ALL
          SELECT Hll_create_sketch(7),
                 Hll_create_sketch(8)),
      tbl2(x, y)
      AS (SELECT Hll_create_sketch(9),
                 Hll_create_sketch(10)
          UNION ALL
          SELECT Hll_create_sketch(11),
                 Hll_create_sketch(12)
          UNION ALL
          SELECT Hll_create_sketch(13),
                 Hll_create_sketch(14)
          UNION ALL
          SELECT Hll_create_sketch(15),
                 Hll_create_sketch(16)
          UNION ALL
          SELECT Hll_create_sketch(NULL),
                 Hll_create_sketch(NULL)),
      tbl3(x, y)
      AS (SELECT *
          FROM   tbl1
          UNION ALL
          SELECT *
          FROM   tbl2)
SELECT Hll_combine_sketches(x, y)
FROM   tbl3;
```

JSON functions

Topics

- Text-based JSON functions

> **Note**
>
> We recommend that you use the following functions for working with JSON:
>
> - JSON_PARSE function
> - CAN_JSON_PARSE function
> - JSON_SERIALIZE function
> - JSON_SERIALIZE_TO_VARBYTE function
>
> With JSON_PARSE, you only need to convert JSON text to a SUPER type value once at ingestion, after which you can operate on the SUPER values. Amazon Redshift parses SUPER values more efficiently than VARCHAR, which is the output for the text-based JSON functions. For more information on working with the SUPER data type, go to Semi-structured data in Amazon Redshift.

When you need to store a relatively small set of key-value pairs, you might save space by storing the data in JSON format. Because JSON strings can be stored in a single column, using JSON might be more efficient than storing your data in tabular format. For example, suppose you have a sparse table, where you need to have many columns to fully represent all possible attributes, but most of the column values are NULL for any given row or any given column. By using JSON for storage, you might be able to store the data for a row in key:value pairs in a single JSON string and eliminate the sparsely-populated table columns.

In addition, you can easily modify JSON strings to store additional key:value pairs when your JSON schema changes without needing to add columns to a table.

We recommend using JSON sparingly. JSON isn't a good choice for storing larger datasets because, by storing disparate data in a single column, JSON doesn't use the Amazon Redshift column store architecture. Though Amazon Redshift supports JSON functions over CHAR and VARCHAR columns, we recommend using SUPER for processing data in JSON serialization format. SUPER uses a post-parse schemaless representation that can efficiently query hierarchical data. For more information about the SUPER data type, see Semi-structured data in Amazon Redshift.

JSON uses UTF-8 encoded text strings, so JSON strings can be stored as CHAR or VARCHAR data types.

JSON strings must be properly formatted JSON, according to the following rules:

- The root level JSON can either be a JSON object or a JSON array. A JSON object is an unordered set of comma-separated key:value pairs enclosed by curly braces.

  For example, `{"one":1, "two":2}`
- A JSON array is an ordered set of comma-separated values enclosed by brackets.

  An example is the following: `["first", {"one":1}, "second", 3, null]`
- JSON arrays use a zero-based index; the first element in an array is at position 0. In a JSON key:value pair, the key is a string in double quotation marks.
- A JSON value can be any of the following:
  - JSON object
  - array
  - string
    - Represented using double quotation marks
  - number
    - Includes integers, decimals, and floats
  - boolean
  - null
- Empty objects and empty arrays are valid JSON values.
- JSON fields are case-sensitive.
- White space between JSON structural elements (such as `{ }, [ ]`) is ignored.

The Amazon Redshift JSON functions and the Amazon Redshift COPY command use the same methods to work with JSON-formatted data. For more information about working with JSON, see [COPY from JSON format]

JSON_PARSE function

The JSON_PARSE function parses data in JSON format and converts it into the SUPER representation.

To ingest into SUPER data type using the INSERT or UPDATE command, use the JSON_PARSE function. When you use JSON_PARSE() to parse JSON strings into SUPER values, certain restrictions apply. For additional information, see Parsing options for SUPER.

Syntax

```
JSON_PARSE( {json_string | binary_value} )
```

Arguments

json_string

An expression that returns serialized JSON as a VARBYTE or VARCHAR type.

binary_value

A VARBYTE type binary value.

Return type

SUPER

Examples

To convert the JSON array [10001,10002,"abc"] into the SUPER data type, use the following example.

```
SELECT JSON_PARSE('[10001,10002,"abc"]');

+---------------------+
|     json_parse      |
+---------------------+
| [10001,10002,"abc"] |
+---------------------+
```

To make sure that the function converted the JSON array into the SUPER data type, use the following example. For more information, see JSON_TYPEOF function

```
SELECT JSON_TYPEOF(JSON_PARSE('[10001,10002,"abc"]'));

+-------------+
```

```
| json_typeof |
+-------------+
| array       |
+-------------+
```

CAN_JSON_PARSE function

The CAN_JSON_PARSE function parses data in JSON format and returns `true` if the result can be converted to a `SUPER` value using the JSON_PARSE function.

Syntax

```
CAN_JSON_PARSE( {json_string | binary_value} )
```

Arguments

json_string

An expression that returns serialized JSON in `VARCHAR` form.

binary_value

A VARBYTE type binary value.

Return type

`BOOLEAN`

Usage notes

- CAN_JSON_PARSE returns false for empty strings. It returns NULL when the input argument is null.

Examples

The following example shows CAN_JSON_PARSE running on a properly formed JSON array using a CASE condition. It returns true, so Amazon Redshift runs the JSON_PARSE function on the example value.

```
SELECT CASE
            WHEN CAN_JSON_PARSE('[10001,10002,"abc"]')
```

```
            THEN JSON_PARSE('[10001,10002,"abc"]')
        END;

 case
---------------------
'[10001,10002,"abc"]'
```

The following example shows CAN_JSON_PARSE running on a value that isn't JSON format using a CASE condition. It returns false, so Amazon Redshift returns the segment in the ELSE clause of the CASE condition instead.

```
SELECT CASE
            WHEN CAN_JSON_PARSE('This is a string.')
            THEN JSON_PARSE('This is a string.')
            ELSE 'This is not JSON.'
        END;

 case
---------------------
"This is not JSON."
```

JSON_SERIALIZE function

The JSON_SERIALIZE function serializes a SUPER expression into textual JSON representation to follow RFC 8259. For more information on that RFC, see [The JavaScript Object Notation (JSON) Data Interchange Format](https://tools.ietf.org/html/rfc8259).

The SUPER size limit is approximately the same as the block limit, and the VARCHAR limit is smaller than the SUPER size limit. Therefore, the JSON_SERIALIZE function returns an error when the JSON format exceeds the VARCHAR limit of the system. To check the size of a SUPER expression, see the JSON_SIZE function.

Syntax

```
JSON_SERIALIZE(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

VARCHAR

> **Note**
>
> The returned VARCHAR value is always a non-null JSON string. If *super_expression* is NULL, JSON_SERIALIZE returns the JSON string `'null'`.

Examples

To serialize a SUPER value to a string, use the following example.

```
SELECT JSON_SERIALIZE(JSON_PARSE('[10001,10002,"abc"]'));

+---------------------+
|   json_serialize    |
+---------------------+
| [10001,10002,"abc"] |
+---------------------+
```

JSON_SERIALIZE_TO_VARBYTE function

The JSON_SERIALIZE_TO_VARBYTE function converts a SUPER value to a JSON string similar to JSON_SERIALIZE(), but stored in a VARBYTE value instead.

Syntax

```
JSON_SERIALIZE_TO_VARBYTE(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

VARBYTE

Examples

To serialize a SUPER value and returns the result in VARBYTE format, use the following example.

```
SELECT JSON_SERIALIZE_TO_VARBYTE(JSON_PARSE('[10001,10002,"abc"]'));

+----------------------------------------+
|       json_serialize_to_varbyte        |
+----------------------------------------+
| 5b31303030312c31303030322c22616263225d |
+----------------------------------------+
```

To serialize a SUPER value and casts the result to VARCHAR format, use the following example. For more information, see CAST function.

```
SELECT CAST((JSON_SERIALIZE_TO_VARBYTE(JSON_PARSE('[10001,10002,"abc"]'))) AS VARCHAR);

+---------------------------+
| json_serialize_to_varbyte |
+---------------------------+
| [10001,10002,"abc"]       |
+---------------------------+
```

Text-based JSON functions

The following functions parse JSON values as VARCHAR. For parsing JSON, we recommend you instead use the following functions, which parse JSON values as SUPER. Amazon Redshift parses SUPER values more efficiently than VARCHAR.

- JSON_PARSE function
- CAN_JSON_PARSE function
- JSON_SERIALIZE function
- JSON_SERIALIZE_TO_VARBYTE function

Topics

- IS_VALID_JSON function
- IS_VALID_JSON_ARRAY function
- JSON_ARRAY_LENGTH function

- JSON_EXTRACT_ARRAY_ELEMENT_TEXT function
- JSON_EXTRACT_PATH_TEXT function

IS_VALID_JSON function

> **Note**
>
> CAN_JSON_PARSE and its associated functions parse JSON values as SUPER, which Amazon Redshift parses more efficiently than VARCHAR.
> Instead of using IS_VALID_JSON, we recommend that you validate your JSON strings using the CAN_JSON_PARSE function.

The IS_VALID_JSON function validates a JSON string. The function returns Boolean `true` if the string is properly formed JSON or `false` if the string is malformed. To validate a JSON array, use IS_VALID_JSON_ARRAY function

For more information, see JSON functions.

Syntax

```
IS_VALID_JSON('json_string')
```

Arguments

json_string

A string or expression that evaluates to a JSON string.

Return type

`BOOLEAN`

Examples

To create a table and insert JSON strings for testing, use the following example.

```
CREATE TABLE test_json(id int IDENTITY(0,1), json_strings VARCHAR);
```

```
-- Insert valid JSON strings --
INSERT INTO test_json(json_strings) VALUES
('{"a":2}'),
('{"a":{"b":{"c":1}}}'),
('{"a": [1,2,"b"]}');

-- Insert invalid JSON strings --
INSERT INTO test_json(json_strings) VALUES
('{{}}'),
('{1:"a"}'),
('[1,2,3]');
```

To validate the strings in the preceding example, use the following example.

```
SELECT id, json_strings, IS_VALID_JSON(json_strings)
FROM test_json
ORDER BY id;

+----+---------------------+---------------+
| id |    json_strings     | is_valid_json |
+----+---------------------+---------------+
|  0 | {"a":2}             | true          |
|  4 | {"a":{"b":{"c":1}}} | true          |
|  8 | {"a": [1,2,"b"]}    | true          |
| 12 | {{}}                | false         |
| 16 | {1:"a"}             | false         |
| 20 | [1,2,3]             | false         |
+----+---------------------+---------------+
```

IS_VALID_JSON_ARRAY function

Note

JSON_PARSE and its associated functions parse JSON values as SUPER, which Amazon Redshift parses more efficiently than VARCHAR.
Instead of using IS_VALID_JSON_ARRAY, we recommend that you parse your JSON strings using the JSON_PARSE function to get a SUPER value. Then, use the IS_ARRAY function function to confirm that the array is properly formed.

The IS_VALID_JSON_ARRAY function validates a JSON array. The function returns Boolean `true` if the array is properly formed JSON or `false` if the array is malformed. To validate a JSON string, use IS_VALID_JSON function

For more information, see JSON functions.

Syntax

```
IS_VALID_JSON_ARRAY('json_array')
```

Arguments

json_array

A string or expression that evaluates to a JSON array.

Return type

BOOLEAN

Examples

To create a table and insert JSON strings for testing, use the following example.

```
CREATE TABLE test_json_arrays(id int IDENTITY(0,1), json_arrays VARCHAR);

-- Insert valid JSON array strings --
INSERT INTO test_json_arrays(json_arrays)
VALUES('[]'),
('["a","b"]'),
('["a",["b",1,["c",2,3,null]]]');

-- Insert invalid JSON array strings --
INSERT INTO test_json_arrays(json_arrays)
VALUES('{"a":1}'),
('a'),
('[1,2,]');
```

To validate the strings in the preceding example, use the following example.

```
SELECT json_arrays, IS_VALID_JSON_ARRAY(json_arrays)
```

```
FROM test_json_arrays ORDER BY id;

+------------------------------+--------------------+
|         json_arrays          | is_valid_json_array |
+------------------------------+--------------------+
| []                           | true               |
| ["a","b"]                    | true               |
| ["a",["b",1,["c",2,3,null]]] | true               |
| {"a":1}                      | false              |
| a                            | false              |
| [1,2,]                       | false              |
+------------------------------+--------------------+
```

JSON_ARRAY_LENGTH function

> **Note**
>
> JSON_PARSE and its associated functions parse JSON values as SUPER, which Amazon Redshift parses more efficiently than VARCHAR.
>
> Instead of using JSON_ARRAY_LENGTH, we recommend that you parse your JSON strings using the JSON_PARSE function to get a SUPER value. Then, use the get_array_length function to get the length of your array.

The JSON_ARRAY_LENGTH function returns the number of elements in the outer array of a JSON string. If the *null_if_invalid* argument is set to `true` and the JSON string is invalid, the function returns `NULL` instead of returning an error.

For more information, see JSON functions.

Syntax

```
JSON_ARRAY_LENGTH('json_array' [, null_if_invalid ] )
```

Arguments

json_array

A properly formatted JSON array.

null_if_invalid

(Optional) A BOOLEAN value that specifies whether to return NULL if the input JSON string is invalid instead of returning an error. To return NULL if the JSON is invalid, specify `true` (`t`). To return an error if the JSON is invalid, specify `false` (`f`). The default is `false`.

Return type

INTEGER

Examples

To return the number of elements in the array, use the following example.

```
SELECT JSON_ARRAY_LENGTH('[11,12,13,{"f1":21,"f2":[25,26]},14]');

+-------------------+
| json_array_length |
+-------------------+
|                 5 |
+-------------------+
```

To return an error because the JSON is invalid, use the following example.

```
SELECT JSON_ARRAY_LENGTH('[11,12,13,{"f1":21,"f2":[25,26]},14');

ERROR: invalid json array object [11,12,13,{"f1":21,"f2":[25,26]},14
```

To set *null_if_invalid* to *true*, so the statement the returns NULL instead of returning an error for invalid JSON, use the following example.

```
SELECT JSON_ARRAY_LENGTH('[11,12,13,{"f1":21,"f2":[25,26]},14',true);

+-------------------+
| json_array_length |
+-------------------+
| NULL              |
+-------------------+
```

JSON_EXTRACT_ARRAY_ELEMENT_TEXT function

> **Note**
>
> JSON_PARSE and its associated functions parse JSON values as SUPER, which Amazon Redshift parses more efficiently than VARCHAR.
> Instead of using JSON_EXTRACT_ARRAY_ELEMENT_TEXT, we recommend that you parse your JSON strings using the JSON_PARSE function to get a SUPER value. Then, query the element you want using its array index, using the `value[element position]` syntax. For more information on querying array elements in SUPER values, go to Querying semi-structured data.

The JSON_EXTRACT_ARRAY_ELEMENT_TEXT function returns a JSON array element in the outermost array of a JSON string, using a zero-based index. The first element in an array is at position 0. If the index is negative or out of bounds, JSON_EXTRACT_ARRAY_ELEMENT_TEXT returns `NULL`. If the *null_if_invalid* argument is set to `TRUE` and the JSON string is invalid, the function returns `NULL` instead of returning an error.

For more information, see JSON functions.

Syntax

```
JSON_EXTRACT_ARRAY_ELEMENT_TEXT('json string', pos [, null_if_invalid ] )
```

Arguments

json_string

A properly formatted JSON string.

pos

An `INTEGER` representing the index of the array element to be returned, using a zero-based array index.

null_if_invalid

(Optional) A BOOLEAN value that specifies whether to return NULL if the input JSON string is invalid instead of returning an error. To return NULL if the JSON is invalid, specify true (t). To return an error if the JSON is invalid, specify false (f). The default is false.

Return type

VARCHAR

A VARCHAR string representing the JSON array element referenced by *pos*.

Examples

To return array element at position 2, which is the third element of a zero-based array index, use the following example.

```
SELECT JSON_EXTRACT_ARRAY_ELEMENT_TEXT('[111,112,113]', 2);

+---------------------------------+
| json_extract_array_element_text |
+---------------------------------+
|                             113 |
+---------------------------------+
```

To return an error because the JSON is invalid, use the following example.

```
SELECT JSON_EXTRACT_ARRAY_ELEMENT_TEXT('["a",["b",1,["c",2,3,null,]]]',1);

ERROR: invalid json array object ["a",["b",1,["c",2,3,null,]]]
```

To set *null_if_invalid* to *true*, so the statement returns NULL instead of returning an error for invalid JSON, use the following example.

```
SELECT JSON_EXTRACT_ARRAY_ELEMENT_TEXT('["a",["b",1,["c",2,3,null,]]]',1,true);

+---------------------------------+
| json_extract_array_element_text |
+---------------------------------+
```

```
| NULL                              |
+-----------------------------------+
```

Consider the following example statements. If the provided JSON string or the index is NULL, JSON_EXTRACT_ARRAY_ELEMENT_TEXT returns NULL regardless of the value of any other parameters.

```
--Statement where json_string is NULL.
SELECT json_extract_array_element_text(NULL, 0)

 json_extract_array_element_text
---------------------------------
                            NULL

--Statement where pos is NULL and json_string is invalid JSON.
SELECT json_extract_array_element_text('invalid_json', NULL);

 json_extract_array_element_text
---------------------------------
                            NULL

--Statement where json_string is NULL and null_if_invalid is FALSE.
SELECT json_extract_array_element_text(NULL, 0, FALSE);

 json_extract_array_element_text
---------------------------------
                            NULL
```

Consider the following example statements. When *null_if_invalid* is TRUE, JSON_EXTRACT_ARRAY_ELEMENT_TEXT returns NULL when *json_string* is invalid JSON. If *null_if_invalid* is FALSE or isn't set, the function returns an error when *json_string* is invalid.

```
--Statement with invalid JSON where null_if_invalid is TRUE.
SELECT json_extract_array_element_text('invalid_json', 0, TRUE);

 json_extract_array_element_text
---------------------------------
                            NULL

--Statement with invalid JSON where null_if_invalid is FALSE.
SELECT json_extract_array_element_text('invalid_json', 0);
```

```
ERROR:  JSON parsing error
```

Consider the following example, where *json_string* is valid JSON, and *pos* refers to a JSON `null` value. In this case, JSON_EXTRACT_ARRAY_ELEMENT_TEXT returns NULL, regardless of the value of *null_if_invalid*.

```
--Statement selecting a null value.
SELECT json_extract_array_element_text('[null]', 0);

  json_extract_array_element_text
---------------------------------
                             NULL
```

JSON_EXTRACT_PATH_TEXT function

> **Note**
>
> JSON_PARSE and its associated functions parse JSON values as SUPER, which Amazon Redshift parses more efficiently than VARCHAR.
> Instead of using JSON_EXTRACT_PATH_TEXT, we recommend that you parse your JSON strings using the JSON_PARSE function to get a SUPER value. Then, query the element you want using the `value.attribute` syntax. For more information on querying array elements in SUPER values, go to Querying semi-structured data.

The JSON_EXTRACT_PATH_TEXT function returns the value for the key-value pair referenced by a series of path elements in a JSON string. The JSON path can be nested up to five levels deep. Path elements are case-sensitive. If a path element does not exist in the JSON string, JSON_EXTRACT_PATH_TEXT returns `NULL`.

If the *null_if_invalid* argument is set to `TRUE` and the JSON string is invalid, the function returns `NULL` instead of returning an error.

JSON_EXTRACT_PATH_TEXT has a 64KB data-size maximum. Thus, if any JSON record is larger than 64KB, processing it with JSON_EXTRACT_PATH_TEXT results in an error.

For information about additional JSON functions, see JSON functions. For more information about working with JSON, see COPY from JSON format.

Syntax

```
JSON_EXTRACT_PATH_TEXT('json_string', 'path_elem' [,'path_elem'[, …] ]
 [, null_if_invalid ] )
```

Arguments

json_string

A properly formatted JSON string.

path_elem

A path element in a JSON string. One path element is required. Additional path elements can be specified, up to five levels deep.

null_if_invalid

(Optional) A BOOLEAN value that specifies whether to return NULL if the input JSON string is invalid instead of returning an error. To return NULL if the JSON is invalid, specify TRUE (t). To return an error if the JSON is invalid, specify FALSE (f). The default is FALSE.

In a JSON string, Amazon Redshift recognizes \n as a newline character and \t as a tab character. To load a backslash, escape it with a backslash (\\). For more information, see Escape characters in JSON.

Return type

VARCHAR

A VARCHAR string representing the JSON value referenced by the path elements.

Examples

To return the value for the path 'f4', 'f6', use the following example.

```
SELECT JSON_EXTRACT_PATH_TEXT('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}','f4', 'f6');

+------------------------+
| json_extract_path_text |
+------------------------+
```

```
| star                   |
+------------------------+
```

To return an error because the JSON is invalid, use the following example.

```
SELECT JSON_EXTRACT_PATH_TEXT('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}','f4', 'f6');

ERROR: invalid json object {"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}
```

To set *null_if_invalid* to *TRUE*, so the statement returns `NULL` for invalid JSON instead of returning an error, use the following example.

```
SELECT JSON_EXTRACT_PATH_TEXT('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}','f4',
 'f6',true);

+------------------------+
| json_extract_path_text |
+------------------------+
| NULL                   |
+------------------------+
```

Consider the following example, which selects the value for the path `'farm', 'barn', 'color'`, where the value retrieved is at the third level, use the following example. This sample is formatted with a JSON lint tool, to make it easier to read.

```
SELECT JSON_EXTRACT_PATH_TEXT('{
    "farm": {
        "barn": {
            "color": "red",
            "feed stocked": true
        }
    }
}', 'farm', 'barn', 'color');
+------------------------+
| json_extract_path_text |
+------------------------+
| red                    |
+------------------------+
```

To return `NULL` because the `'color'` element is missing, use the following example. This sample is formatted with a JSON lint tool.

```
SELECT JSON_EXTRACT_PATH_TEXT('{
    "farm": {
        "barn": {}
    }
}', 'farm', 'barn', 'color');

+------------------------+
| json_extract_path_text |
+------------------------+
| NULL                   |
+------------------------+
```

If the JSON is valid, trying to extract an element that's missing returns `NULL`.

To return the value for the path `'house', 'appliances', 'washing machine', 'brand'`, use the following example.

```
SELECT JSON_EXTRACT_PATH_TEXT('{
  "house": {
    "address": {
      "street": "123 Any St.",
      "city": "Any Town",
      "state": "FL",
      "zip": "32830"
    },
    "bathroom": {
      "color": "green",
      "shower": true
    },
    "appliances": {
      "washing machine": {
        "brand": "Any Brand",
        "color": "beige"
      },
      "dryer": {
        "brand": "Any Brand",
        "color": "white"
      }
    }
  }
}', 'house', 'appliances', 'washing machine', 'brand');

+------------------------+
```

```
| json_extract_path_text |
+------------------------+
| Any Brand              |
+------------------------+
```

The following example creates a sample table and populates it with SUPER values, then returns the value for the path `'f2'` for both rows.

```
CREATE TABLE json_example(id INT, json_text SUPER);

INSERT INTO json_example VALUES
(1, JSON_PARSE('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}')),
(2, JSON_PARSE('{
    "farm": {
        "barn": {
            "color": "red",
            "feed stocked": true
        }
    }
}'));

SELECT * FROM json_example;
id          | json_text
------------+--------------------------------------------
1           | {"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}
2           | {"farm":{"barn":{"color":"red","feed stocked":true}}}


SELECT id, JSON_EXTRACT_PATH_TEXT(JSON_SERIALIZE(json_text), 'f2') FROM json_example;

id          | json_text
------------+--------------------------------------------
1           | {"f3":1}
2           |
```

Consider the following example statements. The provided *path_elem* is NULL, so JSON_EXTRACT_PATH_TEXT returns NULL regardless of the value of any other parameters.

```
--Statement where path_elem is NULL and json_string is valid JSON.
SELECT JSON_EXTRACT_PATH_TEXT('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}',NULL);

 json_extract_path_text
```

```
------------------------
                   NULL

--Statement where only one path_elem is NULL.
SELECT JSON_EXTRACT_PATH_TEXT('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}','f4',NULL);

 json_extract_path_text
------------------------
                   NULL

--Statement where path_elem is NULL and json_string is invalid JSON.
SELECT json_extract_path_text('invalid_json', NULL);

 json_extract_path_text
------------------------
                   NULL

--Statement where path_elem is NULL and null_if_invalid is FALSE.
SELECT json_extract_path_text(NULL, 0, FALSE);

 json_extract_path_text
------------------------
                   NULL
```

Consider the following example statements. When *null_if_invalid* is TRUE, JSON_EXTRACT_PATH_TEXT returns NULL when *json_string* is invalid JSON. If *null_if_invalid* is FALSE or isn't set, the function returns an error when *json_string* is invalid.

```
--Statement with invalid JSON where null_if_invalid is TRUE.
SELECT json_extract_path_text('invalid_json', 0, TRUE);

 json_extract_path_text
------------------------
                   NULL

--Statement with invalid JSON where null_if_invalid is FALSE.
SELECT json_extract_path_text('invalid_json', 0, FALSE);

ERROR:  JSON parsing error
```

Consider the following examples, where *json_string* is valid JSON, and *path_elem* refers to a JSON `null` value. In this case, JSON_EXTRACT_PATH_TEXT returns NULL. Similarly, when *path_elem* refers to a non-existing value, JSON_EXTRACT_PATH_TEXT returns NULL, regardless of the value of *null_if_invalid*.

```
--Statement selecting a null value.
SELECT json_extract_path_text('[null]', 0);

  json_extract_path_text
-------------------------
                    NULL

--Statement selecting a non-existing value.
SELECT json_extract_path_text('{}', 'a');

  json_extract_path_text
-------------------------
                    NULL
```

Machine learning functions

By using Amazon Redshift machine learning (ML), you can train ML models using SQL statements and invoke them in SQL queries for prediction. Amazon Redshift model explainability includes feature-importance values to help you understand how each attribute in your training data contributes to the predicted result.

Following, you can find descriptions for the machine learning functions for SQL that Amazon Redshift supports.

Topics

EXPLAIN_MODEL function

The EXPLAIN_MODEL function returns a SUPER data type that contains a model explainability report in a JSON format. The explainability report contains information about the Shapley value for all model features.

The EXPLAIN_MODEL function currently supports only the AUTO ON or AUTO OFF XGBoost models.

When the explainability report isn't available, the function returns statuses showing on the progress of the model. These include `Waiting for training job to complete`, `Waiting for processing job to complete`, and `Processing job failed`.

When you run the CREATE MODEL statement, the explanation state becomes `Waiting for training job to complete`. When the model has been trained and an explanation request is sent, the explanation state becomes `Waiting for processing job to complete`. When the model explanation completes successfully, the full explainability report is available. Otherwise, the state becomes `Processing job failed`.

When you run the CREATE MODEL statement, you can use the optional `MAX_RUNTIME` parameter to specify the maximum amount of time the training should take. Once model creation reaches that amount of time, Amazon Redshift stops creating the model. If you reach that time limit while creating an autopilot model, Amazon Redshift will return the best model so far. Model explainability becomes available once the model training finishes, so if `MAX_RUNTIME` is set to a low amount of time, the explainability report might not be available. Training time varies and depends on model complexity, data size, and other factors.

Syntax

```
EXPLAIN_MODEL ('schema_name.model_name')
```

Argument

schema_name

The name of the schema. If no schema_name is specified, then the current schema is selected.

model_name

The name of the model. The model name in a schema must be unique.

Return type

The EXPLAIN_MODEL function returns a SUPER data type, as shown following.

```
{"version":"1.0","explanations":{"kernel_shap":{"label0":{"global_shap_values":
{"x0":0.05,"x1":0.10,"x2":0.30,"x3":0.15},"expected_value":0.50}}}}
```

Examples

The following example returns the explanation state `waiting for training job to complete`.

```
select explain_model('customer_churn_auto_model');
                 explain_model
--------------------------------------------------------
{"explanations":"waiting for training job to complete"}
(1 row)
```

When the model explanation completes successfully, the full explainability report is available as follows.

```
select explain_model('customer_churn_auto_model');
                                        explain_model
----------------------------------------------------------------------------------------------------
{"version":"1.0","explanations":{"kernel_shap":{"label0":{"global_shap_values":
{"x0":0.05386043365892927,"x1":0.10801289723274592,"x2":0.23227865827017378,"x3":0.0676685133945
(1 row)
```

Because the EXPLAIN_MODEL function returns the SUPER data type, you can query the explainability report. By doing this, you can extract `global_shap_values`, `expected_value`, or feature-specific Shapley values.

The following example extracts `global_shap_values` for the model.

```
select json_table.report.explanations.kernel_shap.label0.global_shap_values from
 (select explain_model('customer_churn_auto_model') as report) as json_table;
                                                       global_shap_values
----------------------------------------------------------------------------------------------------
{"state":0.10983770427197151,"account_length":0.1772441398408543,"area_code":0.0862682396863959
(1 row)
```

The following example extracts `global_shap_values` for the feature x0.

```
select json_table.report.explanations.kernel_shap.label0.global_shap_values.x0 from
 (select explain_model('customer_churn_auto_model') as report) as json_table;
          x0
------------------------
  0.05386043365892927
```

```
(1 row)
```

If the model is created in a specific schema and you have access to the created model, then you can query the model explanation as shown following.

```
-- Check the current schema
SHOW search_path;
   search_path
------------------
  $user, public
(1 row)
-- If you have the privilege to access the model explanation
-- in `test_schema`
SELECT explain_model('test_schema.test_model_name');
                        explain_model
---------------------------------------------------------
{"explanations":"waiting for training job to complete"}
(1 row)
```

Math functions

Topics

- Mathematical operator symbols
- ABS function
- ACOS function
- ASIN function
- ATAN function
- ATAN2 function
- CBRT function
- CEILING (or CEIL) function
- COS function
- COT function
- DEGREES function
- DEXP function
- DLOG1 function
- DLOG10 function

This section describes the mathematical operators and functions supported in Amazon Redshift.

Mathematical operator symbols

The following table lists the supported mathematical operators.

Supported operators

Operator	Description	Example	Result
+	addition	2 + 3	5
-	subtraction	2 - 3	-1
*	multiplication	2 * 3	6
/	division	4 / 2	2

Operator	Description	Example	Result
%	modulo	5 % 4	1
^	exponentiation	2.0 ^ 3.0	8
|/	square root	| / 25.0	5
||/	cube root	|| / 27.0	3
@	absolute value	@ -5.0	5
<<	bitwise shift left	1 << 4	16
>>	bitwise shift right	8 >> 2	2
&	bitwise and	8 & 2	0

Examples

The following examples use the TICKIT sample database. For more information, see Sample database.

To calculate the commission paid plus a $2.00 handling for a given transaction, use the following example.

```
SELECT
    commission,
    (commission + 2.00) AS comm
FROM
    sales
WHERE
    salesid = 10000;

+------------+-------+
| commission | comm  |
+------------+-------+
```

```
|      28.05 | 30.05 |
+------------+-------+
```

To calculate 20 percent of the sales price for a given transaction, use the following example.

```
SELECT pricepaid, (pricepaid * .20) as twentypct
FROM sales
WHERE salesid=10000;

+-----------+-----------+
| pricepaid | twentypct |
+-----------+-----------+
|       187 |      37.4 |
+-----------+-----------+
```

To forecast ticket sales based on a continuous growth pattern, use the following example. In this example, the subquery returns the number of tickets sold in 2008. That result is multiplied exponentially by a continuous growth rate of 5% over 10 years.

```
SELECT (SELECT SUM(qtysold) FROM sales, date
WHERE sales.dateid=date.dateid AND year=2008)^((5::float/100)*10) AS qty10years;

+------------------+
|    qty10years    |
+------------------+
| 587.664019657491 |
+------------------+
```

To find the total price paid and commission for sales with a date ID that is greater than or equal to 2000, use the following example. Then subtract the total commission from the total price paid.

```
SELECT SUM(pricepaid) AS sum_price, dateid,
SUM(commission) AS sum_comm, (SUM(pricepaid) - SUM(commission)) AS value
FROM sales
WHERE dateid >= 2000
GROUP BY dateid
ORDER BY dateid
LIMIT 10;

+-----------+--------+----------+-----------+
| sum_price | dateid | sum_comm |   value   |
+-----------+--------+----------+-----------+
```

```
|    305885 |   2000 | 45882.75 | 260002.25 |
|    316037 |   2001 | 47405.55 | 268631.45 |
|    358571 |   2002 | 53785.65 | 304785.35 |
|    366033 |   2003 | 54904.95 | 311128.05 |
|    307592 |   2004 |  46138.8 |  261453.2 |
|    333484 |   2005 |  50022.6 |  283461.4 |
|    317670 |   2006 |  47650.5 |  270019.5 |
|    351031 |   2007 | 52654.65 | 298376.35 |
|    313359 |   2008 | 47003.85 | 266355.15 |
|    323675 |   2009 | 48551.25 | 275123.75 |
+-----------+--------+----------+-----------+
```

ABS function

ABS calculates the absolute value of a number, where that number can be a literal or an expression that evaluates to a number.

Syntax

```
ABS(number)
```

Arguments

number

Number or expression that evaluates to a number. It can be the `SMALLINT`, `INTEGER`, `BIGINT`, `DECIMAL`, `FLOAT4`, `FLOAT8`, or `SUPER` type.

Return type

ABS returns the same data type as its argument.

Examples

To calculate the absolute value of `-38`, use the following example.

```
SELECT ABS(-38);

+-----+
| abs |
+-----+
|  38 |
```

```
+-----+
```

To calculate the absolute value of (14-76), use the following example.

```
SELECT ABS(14-76);

+-----+
| abs |
+-----+
|  62 |
+-----+
```

ACOS function

ACOS is a trigonometric function that returns the arc cosine of a number. The return value is in radians and is between 0 and PI.

Syntax

```
ACOS(number)
```

Arguments

number

The input parameter is a DOUBLE PRECISION number.

Return type

DOUBLE PRECISION

Examples

To return the arc cosine of -1, use the following example.

```
SELECT ACOS(-1);

+-------------------+
|       acos        |
+-------------------+
| 3.141592653589793 |
```

```
+--------------------+
```

To convert the arc cosine of .5 to the equivalent number of degrees, use the following example.

```
SELECT (ACOS(.5) * 180/(SELECT PI())) AS degrees;

+--------------------+
|      degrees       |
+--------------------+
| 60.00000000000001  |
+--------------------+
```

ASIN function

ASIN is a trigonometric function that returns the arc sine of a number. The return value is in radians and is between PI/2 and -PI/2.

Syntax

```
ASIN(number)
```

Arguments

number

The input parameter is a DOUBLE PRECISION number.

Return type

DOUBLE PRECISION

Examples

To return the arc sine of 1, use the following example.

```
SELECT ASIN(1) AS halfpi;

+--------------------+
|       halfpi       |
+--------------------+
| 1.5707963267948966 |
```

```
+--------------------+
```

To convert the arc sine of `.5` to the equivalent number of degrees, use the following example.

```
SELECT (ASIN(.5) * 180/(SELECT PI())) AS degrees;

+--------------------+
|      degrees       |
+--------------------+
| 30.000000000000004 |
+--------------------+
```

ATAN function

ATAN is a trigonometric function that returns the arc tangent of a number. The return value is in radians and is between `-PI` and `PI`.

Syntax

```
ATAN(number)
```

Arguments

number

The input parameter is a `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Examples

To return the arc tangent of 1 and multiply it by 4, use the following example.

```
SELECT ATAN(1) * 4 AS pi;

+-------------------+
|        pi         |
+-------------------+
| 3.141592653589793 |
```

```
+--------------------+
```

To convert the arc tangent of 1 to the equivalent number of degrees, use the following example.

```
SELECT (ATAN(1) * 180/(SELECT PI())) AS degrees;

+---------+
| degrees |
+---------+
|      45 |
+---------+
```

ATAN2 function

ATAN2 is a trigonometric function that returns the arc tangent of one number divided by another number. The return value is in radians and is between PI/2 and -PI/2.

Syntax

```
ATAN2(number1, number2)
```

Arguments

number1

A DOUBLE PRECISION number.

number2

A DOUBLE PRECISION number.

Return type

DOUBLE PRECISION

Examples

To return the arc tangent of 2/2 and multiply it by 4, use the following example.

```
SELECT ATAN2(2,2) * 4 AS PI;

+--------------------+
```

```
|        pi        |
+-------------------+
| 3.141592653589793 |
+-------------------+
```

To convert the arc tangent of `1/0` (which evaluates to 0) to the equivalent number of degrees, use the following example.

```
SELECT (ATAN2(1,0) * 180/(SELECT PI())) AS degrees;

+---------+
| degrees |
+---------+
|      90 |
+---------+
```

CBRT function

The CBRT function is a mathematical function that calculates the cube root of a given number.

Syntax

```
CBRT(number)
```

Arguments

CBRT takes a `DOUBLE PRECISION` number as an argument.

Return type

`DOUBLE PRECISION`

Examples

The following example uses the TICKIT sample database. For more information, see Sample database.

To calculate the cube root of the commission paid for a given transaction, use the following example.

```
SELECT CBRT(commission) FROM sales WHERE salesid=10000;

+--------------------+
```

```
|        cbrt        |
+--------------------+
| 3.0383953904884344 |
+--------------------+
```

CEILING (or CEIL) function

The CEILING or CEIL function is used to round a number up to the next whole number. (The FLOOR function rounds a number down to the next whole number.)

Syntax

```
{CEIL | CEILING}(number)
```

Arguments

number

The number or expression that evaluates to a number. It can be the SMALLINT, INTEGER, BIGINT, DECIMAL, FLOAT4, FLOAT8, or SUPER type.

Return type

CEILING and CEIL return the same data type as its argument.

When the input is of the SUPER type, the output retains the same dynamic type as the input while the static type remains the SUPER type. When the dynamic type of SUPER isn't a number, Amazon Redshift returns a null.

Examples

The following example uses the TICKIT sample database. For more information, see Sample database.

To calculate the ceiling of the commission paid for a given sales transaction, use the following example.

```
SELECT CEILING(commission) FROM sales
WHERE salesid=10000;

+---------+
| ceiling |
```

```
+---------+
|      29 |
+---------+
```

COS function

COS is a trigonometric function that returns the cosine of a number. The return value is in radians and is between -1 and 1, inclusive.

Syntax

```
COS(double_precision)
```

Arguments

number

The input parameter is a DOUBLE PRECISION number.

Return type

The COS function returns a DOUBLE PRECISION number.

Examples

To return the cosine of 0, use the following example.

```
SELECT COS(0);

+-----+
| cos |
+-----+
|   1 |
+-----+
```

To return the cosine of pi, use the following example.

```
SELECT COS(PI());

+-----+
| cos |
+-----+
```

```
|  -1 |
+-----+
```

COT function

COT is a trigonometric function that returns the cotangent of a number. The input parameter must be nonzero.

Syntax

```
COT(number)
```

Argument

number

The input parameter is a `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Examples

To return the cotangent of 1, use the following example.

```
SELECT COT(1);

+--------------------+
|        cot         |
+--------------------+
| 0.6420926159343306 |
+--------------------+
```

DEGREES function

Converts an angle in radians to its equivalent in degrees.

Syntax

```
DEGREES(number)
```

Argument

number

The input parameter is a `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Examples

To return the degree equivalent of .5 radians, use the following example.

```
SELECT DEGREES(.5);

+--------------------+
|      degrees       |
+--------------------+
| 28.64788975654116 |
+--------------------+
```

To convert PI radians to degrees, use the following example.

```
SELECT DEGREES(pi());

+---------+
| degrees |
+---------+
|     180 |
+---------+
```

DEXP function

The DEXP function returns the exponential value in scientific notation for a double precision number. The only difference between the DEXP and EXP functions is that the parameter for DEXP must be a `DOUBLE PRECISION`.

Syntax

```
DEXP(number)
```

Argument

number

The input parameter is a DOUBLE PRECISION number.

Return type

DOUBLE PRECISION

Example

The following example uses the TICKIT sample database. For more information, see Sample database.

Use the DEXP function to forecast ticket sales based on a continuous growth pattern. In this example, the subquery returns the number of tickets sold in 2008. That result is multiplied by the result of the DEXP function, which specifies a continuous growth rate of 7% over 10 years.

```
SELECT (SELECT SUM(qtysold)
FROM sales, date
WHERE sales.dateid=date.dateid
AND year=2008) * DEXP((7::FLOAT/100)*10) qty2010;

+-------------------+
|      qty2010      |
+-------------------+
| 695447.4837722216 |
+-------------------+
```

DLOG1 function

The DLOG1 function returns the natural logarithm of the input parameter. Synonym of LN function.

DLOG10 function

The DLOG10 returns the base 10 logarithm of the input parameter.

Synonym of LOG function.

Syntax

```
DLOG10(number)
```

Argument

number

The input parameter is a `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Example

To return the base 10 logarithm of the number 100, use the following example.

```
SELECT DLOG10(100);

+--------+
| dlog10 |
+--------+
|      2 |
+--------+
```

EXP function

The EXP function implements the exponential function for a numeric expression, or the base of the natural logarithm, `e`, raised to the power of expression. The EXP function is the inverse of [LN function](#).

Syntax

```
EXP(expression)
```

Argument

expression

The expression must be an `INTEGER`, `DECIMAL`, or `DOUBLE PRECISION` data type.

Return type

DOUBLE PRECISION

Example

The following example uses the TICKIT sample database. For more information, see [Sample database](#).

Use the EXP function to forecast ticket sales based on a continuous growth pattern. In this example, the subquery returns the number of tickets sold in 2008. That result is multiplied by the result of the EXP function, which specifies a continuous growth rate of 7% over 10 years.

```
SELECT (SELECT SUM(qtysold)
FROM sales, date
WHERE sales.dateid=date.dateid
AND year=2008) * EXP((7::FLOAT/100)*10) qty2018;

+-------------------+
|      qty2018      |
+-------------------+
| 695447.4837722216 |
+-------------------+
```

FLOOR function

The FLOOR function rounds a number down to the next whole number.

Syntax

```
FLOOR(number)
```

Argument

number

The number or expression that evaluates to a number. It can be the SMALLINT, INTEGER, BIGINT, DECIMAL, FLOAT4, FLOAT8, or SUPER type.

Return type

FLOOR returns the same data type as its argument.

When the input is of the SUPER type, the output retains the same dynamic type as the input while the static type remains the SUPER type. When the dynamic type of SUPER isn't a number, Amazon Redshift returns NULL.

Examples

The following examples use the TICKIT sample database. For more information, see Sample database.

To show the value of the commission paid for a given sales transaction before and after using the FLOOR function, use the following example.

```
SELECT commission
FROM sales
WHERE salesid=10000;

+------------+
| commission |
+------------+
|      28.05 |
+------------+

SELECT FLOOR(commission)
FROM sales
WHERE salesid=10000;

+-------+
| floor |
+-------+
|    28 |
+-------+
```

LN function

Returns the natural logarithm of the input parameter.

Synonym of DLOG1 function.

Syntax

```
LN(expression)
```

Argument

expression

The target column or expression that the function operates on.

> **Note**
>
> This function returns an error for some data types if the expression references an Amazon Redshift user-created table or an Amazon Redshift STL or STV system table.

Expressions with the following data types produce an error if they reference a user-created or system table. Expressions with these data types run exclusively on the leader node:

- `BOOLEAN`
- `CHAR`
- `DATE`
- `DECIMAL` or `NUMERIC`
- `TIMESTAMP`
- `VARCHAR`

Expressions with the following data types run successfully on user-created tables and STL or STV system tables:

- `BIGINT`
- `DOUBLE PRECISION`
- `INTEGER`
- `REAL`
- `SMALLINT`

Return type

The LN function returns the same type as the input *expression*.

Examples

To return the natural logarithm or base `e` logarithm of the number 2.718281828, use the following example.

```
SELECT LN(2.718281828);

+--------------------+
|         ln         |
+--------------------+
| 0.9999999998311267 |
+--------------------+
```

Note that the answer is nearly equal to 1.

The following example uses the TICKIT sample database. For more information, see Sample database.

To return the natural logarithm of the values in the userid column in the USERS table, use the following example.

```
SELECT username, LN(userid) FROM users ORDER BY userid LIMIT 10;

+----------+--------------------+
| username |         ln         |
+----------+--------------------+
| JSG99FHE |                  0 |
| PGL08LJI | 0.6931471805599453 |
| IFT66TXU | 1.0986122886681098 |
| XDZ38RDD | 1.3862943611198906 |
| AEB55QTM | 1.6094379124341003 |
| NDQ15VBM |  1.791759469228055 |
| OWY35QYB | 1.9459101490553132 |
| AZG78YIP | 2.0794415416798357 |
| MSD36KVR | 2.1972245773362196 |
| WKW41AIW |  2.302585092994046 |
+----------+--------------------+
```

LOG function

Returns logarithm of a number.

If you're using this function to calculate the base 10 logarithm, you can also use DLOG10 function.

Syntax

```
LOG([base, ]argument)
```

Parameters

base

(Optional) The base of the logarithm function. This number must be positive and can't equal 1. If this parameter is omitted, Amazon Redshift computes the base 10 logarithm of the *argument*.

argument

The argument of the logarithm function. This number must be positive. If the *argument* value is 1, the function returns `0`.

Return type

The LOG function returns a `DOUBLE PRECISION` number.

Examples

To find the base 2 logarithm of 100, use the following example.

```
SELECT LOG(2, 100);
+-------------------+
|        log        |
+-------------------+
| 6.643856189774725 |
+-------------------+
```

To find the base 10 logarithm of 100, use the following example. Note that if you omit the base parameter, Amazon Redshift assumes a base of 10.

```
SELECT LOG(100);

+-----+
| log |
+-----+
|   2 |
+-----+
```

MOD function

Returns the remainder of two numbers, otherwise known as a *modulo* operation. To calculate the result, the first parameter is divided by the second.

Syntax

```
MOD(number1, number2)
```

Arguments

number1

The first input parameter is an `INTEGER`, `SMALLINT`, `BIGINT`, or `DECIMAL` number. If either parameter is a `DECIMAL` type, the other parameter must also be a `DECIMAL` type. If either parameter is an `INTEGER`, the other parameter can be an `INTEGER`, `SMALLINT`, or `BIGINT`. Both parameters can also be `SMALLINT` or `BIGINT`, but one parameter cannot be a `SMALLINT` if the other is a `BIGINT`.

number2

The second parameter is an `INTEGER`, `SMALLINT`, `BIGINT`, or `DECIMAL` number. The same data type rules apply to *number2* as to *number1*.

Return type

The return type of the MOD function is the same numeric type as the input parameters, if both input parameters are the same type. If either input parameter is an `INTEGER`, however, the return type will also be an `INTEGER`. Valid return types are `DECIMAL`, `INT`, `SMALLINT`, and `BIGINT`.

Usage notes

You can use `%` as a modulo operator.

Examples

To return the remainder when a number is divided by another, use the following example.

```
SELECT MOD(10, 4);

+-----+
| mod |
+-----+
|   2 |
+-----+
```

To return a `DECIMAL` result when using the MOD function, use the following example.

```
SELECT MOD(10.5, 4);

+-----+
| mod |
+-----+
| 2.5 |
+-----+
```

To cast a number before running the MOD function, use the following example. For more information, see CAST function.

```
SELECT MOD(CAST(16.4 AS INTEGER), 5);

+-----+
| mod |
+-----+
|   1 |
+-----+
```

To check if the first parameter is even by dividing it by 2, use the following example.

```
SELECT mod(5,2) = 0 AS is_even;

+---------+
| is_even |
+---------+
| false   |
+---------+
```

To use % as a modulo operator, use the following example.

```
SELECT 11 % 4 as remainder;

 +-----------+
| remainder |
+-----------+
|         3 |
+-----------+
```

The following example uses the TICKIT sample database. For more information, see Sample database.

To return information for odd-numbered categories in the CATEGORY table, use the following example.

```
SELECT catid, catname
FROM category
WHERE MOD(catid,2)=1
ORDER BY 1,2;

+-------+-----------+
| catid |  catname  |
+-------+-----------+
|     1 | MLB       |
|     3 | NFL       |
|     5 | MLS       |
|     7 | Plays     |
|     9 | Pop       |
|    11 | Classical |
+-------+-----------+
```

PI function

The PI function returns the value of pi to 14 decimal places.

Syntax

```
PI()
```

Return type

DOUBLE PRECISION

Examples

To return the value of pi, use the following example.

```
SELECT PI();

+-------------------+
|        pi         |
+-------------------+
| 3.141592653589793 |
+-------------------+
```

POWER function

The POWER function is an exponential function that raises a numeric expression to the power of a second numeric expression. For example, 2 to the third power is calculated as `POWER(2,3)`, with a result of 8.

Syntax

```
{POW | POWER}(expression1, expression2)
```

Arguments

expression1

Numeric expression to be raised. Must be an `INTEGER`, `DECIMAL`, or `FLOAT` data type.

expression2

Power to raise *expression1*. Must be an `INTEGER`, `DECIMAL`, or `FLOAT` data type.

Return type

`DOUBLE PRECISION`

Examples

The following examples use the TICKIT sample database. For more information, see [Sample database](#).

In the following example, the POWER function is used to forecast what ticket sales will look like in the next 10 years, based on the number of tickets sold in 2008 (the result of the subquery). The growth rate is set at 7% per year in this example.

```
SELECT (SELECT SUM(qtysold) FROM sales, date
WHERE sales.dateid=date.dateid
AND year=2008) * POW((1+7::FLOAT/100),10) qty2010;

+-------------------+
|      qty2010      |
+-------------------+
| 679353.7540885945 |
+-------------------+
```

The following example is a variation on the previous example, with the growth rate at 7% per year but the interval is set to months (120 months over 10 years).

```
SELECT (SELECT SUM(qtysold) FROM sales, date
WHERE sales.dateid=date.dateid
AND year=2008) * POW((1+7::FLOAT/100/12),120) qty2010;

+-----------------+
|     qty2010     |
+-----------------+
| 694034.54678046 |
+-----------------+
```

RADIANS function

The RADIANS function converts an angle in degrees to its equivalent in radians.

Syntax

```
RADIANS(number)
```

Argument

number

The input parameter is a `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Examples

To return the radian equivalent of 180 degrees, use the following example.

```
SELECT RADIANS(180);

+-------------------+
|      radians      |
+-------------------+
| 3.141592653589793 |
+-------------------+
```

RANDOM function

The RANDOM function generates a random value between 0.0 (inclusive) and 1.0 (exclusive).

Syntax

```
RANDOM()
```

Return type

DOUBLE PRECISION

Usage notes

Call RANDOM after setting a seed value with the SET command to cause RANDOM to generate numbers in a predictable sequence.

Examples

To compute a random value between 0 and 99, use the following example. If the random number is 0 to 1, this query produces a random number from 0 to 100.

```
SELECT CAST(RANDOM() * 100 AS INT);

+------+
| int4 |
+------+
|   59 |
+------+
```

This example uses the SET command to set a SEED value so that RANDOM generates a predictable sequence of numbers.

To return three RANDOM integers without setting the SEED value, use the following example.

```
SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|    6 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
```

```
+------+
| int4 |
+------+
|   68 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   56 |
+------+
```

To set the SEED value to `.25`, and return three more RANDOM numbers, use the following example.

```
SET SEED TO .25;
SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   21 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   79 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   12 |
+------+
```

To reset the SEED value to `.25`, and verify that RANDOM returns the same results as the previous three calls, use the following example.

```
SET SEED TO .25;
```

```
SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   21 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   79 |
+------+

SELECT CAST(RANDOM() * 100 AS INT);
+------+
| int4 |
+------+
|   12 |
+------+
```

The following examples use the TICKIT sample database. For more information, see [Sample database](#).

To retrieve a uniform random sample of 10 items from the SALES table, use the following example.

```
SELECT *
FROM sales
ORDER BY RANDOM()
LIMIT 10;

+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------+
| salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime        |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------+
|   45422 |  51114 |     5983 |   24482 |    4369 |   2118 |       1 |       195 |
 29.25 | 2008-10-19 05:20:07 |
|   42481 |  47638 |     4573 |    6198 |    6479 |   1987 |       4 |      1140 |
   171 | 2008-06-10 09:39:19 |
|   31494 |  34759 |    18895 |    4719 |    7753 |   2090 |       4 |      1024 |
 153.6 | 2008-09-21 03:44:26 |
```

```
|  119388 | 136685 |    21815 |   41905 |    2071 |   1884 |       1 |       359 |
 53.85 | 2008-02-27 10:43:10 |
|  166990 | 225037 |    18529 |    7628 |     746 |   2113 |       1 |      2009 |
 301.35 | 2008-10-14 10:07:44 |
|   11146 |  12096 |    42685 |    6619 |    1876 |   2123 |       1 |        29 |
  4.35 | 2008-10-24 06:23:54 |
|  148537 | 172056 |    15102 |   11787 |    6122 |   1923 |       2 |       480 |
    72 | 2008-04-07 03:58:23 |
|   68945 |  78387 |     7359 |   18323 |    6636 |   1910 |       1 |       457 |
 68.55 | 2008-03-25 08:31:03 |
|   52796 |  59576 |     9909 |   15102 |    7958 |   1951 |       1 |       479 |
 71.85 | 2008-05-05 02:25:08 |
|   90684 | 103522 |    38052 |   21549 |    7384 |   2117 |       1 |       313 |
 46.95 | 2008-10-18 05:43:11 |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------+
```

To retrieve a random sample of 10 items, but choose the items in proportion to their prices, use the following example. For example, an item that is twice the price of another would be twice as likely to appear in the query results.

```
SELECT *
FROM sales
ORDER BY -LOG(RANDOM()) / pricepaid
LIMIT 10;

+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------+
| salesid | listid | sellerid | buyerid | eventid | dateid | qtysold | pricepaid |
 commission |      saletime       |
+---------+--------+----------+---------+---------+--------+---------+-----------
+------------+---------------------+
|  158340 | 208208 |    17082 |   42018 |    1211 |   2160 |       4 |      6852 |
 1027.8 | 2008-11-30 12:21:43 |
|   53250 |  60069 |    12644 |    7066 |    7942 |   1838 |       4 |      1528 |
 229.2 | 2008-01-12 11:24:56 |
|   22929 |  24938 |    47314 |    6503 |     179 |   2000 |       3 |       741 |
 111.15 | 2008-06-23 08:04:50 |
|  164980 | 221181 |     1949 |   19670 |    1471 |   1906 |       1 |      1330 |
 199.5 | 2008-03-21 07:59:51 |
|  159641 | 211179 |    44897 |   16652 |    7458 |   2128 |       1 |      1019 |
 152.85 | 2008-10-29 02:02:15 |
```

```
|   73143 |  83439 |     5716 |    5727 |    7314 |   1903 |       1 |       248 |
  37.2 | 2008-03-18 11:07:42 |
|   84778 |  96749 |    46608 |   32980 |    3883 |   1999 |       2 |       958 |
 143.7 | 2008-06-22 12:13:31 |
|  171096 | 232929 |    43683 |    8536 |    8353 |   1870 |       1 |       929 |
 139.35 | 2008-02-13 01:36:36 |
|   74212 |  84697 |    39809 |   15569 |    5525 |   2105 |       2 |       896 |
 134.4 | 2008-10-06 11:47:50 |
|  158011 | 207556 |    25399 |   16881 |     232 |   2088 |       2 |      2526 |
 378.9 | 2008-09-19 06:00:26 |
+---------+--------+---------+---------+---------+--------+---------+-----------
+------------+--------------------+
```

ROUND function

The ROUND function rounds numbers to the nearest integer or decimal.

The ROUND function can optionally include a second argument as an `INTEGER` to indicate the number of decimal places for rounding, in either direction. When you don't provide the second argument, the function rounds to the nearest whole number. When the second argument *integer* is specified, the function rounds to the nearest number with *integer* decimal places of precision.

Syntax

```
ROUND(number [ , integer ] )
```

Arguments

number

A number or expression that evaluates to a number. It can be the `DECIMAL`, `FLOAT8` or `SUPER` type. Amazon Redshift can implicitly convert other numeric data types.

integer

(Optional) An `INTEGER` that indicates the number of decimal places for rounding in either direction. The `SUPER` data type isn't supported for this argument.

Return type

ROUND returns the same numeric data type as the input *number*.

When the input is of the SUPER type, the output retains the same dynamic type as the input while the static type remains the SUPER type. When the dynamic type of SUPER isn't a number, Amazon Redshift returns NULL.

Examples

The following examples use the TICKIT sample database. For more information, see Sample database.

To round the commission paid for a given transaction to the nearest whole number, use the following example.

```
SELECT commission, ROUND(commission)
FROM sales WHERE salesid=10000;

+------------+-------+
| commission | round |
+------------+-------+
|      28.05 |    28 |
+------------+-------+
```

To round the commission paid for a given transaction to the first decimal place, use the following example.

```
SELECT commission, ROUND(commission, 1)
FROM sales WHERE salesid=10000;

+------------+-------+
| commission | round |
+------------+-------+
|      28.05 |  28.1 |
+------------+-------+
```

To extend the precision in the opposite direction as the previous example, use the following example.

```
SELECT commission, ROUND(commission, -1)
FROM sales WHERE salesid=10000;

+------------+-------+
| commission | round |
```

```
+------------+-------+
|      28.05 |    30 |
+------------+-------+
```

SIN function

SIN is a trigonometric function that returns the sine of a number. The return value is between -1 and 1.

Syntax

```
SIN(number)
```

Argument

number

A DOUBLE PRECISION number in radians.

Return type

DOUBLE PRECISION

Examples

To return the sine of -PI, use the following example.

```
SELECT SIN(-PI());

+-------------------------+
|           sin           |
+-------------------------+
| -0.00000000000000012246 |
+-------------------------+
```

SIGN function

The SIGN function returns the sign (positive or negative) of a number. The result of the SIGN function is 1 if the argument is positive, -1 if the argument is negative, or 0 if the argument is 0.

Syntax

```
SIGN(number)
```

Argument

number

Number or expression that evaluates to a number. It can be a DECIMAL, FLOAT8, or SUPER type. Amazon Redshift can convert other data types per the implicit conversion rules.

Return type

SIGN returns the same numeric data type as the input argument. If the input is DECIMAL, the output is DECIMAL(1,0).

When the input is of the SUPER type, the output retains the same dynamic type as the input while the static type remains the SUPER type. When the dynamic type of SUPER isn't a number, Amazon Redshift returns a NULL.

Examples

The following example shows that column d in table t2 has DOUBLE PRECISION as its type since the input is DOUBLE PRECISION and that column n in table t2 has NUMERIC(1,0) as the output since the input is NUMERIC.

```
CREATE TABLE t1(d DOUBLE PRECISION, n NUMERIC(12, 2));
INSERT INTO t1 VALUES (4.25, 4.25), (-4.25, -4.25);
CREATE TABLE t2 AS SELECT SIGN(d) AS d, SIGN(n) AS n FROM t1;
SELECT table_name, column_name, data_type FROM SVV_REDSHIFT_COLUMNS WHERE
 table_name='t1' OR table_name='t2';

+------------+-------------+-----------------------+
| table_name | column_name |       data_type       |
+------------+-------------+-----------------------+
| t1         | d           | double precision      |
| t1         | n           | numeric(12,2)         |
| t2         | d           | double precision      |
| t2         | n           | numeric(1,0)          |
| t1         | col1        | character varying(20) |
```

```
+------------+-------------+-----------------------+
```

The following example uses the TICKIT sample database. For more information, see Sample database.

To determine the sign of the commission paid for a given transaction from the SALES table, use the following example.

```
SELECT commission, SIGN(commission)
FROM sales WHERE salesid=10000;

+------------+------+
| commission | sign |
+------------+------+
|      28.05 |    1 |
+------------+------+
```

SQRT function

The SQRT function returns the square root of a `NUMERIC` value. The square root is a number multiplied by itself to get the given value.

Syntax

```
SQRT(expression)
```

Argument

expression

The expression must have an `INTEGER`, `DECIMAL`, or `FLOAT` data type, or a data type that implicitly converts to those data types. The *expression* can include functions.

Return type

`DOUBLE PRECISION`

Examples

To return the square root of 16, use the following example.

```
SELECT SQRT(16);

+------+
| sqrt |
+------+
|    4 |
+------+
```

To return the square root of the string 16 using an implicit type conversion, use the following example.

```
SELECT SQRT('16');

+------+
| sqrt |
+------+
|    4 |
+------+
```

To return the square root of 16.4 after using the ROUND function, use the following example.

```
SELECT SQRT(ROUND(16.4));

+------+
| sqrt |
+------+
|    4 |
+------+
```

To return the length of the radius when given the area of a circle, use the following example. It calculates the radius in inches, for instance, when given the area in square inches. The area in the sample is 20.

```
SELECT SQRT(20/PI()) AS radius;

+--------------------+
|       radius       |
+--------------------+
| 2.5231325220201604 |
+--------------------+
```

The following examples use the TICKIT sample database. For more information, see [Sample database](#).

To return the square root for COMMISSION values from the SALES table, use the following example. The COMMISSION column is a `DECIMAL` column. This example shows how you can use the function in a query with more complex conditional logic.

```
SELECT SQRT(commission)
FROM sales WHERE salesid < 10 ORDER BY salesid;

+--------------------+
|        sqrt        |
+--------------------+
| 10.449880382090505 |
| 3.3763886032268267 |
|  7.245688373094719 |
|  5.123475382979799 |
|  4.806245936279167 |
|  7.687652437513028 |
| 10.871982339941507 |
| 5.4359911699707535 |
|   9.41541289588513 |
+--------------------+
```

To return the rounded square root for the same set of COMMISSION values, use the following example.

```
SELECT ROUND(SQRT(commission))
FROM sales WHERE salesid < 10 ORDER BY salesid;

+-------+
| round |
+-------+
|    10 |
|     3 |
|     7 |
|     5 |
|     5 |
|     8 |
|    11 |
|     5 |
|     9 |
```

```
+--------+
```

TAN function

TAN is a trigonometric function that returns the tangent of a number. The input argument is a number (in radians).

Syntax

```
TAN(number)
```

Argument

number

A `DOUBLE PRECISION` number.

Return type

`DOUBLE PRECISION`

Examples

To return the tangent of zero, use the following example.

```
SELECT TAN(0);

+-----+
| tan |
+-----+
|   0 |
+-----+
```

TRUNC function

The TRUNC function truncates numbers to the previous integer or decimal.

The TRUNC function can optionally include a second argument as an `INTEGER` to indicate the number of decimal places for rounding, in either direction. When you don't provide the second argument, the function rounds to the nearest whole number. When the second argument *integer* is specified, the function rounds to the nearest number with *integer* decimal places of precision.

This function can also truncate a TIMESTAMP and return a DATE. For more information, see TRUNC function.

Syntax

```
TRUNC(number [ , integer ])
```

Arguments

number

A number or an expression that evaluates to a number. It can be the DECIMAL, FLOAT8 or SUPER type. Amazon Redshift can convert other data types per the implicit conversion rules.

integer

(Optional) An INTEGER that indicates the number of decimal places of precision, in either direction. If no *integer* is provided, the number is truncated as a whole number; if an *integer* is specified, the number is truncated to the specified decimal place. This isn't supported for the SUPER data type.

Return type

TRUNC returns the same data type as the input *number*.

When the input is of the SUPER type, the output retains the same dynamic type as the input while the static type remains the SUPER type. When the dynamic type of SUPER isn't a number, Amazon Redshift returns NULL.

Examples

Some of the following examples use the TICKIT sample database. For more information, see Sample database.

To truncate the commission paid for a given sales transaction, use the following example.

```
SELECT commission, TRUNC(commission)
FROM sales WHERE salesid=784;
```

```
+------------+-------+
| commission | trunc |
+------------+-------+
|     111.15 |   111 |
+------------+-------+
```

To truncate the same commission value to the first decimal place, use the following example.

```
SELECT commission, TRUNC(commission,1)
FROM sales WHERE salesid=784;

+------------+-------+
| commission | trunc |
+------------+-------+
|     111.15 | 111.1 |
+------------+-------+
```

To truncate the commission with a negative value for the second argument, use the following example. Note that `111.15` is rounded down to `110`.

```
SELECT commission, TRUNC(commission,-1)
FROM sales WHERE salesid=784;

+------------+-------+
| commission | trunc |
+------------+-------+
|     111.15 |   110 |
+------------+-------+
```

Object functions

Following are the SQL object functions that Amazon Redshift supports to create SUPER type objects:

Topics

LOWER_ATTRIBUTE_NAMES function

Converts all applicable attribute names in a SUPER value to lowercase, using the same case conversion routine as the LOWER function. LOWER_ATTRIBUTE_NAMES supports UTF-8 multibyte characters, up to a maximum of four bytes per character.

To convert SUPER attribute names to uppercase, use the UPPER_ATTRIBUTE_NAMES function.

Syntax

```
LOWER_ATTRIBUTE_NAMES(super_expression)
```

Arguments

super_expression

A SUPER expression.

Return type

SUPER

Usage notes

In Amazon Redshift, column identifiers are traditionally case-insensitive and converted to lowercase. If you ingest data from case-sensitive data formats such as JSON, the data might contain mixed-case attribute names.

Consider the following example.

```
CREATE TABLE t1 (s) AS SELECT JSON_PARSE('{"AttributeName": "Value"}');


SELECT s.AttributeName FROM t1;

attributename
-------------
NULL


SELECT s."AttributeName" FROM t1;
```

```
attributename
-------------
NULL
```

Amazon Redshift returns NULL for both queries. To query `AttributeName`, use LOWER_ATTRIBUTE_NAMES to convert the data's attribute names to lowercase. Consider the following example.

```
CREATE TABLE t2 (s) AS SELECT LOWER_ATTRIBUTE_NAMES(s) FROM t1;


SELECT s.attributename FROM t2;

attributename
-------------
"Value"


SELECT s.AttributeName FROM t2;

attributename
-------------
"Value"


SELECT s."attributename" FROM t2;

attributename
-------------
"Value"


SELECT s."AttributeName" FROM t2;

attributename
-------------
"Value"
```

A related option for working with mixed-case object attribute names is the `enable_case_sensitive_super_attribute` configuration option, which lets Amazon Redshift recognize case in SUPER attribute names. This can be an alternative solution to using LOWER_ATTRIBUTE_NAMES. For more information about `enable_case_sensitive_super_attribute`, go to enable_case_sensitive_super_attribute.

Examples

Converting SUPER attribute names to lowercase

The following example uses LOWER_ATTRIBUTE_NAMES to convert the attribute names of all SUPER values in a table.

```
-- Create a table and insert several SUPER values.
CREATE TABLE t (i INT, s SUPER);

INSERT INTO t VALUES
  (1, NULL),
  (2, 'A'::SUPER),
  (3, JSON_PARSE('{"AttributeName": "B"}')),
  (4, JSON_PARSE(
     '[{"Subobject": {"C": "C"},
        "Subarray": [{"D": "D"}, "E"]
      }]'));

-- Convert all attribute names to lowercase.
UPDATE t SET s = LOWER_ATTRIBUTE_NAMES(s);

SELECT i, s FROM t ORDER BY i;

 i |                        s
---+-----------------------------------------------------
 1 | NULL
 2 | "A"
 3 | {"attributename":"B"}
 4 | [{"subobject":{"c":"C"},"subarray":[{"d":"D"}, "E"]}]
```

Observe how LOWER_ATTRIBUTE_NAMES functions.

- NULL values and scalar SUPER values such as `"A"` are unchanged.
- In a SUPER object, all attribute names are changed to lowercase, but attribute values such as `"B"` remain unchanged.
- LOWER_ATTRIBUTE_NAMES applies recursively to any SUPER object that is nested inside a SUPER array or inside another object.

Using LOWER_ATTRIBUTE_NAMES on a SUPER object with duplicate attribute names

If a SUPER object contains attributes whose names differ only in their case, LOWER_ATTRIBUTE_NAMES will raise an error. Consider the following example.

```
SELECT LOWER_ATTRIBUTE_NAMES(JSON_PARSE('{"A": "A", "a": "a"}'));

error:   Invalid input
code:    8001
context: SUPER value has duplicate attributes after case conversion.
```

OBJECT function

Creates an object of the SUPER data type.

Syntax

```
OBJECT ( [ key1, value1 ], [ key2, value2 ...] )
```

Arguments

key1, key2

Expressions that evaluate to VARCHAR type strings.

value1, value2

Expressions of any Amazon Redshift data type except datetime types, since Amazon Redshift doesn't cast datetime types to the SUPER data type. For more information on datetime types, see Datetime types.

`value` expressions in an object don't need to be of the same data type.

Return type

SUPER

Example

```
-- Creates an empty object.
select object();

object
```

```
--------
{}
(1 row)

-- Creates objects with different keys and values.
select object('a', 1, 'b', true, 'c', 3.14);

object
---------------------------
{"a":1,"b":true,"c":3.14}
(1 row)

select object('a', object('aa', 1), 'b', array(2,3), 'c', json_parse('{}'));

object
---------------------------------
{"a":{"aa":1},"b":[2,3],"c":{}}
(1 row)

-- Creates objects using columns from a table.
create table bar (k varchar, v super);
insert into bar values ('k1', json_parse('[1]')), ('k2', json_parse('{}'));
select object(k, v) from bar;

object
------------
{"k1":[1]}
{"k2":{}}
(2 rows)

-- Errors out because DATE type values can't be converted to SUPER type.
select object('k', '2008-12-31'::date);

ERROR:  OBJECT could not convert type date to super
```

OBJECT_TRANSFORM function

Transforms a SUPER object.

Syntax

```
OBJECT_TRANSFORM(
  input
```

```
  [KEEP path1, ...]
  [SET
    path1, value1,
    ...,  ...
  ]
)
```

Arguments

input

An expression that resolves to a SUPER type object.

KEEP

All *path* values specified in this clause are kept and carried over to the output object.

This clause is optional.

path1, *path2*, ...

Constant string literals, in the format of double-quoted path components delimited by periods. For example, `'"a"."b"."c"'` is a valid path value. This applies to the path parameter in both the KEEP and SET clauses.

SET

path and *value* pairs to modify an exiting path or add a new path, and set the value of that path in the output object.

This clause is optional.

value1, *value2*, ...

Expressions that resolve to SUPER type values. Note that numeric, text, and Boolean types are resolvable to SUPER.

Return type

SUPER

Usage notes

OBJECT_TRANSFORM returns a SUPER type object containing the path values from *input* that were specified in KEEP and the *path* and *value* pairs that were specified in SET.

If both KEEP and SET are empty, OBJECT_TRANSFORM returns *input*.

If *input* isn't a SUPER type *object*, OBJECT_TRANSFORM returns *input*, regardless of any KEEP or SET values.

Example

The following example transforms a SUPER object into another SUPER object.

```
CREATE TABLE employees (
    col_person SUPER
);

INSERT INTO employees
VALUES
    (
        json_parse('
            {
                "name": {
                    "first": "John",
                    "last": "Doe"
                },
                "age": 25,
                "ssn": "111-22-3333",
                "company": "Company Inc.",
                "country": "U.S."
            }
        ')
    ),
    (
        json_parse('
            {
                "name": {
                    "first": "Jane",
                    "last": "Appleseed"
                },
                "age": 34,
                "ssn": "444-55-7777",
                "company": "Organization Org.",
                "country": "Ukraine"
            }
        ')
    )
;
```

```
SELECT
    OBJECT_TRANSFORM(
        col_person
        KEEP
            '"name"."first"',
            '"age"',
            '"company"',
            '"country"'
        SET
            '"name"."first"', UPPER(col_person.name.first::TEXT),
            '"age"', col_person.age + 5,
            '"company"', 'Amazon'
    ) AS col_person_transformed
FROM employees;

--This result is formatted for ease of reading.
                  col_person_transformed
-------------------------------------------------------------
{
    "name": {
        "first": "JOHN"
    },
    "age": 30,
    "company": "Amazon",
    "country": "U.S."
}
{
    "name": {
        "first": "JANE"
    },
    "age": 39,
    "company": "Amazon",
    "country": "Ukraine"
}
```

UPPER_ATTRIBUTE_NAMES function

Converts all applicable attribute names in a SUPER value to uppercase, using the same case conversion routine as the UPPER function. UPPER_ATTRIBUTE_NAMES supports UTF-8 multibyte characters, up to a maximum of four bytes per character.

To convert SUPER attribute names to lowercase, use the LOWER_ATTRIBUTE_NAMES function.

Syntax

```
UPPER_ATTRIBUTE_NAMES(super_expression)
```

Arguments

super_expression

A SUPER expression.

Return type

SUPER

Examples

Converting SUPER attribute names to uppercase

The following example uses UPPER_ATTRIBUTE_NAMES to convert the attribute names of all SUPER values in a table.

```
-- Create a table and insert several SUPER values.
CREATE TABLE t (i INT, s SUPER);

INSERT INTO t VALUES
  (1, NULL),
  (2, 'a'::SUPER),
  (3, JSON_PARSE('{"AttributeName": "b"}')),
  (4, JSON_PARSE(
     '[{"Subobject": {"c": "c"},
        "Subarray": [{"d": "d"}, "e"]
      }]'));

-- Convert all attribute names to uppercase.
UPDATE t SET s = UPPER_ATTRIBUTE_NAMES(s);

SELECT i, s FROM t ORDER BY i;

 i |                        s
---+-------------------------------------------------
 1 | NULL
 2 | "a"
```

```
 3 | {"ATTRIBUTENAME":"B"}
 4 | [{"SUBOBJECT":{"C":"c"},"SUBARRAY":[{"D":"d"}, "e"]}]
```

Observe how UPPER_ATTRIBUTE_NAMES functions.

- NULL values and scalar SUPER values such as "a" are unchanged.
- In a SUPER object, all attribute names are changed to uppercase, but attribute values such as "b" remain unchanged.
- UPPER_ATTRIBUTE_NAMES applies recursively to any SUPER object that is nested inside a SUPER array or inside another object.

Using UPPER_ATTRIBUTE_NAMES on a SUPER object with duplicate attribute names

If a SUPER object contains attributes whose names differ only in their case, UPPER_ATTRIBUTE_NAMES will raise an error. Consider the following example.

```
SELECT UPPER_ATTRIBUTE_NAMES(JSON_PARSE('{"A": "A", "a": "a"}'));

error:   Invalid input
code:    8001
context: SUPER value has duplicate attributes after case conversion.
```

Spatial functions

Relationships between geometry objects are based on the Dimensionally Extended nine-Intersection Model (DE-9IM). This model defines predicates such as equals, contains, and covers. For more information about the definition of spatial relationships, see DE-9IM in Wikipedia.

For more information about how to use spatial data with Amazon Redshift, see Querying spatial data in Amazon Redshift.

Amazon Redshift provides spatial functions that work with GEOMETRY and GEOGRAPHY data types. The following lists the functions that support the GEOGRAPHY data type:

- ST_Area
- ST_AsEWKT
- ST_AsGeoJSON

- ST_AsHexEWKB
- ST_AsHexWKB
- ST_AsText
- ST_Distance
- ST_GeogFromText
- ST_GeogFromWKB
- ST_Length
- ST_NPoints
- ST_Perimeter

The following lists the full set of spatial functions supported by Amazon Redshift.

Topics

- ST_AsHexEWKB
- ST_AsText
- ST_Azimuth
- ST_Boundary
- ST_Buffer
- ST_Centroid
- ST_Collect
- ST_Contains
- ST_ContainsProperly
- ST_ConvexHull
- ST_CoveredBy
- ST_Covers
- ST_Crosses
- ST_Dimension
- ST_Disjoint
- ST_Distance
- ST_DistanceSphere
- ST_DWithin
- ST_EndPoint
- ST_Envelope
- ST_Equals
- ST_ExteriorRing
- ST_Force2D
- ST_Force3D
- ST_Force3DM
- ST_Force3DZ
- ST_Force4D
- ST_GeoHash

AddBBox

AddBBox returns a copy of the input geometry that supports encoding with a precomputed bounding box. For more information about support for bounding boxes, see Bounding box.

Syntax

```
AddBBox(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY

If *geom* is null, then null is returned.

Examples

The following SQL returns a copy of an input polygon geometry that supports being encoded with a bounding box.

```
SELECT ST_AsText(AddBBox(ST_GeomFromText('POLYGON((0 0,1 0,0 1,0 0))')));
```

```
 st_astext
----------
 POLYGON((0 0,1 0,0 1,0 0))
```

DropBBox

DropBBox returns a copy of the input geometry that doesn't support encoding with a precomputed bounding box. For more information about support for bounding boxes, see Bounding box.

Syntax

```
DropBBox(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY

If *geom* is null, then null is returned.

Examples

The following SQL returns a copy of an input polygon geometry that doesn't support being encoded with a bounding box.

```
SELECT ST_AsText(DropBBox(ST_GeomFromText('POLYGON((0 0,1 0,0 1,0 0))')));
```

```
 st_astext
----------
 POLYGON((0 0,1 0,0 1,0 0))
```

GeometryType

GeometryType returns the subtype of an input geometry as a string.

Syntax

```
GeometryType(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`VARCHAR` representing the subtype of *geom*.

If *geom* is null, then null is returned.

The values returned are as follows.

Returned string value for 2D, 3DZ, 4D geometries	Returned string value for 3DM geometries	Geometry subtype
`POINT`	`POINTM`	Returned if *geom* is a `POINT` subtype
`LINESTRING`	`LINESTRINGM`	Returned if *geom* is a `LINESTRING` subtype

Returned string value for 2D, 3DZ, 4D geometries	Returned string value for 3DM geometries	Geometry subtype
`POLYGON`	`POLYGONM`	Returned if *geom* is a `POLYGON` subtype
`MULTIPOINT`	`MULTIPOINTM`	Returned if *geom* is a `MULTIPOINT` subtype
`MULTILINESTRING`	`MULTILINESTRINGM`	Returned if *geom* is a `MULTILINESTRING` subtype
`MULTIPOLYGON`	`MULTIPOLYGONM`	Returned if *geom* is a `MULTIPOLYGON` subtype
`GEOMETRYCOLLECTION`	`GEOMETRYCOLLECTIONM`	Returned if *geom* is a `GEOMETRYCOLLECTION` subtype

Examples

The following SQL converts a well-known text (WKT) representation of a polygon and returns the `GEOMETRY` subtype as a string.

```
SELECT GeometryType(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

```
geometrytype
-------------
 POLYGON
```

H3_Boundary

H3_Boundary returns the boundary of an H3 cell ID from an input index. For information about H3 indexing, see H3.

Syntax

```
H3_Boundary(index)
```

Arguments

index

A value of data type BIGINT or VARCHAR that represents the index of an H3 cell. Or, an expression that evaluates to one of these data types.

Return type

POLYGON – represents the polygon with spatial reference system identifier (SRID) of 0.

If *index* is not valid, then an error is returned.

Examples

The following SQL inputs a VARCHAR that represents the index of an H3 cell, and returns a POLYGON with SRID 0 that represents the boundary of the input H3 cell. The output of H3_Boundary is input to ST_AwEWKT to display in extended well-known text (EWKT) representation.

```
SELECT ST_AsEWKT(H3_Boundary('8025fffffffffff'));
```

```
 st_asewkt
-----------------------------------------------------------------------------------------------------
 POLYGON((87.7729641223953 52.6542030078627,86.7082098104731
 40.3127667561966,98.2285042557705 33.6210697806835,110.694610548823
 37.163896485796,116.212895637138 47.3094513028131,106.40349563788
 56.210610737585,87.7729641223953 52.6542030078627))
```

The following SQL inputs a BIGINT that represents the index of an H3 cell, and returns a POLYGON with SRID 0 that represents the boundary of the input H3 cell. The output of H3_Boundary is input to ST_AwEWKT to display in extended well-known text (EWKT) representation.

```
SELECT ST_AsEWKT(H3_Boundary(577129255373111295));
```

```
 st_asewkt
-----------------------------------------------------------------------------------------------------
```

```
POLYGON((87.7729641223953 52.6542030078627,86.7082098104731
 40.3127667561966,98.2285042557705 33.6210697806835,110.694610548823
 37.163896485796,116.212895637138 47.3094513028131,106.40349563788
 56.210610737585,87.7729641223953 52.6542030078627))
```

H3_Center

H3_Center returns the centroid of an H3 cell ID from an input index. For information about H3 indexing, see H3.

Syntax

```
H3_Center(index)
```

Arguments

index

A value of data type `BIGINT` or `VARCHAR` that represents the index of an H3 cell. Or, an expression that evaluates to one of these data types.

Return type

`POINT` – represents the centroid of the H3 cell with spatial reference system identifier (SRID) of `0`.

If *index* is not valid, then an error is returned.

Examples

The following SQL inputs a `VARCHAR` that represents the index of an H3 cell, and returns a POINT with SRID of 0 that represents the centroid of the input H3 cell.

```
SELECT H3_Center('8025fffffffffff');
```

```
 h3_center
--------------------------------------------
 010100000070707A550B605940AEE9D70B327E4640
```

The following SQL inputs a `BIGINT` that represents the index of an H3 cell, and returns a POINT with SRID 0 that represents the centroid of the input H3 cell.

```
SELECT H3_Center(577129255373111295);
```

```
 h3_center
---------------------------------------------
 010100000070707A550B605940AEE9D70B327E4640
```

The following SQL inputs a VARCHAR that represents the index of an H3 cell, and returns a POINT with SRID 0 that represents the centroid of the input H3 cell. The output of H3_Center is input to ST_AwEWKT to display in extended well-known text (EWKT) representation.

```
SELECT ST_AsEWKT(H3_Center('8075fffffffffff'));
```

```
 st_asewkt
-----------------------------------------
POINT(-5.24539029677733 2.30088211162675)
```

H3_FromLongLat

H3_FromLongLat returns the corresponding H3 cell ID from an input longitude, latitude, and resolution. For information about H3 indexing, see H3.

Syntax

```
H3_FromLongLat(longitude, latitude, resolution)
```

Arguments

longitude

A value of data type DOUBLE PRECISION or an expression that evaluates to a DOUBLE PRECISION type.

latitude

A value of data type DOUBLE PRECISION or an expression that evaluates to a DOUBLE PRECISION type.

resolution

A value of data type `INTEGER` or an expression that evaluates to an `INTEGER` type. The value represents the resolution of the H3 grid system. The value must be an integer between 0–15, inclusive. With `0` being the coarsest and `15` being the finest.

Return type

`BIGINT` – represents the H3 cell ID.

If *resolution* is out of bounds, then an error is returned.

Examples

The following SQL returns the H3 cell ID from longitude `0`, latitude `0`, and resolution `10`.

```
SELECT H3_FromLongLat(0, 0, 10);
```

```

 h3_fromlonglat
-------------------
 623560421467684863
```

H3_FromPoint

H3_FromPoint returns the corresponding H3 cell ID from an input geometry point and resolution. For information about H3 indexing, see H3.

Syntax

```
H3_FromPoint(geom, resolution)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The *geom* must be a `POINT`.

resolution

A value of data type INTEGER or an expression that evaluates to an INTEGER type. The value represents the resolution of the H3 grid system. The value must be an integer between 0–15, inclusive. With 0 being the coarsest and 15 being the finest.

Return type

BIGINT – represents the H3 cell ID.

If *geom* is not a POINT, then an error is returned.

If *resolution* is out of bounds, then an error is returned.

If *geom* is empty, then NULL is returned.

Examples

The following SQL returns the H3 cell ID from point 0,0, and resolution 10.

```
SELECT H3_FromPoint(ST_GeomFromText('POINT(0 0)'), 10);
```

```

 h3_frompoint
--------------------
 623560421467684863
```

H3_Polyfill

H3_Polyfill returns the corresponding H3 cell IDs that correspond to the hexagons and pentagons that are contained in the input polygon of the given resolution. For information about H3 indexing, see H3.

Syntax

```
H3_Polyfill(geom, resolution)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The *geom* must be a POLYGON.

resolution

A value of data type INTEGER or an expression that evaluates to an INTEGER type. The value represents the resolution of the H3 grid system. The value must be an integer between 0–15, inclusive. With 0 being the coarsest and 15 being the finest.

Return type

SUPER – represents a list of H3 cell IDs.

If *geom* is not a POLYGON, then an error is returned.

If *resolution* is out of bounds, then an error is returned.

If *geom* is empty, then NULL is returned.

Examples

The following SQL returns a SUPER data type array of H3 cell IDs from a polygon and resolution 4.

```
SELECT H3_Polyfill(ST_GeomFromText('POLYGON((0 0, 0 1, 1 1, 1 0, 0 0))'), 4);
```

```
 h3_polyfill
-------------------------------------------------------------------------------------------------------
 [596538848238895103,596538805289222143,596538856828829695,596538813879156735,59653792052595916
```

ST_AddPoint

ST_AddPoint returns a linestring geometry that is the same as the input geometry with a point added. If an index is provided, then the point is added at the index position. If the index is -1 or not provided, then the point is appended to the linestring.

The index is zero-based. The spatial reference system identifier (SRID) of the result is the same as that of the input geometry.

The dimension of the returned geometry is the same as that of the *geom1* value. If *geom1* and *geom2* have different dimensions, *geom2* is projected to the dimension of *geom1*.

Syntax

```
ST_AddPoint(geom1, geom2)
```

```
ST_AddPoint(geom1, geom2, index)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `POINT`. The point can be the empty point.

index

A value of data type `INTEGER` that represents the position of a zero-based index.

Return type

`GEOMETRY`

If *geom1*, *geom2*, or *index* is null, then null is returned.

If *geom2* is the empty point, then a copy of *geom1* is returned.

If *geom1* is not a `LINESTRING`, then an error is returned.

If *geom2* is not a `POINT`, then an error is returned.

If *index* is out of range, then an error is returned. Valid values for the index position are -1 or a value between 0 and `ST_NumPoints(geom1)`.

Examples

The following SQL adds a point to a linestring to make it a closed linestring.

```
WITH tmp(g) AS (SELECT ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0 5)',4326))
SELECT ST_AsEWKT(ST_AddPoint(g, ST_StartPoint(g))) FROM tmp;
```

```
 st_asewkt
-------------------------------------------------
 SRID=4326;LINESTRING(0 0,10 0,10 10,5 5,0 5,0 0)
```

The following SQL adds a point to a specific position in a linestring.

```
WITH tmp(g) AS (SELECT ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0 5)',4326))
SELECT ST_AsEWKT(ST_AddPoint(g, ST_SetSRID(ST_Point(5, 10), 4326), 3)) FROM tmp;
```

```
 st_asewkt
-------------------------------------------------
 SRID=4326;LINESTRING(0 0,10 0,10 10,5 10,5 5,0 5)
```

ST_Angle

ST_Angle returns the angle in radians between points measured clockwise as follows:

- If three points are input, then the returned angle P1-P2-P3 is measured as if the angle was obtained by rotating from P1 to P3 around P2 clockwise.
- If four points are input, then the returned clockwise angle formed by the directed lines P1-P2 and P3-P4 is returned. If the input is a degenerate case (that is, P1 equals P2, or P3 equals P4), then null is returned.

The return value is in radians and in the range [0, 2π).

ST_Angle operates on 2D projections of the input geometries.

Syntax

```
ST_Angle(geom1, geom2, geom3)
```

```
ST_Angle(geom1, geom2, geom3, geom4)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT.

geom3

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT.

geom4

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT.

Return type

DOUBLE PRECISION.

If *geom1* equals *geom2*, or *geom2* equals *geom3*, then a null is returned.

If *geom1*, *geom2*, *geom3*, or *geom4* is null, then a null is returned.

If any of *geom1*, *geom2*, *geom3*, or *geom4* is the empty point, then an error is returned.

If *geom1*, *geom2*, *geom3*, and *geom4* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

Examples

The following SQL returns the angle converted to degrees of three input points.

```
SELECT ST_Angle(ST_Point(1,1), ST_Point(0,0), ST_Point(1,0)) / Pi() * 180.0 AS angle;
```

```
 angle
---------------
```

```
    45
```

The following SQL returns the angle converted to degrees of four input points.

```
SELECT ST_Angle(ST_Point(1,1), ST_Point(0,0), ST_Point(1,0), ST_Point(2,0)) / Pi() *
 180.0 AS angle;
```

```

 angle
---------------
   225
```

ST_Area

For an input geometry, ST_Area returns the Cartesian area of the 2D projection. The area units are the same as the units in which the coordinates of the input geometry are expressed. For points, linestrings, multipoints, and multilinestrings, the function returns 0. For geometry collections, it returns the sum of the areas of the geometries in the collection.

For an input geography, ST_Area returns the geodesic area of the 2D projection of an input areal geography computed on the spheroid determined by the SRID. The unit of length is in square meters. The function returns zero (0) for points, multipoints, and linear geographies. When the input is a geometry collection, the function returns the sum of the areas of the areal geographies in the collection.

Syntax

```
ST_Area(geo)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

Return type

`DOUBLE PRECISION`

If *geo* is null, then null is returned.

Examples

The following SQL returns the Cartesian area of a multipolygon.

```
SELECT ST_Area(ST_GeomFromText('MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((10 0,20 0,20 10,10
 0)))'));
```

```
 st_area
---------
     100
```

The following SQL returns the area of a polygon in a geography.

```
SELECT ST_Area(ST_GeogFromText('polygon((34 35, 28 30, 25 34, 34 35))'));
```

```
     st_area
------------------
 201824655743.383
```

The following SQL returns zero for a linear geography.

```
SELECT ST_Area(ST_GeogFromText('multipoint(0 0, 1 1, -21.32 121.2)'));
```

```
 st_area
---------
       0
```

ST_AsBinary

ST_AsBinary returns the hexadecimal well-known binary (WKB) representation of an input geometry. For 3DZ, 3DM, and 4D geometries, ST_AsBinary uses the Open Geospatial Consortium (OGC) standard value for the geometry type.

Syntax

```
ST_AsBinary(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`VARBYTE`

If *geom* is null, then null is returned.

Examples

The following SQL returns the hexadecimal WKB representation of a polygon.

```
SELECT ST_AsBinary(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```

```
st_asbinary
--------------------------------
01030000000100000005000000000000000000000000000000000000000000000000000000000000000000F03F00000
```

ST_AsEWKB

ST_AsEWKB returns the extended well-known binary (EWKB) representation of an input geometry. For 3DZ, 3DM, and 4D geometries, ST_AsEWKB uses the Open Geospatial Consortium (OGC) standard value for the geometry type.

Syntax

```
ST_AsEWKB(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

VARBYTE

If *geom* is null, then null is returned.

Examples

The following SQL returns the hexadecimal EWKB representation of a polygon.

```
SELECT ST_AsEWKB(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```

```

st_asewkb
--------------------------------
0103000020E61000000100000005000000000000000000000000000000000000000000000000000000000000000000F
```

ST_AsEWKT

ST_AsEWKT returns the extended well-known text (EWKT) representation of an input geometry or geography. For 3DZ, 3DM, and 4D geometries, ST_AsEWKT appends Z, M, or ZM to the WKT value for the geometry type.

Syntax

```
ST_AsEWKT(geo)
```

```
ST_AsEWKT(geo, precision)
```

Arguments

geo

A value of data type GEOMETRY or GEOGRAPHY, or an expression that evaluates to a GEOMETRY or GEOGRAPHY type.

precision

A value of data type INTEGER. For geometries, the coordinates of *geo* are displayed using the specified precision 1–20. If *precision* is not specified, the default is 15. For geographies, the coordinates of *geo* are displayed using the specified precision. If *precision* is not specified, the default is 15.

Return type

VARCHAR

If *geo* is null, then null is returned.

If *precision* is null, then null is returned.

If the result is larger than a 64-KB VARCHAR, then an error is returned.

Examples

The following SQL returns the EWKT representation of a linestring.

```
SELECT ST_AsEWKT(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)', 4326));
```

```


st_asewkt
--------------------------------
 SRID=4326;LINESTRING(3.14159265358979 -6.28318530717959,2.71828182845905
 -1.41421356237309)
```

The following SQL returns the EWKT representation of a linestring. The coordinates of the geometries are displayed with six digits of precision.

```
SELECT ST_AsEWKT(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)', 4326), 6);
```

```


st_asewkt
--------------------------------
 SRID=4326;LINESTRING(3.14159 -6.28319,2.71828 -1.41421)
```

The following SQL returns the EWKT representation of a geography.

```
SELECT ST_AsEWKT(ST_GeogFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)'));
```

```
                  st_asewkt
----------------------------------------------
 SRID=4326;LINESTRING(110 40,2 3,-10 80,-7 9)
```

ST_AsGeoJSON

ST_AsGeoJSON returns the GeoJSON representation of an input geometry or geography. For more information about GeoJSON, see [GeoJSON](https://en.wikipedia.org/wiki/GeoJSON) in Wikipedia.

For 3DZ and 4D geometries, the output geometry is a 3DZ projection of the input 3DZ or 4D geometry. That is, the `x`, `y`, and `z` coordinates are present in the output. For 3DM geometries, the output geometry is a 2D projection of the input 3DM geometry. That is, only `x` and `y` coordinates are present in the output.

For input geographies, ST_AsGeoJSON returns the GeoJSON representation of an input geography. The coordinates of the geography are displayed using the specified precision.

Syntax

```
ST_AsGeoJSON(geo)
```

```
ST_AsGeoJSON(geo, precision)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

precision

A value of data type `INTEGER`. For geometries, the coordinates of *geo* are displayed using the specified precision 1–20. If *precision* is not specified, the default is 15. For geographies, the coordinates of *geo* are displayed using the specified precision. If *precision* is not specified, the default is 15.

Return type

VARCHAR

If *geo* is null, then null is returned.

If *precision* is null, then null is returned.

If the result is larger than a 64-KB VARCHAR, then an error is returned.

Examples

The following SQL returns the GeoJSON representation of a linestring.

```
SELECT ST_AsGeoJSON(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)'));
```

```


st_asgeojson
-------------------------------------------------------------------------------------------------------------------
 {"type":"LineString","coordinates":[[3.14159265358979,-6.28318530717959],
[2.71828182845905,-1.41421356237309]]}
```

The following SQL returns the GeoJSON representation of a linestring. The coordinates of the geometries are displayed with six digits of precision.

```
SELECT ST_AsGeoJSON(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)'), 6);
```

```


st_asgeojson
-----------------------------------------------------------------------------
  {"type":"LineString","coordinates":[[3.14159,-6.28319],[2.71828,-1.41421]]}
```

The following SQL returns the GeoJSON representation of a geography.

```
SELECT ST_AsGeoJSON(ST_GeogFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)'));
```

```
                              st_asgeojson
-----------------------------------------------------------------------
 {"type":"LineString","coordinates":[[110,40],[2,3],[-10,80],[-7,9]]}
```

ST_AsHexWKB

ST_AsHexWKB returns the hexadecimal well-known binary (WKB) representation of an input geometry or geography using ASCII hexadecimal characters (0–9, A–F). For 3DZ, 3DM, and 4D geometries or geographies, ST_AsHexWKB uses the Open Geospatial Consortium (OGC) standard value for the geometry or geography type.

Syntax

```
ST_AsHexWKB(geo)
```

Arguments

geo

A value of data type GEOMETRY or GEOGRAPHY, or an expression that evaluates to a GEOMETRY or GEOGRAPHY type.

Return type

VARCHAR

If *geo* is null, then null is returned.

If the result is larger than a 64-KB VARCHAR, then an error is returned.

Examples

The following SQL returns the hexadecimal WKB representation of a polygon in a geometry.

```
SELECT ST_AsHexWKB(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```

```
st_ashexwkb
--------------------------------
01030000000100000005000000000000000000000000000000000000000000000000000000000000000000F03F00000
```

The following SQL returns the hexadecimal WKB representation of a polygon in a geography.

```
SELECT ST_AsHexWKB(ST_GeogFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))'));
```

```
st_ashexwkb
--------------------------------
01030000000100000005000000000000000000000000000000000000000000000000000000000000000000F03F00000
```

ST_AsHexEWKB

ST_AsHexEWKB returns the extended well-known binary (EWKB) representation of an input geometry or geography using ASCII hexadecimal characters (0–9, A–F). For 3DZ, 3DM, and 4D geometries or geographies, ST_AsHexEWKB uses the PostGIS extended WKB value for the geometry or geography type.

Syntax

```
ST_AsHexEWKB(geo)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

Return type

`VARCHAR`

If *geo* is null, then null is returned.

If the result is larger than a 64-KB `VARCHAR`, then an error is returned.

Examples

The following SQL returns the hexadecimal EWKB representation of a polygon in a geometry.

```
SELECT ST_AsHexEWKB(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```

```


st_ashexewkb
--------------------------------
0103000020E61000000100000005000000000000000000000000000000000000000000000000000000000000000000F
```

The following SQL returns the hexadecimal EWKB representation of a polygon in a geography.

```
SELECT ST_AsHexEWKB(ST_GeogFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))'));
```

```


st_ashexewkb
--------------------------------
0103000020E61000000100000005000000000000000000000000000000000000000000000000000000000000000000F
```

ST_AsText

ST_AsText returns the well-known text (WKT) representation of an input geometry or geography. For 3DZ, 3DM, and 4D geometries or geographies, ST_AsEWKT appends Z, M, or ZM to the WKT value for the geometry or geography type.

Syntax

```
ST_AsText(geo)
```

```
ST_AsText(geo, precision)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

precision

A value of data type `INTEGER`. For geometries, the coordinates of *geo* are displayed using the specified precision 1–20. If *precision* is not specified, the default is 15. For geogpraphies, the coordinates of *geo* are displayed using the specified precision. If *precision* is not specified, the default is 15.

Return type

`VARCHAR`

If *geo* is null, then null is returned.

If *precision* is null, then null is returned.

If the result is larger than a 64-KB `VARCHAR`, then an error is returned.

Examples

The following SQL returns the WKT representation of a linestring.

```
SELECT ST_AsText(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)', 4326));
```

```

st_astext
-------------------------------
LINESTRING(3.14159265358979 -6.28318530717959,2.71828182845905 -1.41421356237309)
```

The following SQL returns the WKT representation of a linestring. The coordinates of the geometries are displayed with six digits of precision.

```
SELECT ST_AsText(ST_GeomFromText('LINESTRING(3.141592653589793
 -6.283185307179586,2.718281828459045 -1.414213562373095)', 4326), 6);
```

```

st_astext
----------------------------------------------
 LINESTRING(3.14159 -6.28319,2.71828 -1.41421)
```

The following SQL returns the WKT representation of a geography.

```
SELECT ST_AsText(ST_GeogFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)'));
```

```
             st_astext
------------------------------------
 LINESTRING(110 40,2 3,-10 80,-7 9)
```

ST_Azimuth

ST_Azimuth returns the north-based Cartesian azimuth using the 2D projections of the two input points.

Syntax

```
ST_Azimuth(point1, point2)
```

Arguments

point1

A `POINT` value of data type `GEOMETRY`. The spatial reference system identifier (SRID) of *point1* must match the SRID of *point2*.

point2

A `POINT` value of data type `GEOMETRY`. The SRID of *point2* must match the SRID of *point1*.

Return type

A number that is an angle in radians of `DOUBLE PRECISION` data type. Values range from 0 (inclusive) to 2 pi (exclusive).

If *point1* or *point2* is the empty point, then an error is returned.

If either *point1* or *point2* is null, then null is returned.

If *point1* and *point2* are equal, then null is returned.

If *point1* or *point2* is not a point, then an error is returned.

If *point1* and *point2* don't have the value for the spatial reference system identifier (SRID), then an error is returned.

Examples

The following SQL returns the azimuth of the input points.

```
SELECT ST_Azimuth(ST_Point(1,2), ST_Point(5,6));
```

```
st_azimuth
-------------------
 0.7853981633974483
```

ST_Boundary

ST_Boundary returns the boundary of an input geometry as follows:

- If the input geometry is empty (that is, it contains no points) it is returned as is.
- If the input geometry is a point or nonempty multipoint, an empty geometry collection is returned.
- If the input is a linestring or a multilinestring, then a multipoint containing all the points on the boundary is returned. The multipoint might be empty).
- If the input is a polygon that does not have any interior rings, then a closed linestring representing its boundary is returned.
- If the input is a polygon that has interior rings, or is a multipolygon, then a multilinestring is returned. The multilinestring contains all the boundaries of all the rings in the areal geometry as closed linestrings.

To determine point equality, ST_Boundary operates on the 2D projection of the input geometry. If the input geometry is empty, a copy of it is returned in the same dimension as the input. For nonempty 3DM and 4D geometries, their `m` coordinates are dropped. In the special case of 3DZ and 4D multilinestrings, the `z` coordinates of the multilinestring's boundary points are computed as the averages of the distinct z-values of the linestring boundary points with the same 2D projection.

Syntax

```
ST_Boundary(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY

If *geom* is null, then null is returned.

If *geom* is a GEOMETRYCOLLECTION, then an error is returned.

Examples

The following SQL returns the boundary of the input polygon as a multilinestring.

```
SELECT ST_AsEWKT(ST_Boundary(ST_GeomFromText('POLYGON((0 0,10 0,10 10,0 10,0 0),(1 1,1
 2,2 1,1 1))')));
```

```


st_asewkt
--------------------
 MULTILINESTRING((0 0,10 0,10 10,0 10,0 0),(1 1,1 2,2 1,1 1))
```

ST_Buffer

ST_Buffer returns 2D geometry that represents all points whose distance from the input geometry projected on the xy-Cartesian plane is less than or equal to the input distance.

Syntax

```
ST_Buffer(geom, distance)
```

```
ST_Buffer(geom, distance, number_of_segments_per_quarter_circle)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

distance

A value of data type `DOUBLE PRECISION` that represents distance (or radius) of the buffer.

number_of_segments_per_quarter_circle

A value of data type `INTEGER`. This value determines the number of points to approximate a quarter circle around each vertex of the input geometry. Negative values default to zero. The default is 8.

Return type

`GEOMETRY`

The ST_Buffer function returns two-dimensional (2D) geometry in the xy-Cartesian plane.

If *geom* is a `GEOMETRYCOLLECTION`, then an error is returned.

Examples

The following SQL returns the buffer of the input linestring.

```
SELECT ST_AsEwkt(ST_Buffer(ST_GeomFromText('LINESTRING(1 2,5 2,5 8)'), 2));
```

```
               st_asewkt
POLYGON((-1 2,-0.96157056080646 2.39018064403226,-0.847759065022573
 2.76536686473018,-0.662939224605089 3.11114046603921,-0.414213562373093
 3.4142135623731,-0.111140466039201 3.66293922460509,0.234633135269824
 3.84775906502257,0.609819355967748 3.96157056080646,1 4,3 4,3 8,3.03842943919354
 8.39018064403226,3.15224093497743 8.76536686473018,3.33706077539491
 9.11114046603921,3.58578643762691 9.4142135623731,3.8888595339608
 9.66293922460509,4.23463313526982 9.84775906502257,4.60981935596775
 9.96157056080646,5 10,5.39018064403226 9.96157056080646,5.76536686473018
 9.84775906502257,6.11114046603921 9.66293922460509,6.4142135623731
 9.41421356237309,6.66293922460509 9.1111404660392,6.84775906502258
 8.76536686473017,6.96157056080646 8.39018064403225,7 8,7 2,6.96157056080646
 1.60981935596774,6.84775906502257 1.23463313526982,6.66293922460509
 0.888859533960796,6.41421356237309 0.585786437626905,6.1111404660392
 0.33706077539491,5.76536686473018 0.152240934977427,5.39018064403226
 0.0384294391935391,5 0,1 0,0.609819355967744 0.0384294391935391,0.234633135269821
 0.152240934977427,-0.111140466039204 0.337060775394909,-0.414213562373095
 0.585786437626905,-0.662939224605091 0.888859533960796,-0.847759065022574
 1.23463313526982,-0.961570560806461 1.60981935596774,-1 2))
```

The following SQL returns the buffer of the input point geometry which approximates a circle. Because the command doesn't specify the number of segments per quarter circle, the function uses the default value of eight segments to approximate the quarter circle.

```
SELECT ST_AsEwkt(ST_Buffer(ST_GeomFromText('POINT(3 4)'), 2));
```

```
               st_asewkt
POLYGON((1 4,1.03842943919354 4.39018064403226,1.15224093497743
 4.76536686473018,1.33706077539491 5.11114046603921,1.58578643762691
 5.4142135623731,1.8888595339608 5.66293922460509,2.23463313526982
 5.84775906502257,2.60981935596775 5.96157056080646,3 6,3.39018064403226
 5.96157056080646,3.76536686473019 5.84775906502257,4.11114046603921
 5.66293922460509,4.4142135623731 5.41421356237309,4.66293922460509
 5.1111404660392,4.84775906502258 4.76536686473017,4.96157056080646 4.39018064403225,5
 4,4.96157056080646 3.60981935596774,4.84775906502257 3.23463313526982,4.66293922460509
 2.8888595339608,4.41421356237309 2.58578643762691,4.1111404660392
 2.33706077539491,3.76536686473018 2.15224093497743,3.39018064403226 2.03842943919354,3
 2,2.60981935596774 2.03842943919354,2.23463313526982 2.15224093497743,1.8888595339608
 2.33706077539491,1.58578643762691 2.58578643762691,1.33706077539491
 2.8888595339608,1.15224093497743 3.23463313526982,1.03842943919354 3.60981935596774,1
 4))
```

The following SQL returns the buffer of the input point geometry which approximates a circle. Because the command specifies 3 as the number of segments per quarter circle, the function uses three segments to approximate the quarter circle.

```
SELECT ST_AsEwkt(ST_Buffer(ST_GeomFromText('POINT(3 4)'), 2, 3));
```

```
               st_asewkt
POLYGON((1 4,1.26794919243112 5,2 5.73205080756888,3 6,4
 5.73205080756888,4.73205080756888 5,5 4,4.73205080756888 3,4 2.26794919243112,3 2,2
 2.26794919243112,1.26794919243112 3,1 4))
```

ST_Centroid

ST_Centroid returns a point that represents a centroid of a geometry as follows:

- For POINT geometries, it returns the point whose coordinates are the average of the coordinates of the points in the geometry.

- For LINESTRING geometries, it returns the point whose coordinates are the weighted average of the midpoints of the segments of the geometry, where the weights are the lengths of the segments of the geometry.
- For POLYGON geometries, it returns the point whose coordinates are the weighted average of the centroids of a triangulation of the areal geometry where the weights are the areas of the triangles in the triangulation.
- For geometry collections, it returns the weighted average of the centroids of the geometries of maximum topological dimension in the geometry collection.

Syntax

```
ST_Centroid(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY

If *geom* is null, then null is returned.

If *geom* is empty, then null is returned.

Examples

The following SQL returns central point of an input linestring.

```
SELECT ST_AsEWKT(ST_Centroid(ST_GeomFromText('LINESTRING(110 40, 2 3, -10 80, -7 9, -22
 -33)', 4326)))
```

```


                     st_asewkt
----------------------------------------------------
 SRID=4326;POINT(15.6965103455214 27.0206782881905)
```

ST_Collect

ST_Collect has two variants. One accepts two geometries, and one accepts an aggregate expression.

The first variant of ST_Collect creates a geometry from the input geometries. The order of the input geometries is preserved. This variant works as follows:

- If both input geometries are points, then a `MULTIPOINT` with two points is returned.
- If both input geometries are linestrings, then a `MULTILINESTRING` with two linestrings is returned.
- If both input geometries are polygons, then a `MULTIPOLYGON` with two polygons is returned.
- Otherwise, a `GEOMETRYCOLLECTION` with two input geometries is returned.

The second variant of ST_Collect creates a geometry from geometries in a geometry column. There isn't a determined return order of the geometries. Specify the WITHIN GROUP (ORDER BY ...) clause to specify the order of the returned geometries. This variant works as follows:

- If all non-NULL rows in the input aggregate expression are points, then a multipoint containing all the points in the aggregate expression is returned.
- If all non-NULL rows in the aggregate expression are linestrings, then a multilinestring containing all the linestrings in the aggregate expression is returned.
- If all non-NULL rows in the aggregate expression are polygons, the result is a multipolygon containing all the polygons in the aggregate expression is returned.
- Otherwise, a `GEOMETRYCOLLECTION` containing all the geometries in the aggregate expression is returned.

The ST_Collect returns the geometry of the same dimension as the input geometries. All input geometries must be of the same dimension.

Syntax

```
ST_Collect(geom1, geom2)
```

```
ST_Collect(aggregate_expression)  [WITHIN GROUP (ORDER BY sort_expression1 [ASC | DESC]
 [, sort_expression2 [ASC | DESC] ...])]
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

aggregate_expression

A column of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

[WITHIN GROUP (ORDER BY *sort_expression1* [ASC | DESC] [, *sort_expression2* [ASC | DESC] ...])]

An optional clause that specifies the sort order of the aggregated values. The ORDER BY clause contains a list of sort expressions. Sort expressions are expressions similar to valid sort expressions in a query select list, such as a column name. You can specify ascending (ASC) or descending (DESC) order. The default is ASC.

Return type

GEOMETRY of subtype MULTIPOINT, MULTILINESTRING, MULTIPOLYGON, or GEOMETRYCOLLECTION.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometries.

If both *geom1* or *geom2* are null, then null is returned.

If all rows of *aggregate_expression* are null, then null is returned.

If *geom1* is null, then a copy of *geom2* is returned. Likewise, if *geom2* is null, then a copy of *geom1* is returned.

If *geom1* and *geom2* have different SRID values, then an error is returned.

If two geometries in *aggregate_expression* have different SRID values, then an error is returned.

If the returned geometry is larger than the maximum size of a GEOMETRY, then an error is returned.

If *geom1* and *geom2* are of different dimensions, then an error is returned.

If two geometries in *aggregate_expression* are of different dimensions, then an error is returned.

Examples

The following SQL returns a geometry collection that contains the two input geometries.

```
SELECT ST_AsText(ST_Collect(ST_GeomFromText('LINESTRING(0 0,1 1)'),
 ST_GeomFromText('POLYGON((10 10,20 10,10 20,10 10))')));
```

```
st_astext
-----------
 GEOMETRYCOLLECTION(LINESTRING(0 0,1 1),POLYGON((10 10,20 10,10 20,10 10)))
```

The following SQL collects all the geometries from a table into a geometry collection.

```
WITH tbl(g) AS (SELECT ST_GeomFromText('POINT(1 2)', 4326) UNION ALL
SELECT ST_GeomFromText('LINESTRING(0 0,10 0)', 4326) UNION ALL
SELECT ST_GeomFromText('MULTIPOINT(13 4,8 5,4 4)', 4326) UNION ALL
SELECT NULL::geometry UNION ALL
SELECT ST_GeomFromText('POLYGON((0 0,10 0,0 10,0 0))', 4326))
SELECT ST_AsEWKT(ST_Collect(g)) FROM tbl;
```

```
st_astext
-----------
 SRID=4326;GEOMETRYCOLLECTION(POINT(1 2),LINESTRING(0 0,10 0),MULTIPOINT((13 4),(8 5),
(4 4)),POLYGON((0 0,10 0,0 10,0 0)))
```

The following SQL collects all geometries in the table grouped by the id column and ordered by this ID. In this example, resulting geometries are grouped by ID as follows:

- id 1 – points in a multipoint.
- id 2 – linestrings in a multilinestring.
- id 3 – mixed subtypes in a geometry collection.
- id 4 – polygons in a multipolygon.
- id 5 – null and the result is null.

```
WITH tbl(id, g) AS (SELECT 1, ST_GeomFromText('POINT(1 2)', 4326) UNION ALL
```

```
SELECT 1, ST_GeomFromText('POINT(4 5)', 4326) UNION ALL
SELECT 2, ST_GeomFromText('LINESTRING(0 0,10 0)', 4326) UNION ALL
SELECT 2, ST_GeomFromText('LINESTRING(10 0,20 -5)', 4326) UNION ALL
SELECT 3, ST_GeomFromText('MULTIPOINT(13 4,8 5,4 4)', 4326) UNION ALL
SELECT 3, ST_GeomFromText('MULTILINESTRING((-1 -1,-2 -2),(-3 -3,-5 -5))', 4326) UNION
 ALL
SELECT 4, ST_GeomFromText('POLYGON((0 0,10 0,0 10,0 0))', 4326) UNION ALL
SELECT 4, ST_GeomFromText('POLYGON((20 20,20 30,30 20,20 20))', 4326) UNION ALL
SELECT 1, NULL::geometry UNION ALL SELECT 2, NULL::geometry UNION ALL
SELECT 5, NULL::geometry UNION ALL SELECT 5, NULL::geometry)
SELECT id, ST_AsEWKT(ST_Collect(g)) FROM tbl GROUP BY id ORDER BY id;
```

```
 id |                                                   st_asewkt

----
+----------------------------------------------------------------------------------------------------
  1 | SRID=4326;MULTIPOINT((1 2),(4 5))
  2 | SRID=4326;MULTILINESTRING((0 0,10 0),(10 0,20 -5))
  3 | SRID=4326;GEOMETRYCOLLECTION(MULTIPOINT((13 4),(8 5),(4 4)),MULTILINESTRING((-1
 -1,-2 -2),(-3 -3,-5 -5)))
  4 | SRID=4326;MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((20 20,20 30,30 20,20 20)))
  5 |
```

The following SQL collects all geometries from a table in a geometry collection. Results are ordered in descending order by `id`, and then lexicographically based on their minimum and maximum x-coordinates.

```
WITH tbl(id, g) AS (
SELECT 1, ST_GeomFromText('POINT(4 5)', 4326) UNION ALL
SELECT 1, ST_GeomFromText('POINT(1 2)', 4326) UNION ALL
SELECT 2, ST_GeomFromText('LINESTRING(10 0,20 -5)', 4326) UNION ALL
SELECT 2, ST_GeomFromText('LINESTRING(0 0,10 0)', 4326) UNION ALL
SELECT 3, ST_GeomFromText('MULTIPOINT(13 4,8 5,4 4)', 4326) UNION ALL
SELECT 3, ST_GeomFromText('MULTILINESTRING((-1 -1,-2 -2),(-3 -3,-5 -5))', 4326) UNION
 ALL
SELECT 4, ST_GeomFromText('POLYGON((20 20,20 30,30 20,20 20))', 4326) UNION ALL
SELECT 4, ST_GeomFromText('POLYGON((0 0,10 0,0 10,0 0))', 4326) UNION ALL
SELECT 1, NULL::geometry UNION ALL SELECT 2, NULL::geometry UNION ALL
SELECT 5, NULL::geometry UNION ALL SELECT 5, NULL::geometry)
SELECT ST_AsEWKT(ST_Collect(g) WITHIN GROUP (ORDER BY id DESC, ST_XMin(g), ST_XMax(g)))
 FROM tbl;
```

```
                             st_asewkt
-----------------------------------------------------------------------------------------------------
 SRID=4326;GEOMETRYCOLLECTION(POLYGON((0 0,10 0,0 10,0 0)),POLYGON((20 20,20 30,30
 20,20 20)),MULTILINESTRING((-1 -1,-2 -2),(-3 -3,-5 -5)),MULTIPOINT((13 4),(8 5),(4
 4)),LINESTRING(0 0,10 0),LINESTRING(10 0,20 -5),POINT(1 2),POINT(4 5)
```

ST_Contains

ST_Contains returns true if the 2D projection of the first input geometry contains the 2D projection of the second input geometry. Geometry A contains geometry B if every point in B is a point in A, and their interiors have nonempty intersection.

ST_Contains(A, B) is equivalent to ST_Within(B, A).

Syntax

```
ST_Contains(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. This value is compared with *geom1* to determine if it is contained within *geom1*.

Return type

`BOOLEAN`

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon contains the second polygon.

```
SELECT ST_Contains(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'));
```

```
st_contains
-----------
 false
```

ST_ContainsProperly

ST_ContainsProperly returns true if both input geometries are nonempty, and all points of the 2D projection of the second geometry are interior points of the 2D projection of the first geometry.

Syntax

```
ST_ContainsProperly(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype can't be `GEOMETRYCOLLECTION`.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype can't be `GEOMETRYCOLLECTION`. This value is compared with *geom1* to determine if all its points are interior points of *geom1*.

Return type

`BOOLEAN`

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL returns the values of ST_Contains and ST_ContainsProperly where the input linestring intersects the interior and the boundary of the input polygon (but not its exterior). The polygon contains the linestring but doesn't properly contain the linestring.

```
WITH tmp(g1, g2)
AS (SELECT ST_GeomFromText('POLYGON((0 0,10 0,10 10,0 10,0 0))'),
 ST_GeomFromText('LINESTRING(5 5,10 5,10 6,5 5)')) SELECT ST_Contains(g1, g2),
 ST_ContainsProperly(g1, g2)
FROM tmp;
```

```

 st_contains | st_containsproperly
-------------+--------------------
 t           | f
```

ST_ConvexHull

ST_ConvexHull returns a geometry that represents the convex hull of the nonempty points contained in the input geometry.

For empty input, the resulting geometry is the same as the input geometry. For all nonempty input, the function operates on the 2D projection of the input geometry. However, the dimension of the output geometry depends on the dimension of the input geometry. More specifically, when the input geometry is a nonempty 3DM or 3D geometry, `m` coordinates are dropped. That is, the dimension of the returned geometry is 2D or 3DZ, respectively. If the input is a nonempty 2D or 3DZ geometry, the resulting geometry has the same dimension.

Syntax

```
ST_ConvexHull(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

The values returned are as follows.

Number of points on the convex hull	Geometry subtype
0	A copy of *geom* is returned.
1	A `POINT` subtype is returned.
2	A `LINESTRING` subtype is returned. The two points of the returned linestring are lexicographically ordered.
3 or greater	A `POLYGON` subtype with no interior rings is returned. The polygon is clockwise oriented, and the first point of the exterior ring is the lexicographically smallest point of the ring.

Examples

The following SQL returns the extended well-known text (EWKT) representation of a linestring. In this case, the convex hull returned is a polygon.

```
SELECT ST_AsEWKT(ST_ConvexHull(ST_GeomFromText('LINESTRING(0 0,1 0,0 1,1 1,0.5 0.5)')))
 as output;
```

```
output
-------------
POLYGON((0 0,0 1,1 1,1 0,0 0))
```

The following SQL returns the EWKT representation of a linestring. In this case, the convex hull returned is a linestring.

```
SELECT ST_AsEWKT(ST_ConvexHull(ST_GeomFromText('LINESTRING(0 0,1 1,0.2 0.2,0.6 0.6,0.5
 0.5)'))) as output;
```

```
output
-------------
LINESTRING(0 0,1 1)
```

The following SQL returns the EWKT representation of a multipoint. In this case, the convex hull returned is a point.

```
SELECT ST_AsEWKT(ST_ConvexHull(ST_GeomFromText('MULTIPOINT(0 0,0 0,0 0)'))) as output;
```

```
output
-------------
POINT(0 0)
```

ST_CoveredBy

ST_CoveredBy returns true if the 2D projection of the first input geometry is covered by the 2D projection of the second input geometry. Geometry A is covered by geometry B if both are nonempty and every point in A is a point in B.

ST_CoveredBy(A, B) is equivalent to ST_Covers(B, A).

Syntax

```
ST_CoveredBy(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. This value is compared with *geom2* to determine if it's covered by *geom2*.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon is covered by the second polygon.

```
SELECT ST_CoveredBy(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'));
```

```

st_coveredby
-----------
 true
```

ST_Covers

ST_Covers returns true if the 2D projection of the first input geometry covers the 2D projection of the second input geometry. Geometry A covers geometry B if both are nonempty and every point in B is a point in A.

ST_Covers(A, B) is equivalent to ST_CoveredBy(B, A).

Syntax

```
ST_Covers(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. This value is compared with *geom1* to determine if it covers *geom1*.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon covers the second polygon.

```
SELECT ST_Covers(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'));
```

```


st_covers
-----------
 false
```

ST_Crosses

ST_Crosses returns true if the 2D projections of the two input geometries cross each other.

Syntax

```
ST_Crosses(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

Examples

The following SQL checks if the first polygon crosses the second multipoint. In this example, the multipoint intersects both the interior and exterior of the polygon, which is why ST_Crosses returns true.

```
SELECT ST_Crosses (ST_GeomFromText('polygon((0 0,10 0,10 10,0 10,0 0))'),
 ST_GeomFromText('multipoint(5 5,0 0,-1 -1)'));
```

```


st_crosses
-------------
 true
```

The following SQL checks if the first polygon crosses the second multipoint. In this example, the multipoint intersects the exterior of the polygon but not its interior, which is why ST_Crosses returns false.

```
SELECT ST_Crosses (ST_GeomFromText('polygon((0 0,10 0,10 10,0 10,0 0))'),
 ST_GeomFromText('multipoint(0 0,-1 -1)'));
```

```
st_crosses
-------------
 false
```

ST_Dimension

ST_Dimension returns the inherent dimension of an input geometry. The *inherent dimension* is the dimension value of the subtype that is defined in the geometry.

For 3DM, 3DZ, and 4D geometry inputs, ST_Dimension returns the same result as for 2D geometry inputs.

Syntax

```
ST_Dimension(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER` representing the inherent dimension of *geom*.

If *geom* is null, then null is returned.

The values returned are as follows.

Returned value	Geometry subtype
0	Returned if *geom* is a `POINT` or `MULTIPOINT` subtype

Returned value	Geometry subtype
1	Returned if *geom* is a `LINESTRING` or `MULTILINESTRING` subtype.
2	Returned if *geom* is a `POLYGON` or `MULTIPOLYGON` subtype
0	Returned if *geom* is an empty `GEOMETRYCOLLECTION` subtype
Largest dimension of the components of the collection	Returned if *geom* is a `GEOMETRYCOLLECTION` subtype

Examples

The following SQL converts a well-known text (WKT) representation of a four-point LINESTRING to a GEOMETRY object and returns the dimension of the linestring.

```
SELECT ST_Dimension(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'));
```

```
st_dimension
-------------
1
```

ST_Disjoint

ST_Disjoint returns true if the 2D projections of the two input geometries have no points in common.

Syntax

```
ST_Disjoint(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon is disjoint from the second polygon.

```
SELECT ST_Disjoint(ST_GeomFromText('POLYGON((0 0,10 0,10 10,0 10,0 0),(2 2,2 5,5 5,5
 2,2 2))'), ST_Point(4, 4));
```

```


st_disjoint
-----------
 true
```

ST_Distance

For input geometries, ST_Distance returns the minimum Euclidean distance between the 2D projections of the two input geometry values.

For 3DM, 3DZ, 4D geometries, ST_Distance returns the Euclidean distance between the 2D projections of two input geometry values.

For input geographies, ST_Distance returns the geodesic distance of the two 2D points. The unit of distance is in meters. For geographies other than points and empty points an error is returned.

Syntax

```
ST_Distance(geo1, geo2)
```

Arguments

geo1

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type. The data type of *geo1* must be the same as *geo2*.

geo2

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type. The data type of *geo2* must be the same as *geo1*.

Return type

`DOUBLE PRECISION` in the same units as the input geometries or geographies.

If *geo1* or *geo2* is null or empty, then null is returned.

If *geo1* and *geo2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geo1* or *geo2* is a geometry collection, then an error is returned.

Examples

The following SQL returns the distance between two polygons.

```
SELECT ST_Distance(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 -3,-2 -1,0 -3,-1 -3))'));
```

```

  st_distance
-----------
1.4142135623731
```

The following SQL returns the distance (in meters) between the Brandenburg Gate and the Reichstag building in Berlin using a GEOGRAPHY data type.

```
SELECT ST_Distance(ST_GeogFromText('POINT(13.37761826722198 52.516411678282445)'),
 ST_GeogFromText('POINT(13.377950831464005 52.51705102546893)'));
```

```
   st_distance
------------------
 74.64129172609631
```

ST_DistanceSphere

ST_DistanceSphere returns the distance between two point geometries lying on a sphere.

Syntax

```
ST_DistanceSphere(geom1, geom2)
```

```
ST_DistanceSphere(geom1, geom2, radius)
```

Arguments

geom1

A point value in degrees of data type `GEOMETRY` lying on a sphere. The first coordinate of the point is the longitude value. The second coordinate of the point is the latitude value. For 3DZ, 3DM, or 4D geometries, only the first two coordinates are used.

geom2

A point value in degrees of data type `GEOMETRY` lying on a sphere. The first coordinate of the point is the longitude value. The second coordinate of the point is the latitude value. For 3DZ, 3DM, or 4D geometries, only the first two coordinates are used.

radius

The radius of a sphere of data type `DOUBLE PRECISION`. If no *radius* is provided, the sphere defaults to Earth and the radius is computed from the World Geodetic System (WGS) 84 representation of the ellipsoid.

Return type

`DOUBLE PRECISION` in the same units as the radius. If no radius is provided, the distance is in meters.

If *geom1* or *geom2* is null or empty, then null is returned.

If no *radius* is provided, then the result is in meters along the Earth's surface.

If *radius* is a negative number, then an error is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is not a point, then an error is returned.

Examples

The following example SQL computes the distance in kilometers between two points on Earth.

```
SELECT ROUND(ST_DistanceSphere(ST_Point(-122, 47), ST_Point(-122.1, 47.1))/ 1000, 0);
```

```

  round
-----------
 13
```

The following example SQL computes the distances in kilometers between three airport locations in Germany: Berlin Tegel (TXL), Munich International (MUC), and Frankfurt International (FRA).

```
WITH airports_raw(code,lon,lat) AS (
(SELECT 'MUC', 11.786111, 48.353889) UNION
(SELECT 'FRA', 8.570556, 50.033333) UNION
(SELECT 'TXL', 13.287778, 52.559722)),
airports1(code,location) AS (SELECT code, ST_Point(lon, lat) FROM airports_raw),
airports2(code,location) AS (SELECT * from airports1)
SELECT (airports1.code || ' <-> ' || airports2.code) AS airports,
round(ST_DistanceSphere(airports1.location, airports2.location) / 1000, 0) AS
 distance_in_km
FROM airports1, airports2 WHERE airports1.code < airports2.code ORDER BY 1;
```

```
  airports   | distance_in_km
-------------+----------------
 FRA <-> MUC |            299
 FRA <-> TXL |            432
 MUC <-> TXL |            480
```

ST_DWithin

ST_DWithin returns true if the Euclidean distance between the 2D projections of the two input geometry values is not larger than a threshold value.

Syntax

```
ST_DWithin(geom1, geom2, threshold)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

threshold

A value of data type `DOUBLE PRECISION`. This value is in the units of the input arguments.

Return type

`BOOLEAN`

If *geom1* or *geom2* is null, then null is returned.

If *threshold* is negative, then an error is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the distance between two polygons is within five units.

```
SELECT ST_DWithin(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'),5);
```

```
st_dwithin
-----------
 true
```

ST_EndPoint

ST_EndPoint returns the last point of an input linestring. The spatial reference system identifier (SRID) value of the result is the same as that of the input geometry. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_EndPoint(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`.

Return type

`GEOMETRY`

If *geom* is null, then null is returned.

If *geom* is empty, then null is returned.

If *geom* isn't a `LINESTRING`, then null is returned.

Examples

The following SQL returns an extended well-known text (EWKT) representation of a four-point `LINESTRING` to a `GEOMETRY` object and returns the end point of the linestring.

```
SELECT ST_AsEWKT(ST_EndPoint(ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0
 5)',4326)));
```

```
st_asewkt
-------------
 SRID=4326;POINT(0 5)
```

ST_Envelope

ST_Envelope returns the minimum bounding box of the input geometry, as follows:

- If the input geometry is empty, the returned geometry is a copy of the input geometry.
- If the minimum bounding box of the input geometry degenerates to a point, the returned geometry is a point.
- If the minimum bounding box of the input geometry is one-dimensional, a two-point linestring is returned.
- If none of the preceding is true, the function returns a clockwise-oriented polygon whose vertices are the corners of the minimum bounding box.

The spatial reference system identifier (SRID) of the returned geometry is the same as that of the input geometry.

For all nonempty input, the function operates on the 2D projection of the input geometry.

Syntax

```
ST_Envelope(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`

If *geom* is null, then null is returned.

Examples

The following SQL converts a well-known text (WKT) representation of a four-point LINESTRING to a GEOMETRY object and returns a polygon whose vertices whose corners are the minimum bounding box.

```
SELECT ST_AsText(ST_Envelope(ST_GeomFromText('GEOMETRYCOLLECTION(POLYGON((0 0,10 0,0
 10,0 0)),LINESTRING(20 10,20 0,10 0))')));
```

```


    st_astext
------------------------------------
  POLYGON((0 0,0 10,20 10,20 0,0 0))
```

ST_Equals

ST_Equals returns true if the 2D projections of the input geometries are geometrically equal. Geometries are considered geometrically equal if they have equal point sets and their interiors have a nonempty intersection.

Syntax

```
ST_Equals(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. This value is compared with *geom1* to determine if it is equal to *geom1*.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then an error is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the two polygons are geometrically equal.

```
SELECT ST_Equals(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'));
```

```
st_equals
-----------
 false
```

The following SQL checks if the two linestrings are geometrically equal.

```
SELECT ST_Equals(ST_GeomFromText('LINESTRING(1 0,10 0)'), ST_GeomFromText('LINESTRING(1
 0,5 0,10 0)'));
```

```
st_equals
-----------
 true
```

ST_ExteriorRing

ST_ExteriorRing returns a closed linestring that represents the exterior ring of an input polygon. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_ExteriorRing(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY` of subtype `LINESTRING`.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

If *geom* is not a polygon, then null is returned.

If *geom* is empty, then an empty polygon is returned.

Examples

The following SQL returns the exterior ring of a polygon as a closed linestring.

```
SELECT ST_AsEWKT(ST_ExteriorRing(ST_GeomFromText('POLYGON((7 9,8 7,11 6,15 8,16 6,17
 7,17 10,18 12,17 14,15 15,11 15,10 13,9 12,7 9),(9 9,10 10,11 11,11 10,10 8,9 9),(12
 14,15 14,13 11,12 14))')));
```

```
st_asewkt
-----------
 LINESTRING(7 9,8 7,11 6,15 8,16 6,17 7,17 10,18 12,17 14,15 15,11 15,10 13,9 12,7 9)
```

ST_Force2D

ST_Force2D returns a 2D geometry of the input geometry. For 2D geometries, a copy of the input is returned. For 3DZ, 3DM, and 4D geometries, ST_Force2D projects the geometry to the xy-Cartesian plane. Empty points in the input geometry remain empty points in the output geometry.

Syntax

```
ST_Force2D(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

If *geom* is empty, then an empty geometry is returned.

Examples

The following SQL returns a 2D geometry from a 3DZ geometry.

```
SELECT ST_AsEWKT(ST_Force2D(ST_GeomFromText('MULTIPOINT Z(0 1 2, EMPTY, 2 3 4, 5 6
 7)')));
```

```
st_asewkt
-----------
  MULTIPOINT((0 1),EMPTY,(2 3),(5 6))
```

ST_Force3D

ST_Force3D is an alias for ST_Force3DZ. For more information, see ST_Force3DZ.

ST_Force3DM

ST_Force3DM returns a 3DM geometry of the input geometry. For 2D geometries, the m coordinates of the nonempty points in the output geometry are all set to 0. For 3DM geometries, a copy of the input geometry is returned. For 3DZ geometries, the geometry is projected to the xy-Cartesian plane, and the m coordinates of the nonempty points in the output geometry are all set to 0. For 4D geometries, the geometry is projected to the xym-Cartesian space. Empty points in the input geometry remain empty points in the output geometry.

Syntax

```
ST_Force3DM(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

If *geom* is empty, then an empty geometry is returned.

Examples

The following SQL returns a 3DM geometry from a 3DZ geometry.

```
SELECT ST_AsEWKT(ST_Force3DM(ST_GeomFromText('MULTIPOINT Z(0 1 2, EMPTY, 2 3 4, 5 6
 7)')));
```

```


st_asewkt
-----------
  MULTIPOINT M ((0 1 0),EMPTY,(2 3 0),(5 6 0))
```

ST_Force3DZ

ST_Force3DZ returns a 3DZ geometry from the input geometry. For 2D geometries, the z coordinates of the nonempty points in the output geometry are all set to 0. For 3DM geometries, the geometry is projected on the xy-Cartesian plane, and the z coordinates of the nonempty points in the output geometry are all set to 0. For 3DZ geometries, a copy of the input geometry is returned. For 4D geometries, the geometry is projected to the xyz-Cartesian space. Empty points in the input geometry remain empty points in the output geometry.

Syntax

```
ST_Force3DZ(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

If *geom* is empty, then an empty geometry is returned.

Examples

The following SQL returns a 3DZ geometry from a 3DM geometry.

```
SELECT ST_AsEWKT(ST_Force3DZ(ST_GeomFromText('MULTIPOINT M(0 1 2, EMPTY, 2 3 4, 5 6
 7)')));
```

```

st_asewkt
-----------
  MULTIPOINT Z ((0 1 0),EMPTY,(2 3 0),(5 6 0))
```

ST_Force4D

ST_Force4D returns a 4D geometry of the input geometry. For 2D geometries, the `z` and `m` coordinates of the nonempty points in the output geometry are all set to `0`. For 3DM geometries, the `z` coordinates of the nonempty points in the output geometry are all set to `0`. For 3DZ geometries, the `m` coordinates of the nonempty points in the output geometry are all set to `0`.

For 4D geometries, a copy of the input geometry is returned. Empty points in the input geometry remain empty points in the output geometry.

Syntax

```
ST_Force4D(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* is null, then null is returned.

If *geom* is empty, then an empty geometry is returned.

Examples

The following SQL returns a 4D geometry from a 3DM geometry.

```
SELECT ST_AsEWKT(ST_Force4D(ST_GeomFromText('MULTIPOINT M(0 1 2, EMPTY, 2 3 4, 5 6
 7)')));
```

```


st_asewkt
-----------
  MULTIPOINT ZM ((0 1 0 2),EMPTY,(2 3 0 4),(5 6 0 7))
```

ST_GeoHash

ST_GeoHash returns the `geohash` representation of the input point with the specified precision. The default precision value is 20. For more information about the definition of geohash, see [Geohash](https://en.wikipedia.org/wiki/Geohash) in Wikipedia.

Syntax

```
ST_GeoHash(geom)
```

```
ST_GeoHash(geom, precision)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

precision

A value of data type `INTEGER`. The default is 20.

Return type

`GEOMETRY`

The function returns the `geohash` representation of the input point.

If the input point is empty, the function returns null.

If the input geometry is not a point, the function returns an error.

Examples

The following SQL returns the geohash representation of the input point.

```
SELECT ST_GeoHash(ST_GeomFromText('POINT(45 -45)'), 25) AS geohash;
```

```
          geohash
---------------------------
 m000000000000000000000gzz
```

The following SQL returns null because the input point is empty.

```
SELECT ST_GeoHash(ST_GeomFromText('POINT EMPTY'), 10) IS NULL AS result;
```

```
 result
---------
 true
```

ST_GeogFromText

ST_GeogFromText constructs a geography object from a well-known text (WKT) or extended well-known text (EWKT) representation of an input geography.

Syntax

```
ST_GeogFromText(wkt_string)
```

Arguments

wkt_string

A value of data type VARCHAR that is a WKT or EWKT representation of a geography.

Return type

GEOGRAPHY

If the SRID value is set to the provided value in the input. If SRID is not provided, it is set to 4326.

If *wkt_string* is null, then null is returned.

If *wkt_string* is not valid, then an error is returned.

Examples

The following SQL constructs a polygon from a geography object with an SRID value.

```
SELECT ST_AsEWKT(ST_GeogFromText('SRID=4324;POLYGON((0 0,0 1,1 1,10 10,1 0,0 0))'));
```

```
  st_asewkt
------------------------------------------------
 SRID=4324;POLYGON((0 0,0 1,1 1,10 10,1 0,0 0))
```

The following SQL constructs a polygon from a geography object. The SRID value is set to 4326.

```
SELECT ST_AsEWKT(ST_GeogFromText('POLYGON((0 0,0 1,1 1,10 10,1 0,0 0))'));
```

```
 st_asewkt
------------------------------------------------
 SRID=4326;POLYGON((0 0,0 1,1 1,10 10,1 0,0 0))
```

ST_GeogFromWKB

ST_GeogFromWKB constructs a geography object from a hexadecimal well-known binary (WKB) representation of an input geography.

Syntax

```
ST_GeogFromWKB(wkb_string)
```

Arguments

wkb_string

A value of data type VARCHAR that is a hexadecimal WKB representation of a geography.

Return type

GEOGRAPHY

If the SRID value is provided it is set to the provided value. If SRID is not provided, it is set to 4326.

If *wkb_string* is null, then null is returned.

If *wkb_string* is not valid, then an error is returned.

Examples

The following SQL constructs a geography from a hexadecimal WKB value.

```
SELECT
 ST_AsEWKT(ST_GeogFromWKB('01030000000100000005000000000000000000000000000000000000000000000
```

```


 st_asewkt
------------------------------------------
 SRID=4326;POLYGON((0 0,0 1,1 1,1 0,0 0))
```

ST_GeometryN

ST_GeometryN returns a geometry pointed to by the input index of the input geometry, as follows:

- If the input is a point, linestring, or polygon, then a geometry is returned as is if the index is equal to one (1), and null if the index is other than one (1).
- If the input is a multipoint, multilinestring, multipolygon, or geometry collection, then a point, linestring, polygon, or geometry collection is returned as pointed to by an input index.

The index is one-based. The spatial reference system identifier (SRID) of the result is the same as that of the input geometry. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_GeometryN(geom, index)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

index

A value of data type `INTEGER` that represents the position of a one-based index.

Return type

`GEOMETRY`

If *geom* or *index* is null, then null is returned.

If *index* is out of range, then an error is returned.

Examples

The following SQL returns the geometries in a geometry collection.

```
WITH tmp1(idx) AS (SELECT 1 UNION SELECT 2),
tmp2(g) AS (SELECT ST_GeomFromText('GEOMETRYCOLLECTION(POLYGON((0 0,10 0,0 10,0
 0)),LINESTRING(20 10,20 0,10 0))'))
SELECT idx, ST_AsEWKT(ST_GeometryN(g, idx)) FROM tmp1, tmp2 ORDER BY idx;
```

```
 idx |          st_asewkt
-----+------------------------------
   1 | POLYGON((0 0,10 0,0 10,0 0))
   2 | LINESTRING(20 10,20 0,10 0)
```

ST_GeometryType

ST_GeometryType returns the subtype of an input geometry as a string.

For 3DM, 3DZ, and 4D geometry inputs, ST_GeometryType returns the same result as for 2D geometry inputs.

Syntax

```
ST_GeometryType(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

VARCHAR representing the subtype of *geom*.

If *geom* is null, then null is returned.

The values returned are as follows.

Returned string value	Geometry subtype
`ST_Point`	Returned if *geom* is a `POINT` subtype
`ST_LineString`	Returned if *geom* is a `LINESTRING` subtype
`ST_Polygon`	Returned if *geom* is a `POLYGON` subtype
`ST_MultiPoint`	Returned if *geom* is a `MULTIPOINT` subtype
`ST_MultiLineString`	Returned if *geom* is a `MULTILINESTRING` subtype
`ST_MultiPolygon`	Returned if *geom* is a `MULTIPOLYGON` subtype
`ST_GeometryCollection`	Returned if *geom* is a `GEOMETRYCOLLECTION` subtype

Examples

The following SQL returns the subtype of the input linestring geometry.

```
SELECT ST_GeometryType(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'));
```

```
st_geometrytype
-------------
 ST_LineString
```

ST_GeomFromEWKB

ST_GeomFromEWKB constructs a geometry object from the extended well-known binary (EWKB) representation of an input geometry.

ST_GeomFromEWKB accepts 3DZ, 3DM, and 4D geometries written in WKB and EWKB hexadecimal format.

Syntax

```
ST_GeomFromEWKB(ewkb_string)
```

Arguments

ewkb_string

A value of data type VARCHAR that is a hexadecimal EWKB representation of a geometry.

Return type

GEOMETRY

If *ewkb_string* is null, then null is returned.

If *ewkb_string* is not valid, then an error is returned.

Examples

The following SQL constructs a polygon from an EWKB value and returns the EWKT representation of a polygon.

```
SELECT
 ST_AsEWKT(ST_GeomFromEWKB('0103000020E61000000100000005000000000000000000000000000000000000000
```

```

 st_asewkt
--------------------------------
 SRID=4326;POLYGON((0 0,0 1,1 1,1 0,0 0))
```

ST_GeomFromEWKT

ST_GeomFromEWKT constructs a geometry object from the extended well-known text (EWKT) representation of an input geometry.

ST_GeomFromEWKT accepts 3DZ, 3DM, and 4D where the geometry type is prefixed with Z, M, or ZM, respectively.

Syntax

```
ST_GeomFromEWKT(ewkt_string)
```

Arguments

ewkt_string

A value of data type VARCHAR or an expression that evaluates to a VARCHAR type, that is an EWKT representation of a geometry.

You can use the WKT keyword EMPTY to designate an empty point, a multipoint with an empty point, or a geometry collection with an empty point. The following example creates an empty point.

```
ST_GeomFromEWKT('SRID=4326;POINT EMPTY');
```

Return type

GEOMETRY

If *ewkt_string* is null, then null is returned.

If *ewkt_string* is not valid, then an error is returned.

Examples

The following SQL constructs a multilinestring from an EWKT value and returns a geometry. It also returns the ST_AsEWKT result of the geometry.

```
SELECT ST_GeomFromEWKT('SRID=4326;MULTILINESTRING((1 0,1 0),(2 0,3 0),(4 0,5 0,6 0))')
 as geom, ST_AsEWKT(geom);
```

```
                                                              geom
                                              |                          st_asewkt
--------------------------------------------------------------------------------------------------
+--------------------------------------------------------------
```

```
 0105000020E610000003000000010200000002000000000000000000F03F0000000000000000000000000000F03F00
 | SRID=4326;MULTILINESTRING((1 0,1 0),(2 0,3 0),(4 0,5 0,6 0))
```

ST_GeomFromGeoHash

ST_GeomFromGeoHash constructs a geometry object from the geohash representation of an input geometry. ST_GeomFromGeoHash returns a two-dimensional (2D) geometry with the spatial reference identifier (SRID) of zero (0). For more information about the geohash format, see Geohash in Wikipedia.

Syntax

```
ST_GeomFromGeoHash(geohash_string)
```

```
ST_GeomFromGeoHash(geohash_string, precision)
```

Arguments

geohash_string

A value of data type `VARCHAR` or an expression that evaluates to a `VARCHAR` type, that is a geohash representation of a geometry.

precision

A value of data type `INTEGER` that represents the precision of the geohash. The value is the number of characters of the geohash to be used as precision. If the value is not specified, less than zero, or greater than the *geohash_string* length. then the *geohash_string* length is used.

Return type

`GEOMETRY`

If *geohash_string* is null, then null is returned.

If *geohash_string* is not valid, then an error is returned.

Examples

The following SQL returns a polygon with high precision.

```
SELECT ST_AsText(ST_GeomFromGeoHash('9qqj7nmxncgyy4d0dbxqz0'));
```

```
 st_asewkt
-----------------------
 POLYGON((-115.172816 36.114646,-115.172816 36.114646,-115.172816 36.114646,-115.172816
 36.114646,-115.172816 36.114646))
```

The following SQL returns a point with high precision.

```
SELECT ST_AsText(ST_GeomFromGeoHash('9qqj7nmxncgyy4d0dbxqz00'));
```

```
 st_asewkt
-----------------------
 POINT(-115.172816 36.114646)
```

The following SQL returns a polygon with low precision.

```
SELECT ST_AsText(ST_GeomFromGeoHash('9qq'));
```

```
 st_asewkt
-----------------------
 POLYGON((-115.3125 35.15625,-115.3125 36.5625,-113.90625 36.5625,-113.90625
 35.15625,-115.3125 35.15625))
```

The following SQL returns a polygon with precision 3.

```
SELECT ST_AsText(ST_GeomFromGeoHash('9qqj7nmxncgyy4d0dbxqz0', 3));
```

```
 st_asewkt
-----------------------
 POLYGON((-115.3125 35.15625,-115.3125 36.5625,-113.90625 36.5625,-113.90625
 35.15625,-115.3125 35.15625))
```

ST_GeomFromGeoJSON

ST_GeomFromGeoJSON constructs a geometry object from the GeoJSON representation of an input geometry. For more information about the GeoJSON format, see GeoJSON in Wikipedia.

If there is at least one point with three or more coordinates, the resulting geometry is 3DZ, where the Z component is zero for the points that have only two coordinates. If all points in the input GeoJSON contain two coordinates or are empty, ST_GeomFromGeoJSON returns a 2D geometry. The returned geometry always has the spatial reference identifier (SRID) of 4326.

Syntax

```
ST_GeomFromGeoJSON(geojson_string)
```

Arguments

geojson_string

A value of data type VARCHAR or SUPER, or an expression that evaluates to a VARCHAR type, that is a GeoJSON representation of a geometry.

Return type

GEOMETRY

If *geojson_string* is null, then null is returned.

If *geojson_string* is not valid, then an error is returned.

Examples

The following SQL returns a 2D geometry represented in the input GeoJSON.

```
SELECT ST_AsEWKT(ST_GeomFromGeoJSON('{"type":"Point","coordinates":[1,2]}'));
```

```
 st_asewkt
```

```
-----------------------
 SRID=4326;POINT(1 2)
```

The following SQL returns a 3DZ geometry represented in the input GeoJSON.

```
SELECT ST_AsEWKT(ST_GeomFromGeoJSON('{"type":"LineString","coordinates":[[1,2,3],
[4,5,6],[7,8,9]]}'));
```

```
 st_asewkt
------------------------------------------
 SRID=4326;LINESTRING Z (1 2 3,4 5 6,7 8 9)
```

The following SQL returns 3DZ geometry when only one point has three coordinates while all other points have two coordinates in the input GeoJSON.

```
SELECT ST_AsEWKT(ST_GeomFromGeoJSON('{"type":"Polygon","coordinates":[[[0, 0],[0, 1,
 8],[1, 0],[0, 0]]]}'));
```

```
 st_asewkt
------------------------------------------------
 SRID=4326;POLYGON Z ((0 0 0,0 1 8,1 0 0,0 0 0))
```

ST_GeomFromGeoSquare

ST_GeomFromGeoSquare returns a geometry that covers the area that is represented by an input geosquare value. The returned geometry is always two-dimensional. To calculate a geosquare value, see ST_GeoSquare.

Syntax

```
ST_GeomFromGeoSquare(geosquare)
```

```
ST_GeomFromGeoSquare(geosquare, max_depth)
```

Arguments

geosquare

A value of data type BIGINT or an expression that evaluates to a BIGINT type that is a geosquare value that describes the sequence of subdivisions made on the initial domain to reach the desired square. This value is calculated by ST_GeoSquare.

max_depth

A value of data type INTEGER that represents the maximum number of domain subdivisions made on the initial domain. The value must be greater than or equal to 1.

Return type

GEOMETRY

If *geosquare* is not valid, the function returns an error.

If the input *max_depth* is not within range, the function returns an error.

Examples

The following SQL returns a geometry from a geosquare value.

```
SELECT ST_AsText(ST_GeomFromGeoSquare(797852));
```

```
 st_astext
--------------------------------------------------------------------------------------------------------
 POLYGON((13.359375 52.3828125,13.359375 52.734375,13.7109375 52.734375,13.7109375
 52.3828125,13.359375 52.3828125))
```

The following SQL returns a geometry from a geosquare value and a maximum depth of 3.

```
SELECT ST_AsText(ST_GeomFromGeoSquare(797852, 3));
```

```
 st_astext
--------------------------------------
 POLYGON((0 45,0 90,45 90,45 45,0 45))
```

The following SQL first calculates the geosquare value for Seattle by specifying the x coordinate as longitude and the y coordinate as latitude (-122.3, 47.6). Then it returns the polygon for the geosquare. Although the output is a two-dimensional geometry, it can be used to calculate spatial data in terms of longitude and latitude.

```
SELECT ST_AsText(ST_GeomFromGeoSquare(ST_GeoSquare(ST_Point(-122.3, 47.6))));
```

```
 st_astext
-------------------------------------------------------------------------------------------------
POLYGON((-122.335167014971 47.6080129947513,-122.335167014971
 47.6080130785704,-122.335166931152 47.6080130785704,-122.335166931152
 47.6080129947513,-122.335167014971 47.6080129947513))
```

ST_GeomFromText

ST_GeomFromText constructs a geometry object from a well-known text (WKT) representation of an input geometry.

ST_GeomFromText accepts 3DZ, 3DM, and 4D where the geometry type is prefixed with Z, M, or ZM, respectively.

Syntax

```
ST_GeomFromText(wkt_string)
```

```
ST_GeomFromText(wkt_string, srid)
```

Arguments

wkt_string

A value of data type VARCHAR that is a WKT representation of a geometry.

You can use the WKT keyword EMPTY to designate an empty point, a multipoint with an empty point, or a geometry collection with an empty point. The following example creates a multipoint with one empty and one nonempty point.

```
ST_GeomFromEWKT('MULTIPOINT(1 0,EMPTY)');
```

srid

A value of data type `INTEGER` that is a spatial reference identifier (SRID). If an SRID value is provided, the returned geometry has this SRID value. Otherwise, the SRID value of the returned geometry is set to zero (0).

Return type

`GEOMETRY`

If *wkt_string* or *srid* is null, then null is returned.

If *srid* is negative, then null is returned.

If *wkt_string* is not valid, then an error is returned.

If *srid* is not valid, then an error is returned.

Examples

The following SQL constructs a geometry object from the WKT representation and SRID value.

```
SELECT ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326);
```

```


st_geomfromtext
--------------------------------
0103000020E610000001000000050000000000000000000000000000000000000000000000000000000000000000000000F
```

ST_GeomFromWKB

ST_GeomFromWKB constructs a geometry object from a hexadecimal well-known binary (WKB) representation of an input geometry.

ST_GeomFromWKB accepts 3DZ, 3DM, and 4D geometries written in WKB hexadecimal format.

Syntax

```
ST_GeomFromWKB(wkb_string)
```

```
ST_GeomFromWKB(wkb_string, srid)
```

Arguments

wkb_string

A value of data type VARCHAR that is a hexadecimal WKB representation of a geometry.

srid

A value of data type INTEGER that is a spatial reference identifier (SRID). If an SRID value is provided, the returned geometry has this SRID value. Otherwise, the SRID value of the returned geometry is set to 0.

Return type

GEOMETRY

If *wkb_string* or *srid* is null, then null is returned.

If *srid* is negative, then null is returned.

If *wkb_string* is not valid, then an error is returned.

If *srid* is not valid, then an error is returned.

Examples

The following SQL constructs a polygon from a WKB value and returns the WKT representation of a polygon.

```
SELECT
 ST_AsText(ST_GeomFromWKB('010300000001000000050000000000000000000000000000000000000000000000000
```

```


 st_astext
--------------------------------
 POLYGON((0 0,0 1,1 1,1 0,0 0))
```

ST_GeoSquare

ST_GeoSquare recursively subdivides the domain ([-180, 180], [-90, 90]) into equal square regions called *geosquares* to a specified depth. The subdivision is based on the location of a provided point. One of the geosquares containing the point is subdivided at each step until reaching the maximum depth. The selection of this geosquare is stable, that is, the function result depends on the input arguments only. The function returns a unique value that identifies the final geosquare in which the point is located.

The ST_GeoSquare accepts a POINT where the x coordinate is representing the longitude, and the y coordinate is representing the latitude. The longitude and latitude are limited to [-180, 180] and [-90, 90], respectively. The output of ST_GeoSquare can be used as input to the ST_GeomFromGeoSquare function.

There are 360° around the arc of the equatorial circumference of the Earth that are divided into two hemispheres (Eastern and Western), each with 180° of longitudinal lines (Meridians) from the 0° Meridian. By convention, the eastern longitudes are "+" (positive) coordinates when projected to an x-axis on a Cartesian plane and the western longitudes are "-" (negative) coordinates when projected to an x-axis on a Cartesian plane. There are 90° of latitudinal lines north and south of the 0° equatorial circumference of the Earth, each parallel to the 0° equatorial circumference of the Earth. By convention, the northern latitudinal lines intersect the "+" (positive) y-axis when projected to a Cartesian plane, and the southern latitudinal lines intersect the "-" (negative) y-axis when projected to a Cartesian plane. The spherical grid formed by the intersection of longitudinal lines and latitudinal lines is converted to a grid projected onto a Cartesian plane with standard positive and negative x-coordinates and positive and negative y-coordinates on the Cartesian plane.

The purpose of ST_GeoSquare is to tag or mark close points with equal code values. Points that are located in the same geosquare receive the same code value. A geosquare is used to encode geographic coordinates (latitude and longitude) into an integer. A larger region is divided into grids to delineate an area on a map with varying resolutions. A geosquare can be used for spatial indexing, spatial binning, proximity searches, location searching, and creating unique place identifiers. The ST_GeoHash function follows a similar process of dividing a region into grids, but has a different encoding.

Syntax

```
ST_GeoSquare(geom)
```

```
ST_GeoSquare(geom, max_depth)
```

Arguments

geom

A POINT value of data type `GEOMETRY` or an expression that evaluates to a POINT subtype. The x coordinate (longitude) of the point must be within the range: `-180` – `180`. The y coordinate (latitude) of the point must be within the range: `-90` – `90`.

max_depth

A value of data type `INTEGER`. The maximum number of times the domain containing the point is subdivided recursively. The value must be an integer from 1 – 32. The default is 32. The actual final number of the subdivisions is less than or equal to the specified *max_depth*.

Return type

`BIGINT`

The function returns a unique value that identifies the final geosquare in which the input point is located.

If the input *geom* is not a point, the function returns an error.

If the input point is empty, the return value is not a valid input to the ST_GeomFromGeoSquare function. Use the ST_IsEmpty function to prevent calls to ST_GeoSquare with an empty point.

If the input point is not within range, the function returns an error.

If the input *max_depth* is out of range, the function returns an error.

Examples

The following SQL returns a geosquare from an input point.

```
SELECT ST_GeoSquare(ST_Point(13.5, 52.5));
```

```
  st_geosquare
-----------------------
 -4410772491521635895
```

The following SQL returns a geosquare from an input point with a maximum depth of 10.

```
SELECT ST_GeoSquare(ST_Point(13.5, 52.5), 10);
```

```
 st_geosquare
--------------
 797852
```

ST_InteriorRingN

ST_InteriorRingN returns a closed linestring corresponding to the interior ring of an input polygon at the index position. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_InteriorRingN(geom, index)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

index

A value of data type INTEGER that represents the position of a ring of a one-based index.

Return type

GEOMETRY of subtype LINESTRING.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *geom* or *index* is null, then null is returned.

If *index* is out of range, then null is returned.

If *geom* is not a polygon, then null is returned.

If *geom* is an empty polygon, then null is returned.

Examples

The following SQL returns the second ring of the polygon as a closed linestring.

```
SELECT ST_AsEWKT(ST_InteriorRingN(ST_GeomFromText('POLYGON((7 9,8 7,11 6,15 8,16 6,17
 7,17 10,18 12,17 14,15 15,11 15,10 13,9 12,7 9),(9 9,10 10,11 11,11 10,10 8,9 9),(12
 14,15 14,13 11,12 14))'),2));
```

```


st_asewkt
-----------
 LINESTRING(12 14,15 14,13 11,12 14)
```

ST_Intersects

ST_Intersects returns true if the 2D projections of the two input geometries have at least one point in common.

Syntax

```
ST_Intersects(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon intersects the second polygon.

```
SELECT ST_Intersects(ST_GeomFromText('POLYGON((0 0,10 0,10 10,0 10,0 0),(2 2,2 5,5 5,5
 2,2 2))'), ST_GeomFromText('MULTIPOINT((4 4),(6 6))'));
```

```


st_intersects
-------------
 true
```

ST_Intersection

ST_Intersection returns a geometry representing the point-set intersection of two geometries. That is, it returns the portion of the two input geometries that is shared between them.

Syntax

```
ST_Intersection(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`

If *geom1* and *geom2* don't share any space (they are disjoint), then an empty geometry is returned.

If *geom1* or *geom2* are empty, then an empty geometry is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

If *geom1* or *geom2* is not a two-dimensional (2D) geometry, then an error is returned.

Examples

The following SQL returns the non-empty geometry representing the intersection of two input geometries.

```
SELECT ST_AsEWKT(ST_Intersection(ST_GeomFromText('polygon((0 0,100 100,0 200,0 0))'),
 ST_GeomFromText('polygon((0 0,10 0,0 10,0 0))')));
```

```
        st_asewkt
-------------------------
 POLYGON((0 0,0 10,5 5,0 0))
```

The following SQL returns an empty geometry when passed disjoint (non-intersecting) input geometries.

```
SELECT ST_AsEWKT(ST_Intersection(ST_GeomFromText('linestring(0 100,0 0)'),
 ST_GeomFromText('polygon((1 0,10 0,1 10,1 0))')));
```

```
    st_asewkt
------------------
 LINESTRING EMPTY
```

ST_IsPolygonCCW

ST_IsPolygonCCW returns true if the 2D projection of the input polygon or multipolygon is counterclockwise. If the input geometry is a point, linestring, multipoint, or multilinestring, then true is returned. For geometry collections, ST_IsPolygonCCW returns true if all the geometries in the collection are counterclockwise.

Syntax

```
ST_IsPolygonCCW(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom* is null, then null is returned.

Examples

The following SQL checks if the polygon is counterclockwise.

```
SELECT ST_IsPolygonCCW(ST_GeomFromText('POLYGON((7 9,8 7,11 6,15 8,16 6,17 7,17 10,18
 12,17 14,15 15,11 15,10 13,9 12,7 9),(9 9,10 10,11 11,11 10,10 8,9 9),(12 14,15 14,13
 11,12 14))'));
```

```


 st_ispolygonccw
----------
 true
```

ST_IsPolygonCW

ST_IsPolygonCW returns true if the 2D projection of the input polygon or multipolygon is clockwise. If the input geometry is a point, linestring, multipoint, or multilinestring, then true is returned. For geometry collections, ST_IsPolygonCW returns true if all the geometries in the collection are clockwise.

Syntax

```
ST_IsPolygonCW(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom* is null, then null is returned.

Examples

The following SQL checks if the polygon is clockwise.

```
SELECT ST_IsPolygonCW(ST_GeomFromText('POLYGON((7 9,8 7,11 6,15 8,16 6,17 7,17 10,18
 12,17 14,15 15,11 15,10 13,9 12,7 9),(9 9,10 10,11 11,11 10,10 8,9 9),(12 14,15 14,13
 11,12 14))'));
```

```

 st_ispolygonccw
----------
 true
```

ST_IsClosed

ST_IsClosed returns true if the 2D projection of the input geometry is closed. The following rules define a closed geometry:

- The input geometry is a point or a multipoint.
- The input geometry is a linestring, and the start and end points of the linestring coincide.
- The input geometry is a nonempty multilinestring and all its linestrings are closed.
- The input geometry is a nonempty polygon, all polygon's rings are nonempty, and the start and end points of all its rings coincide.
- The input geometry is a nonempty multipolygon and all its polygons are closed.
- The input geometry is a nonempty geometry collection and all its components are closed.

Syntax

```
ST_IsClosed(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom* is an empty point, then false is returned.

If *geom* is null, then null is returned.

Examples

The following SQL checks if the polygon is closed.

```
SELECT ST_IsClosed(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

```

st_isclosed
-----------
 true
```

ST_IsCollection

ST_IsCollection returns true if the input geometry is one of the following subtypes: GEOMETRYCOLLECTION, MULTIPOINT, MULTILINESTRING, or MULTIPOLYGON.

Syntax

```
ST_IsCollection(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom* is null, then null is returned.

Examples

The following SQL checks if the polygon is a collection.

```
SELECT ST_IsCollection(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

```

st_iscollection
-----------
 false
```

ST_IsEmpty

ST_IsEmpty returns true if the input geometry is empty. A geometry is not empty if it contains at least one nonempty point.

ST_IsEmpty returns true if the input geometry has at least one nonempty point.

Syntax

```
ST_IsEmpty(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

BOOLEAN

If *geom* is null, then null is returned.

Examples

The following SQL checks if the specified polygon is empty.

```
SELECT ST_IsEmpty(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

```


st_isempty
-----------
 false
```

ST_IsRing

ST_IsRing returns true if the input linestring is a ring. A linestring is a ring if it is closed and simple.

Syntax

```
ST_IsRing(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The geometry must be a LINESTRING.

Return type

BOOLEAN

If *geom* is not a LINESTRING, then an error is returned.

Examples

The following SQL checks if the specified linestring is a ring.

```
SELECT ST_IsRing(ST_GeomFromText('linestring(0 0, 1 1, 1 2, 0 0)'));
```

```
st_isring
-----------
 true
```

ST_IsSimple

ST_IsSimple returns true if the 2D projection of the input geometry is simple. For more information about the definition of a simple geometry, see Geometric simplicity.

Syntax

```
ST_IsSimple(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom* is null, then null is returned.

Examples

The following SQL checks if the specified linestring is simple. In this example, it isn't simple because it has self-intersection.

```
SELECT ST_IsSimple(ST_GeomFromText('LINESTRING(0 0,10 0,5 5,5 -5)'));
```

```
 st_issimple
-----------
 false
```

ST_IsValid

ST_IsValid returns true if the 2D projection of the input geometry is valid. For more information about the definition of a valid geometry, see Geometric validity.

Syntax

```
ST_IsValid(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`BOOLEAN`

If *geom* is null, then null is returned.

Examples

The following SQL checks if the specified polygon is valid. In this example, the polygon is invalid because the interior of the polygon isn't simply connected.

```
SELECT ST_IsValid(ST_GeomFromText('POLYGON((0 0,10 0,10 10,0 10,0 0),(5 0,10 5,5 10,0
 5,5 0))'));
```

```

 st_isvalid
-----------
 false
```

ST_Length

For a linear geometry, ST_Length returns the Cartesian length of a 2D projection. The length units are the same as the units in which the coordinates of the input geometry are expressed. The function returns zero (0) for points, multipoints, and areal geometries. When the input is a geometry collection, the function returns the sum of the lengths of the geometries in the collection.

For a geography, ST_Length returns the geodesic length of the 2D projection of an input linear geography computed on the spheroid determined by the SRID. The unit of length is in meters. The function returns zero (0) for points, multipoints, and areal geographies. When the input is a geometry collection, the function returns the sum of the lengths of the geographies in the collection.

Syntax

```
ST_Length(geo)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

Return type

`DOUBLE PRECISION`

If *geo* is null, then null is returned.

If the SRID value is not found, then an error is returned.

Examples

The following SQL returns the Cartesian length of a multilinestring.

```
SELECT ST_Length(ST_GeomFromText('MULTILINESTRING((0 0,10 0,0 10),(10 0,20 0,20
 10))'));
```

```


st_length
--------------------------------
  44.142135623731
```

The following SQL returns the length of a linestring in a geography.

```
SELECT ST_Length(ST_GeogFromText('SRID=4326;LINESTRING(5 0,6 0,4 0)'));
```

```
 st_length
------------------
 333958.472379804
```

The following SQL returns the length of a point in a geography.

```
SELECT ST_Length(ST_GeogFromText('SRID=4326;POINT(4 5)'));
```

```
 st_length
-----------
 0
```

ST_LengthSphere

ST_LengthSphere returns the length of a linear geometry in meters. For point, multipoint, and areal geometries, ST_LengthSphere returns 0. For geometry collections, ST_LengthSphere returns the total length of the linear geometries in the collection in meters.

ST_LengthSphere interprets the coordinates of each point of the input geometry as longitude and latitude in degrees. For 3DZ, 3DM, or 4D geometries, only the first two coordinates are used.

Syntax

```
ST_LengthSphere(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` length in meters. The length computation is based on the spherical model of the Earth whose radius is Earth's mean radius of the World Geodetic System (WGS) 84 ellipsoidal model of the Earth.

If *geom* is null, then null is returned.

Examples

The following example SQL computes the length of a linestring in meters.

```
SELECT ST_LengthSphere(ST_GeomFromText('LINESTRING(10 10,45 45)'));
```

```
 st_lengthsphere
------------------
 5127736.08292556
```

ST_Length2D

ST_Length2D is an alias for ST_Length. For more information, see ST_Length.

ST_LineFromMultiPoint

ST_LineFromMultiPoint returns a linestring from an input multipoint geometry. The order of the points is preserved. The spatial reference system identifier (SRID) of the returned geometry is the same as that of the input geometry. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_LineFromMultiPoint(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be MULTIPOINT.

Return type

GEOMETRY

If *geom* is null, then null is returned.

If *geom* is empty, then an empty LINESTRING is returned.

If *geom* contains empty points, then these empty points are ignored.

If *geom* isn't a MULTIPOINT, then error is returned.

Examples

The following SQL creates a linestring from a multipoint.

```
SELECT ST_AsEWKT(ST_LineFromMultiPoint(ST_GeomFromText('MULTIPOINT(0 0,10 0,10 10,5 5,0
 5)',4326)));
```

```

 st_asewkt
---------------------------------------------
 SRID=4326;LINESTRING(0 0,10 0,10 10,5 5,0 5)
```

ST_LineInterpolatePoint

ST_LineInterpolatePoint returns a point along a line at a fractional distance from the start of the line.

To determine point equality, ST_LineInterpolatePoint operates on the 2D projection of the input geometry. If the input geometry is empty, a copy of it is returned in the same dimension as the input. For 3DZ, 3DM, and 4D geometries, the z or m coordinate is the average of the z or m coordinates of the segment where the point lies.

Syntax

```
ST_LineInterpolatePoint(geom, fraction)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype is LINESTRING.

fraction

A value of data type `DOUBLE PRECISION` that represents the position of a point along the linestring for the line. The value is a fraction in the range 0–1, inclusive.

Return type

`GEOMETRY` of subtype `POINT`.

If *geom* or *fraction* is null, then null is returned.

If *geom* is empty, then the empty point is returned.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

If *fraction* is out of range, then an error is returned.

If *geom* is not a linestring, then an error is returned.

Examples

The following SQL returns a point halfway along a linestring.

```
SELECT ST_AsEWKT(ST_LineInterpolatePoint(ST_GeomFromText('LINESTRING(0 0, 5 5, 7 7, 10
 10)'), 0.50));
```

```


st_asewkt
-----------
 POINT(5 5)
```

The following SQL returns a point 90 percent of the way along a linestring.

```
SELECT ST_AsEWKT(ST_LineInterpolatePoint(ST_GeomFromText('LINESTRING(0 0, 5 5, 7 7, 10
 10)'), 0.90));
```

```


st_asewkt
-----------
 POINT(9 9)
```

ST_M

ST_M returns the m coordinate of an input point.

Syntax

```
ST_M(point)
```

Arguments

point

A POINT value of data type GEOMETRY.

Return type

DOUBLE PRECISION value of the m coordinate.

If *point* is null, then null is returned.

If *point* is a 2D or 3DZ point, then null is returned.

If *point* is the empty point, then null is returned.

If *point* is not a POINT, then an error is returned.

Examples

The following SQL returns the m coordinate of a point in a 3DM geometry.

```
SELECT ST_M(ST_GeomFromEWKT('POINT M (1 2 3)'));
```

```
st_m
-----------
 3
```

The following SQL returns the m coordinate of a point in a 4D geometry.

```
SELECT ST_M(ST_GeomFromEWKT('POINT ZM (1 2 3 4)'));
```

```
st_m
-----------
 4
```

ST_MakeEnvelope

ST_MakeEnvelope returns a geometry as follows:

- If the input coordinates specify a point, then the returned geometry is a point.
- If the input coordinates specify a line, then the returned geometry is a linestring.
- Otherwise, the returned geometry is a polygon, where the input coordinates specify the lower-left and upper-right corners of a box.

If provided, the spatial reference system identifier (SRID) value of the returned geometry is set to the input SRID value.

Syntax

```
ST_MakeEnvelope(xmin, ymin, xmax, ymax)
```

```
ST_MakeEnvelope(xmin, ymin, xmax, ymax, srid)
```

Arguments

xmin

A value of data type `DOUBLE PRECISION`. This value is the first coordinate of the lower-left corner of a box.

ymin

A value of data type `DOUBLE PRECISION`. This value is the second coordinate of the lower-left corner of a box.

xmax

A value of data type `DOUBLE PRECISION`. This value is the first coordinate of the upper-right corner of a box.

ymax

A value of data type `DOUBLE PRECISION`. This value is the second coordinate of the upper-right corner of a box.

srid

A value of data type `INTEGER` that represents a spatial reference system identifier (SRID). If the SRID value is not provided, then it is set to zero.

Return type

`GEOMETRY` of subtype `POINT`, `LINESTRING`, or `POLYGON`.

The SRID of the returned geometry is set to `srid` or zero if `srid` isn't set.

If *xmin*, *ymin*, *xmax*, *ymax*, or *srid* is null, then null is returned.

If *srid* is negative, then an error is returned.

Examples

The following SQL returns a polygon representing an envelope defined by the four input coordinate values.

```
SELECT ST_AsEWKT(ST_MakeEnvelope(2,4,5,7));
```

```

 st_astext
---------------
 POLYGON((2 4,2 7,5 7,5 4,2 4))
```

The following SQL returns a polygon representing an envelope defined by the four input coordinate values and an SRID value.

```
SELECT ST_AsEWKT(ST_MakeEnvelope(2,4,5,7,4326));
```

```

 st_astext
----------------------------------
```

```
SRID=4326;POLYGON((2 4,2 7,5 7,5 4,2 4))
```

ST_MakeLine

ST_MakeLine creates a linestring from the input geometries.

The dimension of the returned geometry is the same as that of the input geometries. Both input geometries must of the same dimension.

Syntax

```
ST_MakeLine(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `POINT`, `LINESTRING`, or `MULTIPOINT`.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `POINT`, `LINESTRING`, or `MULTIPOINT`.

Return type

`GEOMETRY` of subtype `LINESTRING`.

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* is the empty point or contains empty points, then these empty points are ignored.

If *geom1* and *geom2* are empty, then the empty `LINESTRING` is returned.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometries.

If *geom1* and *geom2* have different SRID values, then an error is returned.

If *geom1* or *geom2* is not a `POINT`, `LINESTRING`, or `MULTIPOINT`, then an error is returned.

If *geom1* and *geom2* have different dimensions, then an error is returned.

Examples

The following SQL constructs a linestring from two input linestrings.

```
SELECT ST_MakeLine(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'), ST_GeomFromText('LINESTRING(88.29 39.07,88.42 39.26,88.27
 39.31,88.29 39.07)'));
```

```
st_makeline
-----------
 010200000008000000C3F5285C8F52534052B81E85EB113D407B14AE47E15A5340C3F5285C8F423D40E17A14AE4751
```

ST_MakePoint

ST_MakePoint returns a point geometry whose coordinate values are the input values.

Syntax

```
ST_MakePoint(x, y)
```

```
ST_MakePoint(x, y, z)
```

```
ST_MakePoint(x, y, z, m)
```

Arguments

x

A value of data type `DOUBLE PRECISION` representing the first coordinate.

y

A value of data type `DOUBLE PRECISION` representing the second coordinate.

z

A value of data type `DOUBLE PRECISION` representing the third coordinate.

m

A value of data type DOUBLE PRECISION representing the fourth coordinate.

Return type

GEOMETRY of subtype POINT.

The spatial reference system identifier (SRID) value of the returned geometry is set to 0.

If *x*, *y*, *z*, or *m* is null, then null is returned.

Examples

The following SQL returns a GEOMETRY type of subtype POINT with the provided coordinates.

```
SELECT ST_AsText(ST_MakePoint(1,3));
```

```
st_astext
-----------
 POINT(1 3)
```

The following SQL returns a GEOMETRY type of subtype POINT with the provided coordinates.

```
SELECT ST_AsEWKT(ST_MakePoint(1, 2, 3));
```

```
st_asewkt
----------------
 POINT Z (1 2 3)
```

The following SQL returns a GEOMETRY type of subtype POINT with the provided coordinates.

```
SELECT ST_AsEWKT(ST_MakePoint(1, 2, 3, 4));
```

```
st_asewkt
-------------------
 POINT ZM (1 2 3 4)
```

ST_MakePolygon

ST_MakePolygon has two variants that return a polygon. One takes a single geometry, and another takes two geometries.

- The input of the first variant is a linestring that defines the outer ring of the output polygon.
- The input of the second variant is a linestring and a multilinestring. Both of these are empty or closed.

  The boundary of the exterior ring of the output polygon is the input linestring, and the boundaries of the interior rings of the polygon are the linestrings in the input multilinestring. If the input linestring is empty, an empty polygon is returned. Empty linestrings in the multilinestring are disregarded. The spatial reference system identifier (SRID) of the resulting geometry is the common SRID of the two input geometries.

The dimension of the returned geometry is the same as that of the input geometries. The exterior ring and interior rings must of the same dimension.

Syntax

```
ST_MakePolygon(geom1)
```

```
ST_MakePolygon(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`. The *linestring* value must be closed or empty.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `MULTILINESTRING`.

Return type

`GEOMETRY` of subtype `POLYGON`.

The spatial reference system identifier (SRID) of the returned geometry is equal to the SRID of the inputs.

If *geom1*, or *geom2* is null, then null is returned.

If *geom1* is not a linestring, then an error is returned.

If *geom2* is not a multilinestring, then an error is returned.

If *geom1* is not closed, then an error is returned.

If *geom1* is a single point or is not closed, then an error is returned.

If *geom2* contains at least one linestring that has a single point or is not closed, then an error is returned.

If *geom1* and *geom2* have different SRID values, then an error is returned.

If *geom1* and *geom2* have different dimensions, then an error is returned.

Examples

The following SQL returns a polygon from an input linestring.

```
SELECT ST_AsText(ST_MakePolygon(ST_GeomFromText('LINESTRING(77.29 29.07,77.42
 29.26,77.27 29.31,77.29 29.07)')));
```

```
 st_astext
---------------
POLYGON((77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07))
```

The following SQL creates a polygon from a closed linestring and a closed multilinestring. The linestring is used for the exterior ring of the polygon. The linestrings in the multilinestrings are used for the interior rings of the polygon.

```
SELECT ST_AsEWKT(ST_MakePolygon(ST_GeomFromText('LINESTRING(0 0,10 0,10 10,0 10,0 0)'),
 ST_GeomFromText('MULTILINESTRING((1 1,1 2,2 1,1 1),(3 3,3 4,4 3,3 3))')));
```

```
 st_astext
----------------------------------
```

```
POLYGON((0 0,10 0,10 10,0 10,0 0),(1 1,1 2,2 1,1 1),(3 3,3 4,4 3,3 3))
```

ST_MemSize

ST_MemSize returns the amount of memory space (in bytes) used by the input geometry. This size depends on the Amazon Redshift internal representation of the geometry and thus can change if the internal representation changes. You can use this size as an indication of the relative size of geometry objects in Amazon Redshift.

Syntax

```
ST_MemSize(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER` representing the inherent dimension of *geom*.

If *geom* is null, then null is returned.

Examples

The following SQL returns the memory size of a geometry collection.

```
SELECT ST_MemSize(ST_GeomFromText('GEOMETRYCOLLECTION(POLYGON((0 0,10 0,0 10,0
 0)),LINESTRING(20 10,20 0,10 0))'))::varchar + ' bytes';
```

```

 ?column?
-----------
 172 bytes
```

ST_MMax

ST_MMax returns the maximum `m` coordinate of an input geometry.

Syntax

```
ST_MMax(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the maximum `m` coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

If *geom* is a 2D or 3DZ geometry, then null is returned.

Examples

The following SQL returns the largest `m` coordinate of a linestring in a 3DM geometry.

```
SELECT ST_MMax(ST_GeomFromEWKT('LINESTRING M (0 1 2, 3 4 5, 6 7 8)'));
```

```
st_mmax
-----------
  8
```

The following SQL returns the largest `m` coordinate of a linestring in a 4D geometry.

```
SELECT ST_MMax(ST_GeomFromEWKT('LINESTRING ZM (0 1 2 3, 4 5 6 7, 8 9 10 11)'));
```

```
st_mmax
-----------
  11
```

ST_MMin

ST_MMin returns the minimum m coordinate of an input geometry.

Syntax

```
ST_MMin(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

DOUBLE PRECISION value of the minimum m coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

If *geom* is a 2D or 3DZ geometry, then null is returned.

Examples

The following SQL returns the smallest m coordinate of a linestring in a 3DM geometry.

```
SELECT ST_MMin(ST_GeomFromEWKT('LINESTRING M (0 1 2, 3 4 5, 6 7 8)'));
```

```
st_mmin
-----------
  2
```

The following SQL returns the smallest m coordinate of a linestring in a 4D geometry.

```
SELECT ST_MMin(ST_GeomFromEWKT('LINESTRING ZM (0 1 2 3, 4 5 6 7, 8 9 10 11)'));
```

```
st_mmin
```

```
-----------
  3
```

ST_Multi

ST_Multi converts a geometry to the corresponding multitype. If the input geometry is already a multitype or a geometry collection, a copy of it is returned. If the input geometry is a point, linestring, or polygon, then a multipoint, multilinestring, or multipolygon, respectively, that contains the input geometry is returned.

Syntax

```
ST_Multi(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY` with subtype `MULTIPOINT`, `MULTILINESTRING`, `MULTIPOLYGON`, or `GEOMETRYCOLLECTION`.

The spatial reference system identifier (SRID) of the returned geometry is the same as that of the input geometry.

If *geom* is null, then null is returned.

Examples

The following SQL returns a multipoint from an input multipoint.

```
SELECT ST_AsEWKT(ST_Multi(ST_GeomFromText('MULTIPOINT((1 2),(3 4))', 4326)));
```

```
    st_asewkt
------------------------------------
  SRID=4326;MULTIPOINT((1 2),(3 4))
```

The following SQL returns a multipoint from an input point.

```
SELECT ST_AsEWKT(ST_Multi(ST_GeomFromText('POINT(1 2)', 4326)));
```

```
    st_asewkt
------------------------------------
  SRID=4326;MULTIPOINT((1 2))
```

The following SQL returns a geometry collection from an input geometry collection.

```
SELECT ST_AsEWKT(ST_Multi(ST_GeomFromText('GEOMETRYCOLLECTION(POINT(1 2),MULTIPOINT((1
 2),(3 4)))', 4326)));
```

```
    st_asewkt
------------------------------------
  SRID=4326;GEOMETRYCOLLECTION(POINT(1 2),MULTIPOINT((1 2),(3 4)))
```

ST_NDims

ST_NDims returns the coordinate dimension of a geometry. ST_NDims doesn't consider the topological dimension of a geometry. Instead, it returns a constant value depending on the dimension of the geometry.

Syntax

```
ST_NDims(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER` representing the inherent dimension of *geom*.

If *geom* is null, then null is returned.

The values returned are as follows.

Returned value	Dimension of input geometry
2	2D
3	3DZ or 3DM
4	4D

Examples

The following SQL returns the number of dimensions of a 2D linestring.

```
SELECT ST_NDims(ST_GeomFromText('LINESTRING(0 0,1 1,2 2,0 0)'));
```

```
st_ndims
-------------
 2
```

The following SQL returns the number of dimensions of a 3DZ linestring.

```
SELECT ST_NDims(ST_GeomFromText('LINESTRING Z(0 0 3,1 1 3,2 2 3,0 0 3)'));
```

```
st_ndims
-------------
 3
```

The following SQL returns the number of dimensions of a 3DM linestring.

```
SELECT ST_NDims(ST_GeomFromText('LINESTRING M(0 0 4,1 1 4,2 2 4,0 0 4)'));
```

```
st_ndims
-------------
 3
```

The following SQL returns the number of dimensions of a 4D linestring.

```
SELECT ST_NDims(ST_GeomFromText('LINESTRING ZM(0 0 3 4,1 1 3 4,2 2 3 4,0 0 3 4)'));
```

```
st_ndims
-------------
 4
```

ST_NPoints

ST_NPoints returns the number of nonempty points in an input geometry or geography.

Syntax

```
ST_NPoints(geo)
```

Arguments

geo

A value of data type `GEOMETRY` or `GEOGRAPHY`, or an expression that evaluates to a `GEOMETRY` or `GEOGRAPHY` type.

Return type

`INTEGER`

If *geo* is an empty point, then `0` is returned.

If *geo* is null, then null is returned.

Examples

The following SQL returns the number of points in a linestring.

```
SELECT ST_NPoints(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```
st_npoints
-------------
 4
```

The following SQL returns the number of points in a linestring in a geography.

```
SELECT ST_NPoints(ST_GeogFromText('LINESTRING(110 40, 2 3, -10 80, -7 9)'));
```

```

st_npoints
-------------
 4
```

ST_NRings

ST_NRings returns the number of rings in an input geometry.

Syntax

```
ST_NRings(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER`

If *geom* is null, then null is returned.

The values returned are as follows.

Returned value	Geometry subtype
0	Returned if *geom* is a `POINT`, `LINESTRING`, `MULTIPOINT`, or `MULTILINESTRING` subtype

Returned value	Geometry subtype
The number of rings.	Returned if *geom* is a `POLYGON` or `MULTIPOLYGON` subtype
The number of rings in all components	Returned if *geom* is a `GEOMETRYCOLLECTION` subtype

Examples

The following SQL returns the number of rings in a multipolygon.

```
SELECT ST_NRings(ST_GeomFromText('MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((0 0,-10 0,0
 -10,0 0)))'));
```

```
 st_nrings
-------------
 2
```

ST_NumGeometries

ST_NumGeometries returns the number of geometries in an input geometry.

Syntax

```
ST_NumGeometries(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER` representing the number of geometries in *geom*.

If *geom* is null, then null is returned.

If *geom* is a single empty geometry, then `0` is returned.

If *geom* is a single nonempty geometry, then `1` is returned.

If *geom* is a `GEOMETRYCOLLECTION` or a `MULTI` subtype, then the number of geometries is returned.

Examples

The following SQL returns the number of geometries in the input multilinestring.

```
SELECT ST_NumGeometries(ST_GeomFromText('MULTILINESTRING((0 0,1 0,0 5),(3 4,13 26))'));
```

```


st_numgeometries
-------------
 2
```

ST_NumInteriorRings

ST_NumInteriorRings returns the number of rings in an input polygon geometry.

Syntax

```
ST_NumInteriorRings(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER`

If *geom* is null, then null is returned.

If *geom* is not a polygon, then null is returned.

Examples

The following SQL returns the number of interior rings in the input polygon.

```
SELECT ST_NumInteriorRings(ST_GeomFromText('POLYGON((0 0,100 0,100 100,0 100,0 0),(1
 1,1 5,5 1,1 1),(7 7,7 8,8 7,7 7))'));
```

```
 st_numinteriorrings
-------------
 2
```

ST_NumPoints

ST_NumPoints returns the number of points in an input geometry.

Syntax

```
ST_NumPoints(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER`

If *geom* is null, then null is returned.

If *geom* is not of subtype `LINESTRING`, then null is returned.

Examples

The following SQL returns the number of points in the input linestring.

```
SELECT ST_NumPoints(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'));
```

```
st_numpoints
-------------
```

```
4
```

The following SQL returns null because the input *geom* is not of subtype LINESTRING.

```
SELECT ST_NumPoints(ST_GeomFromText('MULTIPOINT(1 2,3 4)'));
```

```
st_numpoints
-------------
```

ST_Perimeter

For an input areal geometry, ST_Perimeter returns the Cartesian perimeter (length of the boundary) of the 2D projection. The perimeter units are the same as the units in which the coordinates of the input geometry are expressed. The function returns zero (0) for points, multipoints, and linear geometries. When the input is a geometry collection, the function returns the sum of the perimeters of the geometries in the collection.

For an input geography, ST_Perimeter returns the geodesic perimeter (length of the boundary) of the 2D projection of an input areal geography computed on the spheroid determined by the SRID. The unit of perimeter is in meters. The function returns zero (0) for points, multipoints, and linear geographies. When the input is a geometry collection, the function returns the sum of the perimeters of the geographies in the collection.

Syntax

```
ST_Perimeter(geo)
```

Arguments

geo

A value of data type GEOMETRY or GEOGRAPHY, or an expression that evaluates to a GEOMETRY or GEOGRAPHY type.

Return type

DOUBLE PRECISION

If *geo* is null, then null is returned.

If the SRID value is not found, then an error is returned.

Examples

The following SQL returns the Cartesian perimeter of a multipolygon.

```
SELECT ST_Perimeter(ST_GeomFromText('MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((10 0,20 0,20
 10,10 0)))'));
```

```

 st_perimeter
--------------------------------
    68.2842712474619
```

The following SQL returns the Cartesian perimeter of a multipolygon.

```
SELECT ST_Perimeter(ST_GeomFromText('MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((10 0,20 0,20
 10,10 0)))'));
```

```

 st_perimeter
--------------------------------
    68.2842712474619
```

The following SQL returns the perimeter of a polygon in a geography.

```
SELECT ST_Perimeter(ST_GeogFromText('SRID=4326;POLYGON((0 0,1 0,0 1,0 0))'));
```

```

 st_perimeter
------------------
 378790.428393693
```

The following SQL returns the perimeter of a linestring in a geography.

```
SELECT ST_Perimeter(ST_GeogFromText('SRID=4326;LINESTRING(5 0,10 0)'));
```

```
 st_perimeter
--------------
 0
```

ST_Perimeter2D

ST_Perimeter2D is an alias for ST_Perimeter. For more information, see ST_Perimeter.

ST_Point

ST_Point returns a point geometry from the input coordinate values.

Syntax

```
ST_Point(x, y)
```

Arguments

x

A value of data type `DOUBLE PRECISION` that represents a first coordinate.

y

A value of data type `DOUBLE PRECISION` that represents a second coordinate.

Return type

`GEOMETRY` of subtype `POINT`.

The spatial reference system identifier (SRID) value of the returned geometry is set to 0.

If *x* or *y* is null, then null is returned.

Examples

The following SQL constructs a point geometry from the input coordinates.

```
SELECT ST_AsText(ST_Point(5.0, 7.0));
```

```
st_astext
```

```
-------------
POINT(5 7)
```

ST_PointN

ST_PointN returns a point in a linestring as specified by an index value. Negative index values are counted backward from the end of the linestring, so that -1 is the last point.

The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_PointN(geom, index)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`.

index

A value of data type `INTEGER` that represents the index of a point in a linestring.

Return type

`GEOMETRY` of subtype `POINT`.

The spatial reference system identifier (SRID) value of the returned geometry is set to 0.

If *geom* or *index* is null, then null is returned.

If *index* is out of range, then null is returned.

If *geom* is empty, then null is returned.

If *geom* is not a `LINESTRING`, then null is returned.

Examples

The following SQL returns an extended well-known text (EWKT) representation of a six-point `LINESTRING` to a `GEOMETRY` object and returns the point at index 5 of the linestring.

```
SELECT ST_AsEWKT(ST_PointN(ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0 5,0
 0)',4326), 5));
```

```
st_asewkt
-------------
 SRID=4326;POINT(0 5)
```

ST_Points

ST_Points returns a multipoint geometry containing all nonempty points in the input geometry. ST_Points doesn't remove points that are duplicated in the input, including the start and end points of ring geometries.

Syntax

```
ST_Points(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

GEOMETRY of subtype MULTIPOINT.

The spatial reference system identifier (SRID) value of the returned geometry is the same as *geom*.

If *geom* is null, then null is returned.

If *geom* is empty, then the empty multipoint is returned.

Examples

The following SQL examples construct a multipoint geometry from the input geometry. The result is a multipoint geometry containing the nonempty points in the input geometry.

```
SELECT ST_AsEWKT(ST_Points(ST_SetSRID(ST_GeomFromText('LINESTRING(1 0,2 0,3 0)'),
 4326)));
```

```
st_asewkt
-------------
SRID=4326;MULTIPOINT((1 0),(2 0),(3 0))
```

```
SELECT ST_AsEWKT(ST_Points(ST_SetSRID(ST_GeomFromText('MULTIPOLYGON(((0 0,1 0,0 1,0
 0)))'), 4326)));
```

```
st_asewkt
-------------
SRID=4326;MULTIPOINT((0 0),(1 0),(0 1),(0 0))
```

ST_Polygon

ST_Polygon returns a polygon geometry whose outer ring is the input linestring with the value that was input for the spatial reference system identifier (SRID).

The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_Polygon(linestring, srid)
```

Arguments

linestring

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING` that represents a linestring. The *linestring* value must be closed.

srid

A value of data type `INTEGER` that represents a SRID.

Return type

`GEOMETRY` of subtype `POLYGON`.

The SRID value of the returned geometry is set to *srid*.

If *linestring* or *srid* is null, then null is returned.

If *linestring* is not a linestring, then an error is returned.

If *linestring* is not closed, then an error is returned.

If *srid* is negative, then an error is returned.

Examples

The following SQL constructs a polygon with an SRID value.

```
SELECT ST_AsEWKT(ST_Polygon(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'),4356));
```

```
st_asewkt
-------------
 SRID=4356;POLYGON((77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07))
```

ST_RemovePoint

ST_RemovePoint returns a linestring geometry that has the point of the input geometry at an index position removed.

The index is zero-based. The spatial reference system identifier (SRID) of the result is the same as the input geometry. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_RemovePoint(geom, index)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`.

index

A value of data type `INTEGER` that represents the position of a zero-based index.

Return type

`GEOMETRY`

If *geom* or *index* is null, then null is returned.

If *geom* is not subtype `LINESTRING`, then an error is returned.

If *index* is out of range, then an error is returned. Valid values for the index position are between 0 and `ST_NumPoints(geom)` minus 1.

Examples

The following SQL removes the last point in a linestring.

```
WITH tmp(g) AS (SELECT ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0 5)',4326))
SELECT ST_AsEWKT(ST_RemovePoint(g, ST_NumPoints(g) - 1)) FROM tmp;
```

```


   st_asewkt
-----------------------------------------
 SRID=4326;LINESTRING(0 0,10 0,10 10,5 5)
```

ST_Reverse

ST_Reverse reverses the order of the vertices for linear and areal geometries. For point or multipoint geometries, a copy of the original geometry is returned. For geometry collections, ST_Reverse reverses the order of the vertices for each of the geometries in the collection.

The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_Reverse(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

GEOMETRY

The spatial reference system identifier (SRID) of the returned geometry is the same as that of the input geometry.

If *geom* is null, then null is returned.

Examples

The following SQL reverses the order of the points in a linestring.

```
SELECT ST_AsEWKT(ST_Reverse(ST_GeomFromText('LINESTRING(1 0,2 0,3 0,4 0)', 4326)));
```

```
   st_asewkt
------------------------------------
 SRID=4326;LINESTRING(4 0,3 0,2 0,1 0)
```

ST_SetPoint

ST_SetPoint returns a linestring with updated coordinates with respect to the input linestring's position as specified by the index. The new coordinates are the coordinates of the input point.

The dimension of the returned geometry is the same as that of the *geom1* value. If *geom1* and *geom2* have different dimensions, *geom2* is projected to the dimension of *geom1*.

Syntax

```
ST_SetPoint(geom1, index, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be LINESTRING.

index

A value of data type INTEGER that represents the position of an index. A 0 refers to the first point of the linestring from the left, 1 refers to the second point, and so on. The index can be a negative value. A -1 refers to the first point of the linestring from the right, -2 refers to the second point of the linestring from the right, and so on.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT.

Return type

GEOMETRY

If *geom2* is the empty point, then *geom1* is returned.

If *geom1*, *geom2*, or *index* is null, then null is returned.

If *geom1* is not a linestring, then an error is returned.

If *index* is not within a valid index range, then an error is returned.

If *geom2* is not a point, then an error is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

Examples

The following SQL returns a new linestring where we set the second point of the input linestring with the specified point.

```
SELECT ST_AsText(ST_SetPoint(ST_GeomFromText('LINESTRING(1 2, 3 2, 5 2, 1 2)'), 2,
 ST_GeomFromText('POINT(7 9)')));
```

```
st_astext
-------------
 LINESTRING(1 2,3 2,7 9,1 2)
```

The following SQL example returns a new linestring where we set the third point from the right (the index is negative) of the linestring with the specified point.

```
SELECT ST_AsText(ST_SetPoint(ST_GeomFromText('LINESTRING(1 2, 3 2, 5 2, 1 2)'), -3,
 ST_GeomFromText('POINT(7 9)')));
```

```
st_astext
-------------
 LINESTRING(1 2,7 9,5 2,1 2)
```

ST_SetSRID

ST_SetSRID returns a geometry that is the same as input geometry, except updated with the value input for the spatial reference system identifier (SRID).

Syntax

```
ST_SetSRID(geom, srid)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

srid

A value of data type `INTEGER` that represents a SRID.

Return type

`GEOMETRY`

The SRID value of the returned geometry is set to *srid*.

If *geom* or *srid* is null, then null is returned.

If *srid* is negative, then an error is returned.

Examples

The following SQL sets the SRID value of a linestring.

```
SELECT ST_AsEWKT(ST_SetSRID(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27
 29.31,77.29 29.07)'),50));
```

```
st_asewkt
-------------
 SRID=50;LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07)
```

ST_Simplify

ST_Simplify returns a simplified copy of the input geometry using the Ramer-Douglas-Peucker algorithm with the given tolerance. The topology of the input geometry might not be preserved. For more information about the algorithm, see Ramer–Douglas–Peucker algorithm in Wikipedia.

When ST_Simplify calculates distances to simplify a geometry, ST_Simplify operates on the 2D projection of the input geometry.

Syntax

```
ST_Simplify(geom, tolerance)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

tolerance

A value of data type `DOUBLE PRECISION` that represents the tolerance level of the Ramer-Douglas-Peucker algorithm. If *tolerance* is a negative number, then zero is used.

Return type

`GEOMETRY`.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometry.

The dimension of the returned geometry is the same as that of the input geometry.

If *geom* is null, then null is returned.

Examples

The following SQL simplifies the input linestring using a Euclidean distance tolerance of 1 with the Ramer-Douglas-Peucker algorithm. The units of the distance are the same as those of the coordinates of the geometry.

```
SELECT ST_AsEWKT(ST_Simplify(ST_GeomFromText('LINESTRING(0 0,1 2,1 1,2 2,2 1)'), 1));
```

```

 st_asewkt
-----------
LINESTRING(0 0,1 2,2 1)
```

ST_SRID

ST_SRID returns the spatial reference system identifier (SRID) of an input geometry. For more information about an SRID, see Querying spatial data in Amazon Redshift.

Syntax

```
ST_SRID(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`INTEGER` representing the SRID value of *geom*.

If *geom* is null, then null is returned.

Examples

The following SQL returns an SRID value of a linestring that is set to SRID 4326.

```
SELECT ST_SRID(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)',4326));
```

```
st_srid
-------------
 4326
```

The following SQL returns an SRID value of a linestring that is not set when constructed. This results in `0` for the SRID value.

```
SELECT ST_SRID(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```
st_srid
-------------
 0
```

ST_StartPoint

ST_StartPoint returns the first point of an input linestring. The spatial reference system identifier (SRID) value of the result is the same as that of the input geometry. The dimension of the returned geometry is the same as that of the input geometry.

Syntax

```
ST_StartPoint(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type. The subtype must be `LINESTRING`.

Return type

`GEOMETRY`

If *geom* is null, then null is returned.

If *geom* is empty, then null is returned.

If *geom* isn't a LINESTRING, then null is returned.

Examples

The following SQL returns an extended well-known text (EWKT) representation of a four-point LINESTRING to a GEOMETRY object and returns the start point of the linestring.

```
SELECT ST_AsEWKT(ST_StartPoint(ST_GeomFromText('LINESTRING(0 0,10 0,10 10,5 5,0
 5)',4326)));
```

```


st_asewkt
-------------
 SRID=4326;POINT(0 0)
```

ST_Touches

ST_Touches returns true if the 2D projections of the two input geometries touch. The two geometries touch if they are nonempty, intersect, and have no interior points in common.

Syntax

```
ST_Touches(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if a polygon touches a linestring.

```
SELECT ST_Touches(ST_GeomFromText('POLYGON((0 0,10 0,0 10,0 0))'),
 ST_GeomFromText('LINESTRING(20 10,20 0,10 0)'));
```

```

 st_touches
-------------
 t
```

ST_Transform

ST_Transform returns a new geometry with coordinates that are transformed in a spatial reference system defined by the input spatial reference system identifier (SRID).

Syntax

```
ST_Transform(geom, srid)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

srid

A value of data type `INTEGER` that represents an SRID.

Return type

`GEOMETRY`.

The SRID value of the returned geometry is set to *srid*.

If *geom* or *srid* is null, then null is returned.

If the SRID value associated with the input *geom* does not exist, then an error is returned.

If *srid* does not exist, then an error is returned.

Examples

The following SQL transforms the SRID of an empty geometry collection.

```
SELECT ST_AsEWKT(ST_Transform(ST_GeomFromText('GEOMETRYCOLLECTION EMPTY', 3857),
 4326));
```

```
             st_asewkt
------------------------------------
 SRID=4326;GEOMETRYCOLLECTION EMPTY
```

The following SQL transforms the SRID of a linestring.

```
SELECT ST_AsEWKT(ST_Transform(ST_GeomFromText('LINESTRING(110 40, 2 3, -10 80, -7 9,
 -22 -33)', 4326), 26918));
```

```
     st_asewkt
--------------------------------------------------------------------------------------------------------
 SRID=26918;LINESTRING(73106.6977300955 15556182.9688576,14347201.5059964
 1545178.32934967,1515090.41262989 9522193.25115316,10491250.83295
 2575457.28410878,5672303.72135968 -5233682.61176205)
```

The following SQL transforms the SRID of a polygon.

```
SELECT ST_AsEWKT(ST_Transform(ST_GeomFromText('POLYGON Z ((-10 10 -7, -65 10 -6, -10 64
 -5, -10 10 -7), (-11 11 5, -11 12 6, -12 11 7, -11 11 5))', 6989), 6317));
```

```
                                         st_asewkt
--------------------------------------------------------------------------------------------------------
 SRID=6317;POLYGON Z ((6186430.2771091 -1090834.57212608
 1100247.33216237,2654831.67853801 -5693304.90741276 1100247.50581055,2760987.41750022
 -486836.575101877 5709710.44137268,6186430.2771091 -1090834.57212608
 1100247.33216237),(6146675.25029258 -1194792.63532103 1209007.1115113,6125027.87562215
```

```
-1190584.81194058 1317403.77865723,6124888.99555252 -1301885.3455052
1209007.49312929,6146675.25029258 -1194792.63532103 1209007.1115113))
```

ST_Union

ST_Union returns a geometry representing the union of two geometries. That is, it merges the input geometries to produce a resulting geometry with no overlaps.

Syntax

```
ST_Union(geom1, geom2)
```

Arguments

geom1

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

geom2

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`GEOMETRY`

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometries.

If *geom1* or *geom2* is null, then null is returned.

If *geom1* or *geom2* are empty, then an empty geometry is returned.

If *geom1* and *geom2* don't have the same value for the spatial reference system identifier (SRID), then an error is returned.

If *geom1* or *geom2* is a geometry collection, linestring, or multilinestring, then an error is returned.

If *geom1* or *geom2* is not a two-dimensional (2D) geometry, then an error is returned.

Examples

The following SQL returns the non-empty geometry representing the union of two input geometries.

```
SELECT ST_AsEWKT(ST_Union(ST_GeomFromText('POLYGON((0 0,100 100,0 200,0 0))'),
 ST_GeomFromText('POLYGON((0 0,10 0,0 10,0 0))')));
```

```
        st_asewkt
-------------------------
 POLYGON((0 0,0 200,100 100,5 5,10 0,0 0))
```

ST_Within

ST_Within returns true if the 2D projection of the first input geometry is within the 2D projection of the second input geometry.

For example, geometry A is within geometry B if every point in A is a point in B and their interiors have nonempty intersection.

ST_Within(A, B) is equivalent to ST_Contains(B, A).

Syntax

```
ST_Within(geom1, geom2)
```

Arguments

geom1

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. This value is compared with *geom2* to determine if it is within *geom2*.

geom2

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom1* or *geom2* is null, then null is returned.

If *geom1* and *geom2* don't have the same spatial reference system identifier (SRID) value, then an error is returned.

If *geom1* or *geom2* is a geometry collection, then an error is returned.

Examples

The following SQL checks if the first polygon is within the second polygon.

```
SELECT ST_Within(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'),
 ST_GeomFromText('POLYGON((-1 3,2 1,0 -3,-1 3))'));
```

```


st_within
-----------
 true
```

ST_X

ST_X returns the first coordinate of an input point.

Syntax

```
ST_X(point)
```

Arguments

point

A `POINT` value of data type `GEOMETRY`.

Return type

`DOUBLE PRECISION` value of the first coordinate.

If *point* is null, then null is returned.

If *point* is the empty point, then null is returned.

If *point* is not a `POINT`, then an error is returned.

Examples

The following SQL returns the first coordinate of a point.

```
SELECT ST_X(ST_Point(1,2));
```

```
st_x
-----------
 1.0
```

ST_XMax

ST_XMax returns the maximum first coordinate of an input geometry.

Syntax

```
ST_XMax(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the maximum first coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

Examples

The following SQL returns the largest first coordinate of a linestring.

```
SELECT ST_XMax(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```
st_xmax
-----------
 77.42
```

ST_XMin

ST_XMin returns the minimum first coordinate of an input geometry.

Syntax

```
ST_XMin(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the minimum first coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

Examples

The following SQL returns the smallest first coordinate of a linestring.

```
SELECT ST_XMin(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```


st_xmin
-----------
 77.27
```

ST_Y

ST_Y returns the second coordinate of an input point.

Syntax

```
ST_Y(point)
```

Arguments

point

A POINT value of data type GEOMETRY.

Return type

DOUBLE PRECISION value of the second coordinate.

If *point* is null, then null is returned.

If *point* is the empty point, then null is returned.

If *point* is not a POINT, then an error is returned.

Examples

The following SQL returns the second coordinate of a point.

```
SELECT ST_Y(ST_Point(1,2));
```

```
st_y
-----------
 2.0
```

ST_YMax

ST_YMax returns the maximum second coordinate of an input geometry.

Syntax

```
ST_YMax(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

`DOUBLE PRECISION` value of the maximum second coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

Examples

The following SQL returns the largest second coordinate of a linestring.

```
SELECT ST_YMax(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```


st_ymax
-----------
 29.31
```

ST_YMin

ST_YMin returns the minimum second coordinate of an input geometry.

Syntax

```
ST_YMin(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the minimum second coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

Examples

The following SQL returns the smallest second coordinate of a linestring.

```
SELECT ST_YMin(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29
 29.07)'));
```

```
st_ymin
-----------
 29.07
```

ST_Z

ST_Z returns the z coordinate of an input point.

Syntax

```
ST_Z(point)
```

Arguments

point

A POINT value of data type GEOMETRY.

Return type

DOUBLE PRECISION value of the m coordinate.

If *point* is null, then null is returned.

If *point* is a 2D or 3DM point, then null is returned.

If *point* is the empty point, then null is returned.

If *point* is not a POINT, then an error is returned.

Examples

The following SQL returns the z coordinate of a point in a 3DZ geometry.

```
SELECT ST_Z(ST_GeomFromEWKT('POINT Z (1 2 3)'));
```

```
st_z
-----------
 3
```

The following SQL returns the z coordinate of a point in a 4D geometry.

```
SELECT ST_Z(ST_GeomFromEWKT('POINT ZM (1 2 3 4)'));
```

```
st_z
-----------
 3
```

ST_ZMax

ST_ZMax returns the maximum z coordinate of an input geometry.

Syntax

```
ST_ZMax(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the maximum z coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

If *geom* is a 2D or 3DM geometry, then null is returned.

Examples

The following SQL returns the largest z coordinate of a linestring in a 3DZ geometry.

```
SELECT ST_ZMax(ST_GeomFromEWKT('LINESTRING Z (0 1 2, 3 4 5, 6 7 8)'));
```

```

st_zmax
-----------
  8
```

The following SQL returns the largest z coordinate of a linestring in a 4D geometry.

```
SELECT ST_ZMax(ST_GeomFromEWKT('LINESTRING ZM (0 1 2 3, 4 5 6 7, 8 9 10 11)'));
```

```

st_zmax
-----------
  10
```

ST_ZMin

ST_ZMin returns the minimum z coordinate of an input geometry.

Syntax

```
ST_ZMin(geom)
```

Arguments

geom

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return type

`DOUBLE PRECISION` value of the minimum z coordinate.

If *geom* is empty, then null is returned.

If *geom* is null, then null is returned.

If *geom* is a 2D or 3DM geometry, then null is returned.

Examples

The following SQL returns the smallest z coordinate of a linestring in a 3DZ geometry.

```
SELECT ST_ZMin(ST_GeomFromEWKT('LINESTRING Z (0 1 2, 3 4 5, 6 7 8)'));
```

```
st_zmin
-----------
  2
```

The following SQL returns the smallest z coordinate of a linestring in a 4D geometry.

```
SELECT ST_ZMin(ST_GeomFromEWKT('LINESTRING ZM (0 1 2 3, 4 5 6 7, 8 9 10 11)'));
```

```
st_zmin
-----------
  2
```

SupportsBBox

SupportsBBox returns true if the input geometry supports encoding with a precomputed bounding box. For more information about support for bounding boxes, see Bounding box.

Syntax

```
SupportsBBox(geom)
```

Arguments

geom

A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type.

Return type

BOOLEAN

If *geom* is null, then null is returned.

Examples

The following SQL returns true because the input point geometry supports being encoded with a bounding box.

```
SELECT SupportsBBox(AddBBox(ST_GeomFromText('POLYGON((0 0,1 0,0 1,0 0))')));
```

```

supportsbbox
--------------
t
```

The following SQL returns false because the input point geometry doesn't support being encoded with a bounding box.

```
SELECT SupportsBBox(DropBBox(ST_GeomFromText('POLYGON((0 0,1 0,0 1,0 0))')));
```

```

supportsbbox
--------------
f
```

String functions

Topics

- || (Concatenation) operator
- ASCII function
- BPCHARCMP function
- BTRIM function
- BTTEXT_PATTERN_CMP function
- CHAR_LENGTH function

- STRPOS function
- STRTOL function
- SUBSTRING function
- TEXTLEN function
- TRANSLATE function
- TRIM function
- UPPER function

String functions process and manipulate character strings or expressions that evaluate to character strings. When the *string* argument in these functions is a literal value, it must be enclosed in single quotation marks. Supported data types include CHAR and VARCHAR.

The following section provides the function names, syntax, and descriptions for supported functions. All offsets into strings are one-based.

Deprecated leader node-only functions

The following string functions are deprecated because they run only on the leader node. For more information, see Leader node–only functions

- GET_BYTE
- SET_BIT
- SET_BYTE
- TO_ASCII

|| (Concatenation) operator

Concatenates two expressions on either side of the `||` symbol and returns the concatenated expression.

Similar to CONCAT function.

> **Note**
>
> If one or both of the expressions is null, the result of the concatenation is `NULL`.

Syntax

```
expression1 || expression2
```

Arguments

expression1

A CHAR string, a VARCHAR string, a binary expression, or an expression that evaluates to one of these types.

expression2

A CHAR string, a VARCHAR string, a binary expression, or an expression that evaluates to one of these types.

Return type

The return type of the string is the same as the type of the input arguments. For example, concatenating two strings of type VARCHAR returns a string of type VARCHAR.

Examples

The following examples use the USERS and VENUE tables from the TICKIT sample database. For more information, see Sample database.

To concatenate the FIRSTNAME and LASTNAME fields from the USERS table in the sample database, use the following example.

```
SELECT (firstname || ' ' || lastname) as fullname
FROM users
ORDER BY 1
LIMIT 10;

+-----------------+
|    fullname     |
+-----------------+
| Aaron Banks     |
| Aaron Booth     |
| Aaron Browning  |
| Aaron Burnett   |
```

```
| Aaron Casey      |
| Aaron Cash       |
| Aaron Castro     |
| Aaron Dickerson |
| Aaron Dixon      |
| Aaron Dotson     |
+-----------------+
```

To concatenate columns that might contain nulls, use the [NVL and COALESCE functions](#) expression. The following example uses NVL to return a `0` whenever `NULL` is encountered.

```
SELECT (venuename || ' seats ' || NVL(venueseats, 0)) as seating
FROM venue
WHERE venuestate = 'NV' or venuestate = 'NC'
ORDER BY 1
LIMIT 10;

+-------------------------------------+
|               seating               |
+-------------------------------------+
| Ballys Hotel seats 0                |
| Bank of America Stadium seats 73298 |
| Bellagio Hotel seats 0              |
| Caesars Palace seats 0              |
| Harrahs Hotel seats 0               |
| Hilton Hotel seats 0                |
| Luxor Hotel seats 0                 |
| Mandalay Bay Hotel seats 0          |
| Mirage Hotel seats 0                |
| New York New York seats 0           |
+-------------------------------------+
```

ASCII function

The ASCII function returns the ASCII code, or the Unicode code-point, of the first character in the string that you specify. The function returns `0` if the string is empty. It returns `NULL` if the string is null.

Syntax

```
ASCII('string')
```

Argument

string

A CHAR string or a VARCHAR string.

Return type

INTEGER

Examples

To return NULL, use the following example. The NULLIF function returns NULL if the two arguments are the same, so the input argument for the ASCII function is NULL. For more information, see NULLIF function.

```
SELECT ASCII(NULLIF('',''));

+-------+
| ascii |
+-------+
|  NULL |
+-------+
```

To return the ASCII code 0, use the following example.

```
SELECT ASCII('');

+-------+
| ascii |
+-------+
|     0 |
+-------+
```

To return the ASCII code 97 for the first letter of the word amazon, use the following example.

```
SELECT ASCII('amazon');

+-------+
| ascii |
+-------+
```

```
|    97 |
+-------+
```

To return the ASCII code 65 for the first letter of the word Amazon, use the following example.

```
SELECT ASCII('Amazon');

+-------+
| ascii |
+-------+
|    65 |
+-------+
```

BPCHARCMP function

Compares the value of two strings and returns an integer. If the strings are identical, the function returns `0`. If the first string is greater alphabetically, the function returns `1`. If the second string is greater, the function returns `-1`.

For multibyte characters, the comparison is based on the byte encoding.

Synonym of BTTEXT_PATTERN_CMP function.

Syntax

```
BPCHARCMP(string1, string2)
```

Arguments

string1

A CHAR string or a VARCHAR string.

string2

A CHAR string or a VARCHAR string.

Return type

INTEGER

Examples

The following examples use the USERS table from the TICKIT sample database. For more information, see Sample database.

To determine whether a user's first name is alphabetically greater than the user's last name for the first ten entries in the USERS table, use the following example. For entries where the string for FIRSTNAME is later alphabetically than the string for LASTNAME, the function returns 1. If the LASTNAME is alphabetically later than FIRSTNAME, the function returns -1.

```
SELECT userid, firstname, lastname, BPCHARCMP(firstname, lastname)
FROM users
ORDER BY 1, 2, 3, 4
LIMIT 10;

+--------+-----------+-----------+-----------+
| userid | firstname | lastname  | bpcharcmp |
+--------+-----------+-----------+-----------+
|      1 | Rafael    | Taylor    |        -1 |
|      2 | Vladimir  | Humphrey  |         1 |
|      3 | Lars      | Ratliff   |        -1 |
|      4 | Barry     | Roy       |        -1 |
|      5 | Reagan    | Hodge     |         1 |
|      6 | Victor    | Hernandez |         1 |
|      7 | Tamekah   | Juarez    |         1 |
|      8 | Colton    | Roy       |        -1 |
|      9 | Mufutau   | Watkins   |        -1 |
|     10 | Naida     | Calderon  |         1 |
+--------+-----------+-----------+-----------+
```

To return all entries in the USERS table where the function returns `0`, use the following example. The function returns `0` when FIRSTNAME is identical to LASTNAME.

```
SELECT userid, firstname, lastname,
BPCHARCMP(firstname, lastname)
FROM users
WHERE BPCHARCMP(firstname, lastname)=0
ORDER BY 1, 2, 3, 4;

+--------+-----------+----------+-----------+
| userid | firstname | lastname | bpcharcmp |
+--------+-----------+----------+-----------+
```

```
|     62 | Chase     | Chase    |          0 |
|   4008 | Whitney   | Whitney  |          0 |
|  12516 | Graham    | Graham   |          0 |
|  13570 | Harper    | Harper   |          0 |
|  16712 | Cooper    | Cooper   |          0 |
|  18359 | Chase     | Chase    |          0 |
|  27530 | Bradley   | Bradley  |          0 |
|  31204 | Harding   | Harding  |          0 |
+--------+-----------+----------+-----------+
```

BTRIM function

The BTRIM function trims a string by removing leading and trailing blanks or by removing leading and trailing characters that match an optional specified string.

Syntax

```
BTRIM(string [, trim_chars ] )
```

Arguments

string

The input VARCHAR string to be trimmed.

trim_chars

The VARCHAR string containing the characters to be matched.

Return type

The BTRIM function returns a VARCHAR string.

Examples

The following example trims leading and trailing blanks from the string `'    abc    '`:

```
select '     abc    ' as untrim, btrim('     abc    ') as trim;

untrim    | trim
----------+------
```

```
   abc     | abc
```

The following example removes the leading and trailing `'xyz'` strings from the string `'xyzaxyzbxyzcxyz'`. The leading and trailing occurrences of `'xyz'` are removed, but occurrences that are internal within the string are not removed.

```
select 'xyzaxyzbxyzcxyz' as untrim,
btrim('xyzaxyzbxyzcxyz', 'xyz') as trim;

     untrim      |   trim
-----------------+-----------
 xyzaxyzbxyzcxyz | axyzbxyzc
```

The following example removes the leading and trailing parts from the string `'setuphistorycassettes'` that match any of the characters in the *trim_chars* list `'tes'`. Any `t`, `e`, or `s` that occur before another character that is not in the *trim_chars* list at the beginning or ending of the input string are removed.

```
SELECT btrim('setuphistorycassettes', 'tes');

     btrim
-----------------
 uphistoryca
```

BTTEXT_PATTERN_CMP function

Synonym for the BPCHARCMP function.

See BPCHARCMP function for details.

CHAR_LENGTH function

Synonym of the LEN function.

See LEN function.

CHARACTER_LENGTH function

Synonym of the LEN function.

See LEN function.

CHARINDEX function

Returns the location of the specified substring within a string.

See POSITION function and STRPOS function for similar functions.

Syntax

```
CHARINDEX( substring, string )
```

Arguments

substring

The substring to search for within the *string*.

string

The string or column to be searched.

Return type

INTEGER

The CHARINDEX function returns an `INTEGER` corresponding to the position of the substring (one-based, not zero-based). The position is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. CHARINDEX returns `0` if the substring is not found within the string.

Examples

To return the position of the string `fish` within the word `dog`, use the following example.

```
SELECT CHARINDEX('fish', 'dog');

+-----------+
| charindex |
+-----------+
|         0 |
+-----------+
```

To return the position of the string `fish` within the word `dogfish`, use the following example.

```
SELECT CHARINDEX('fish', 'dogfish');

+-----------+
| charindex |
+-----------+
|         4 |
+-----------+
```

The following example uses the SALES table from the TICKIT sample database. For more information, see Sample database.

To return the number of distinct sales transactions with a commission over 999.00 from the SALES table, use the following example. This command counts commissions greater than 999.00 by checking if the decimal is more than 4 places from the beginning of the commission value.

```
SELECT DISTINCT CHARINDEX('.', commission), COUNT (CHARINDEX('.', commission))
FROM sales
WHERE CHARINDEX('.', commission) > 4
GROUP BY CHARINDEX('.', commission)
ORDER BY 1,2;

+-----------+-------+
| charindex | count |
+-----------+-------+
|         5 |   629 |
+-----------+-------+
```

CHR function

The CHR function returns the character that matches the ASCII code point value specified by the input parameter.

Syntax

```
CHR(number)
```

Argument

number

The input parameter is an `INTEGER` that represents an ASCII code point value.

Return type

CHAR

> The CHR function returns a CHAR string if an ASCII character matches the input value. If the input number has no ASCII match, the function returns NULL.

Examples

To return the character that corresponds with ASCII code point 0, use the following example. Note that the CHR function returns NULL for the input 0.

```
SELECT CHR(0);

+-----+
| chr |
+-----+
|     |
+-----+
```

To return the character that corresponds with ASCII code point 65, use the following example.

```
SELECT CHR(65);

+-----+
| chr |
+-----+
| A   |
+-----+
```

To return distinct event names that begin with a capital A (ASCII code point 65), use the following example. The following example uses the EVENT table from the TICKIT sample database. For more information, see Sample database.

```
SELECT DISTINCT eventname FROM event
WHERE SUBSTRING(eventname, 1, 1)=CHR(65) LIMIT 5;

+-----------------------+
|       eventname       |
+-----------------------+
| A Catered Affair      |
```

```
| As You Like It         |
| A Man For All Seasons  |
| Alan Jackson           |
| Armando Manzanero      |
+------------------------+
```

COLLATE function

The COLLATE function overrides the collation of a string column or expression.

For information on how to create tables using database collation, see CREATE TABLE.

For information on how to create databases using database collation, see CREATE DATABASE.

Syntax

```
COLLATE( string, 'case_sensitive' | 'cs' | 'case_insensitive' | 'ci');
```

Arguments

string

A string column or expression that you want to override.

'case_sensitive' | *'cs'* | *'case_insensitive'* | *'ci'*

A string constant of a collation name. Amazon Redshift only supports the following values for this parameter:

- *case_sensitive*
- *cs*
- *case_insensitive*
- *ci*

case_sensitive and *cs* are interchangeable and yield the same results. Similarly, *case_insensitive* and *ci* are interchangeable and yield the same results.

Return type

The COLLATE function returns VARCHAR or CHAR depending on the first input expression type. This function only changes the collation of the first input argument and won't change its output value.

Examples

To create table T and define col1 in table T as `case_sensitive`, use the following example.

```
CREATE TABLE T ( col1 Varchar(20) COLLATE case_sensitive );

INSERT INTO T VALUES ('john'),('JOHN');
```

When you run the first query, Amazon Redshift only returns `john`. After the COLLATE function runs on col1, the collation becomes `case_insensitive`. The second query returns both `john` and `JOHN`.

```
SELECT * FROM T WHERE col1 = 'john';

+------+
| col1 |
+------+
| john |
+------+

SELECT * FROM T WHERE COLLATE(col1, 'case_insensitive') = 'john';

+------+
| col1 |
+------+
| john |
| JOHN |
+------+
```

To create table A and define col1 in table A as `case_insensitive`, use the following example.

```
CREATE TABLE A ( col1 Varchar(20) COLLATE case_insensitive );

INSERT INTO A VALUES ('john'),('JOHN');
```

When you run the first query, Amazon Redshift returns both `john` and `JOHN`. After the COLLATE function runs on col1, the collation becomes `case_sensitive`. The second query returns only `john`.

```
SELECT * FROM A WHERE col1 = 'john';
```

```
+------+
| col1 |
+------+
| john |
| JOHN |
+------+

SELECT * FROM A WHERE COLLATE(col1, 'case_sensitive') = 'john';

+------+
| col1 |
+------+
| john |
+------+
```

CONCAT function

The CONCAT function concatenates two expressions and returns the resulting expression. To concatenate more than two expressions, use nested CONCAT functions. The concatenation operator (||) between two expressions produces the same results as the CONCAT function.

Syntax

```
CONCAT ( expression1, expression2 )
```

Arguments

expression1, *expression2*

Both arguments can be a fixed-length character string, a variable-length character string, a binary expression, or an expression that evaluates to one of these inputs.

Return type

CONCAT returns an expression. The data type of the expression is the same type as the input arguments.

If the input expressions are of different types, Amazon Redshift tries to implicitly type casts one of the expressions. If values can't be cast, an error is returned.

Usage notes

- For both the CONCAT function and the concatenation operator, if one or both expressions is null, the result of the concatenation is null.

Examples

The following example concatenates two character literals:

```
SELECT CONCAT('December 25, ', '2008');

concat
-------------------
December 25, 2008
(1 row)
```

The following query, using the || operator instead of CONCAT, produces the same result:

```
SELECT 'December 25, '||'2008';

?column?
-------------------
December 25, 2008
(1 row)
```

The following example uses a nested CONCAT function inside another CONCAT function to concatenate three character strings:

```
SELECT CONCAT('Thursday, ', CONCAT('December 25, ', '2008'));

concat
-----------------------------
Thursday, December 25, 2008
(1 row)
```

To concatenate columns that might contain NULLs, use the NVL and COALESCE functions, which returns a given value when it encounters NULL. The following example uses NVL to return a 0 whenever NULL is encountered.

```
SELECT CONCAT(venuename, CONCAT(' seats ', NVL(venueseats, 0))) AS seating
FROM venue WHERE venuestate = 'NV' OR venuestate = 'NC'
```

```
ORDER BY 1
LIMIT 5;

seating
-----------------------------------
Ballys Hotel seats 0
Bank of America Stadium seats 73298
Bellagio Hotel seats 0
Caesars Palace seats 0
Harrahs Hotel seats 0
(5 rows)
```

The following query concatenates CITY and STATE values from the VENUE table:

```
SELECT CONCAT(venuecity, venuestate)
FROM venue
WHERE venueseats > 75000
ORDER BY venueseats;

concat
-------------------
DenverCO
Kansas CityMO
East RutherfordNJ
LandoverMD
(4 rows)
```

The following query uses nested CONCAT functions. The query concatenates CITY and STATE values from the VENUE table but delimits the resulting string with a comma and a space:

```
SELECT CONCAT(CONCAT(venuecity,', '),venuestate)
FROM venue
WHERE venueseats > 75000
ORDER BY venueseats;

concat
---------------------
Denver, CO
Kansas City, MO
East Rutherford, NJ
Landover, MD
(4 rows)
```

The following example concatenates two binary expressions. Where `abc` is a binary value (with a hexadecimal representation of `616263`) and `def` is a binary value (with hexadecimal representation of `646566`). The result is automatically shown as the hexadecimal representation of the binary value.

```
SELECT CONCAT('abc'::VARBYTE, 'def'::VARBYTE);

concat
-------------------
616263646566
```

CRC32 function

CRC32 is a function used for error detection. The function uses a CRC32 algorithm to detect changes between source and target data. The CRC32 function converts a variable-length string into an 8-character string that is a text representation of the hexadecimal value of a 32 bit-binary sequence. To detect changes between source and target data, use the CRC32 function on the source data and store the output. Then, use the CRC32 function on the target data and compare that output to the output from the source data. The outputs will be the same if the data was not modified, and the outputs will be different if the data was modified.

Syntax

```
CRC32(string)
```

Arguments

string

A CHAR string, a VARCHAR string, or an expression that implicitly evaluates to a CHAR or VARCHAR type.

Return type

The CRC32 function returns an 8-character string that is a text representation of the hexadecimal value of a 32-bit binary sequence. The Amazon Redshift CRC32 function is based on the CRC-32C polynomial.

Examples

To show the 8-bit value for the string `Amazon Redshift`.

```
SELECT CRC32('Amazon Redshift');

+----------+
|  crc32   |
+----------+
| f2726906 |
+----------+
```

DIFFERENCE function

The DIFFERENCE function compares the American Soundex codes of two strings. The function returns an `INTEGER` to indicate the number of matching characters between the Soundex codes.

A Soundex code is a string that is four characters long. A Soundex code represents how a word sounds rather than how it is spelled. For example, `Smith` and `Smyth` have the same Soundex code.

Syntax

```
DIFFERENCE(string1, string2)
```

Arguments

string1

A `CHAR` string, a `VARCHAR` string, or an expression that implicitly evaluates to a `CHAR` or `VARCHAR` type.

string2

A `CHAR` string, a `VARCHAR` string, or an expression that implicitly evaluates to a `CHAR` or `VARCHAR` type.

Return type

INTEGER

The DIFFERENCE function returns an `INTEGER` value from 0–4 that counts the number of matching characters in the American Soundex codes of the two strings. A Soundex code has 4 characters, so the DIFFERENCE function returns 4 when all 4 characters of the strings' American Soundex code values are the same. DIFFERENCE returns `0` if one of the two strings is empty. The function returns 1 if neither string contains valid characters. The DIFFERENCE function converts only English alphabetical lowercase or uppercase ASCII characters, including a–z and A–Z. DIFFERENCE ignores other characters.

Examples

To compare the Soundex values of the strings `%` and `@`, use the following example. The function returns 1 because neither string contains valid characters.

```
SELECT DIFFERENCE('%', '@');

+------------+
| difference |
+------------+
|          1 |
+------------+
```

To compare the Soundex values of `Amazon` and an empty string, use the following example. The function returns `0` because one of the two strings is empty.

```
SELECT DIFFERENCE('Amazon', '');

+------------+
| difference |
+------------+
|          0 |
+------------+
```

To compare the Soundex values of the strings `Amazon` and `Ama`, use the following example. The function returns 2 because 2 characters of the strings' Soundex values are the same.

```
SELECT DIFFERENCE('Amazon', 'Ama');

+------------+
| difference |
+------------+
|          2 |
+------------+
```

To compare the Soundex values of the strings `Amazon` and `+-*/%Amazon`, use the following example. The function returns `4` because all 4 characters of the strings' Soundex values are the same. Notice that the function ignores the invalid characters `+-*/%` in the second string.

```
SELECT DIFFERENCE('Amazon', '+-*/%Amazon');

+------------+
| difference |
+------------+
|          4 |
+------------+
```

To compare the Soundex values of the strings `AC/DC` and `Ay See Dee See`, use the following example. The function returns `4` because all 4 characters of the strings' Soundex values are the same.

```
SELECT DIFFERENCE('AC/DC', 'Ay See Dee See');

+------------+
| difference |
+------------+
|          4 |
+------------+
```

INITCAP function

Capitalizes the first letter of each word in a specified string. INITCAP supports UTF-8 multibyte characters, up to a maximum of four bytes per character.

Syntax

```
INITCAP(string)
```

Argument

string

A CHAR string, a VARCHAR string, or an expression that implicitly evaluates to a CHAR or VARCHAR type.

Return type

VARCHAR

Usage notes

The INITCAP function makes the first letter of each word in a string uppercase, and any subsequent letters are made (or left) lowercase. Therefore, it is important to understand which characters (other than space characters) function as word separators. A *word separator* character is any non-alphanumeric character, including punctuation marks, symbols, and control characters. All of the following characters are word separators:

```
! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [ \ ] ^ _ ` { | } ~
```

Tabs, newline characters, form feeds, line feeds, and carriage returns are also word separators.

Examples

The following examples use data from the CATEGORY and USERS tables in the TICKIT sample database. For more information, see [Sample database](#).

To capitalize the initials of each word in the CATDESC column, use the following example.

```
SELECT catid, catdesc, INITCAP(catdesc)
FROM category
ORDER BY 1, 2, 3;

+-------+--------------------------------------------
+--------------------------------------------+
| catid |                  catdesc                   |                  initcap
          |
+-------+--------------------------------------------
+--------------------------------------------+
|     1 | Major League Baseball                      | Major League Baseball
          |
|     2 | National Hockey League                     | National Hockey League
          |
|     3 | National Football League                   | National Football League
          |
|     4 | National Basketball Association            | National Basketball Association
          |
|     5 | Major League Soccer                        | Major League Soccer
          |
```

```
|      6 | Musical theatre                              | Musical Theatre
           |
|      7 | All non-musical theatre                      | All Non-Musical Theatre
           |
|      8 | All opera and light opera                    | All Opera And Light Opera
           |
|      9 | All rock and pop music concerts              | All Rock And Pop Music Concerts
           |
|     10 | All jazz singers and bands                   | All Jazz Singers And Bands
           |
|     11 | All symphony, concerto, and choir concerts | All Symphony, Concerto, And
 Choir Concerts |
+-------+-------------------------------------------------
+---------------------------------------------+
```

To show that the INITCAP function does not preserve uppercase characters when they do not begin words, use the following example. For example, the string `MLB` becomes `Mlb`.

```
SELECT INITCAP(catname)
FROM category
ORDER BY catname;

+-----------+
|  initcap  |
+-----------+
| Classical |
| Jazz      |
| Mlb       |
| Mls       |
| Musicals  |
| Nba       |
| Nfl       |
| Nhl       |
| Opera     |
| Plays     |
| Pop       |
+-----------+
```

To show that non-alphanumeric characters other than spaces function as word separators, use the following example. Several letters in each string will be capitalized.

```
SELECT email, INITCAP(email)
```

```
FROM users
ORDER BY userid DESC LIMIT 5;

+-------------------------------------+-------------------------------------+
|                email                |               initcap               |
+-------------------------------------+-------------------------------------+
| urna.Ut@egetdictumplacerat.edu      | Urna.Ut@Egetdictumplacerat.Edu      |
| nibh.enim@egestas.ca                | Nibh.Enim@Egestas.Ca                |
| in@Donecat.ca                       | In@Donecat.Ca                       |
| sodales@blanditviverraDonec.ca      | Sodales@Blanditviverradonec.Ca      |
| sociis.natoque.penatibus@vitae.org | Sociis.Natoque.Penatibus@Vitae.Org |
+-------------------------------------+-------------------------------------+
```

LEFT and RIGHT functions

These functions return the specified number of leftmost or rightmost characters from a character string.

The number is based on the number of characters, not bytes, so that multibyte characters are counted as single characters.

Syntax

```
LEFT( string,  integer )

RIGHT( string,  integer )
```

Arguments

string

A CHAR string, a VARCHAR string, or any expression that evaluates to a CHAR or VARCHAR string.

integer

A positive integer.

Return type

VARCHAR

Examples

The following example uses data from the EVENT table in the TICKIT sample database. For more information, see Sample database.

To return the leftmost 5 and rightmost 5 characters from event names that have event IDs between 1000 and 1005, use the following example.

```
SELECT eventid, eventname,
LEFT(eventname,5) AS left_5,
RIGHT(eventname,5) AS right_5
FROM event
WHERE eventid BETWEEN 1000 AND 1005
ORDER BY 1;

+---------+----------------+--------+---------+
| eventid |   eventname    | left_5 | right_5 |
+---------+----------------+--------+---------+
|    1000 | Gypsy          | Gypsy  | Gypsy   |
|    1001 | Chicago        | Chica  | icago   |
|    1002 | The King and I | The K  | and I   |
|    1003 | Pal Joey       | Pal J  | Joey    |
|    1004 | Grease         | Greas  | rease   |
|    1005 | Chicago        | Chica  | icago   |
+---------+----------------+--------+---------+
```

LEN function

Returns the length of the specified string as the number of characters.

Syntax

LEN is a synonym of LENGTH function, CHAR_LENGTH function, CHARACTER_LENGTH function, and TEXTLEN function.

```
LEN(expression)
```

Argument

expression

A CHAR string, a VARCHAR string, a VARBYTE expression, or an expression that implicitly evaluates to a CHAR, VARCHAR, or VARBYTE type.

Return type

INTEGER

The LEN function returns an integer indicating the number of characters in the input string.

If the input string is a character string, the LEN function returns the actual number of characters in multi-byte strings, not the number of bytes. For example, a `VARCHAR(12)` column is required to store three four-byte Chinese characters. The LEN function will return 3 for that same string. To get the length of a string in bytes, use the OCTET_LENGTH function.

Usage notes

If *expression* is a CHAR string, trailing spaces are not counted.

If *expression* is a VARCHAR string, trailing spaces are counted.

Examples

To return the number of bytes and the number of characters in the string `français`, use the following example.

```
SELECT OCTET_LENGTH('français'),
LEN('français');

+--------------+-----+
| octet_length | len |
+--------------+-----+
|            9 |   8 |
+--------------+-----+
```

To return the number of bytes and the number of characters in the string `français` without using the OCTET_LENGTH function, use the following example. For more information, see the CAST function.

```
SELECT LEN(CAST('français' AS VARBYTE)) as bytes, LEN('français');

+-------+-----+
| bytes | len |
+-------+-----+
|     9 |   8 |
```

```
+-------+-----+
```

To return the number of characters in the strings `cat` with no trailing spaces, `cat   ` with three trailing spaces, `cat   ` with three trailing spaces cast as a CHAR of length 6, and `cat   ` with three trailing spaces cast as a VARCHAR of length 6, use the following example. Notice that the function does not count trailing spaces for CHAR strings, but it does count trailing spaces for VARCHAR strings.

```
SELECT LEN('cat'), LEN('cat   '), LEN(CAST('cat   ' AS CHAR(6))) AS len_char,
 LEN(CAST('cat   ' AS VARCHAR(6))) AS len_varchar;

+-----+-----+----------+-------------+
| len | len | len_char | len_varchar |
+-----+-----+----------+-------------+
|   3 |   6 |        3 |           6 |
+-----+-----+----------+-------------+
```

The following example uses data from the VENUE table in the TICKIT sample database. For more information, see Sample database.

To return the 10 longest venue names in the VENUE table, use the following example.

```
SELECT venuename, LEN(venuename)
FROM venue
ORDER BY 2 DESC, 1
LIMIT 10;

+-----------------------------------------+-----+
|                venuename                | len |
+-----------------------------------------+-----+
| Saratoga Springs Performing Arts Center |  39 |
| Lincoln Center for the Performing Arts  |  38 |
| Nassau Veterans Memorial Coliseum       |  33 |
| Jacksonville Municipal Stadium          |  30 |
| Rangers BallPark in Arlington           |  29 |
| University of Phoenix Stadium           |  29 |
| Circle in the Square Theatre            |  28 |
| Hubert H. Humphrey Metrodome            |  28 |
| Oriole Park at Camden Yards             |  27 |
| Dick's Sporting Goods Park              |  26 |
+-----------------------------------------+-----+
```

LENGTH function

Synonym of the LEN function.

See LEN function.

LOWER function

Converts a string to lowercase. LOWER supports UTF-8 multibyte characters, up to a maximum of four bytes per character.

Syntax

```
LOWER(string)
```

Argument

string

A VARCHAR string or any expression that evaluates to the VARCHAR type.

Return type

string

The LOWER function returns a string that is the same data type as the input string. For example, if the input is a CHAR string, the function will return a CHAR string.

Examples

The following example uses data from the CATEGORY table in the TICKIT sample database. For more information, see Sample database.

To convert the VARCHAR strings in the CATNAME column to lowercase, use the following example.

```
SELECT catname, LOWER(catname) FROM category ORDER BY 1,2;

+-----------+-----------+
|  catname  |   lower   |
+-----------+-----------+
```

```
| Classical | classical |
| Jazz      | jazz      |
| MLB       | mlb       |
| MLS       | mls       |
| Musicals  | musicals  |
| NBA       | nba       |
| NFL       | nfl       |
| NHL       | nhl       |
| Opera     | opera     |
| Plays     | plays     |
| Pop       | pop       |
+-----------+-----------+
```

LPAD and RPAD functions

These functions prepend or append characters to a string, based on a specified length.

Syntax

```
LPAD(string1, length, [ string2 ])
```

```
RPAD(string1, length, [ string2 ])
```

Arguments

string1

A CHAR string, a VARCHAR string, or an expression that implicitly evaluates to a CHAR or VARCHAR type.

length

An integer that defines the length of the result of the function. The length of a string is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. If *string1* is longer than the specified length, it is truncated (on the right). If *length* is zero or a negative number, the result of the function is an empty string.

string2

(Optional) One or more characters that are prepended or appended to *string1*. If this argument is not specified, spaces are used.

Return type

VARCHAR

Examples

The following examples use data from the EVENT table in the TICKIT sample database. For more information, see Sample database.

To truncate a specified set of event names to 20 characters and prepend the shorter names with spaces, use the following example.

```
SELECT LPAD(eventname, 20) FROM event
WHERE eventid BETWEEN 1 AND 5 ORDER BY 1;

+---------------------+
|         lpad        |
+---------------------+
|              Salome |
|         Il Trovatore |
|        Boris Godunov |
|      Gotterdammerung |
|La Cenerentola (Cind |
+-----------------------+
```

To truncate the same set of event names to 20 characters but append the shorter names with 0123456789, use the following example.

```
SELECT RPAD(eventname, 20,'0123456789') FROM event
WHERE eventid BETWEEN 1 AND 5 ORDER BY 1;

+----------------------+
|         rpad         |
+----------------------+
| Boris Godunov0123456 |
| Gotterdammerung01234 |
| Il Trovatore01234567 |
| La Cenerentola (Cind |
| Salome01234567890123 |
+----------------------+
```

LTRIM function

Trims characters from the beginning of a string. Removes the longest string containing only characters in the trim characters list. Trimming is complete when a trim character does not appear in the input string.

Syntax

```
LTRIM( string [, trim_chars] )
```

Arguments

string

A string column, expression, or string literal to be trimmed.

trim_chars

A string column, expression, or string literal that represents the characters to be trimmed from the beginning of *string*. If not specified, a space is used as the trim character.

Return type

The LTRIM function returns a character string that is the same data type as the input *string* (CHAR or VARCHAR).

Examples

The following example trims the year from the `listime` column. The trim characters in string literal `'2008-'` indicate the characters to be trimmed from the left. If you use the trim characters `'028-'`, you achieve the same result.

```
select listid, listtime, ltrim(listtime, '2008-')
from listing
order by 1, 2, 3
limit 10;

listid |      listtime       |     ltrim
-------+---------------------+----------------
     1 | 2008-01-24 06:43:29 | 1-24 06:43:29
     2 | 2008-03-05 12:25:29 | 3-05 12:25:29
     3 | 2008-11-01 07:35:33 | 11-01 07:35:33
```

```
     4 | 2008-05-24 01:18:37 | 5-24 01:18:37
     5 | 2008-05-17 02:29:11 | 5-17 02:29:11
     6 | 2008-08-15 02:08:13 | 15 02:08:13
     7 | 2008-11-15 09:38:15 | 11-15 09:38:15
     8 | 2008-11-09 05:07:30 | 11-09 05:07:30
     9 | 2008-09-09 08:03:36 | 9-09 08:03:36
    10 | 2008-06-17 09:44:54 | 6-17 09:44:54
```

LTRIM removes any of the characters in *trim_chars* when they appear at the beginning of *string*. The following example trims the characters 'C', 'D', and 'G' when they appear at the beginning of VENUENAME, which is a VARCHAR column.

```
select venueid, venuename, ltrim(venuename, 'CDG')
from venue
where venuename like '%Park'
order by 2
limit 7;

venueid | venuename                  | btrim
--------+----------------------------+--------------------------
    121 | ATT Park                   | ATT Park
    109 | Citizens Bank Park         | itizens Bank Park
    102 | Comerica Park              | omerica Park
      9 | Dick's Sporting Goods Park | ick's Sporting Goods Park
     97 | Fenway Park                | Fenway Park
    112 | Great American Ball Park   | reat American Ball Park
    114 | Miller Park                | Miller Park
```

The following example uses the trim character 2 which is retrieved from the `venueid` column.

```
select ltrim('2008-01-24 06:43:29', venueid)
from venue where venueid=2;

ltrim
------------------
008-01-24 06:43:29
```

The following example does not trim any characters because a 2 is found before the `'0'` trim character.

```
select ltrim('2008-01-24 06:43:29', '0');
```

```
ltrim
-------------------
2008-01-24 06:43:29
```

The following example uses the default space trim character and trims the two spaces from the beginning of the string.

```
select ltrim('  2008-01-24 06:43:29');

ltrim
-------------------
2008-01-24 06:43:29
```

OCTETINDEX function

The OCTETINDEX function returns the location of a substring within a string as a number of bytes.

Syntax

```
OCTETINDEX(substring, string)
```

Arguments

substring

A CHAR string, a VARCHAR string, or an expression that implicitly evaluates to a CHAR or VARCHAR type.

string

A CHAR string, a VARCHAR string, or an expression that implicitly evaluates to a CHAR or VARCHAR type.

Return type

INTEGER

The OCTETINDEX function returns an INTEGER value corresponding to the position of the *substring* within the *string* as a number of bytes, where the first character in the *string* is counted as 1. If the *string* doesn't contain multibyte characters, the result is equal to the result of the CHARINDEX function. If the *string* does not contain the *substring*, the function returns `0`. If the *substring* is empty, the function returns 1.

Examples

To return the postion of the substring q in the string `Amazon Redshift`, use the following example. This example returns `0` because the *substring* is not in the *string*.

```
SELECT OCTETINDEX('q', 'Amazon Redshift');

+------------+
| octetindex |
+------------+
|          0 |
+------------+
```

To return the postion of an empty substring in the string `Amazon Redshift`, use the following example. This example returns 1 because the *substring* is empty.

```
SELECT OCTETINDEX('', 'Amazon Redshift');

+------------+
| octetindex |
+------------+
|          1 |
+------------+
```

To return the postion of the substring `Redshift` in the string `Amazon Redshift`, use the following example. This example returns 8 because the *substring* begins on the eighth byte of the *string*.

```
SELECT OCTETINDEX('Redshift', 'Amazon Redshift');

+------------+
| octetindex |
+------------+
|          8 |
+------------+
```

To return the postion of the substring `Redshift` in the string `Amazon Redshift`, use the following example. This example returns 21 because the first six characters of the *string* are double-byte characters.

```
SELECT OCTETINDEX('Redshift', 'Άμαζον Amazon Redshift');

+------------+
| octetindex |
+------------+
|         21 |
+------------+
```

OCTET_LENGTH function

Returns the length of the specified string as the number of bytes.

Syntax

```
OCTET_LENGTH(expression)
```

Argument

expression

A CHAR string, a VARCHAR string, a VARBYTE expression, or an expression that implicitly evaluates to a CHAR, VARCHAR, or VARBYTE type.

Return type

INTEGER

The OCTET_LENGTH function returns an integer indicating the number of bytes in the input string.

If the input string is a character string, the LEN function returns the actual number of characters in multi-byte strings, not the number of bytes. For example, a `VARCHAR(12)` column is required to store three four-byte Chinese characters. The OCTET_LENGTH function will return 12 for that string, and the LEN function will return 3 for that same string.

Usage notes

If *expression* is a CHAR string, the function returns the length of the CHAR string. For example, the output of a CHAR(6) input is a CHAR(6).

If *expression* is a VARCHAR string, trailing spaces are counted.

Examples

To return the number of bytes when the string francais with three trailing spaces is cast to a CHAR and a VARCHAR type, use the following example. For more information, see the CAST function.

```
SELECT OCTET_LENGTH(CAST('francais   ' AS CHAR(15))) AS octet_length_char,
 OCTET_LENGTH(CAST('francais   ' AS VARCHAR(15))) AS octet_length_varchar;

+-------------------+----------------------+
| octet_length_char | octet_length_varchar |
+-------------------+----------------------+
|                15 |                   11 |
+-------------------+----------------------+
```

To return the number of bytes and the number of characters in the string français, use the following example.

```
SELECT OCTET_LENGTH('français'), LEN('français');

+--------------+-----+
| octet_length | len |
+--------------+-----+
|            9 |   8 |
+--------------+-----+
```

To return the number of bytes when the string français is cast as a VARBYTE, use the following example.

```
SELECT OCTET_LENGTH(CAST('français' AS VARBYTE));

+--------------+
| octet_length |
+--------------+
```

```
|            9 |
+--------------+
```

POSITION function

Returns the location of the specified substring within a string.

See CHARINDEX function and STRPOS function for similar functions.

Syntax

```
POSITION(substring IN string )
```

Arguments

substring

The substring to search for within the *string*.

string

The string or column to be searched.

Return type

The POSITION function returns an `INTEGER` corresponding to the position of the substring (one-based, not zero-based). The position is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. POSITION returns `0` if the substring is not found within the string.

Examples

To return the position of the string `fish` within the word dog, use the following example.

```
SELECT POSITION('fish' IN 'dog');

+-----------+
|  position |
+-----------+
|         0 |
```

```
+-----------+
```

To return the position of the string `fish` within the word `dogfish`, use the following example.

```
SELECT POSITION('fish' IN 'dogfish');

+-----------+
|  position |
+-----------+
|         4 |
+-----------+
```

The following example uses the SALES table from the TICKIT sample database. For more information, see Sample database.

To return the number of distinct sales transactions with a commission over 999.00 from the SALES table, use the following example. This command counts commissions greater than 999.00 by checking if the decimal is more than 4 places from the beginning of the commission value.

```
SELECT DISTINCT POSITION('.' IN commission), COUNT (POSITION('.' IN commission))
FROM sales
WHERE POSITION('.' IN commission) > 4
GROUP BY POSITION('.' IN commission)
ORDER BY 1,2;

+-----------+-------+
|  position | count |
+-----------+-------+
|         5 |   629 |
+-----------+-------+
```

QUOTE_IDENT function

The QUOTE_IDENT function returns the specified string as a string with a leading double quotation mark and a trailing double quotation mark. The function output can be used as an identifier in a SQL statement. The function appropriately doubles any embedded double quotation marks.

QUOTE_IDENT adds double quotation marks only where necessary to create a valid identifier, when the string contains non-identifier characters or would otherwise be folded to lowercase. To always return a single-quoted string, use QUOTE_LITERAL.

Syntax

```
QUOTE_IDENT(string)
```

Argument

string

A CHAR or VARCHAR string.

Return type

The QUOTE_IDENT function returns the same type of string as the input *string*.

Examples

To return the string "CAT" with doubled quotation marks, use the following example.

```
SELECT QUOTE_IDENT('"CAT"');

+-------------+
| quote_ident |
+-------------+
| """CAT"""   |
+-------------+
```

The following example uses data from the CATEGORY table in the TICKIT sample database. For more information, see Sample database.

To return the CATNAME column surrounded by quotation marks, use the following example.

```
SELECT catid, QUOTE_IDENT(catname)
FROM category
ORDER BY 1,2;

+-------+-------------+
| catid | quote_ident |
+-------+-------------+
|     1 | "MLB"       |
|     2 | "NHL"       |
|     3 | "NFL"       |
```

```
|      4 | "NBA"       |
|      5 | "MLS"       |
|      6 | "Musicals"  |
|      7 | "Plays"     |
|      8 | "Opera"     |
|      9 | "Pop"       |
|     10 | "Jazz"      |
|     11 | "Classical" |
+-------+-------------+
```

QUOTE_LITERAL function

The QUOTE_LITERAL function returns the specified string as a single quoted string so that it can be used as a string literal in a SQL statement. If the input parameter is a number, QUOTE_LITERAL treats it as a string. Appropriately doubles any embedded single quotation marks and backslashes.

Syntax

```
QUOTE_LITERAL(string)
```

Argument

string

A CHAR or VARCHAR string.

Return type

The QUOTE_LITERAL function returns a CHAR or VARCHAR string that is the same data type as the input *string*.

Examples

To return the string `''CAT''` with SINGLE quotation marks, use the following example.

```
SELECT QUOTE_LITERAL('''CAT''');

+---------------+
| quote_literal |
+---------------+
| '''CAT'''     |
```

```
+---------------+
```

The following examples use data from the CATEGORY table in the TICKIT sample database. For more information, see Sample database.

To return the CATNAME column surrounded by single quotation marks, use the following example.

```
SELECT catid, QUOTE_LITERAL(catname)
FROM category
ORDER BY 1,2;

+-------+---------------+
| catid | quote_literal |
+-------+---------------+
|     1 | 'MLB'         |
|     2 | 'NHL'         |
|     3 | 'NFL'         |
|     4 | 'NBA'         |
|     5 | 'MLS'         |
|     6 | 'Musicals'    |
|     7 | 'Plays'       |
|     8 | 'Opera'       |
|     9 | 'Pop'         |
|    10 | 'Jazz'        |
|    11 | 'Classical'   |
+-------+---------------+
```

To return the CATID column surrounded by single quotation marks, use the following example.

```
SELECT QUOTE_LITERAL(catid), catname
FROM category
ORDER BY 1,2;

+---------------+-----------+
| quote_literal |  catname  |
+---------------+-----------+
| '1'           | MLB       |
| '10'          | Jazz      |
| '11'          | Classical |
| '2'           | NHL       |
| '3'           | NFL       |
| '4'           | NBA       |
| '5'           | MLS       |
```

```
| '6'           | Musicals  |
| '7'           | Plays     |
| '8'           | Opera     |
| '9'           | Pop       |
+---------------+-----------+
```

REGEXP_COUNT function

Searches a string for a regular expression pattern and returns an integer that indicates the number of times the specified pattern occurs in the string. If no match is found, then the function returns `0`. For more information about regular expressions, see POSIX operators and Regular expression in Wikipedia.

Syntax

```
REGEXP_COUNT( source_string, pattern [, position [, parameters ] ] )
```

Arguments

source_string

A CHAR or VARCHAR string.

pattern

A UTF-8 string literal that represents a regular expression pattern. For more information, see POSIX operators.

position

(Optional) A positive `INTEGER` that indicates the position within *source_string* to begin searching. The position is based on the number of characters, not bytes, so that multibyte characters are counted as single characters. The default is 1. If *position* is less than 1, the search begins at the first character of *source_string*. If *position* is greater than the number of characters in *source_string*, the result is `0`.

parameters

(Optional) One or more string literals that indicate how the function matches the pattern. The possible values are the following:

- c – Perform case-sensitive matching. The default is to use case-sensitive matching.
- i – Perform case-insensitive matching.

- p – Interpret the pattern with Perl Compatible Regular Expression (PCRE) dialect. For more information about PCRE, see Perl Compatible Regular Expressions in Wikipedia.

Return type

INTEGER

Examples

To count the number of times a three-letter sequence occurs, use the following example.

```
SELECT REGEXP_COUNT('abcdefghijklmnopqrstuvwxyz', '[a-z]{3}');

+--------------+
| regexp_count |
+--------------+
|            8 |
+--------------+
```

To count the occurrences of the string FOX using case-insensitive matching, use the following example.

```
SELECT REGEXP_COUNT('the fox', 'FOX', 1, 'i');

+--------------+
| regexp_count |
+--------------+
|            1 |
+--------------+
```

To use a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter, use the following example. The example uses the ?= operator, which has a specific look-ahead connotation in PCRE. This example counts the number of occurrences of such words, with case-sensitive matching.

```
SELECT REGEXP_COUNT('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 'p');

+--------------+
| regexp_count |
```

```
+--------------+
|            2 |
+--------------+
```

To use a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter, use the following example. It uses the ?= operator, which has a specific connotation in PCRE. This example counts the number of occurrences of such words, but differs from the previous example in that it uses case-insensitive matching.

```
SELECT REGEXP_COUNT('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 'ip');

+--------------+
| regexp_count |
+--------------+
|            3 |
+--------------+
```

The following example uses data from the USERS table in the TICKIT sample database. For more information, see Sample database.

To count the number of times the top-level domain name is either `org` or `edu`, use the following example.

```
SELECT email, REGEXP_COUNT(email,'@[^.]*\.(org|edu)') FROM users
ORDER BY userid LIMIT 4;

+-----------------------------------------------+--------------+
|                     email                     | regexp_count |
+-----------------------------------------------+--------------+
| Etiam.laoreet.libero@sodalesMaurisblandit.edu |            1 |
| Suspendisse.tristique@nonnisiAenean.edu       |            1 |
| amet.faucibus.ut@condimentumegetvolutpat.ca   |            0 |
| sed@lacusUtnec.ca                             |            0 |
+-----------------------------------------------+--------------+
```

REGEXP_INSTR function

Searches a string for a regular expression pattern and returns an integer that indicates the beginning position or ending position of the matched substring. If no match is found, then the function returns `0`. REGEXP_INSTR is similar to the POSITION function, but lets you search a string for a regular expression pattern. For more information about regular expressions, see POSIX operators and Regular expression in Wikipedia.

Syntax

```
REGEXP_INSTR( source_string, pattern [, position [, occurrence] [, option [, parameters
 ] ] ] ] )
```

Arguments

source_string

A string expression, such as a column name, to be searched.

pattern

A UTF-8 string literal that represents a regular expression pattern. For more information, see POSIX operators.

position

(Optional) A positive `INTEGER` that indicates the position within *source_string* to begin searching. The position is based on the number of characters, not bytes, so that multibyte characters are counted as single characters. The default is 1. If *position* is less than 1, the search begins at the first character of *source_string*. If *position* is greater than the number of characters in *source_string*, the result is `0`.

occurrence

(Optional) A positive `INTEGER` that indicates which occurrence of the pattern to use. REGEXP_INSTR skips the first `occurrence-1` matches. The default is 1. If *occurrence* is less than 1 or greater than the number of characters in *source_string*, the search is ignored and the result is `0`.

option

(Optional) A value that indicates whether to return the position of the first character of the match (`0`) or the position of the first character following the end of the match (1). A nonzero value is the same as 1. The default value is `0`.

parameters

(Optional) One or more string literals that indicate how the function matches the pattern. The possible values are the following:

- c – Perform case-sensitive matching. The default is to use case-sensitive matching.
- i – Perform case-insensitive matching.
- e – Extract a substring using a subexpression.

  If *pattern* includes a subexpression, REGEXP_INSTR matches a substring using the first subexpression in *pattern*. REGEXP_INSTR considers only the first subexpression; additional subexpressions are ignored. If the pattern doesn't have a subexpression, REGEXP_INSTR ignores the 'e' parameter.
- p – Interpret the pattern with Perl Compatible Regular Expression (PCRE) dialect. For more information about PCRE, see [Perl Compatible Regular Expressions](https://en.wikipedia.org/wiki/Perl_Compatible_Regular_Expressions) in Wikipedia.

Return type

Integer

Examples

The following examples use data from the USERS table in the TICKIT sample database. For more information, see Sample database.

To search for the `@` character that begins a domain name and returns the starting position of the first match, use the following example.

```
SELECT email, REGEXP_INSTR(email, '@[^.]*')
FROM users
ORDER BY userid LIMIT 4;

+-----------------------------------------------+--------------+
|                     email                     | regexp_instr |
+-----------------------------------------------+--------------+
| Etiam.laoreet.libero@sodalesMaurisblandit.edu |           21 |
| Suspendisse.tristique@nonnisiAenean.edu       |           22 |
| amet.faucibus.ut@condimentumegetvolutpat.ca   |           17 |
| sed@lacusUtnec.ca                             |            4 |
+-----------------------------------------------+--------------+
```

To search for variants of the word `Center` and returns the starting position of the first match, use the following example.

```
SELECT venuename, REGEXP_INSTR(venuename,'[cC]ent(er|re)$')
```

```
FROM venue
WHERE REGEXP_INSTR(venuename,'[cC]ent(er|re)$') > 0
ORDER BY venueid LIMIT 4;

+-----------------------+--------------+
|       venuename       | regexp_instr |
+-----------------------+--------------+
| The Home Depot Center |           16 |
| Izod Center           |            6 |
| Wachovia Center       |           10 |
| Air Canada Centre     |           12 |
+-----------------------+--------------+
```

To find the starting position of the first occurrence of the string FOX, using case-insensitive matching logic, use the following example.

```
SELECT REGEXP_INSTR('the fox', 'FOX', 1, 1, 0, 'i');

+--------------+
| regexp_instr |
+--------------+
|            5 |
+--------------+
```

To use a pattern written in PCRE dialect to locate words containing at least one number and one lowercase letter, use the following example. It uses the ?= operator, which has a specific look-ahead connotation in PCRE. This example finds the starting position of the second such word.

```
SELECT REGEXP_INSTR('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 2, 0, 'p');

+--------------+
| regexp_instr |
+--------------+
|           21 |
+--------------+
```

To use a pattern written in PCRE dialect to locate words containing at least one number and one lowercase letter, use the following example. It uses the ?= operator, which has a specific look-ahead connotation in PCRE. This example finds the starting position of the second such word, but differs from the previous example in that it uses case-insensitive matching.

```
SELECT REGEXP_INSTR('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 2, 0, 'ip');

+--------------+
| regexp_instr |
+--------------+
|           15 |
+--------------+
```

REGEXP_REPLACE function

Searches a string for a regular expression pattern and replaces every occurrence of the pattern with the specified string. REGEXP_REPLACE is similar to the REPLACE function, but lets you search a string for a regular expression pattern. For more information about regular expressions, see POSIX operators and Regular expression in Wikipedia.

REGEXP_REPLACE is similar to the TRANSLATE function and the REPLACE function, except that TRANSLATE makes multiple single-character substitutions and REPLACE substitutes one entire string with another string, while REGEXP_REPLACE lets you search a string for a regular expression pattern.

Syntax

```
REGEXP_REPLACE( source_string, pattern [, replace_string [ , position [, parameters
 ] ] ] )
```

Arguments

source_string

A CHAR or VARCHAR string expression, such as a column name, to be searched.

pattern

A UTF-8 string literal that represents a regular expression pattern. For more information, see POSIX operators.

replace_string

(Optional) A CHAR or VARCHAR string expression, such as a column name, that will replace each occurrence of pattern. The default is an empty string ("").

position

(Optional) A positive integer that indicates the position within *source_string* to begin searching. The position is based on the number of characters, not bytes, so that multibyte characters are counted as single characters. The default is 1. If *position* is less than 1, the search begins at the first character of *source_string*. If *position* is greater than the number of characters in *source_string*, the result is *source_string*.

parameters

(Optional) One or more string literals that indicate how the function matches the pattern. The possible values are the following:

- c – Perform case-sensitive matching. The default is to use case-sensitive matching.
- i – Perform case-insensitive matching.
- p – Interpret the pattern with Perl Compatible Regular Expression (PCRE) dialect. For more information about PCRE, see [Perl Compatible Regular Expressions](https://en.wikipedia.org/wiki/Perl_Compatible_Regular_Expressions) in Wikipedia.

Return type

VARCHAR

If either *pattern* or *replace_string* is `NULL`, the function returns `NULL`.

Examples

To replace all occurrences of the string `FOX` within the value `quick brown fox` using case-insensitive matching, use the following example.

```
SELECT REGEXP_REPLACE('the fox', 'FOX', 'quick brown fox', 1, 'i');

+---------------------+
|   regexp_replace    |
+---------------------+
| the quick brown fox |
+---------------------+
```

The following example uses a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter. It uses the `?=` operator, which has a specific look-ahead connotation in PCRE. To replace each occurrence of such a word with the value `[hidden]`, use the following example.

```
SELECT REGEXP_REPLACE('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 '[hidden]', 1, 'p');

+-------------------------------+
|        regexp_replace         |
+-------------------------------+
| [hidden] plain A1234 [hidden] |
+-------------------------------+
```

The following example uses a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter. It uses the ?= operator, which has a specific look-ahead connotation in PCRE. To replace each occurrence of such a word with the value `[hidden]`, but differs from the previous example in that it uses case-insensitive matching, use the following example.

```
SELECT REGEXP_REPLACE('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 '[hidden]', 1, 'ip');

+----------------------------------+
|          regexp_replace          |
+----------------------------------+
| [hidden] plain [hidden] [hidden] |
+----------------------------------+
```

The following examples use data from the USERS table in the TICKIT sample database. For more information, see [Sample database](#).

To delete the `@` and domain name from email addresses, use the following example.

```
SELECT email, REGEXP_REPLACE(email, '@.*\\.(org|gov|com|edu|ca)$')
FROM users
ORDER BY userid LIMIT 4;

+-----------------------------------------------+-----------------------+
|                     email                     |    regexp_replace     |
+-----------------------------------------------+-----------------------+
| Etiam.laoreet.libero@sodalesMaurisblandit.edu | Etiam.laoreet.libero  |
| Suspendisse.tristique@nonnisiAenean.edu       | Suspendisse.tristique |
| amet.faucibus.ut@condimentumegetvolutpat.ca   | amet.faucibus.ut      |
| sed@lacusUtnec.ca                             | sed                   |
+-----------------------------------------------+-----------------------+
```

To replace the domain names of email addresses with `internal.company.com`, use the following example.

```
SELECT email, REGEXP_REPLACE(email, '@.*\\.[[:alpha:]]{2,3}','@internal.company.com')
FROM users
ORDER BY userid LIMIT 4;

+-----------------------------------------------
+-----------------------------------------------+
|                      email                   |                regexp_replace
      |
+-----------------------------------------------
+-----------------------------------------------+
| Etiam.laoreet.libero@sodalesMaurisblandit.edu |
 Etiam.laoreet.libero@internal.company.com   |
| Suspendisse.tristique@nonnisiAenean.edu       |
 Suspendisse.tristique@internal.company.com |
| amet.faucibus.ut@condimentumegetvolutpat.ca   | amet.faucibus.ut@internal.company.com
      |
| sed@lacusUtnec.ca                             | sed@internal.company.com
      |
+-----------------------------------------------
+-----------------------------------------------+
```

REGEXP_SUBSTR function

Returns characters from a string by searching it for a regular expression pattern. REGEXP_SUBSTR is similar to the SUBSTRING function function, but lets you search a string for a regular expression pattern. If the function can't match the regular expression to any characters in the string, it returns an empty string. For more information about regular expressions, see POSIX operators and Regular expression in Wikipedia.

Syntax

```
REGEXP_SUBSTR( source_string, pattern [, position [, occurrence [, parameters ] ] ] )
```

Arguments

source_string

A string expression to be searched.

pattern

A UTF-8 string literal that represents a regular expression pattern. For more information, see [POSIX operators].

position

A positive integer that indicates the position within *source_string* to begin searching. The position is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. The default is 1. If *position* is less than 1, the search begins at the first character of *source_string*. If *position* is greater than the number of characters in *source_string*, the result is an empty string ("").

occurrence

A positive integer that indicates which occurrence of the pattern to use. REGEXP_SUBSTR skips the first *occurrence* -1 matches. The default is 1. If *occurrence* is less than 1 or greater than the number of characters in *source_string*, the search is ignored and the result is empty.

parameters

One or more string literals that indicate how the function matches the pattern. The possible values are the following:

- c – Perform case-sensitive matching. The default is to use case-sensitive matching.
- i – Perform case-insensitive matching.
- e – Extract a substring using a subexpression.

  If *pattern* includes a subexpression, REGEXP_SUBSTR matches a substring using the first subexpression in *pattern*. A subexpression is an expression within the pattern that is bracketed with parentheses. For example, for the pattern `'This is a (\\w+)'` matches the first expression with the string `'This is a '` followed by a word. Instead of returning *pattern*, REGEXP_SUBSTR with the `e` parameter returns only the string inside the subexpression.

  REGEXP_SUBSTR considers only the first subexpression; additional subexpressions are ignored. If the pattern doesn't have a subexpression, REGEXP_SUBSTR ignores the 'e' parameter.
- p – Interpret the pattern with Perl Compatible Regular Expression (PCRE) dialect. For more information about PCRE, see [Perl Compatible Regular Expressions] in Wikipedia.

Return type

VARCHAR

Examples

The following example returns the portion of an email address between the @ character and the domain extension. The `users` data queried is from the Amazon Redshift sample data. For more information, see Sample database.

```
SELECT email, regexp_substr(email,'@[^.]*')
FROM users
ORDER BY userid LIMIT 4;

                     email                     |      regexp_substr
-----------------------------------------------+--------------------------
 Suspendisse.tristique@nonnisiAenean.edu       | @nonnisiAenean
 amet.faucibus.ut@condimentumegetvolutpat.ca   | @condimentumegetvolutpat
 sed@lacusUtnec.ca                             | @lacusUtnec
 Cum@accumsan.com                              | @accumsan
```

The following example returns the portion of the input corresponding to the first occurrence of the string `FOX` using case-insensitive matching.

```
SELECT regexp_substr('the fox', 'FOX', 1, 1, 'i');

 regexp_substr
---------------
 fox
```

The following example returns the portion of the input corresponding to the second occurrence of the string `FOX` using case-insensitive matching. The result is empty (non-null, length 0) because there is no second occurrence.

```
SELECT regexp_substr('the fox', 'FOX', 1, 2, 'i');

 regexp_substr
---------------
```

The following example returns the first portion of the input that begins with lowercase letters. This is functionally identical to the same SELECT statement without the c parameter.

```
SELECT regexp_substr('THE SECRET CODE IS THE LOWERCASE PART OF 1931abc0EZ.', '[a-z]+',
 1, 1, 'c');

 regexp_substr
---------------
 abc
```

The following example uses a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter. It uses the ?= operator, which has a specific look-ahead connotation in PCRE. This example returns the portion of the input corresponding to the second such word.

```
SELECT regexp_substr('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 2, 'p');

 regexp_substr
---------------
 a1234
```

The following example uses a pattern written in the PCRE dialect to locate words containing at least one number and one lowercase letter. It uses the ?= operator, which has a specific look-ahead connotation in PCRE. This example returns the portion of the input corresponding to the second such word, but differs from the previous example in that it uses case-insensitive matching.

```
SELECT regexp_substr('passwd7 plain A1234 a1234', '(?=[^ ]*[a-z])(?=[^ ]*[0-9])[^ ]+',
 1, 2, 'ip');

 regexp_substr
---------------
 A1234
```

The following example uses a subexpression to find the second string matching the pattern `'this is a (\\w+)'` using case-insensitive matching. It returns the subexpression inside the parentheses.

```
SELECT regexp_substr(
```

```
                'This is a cat, this is a dog. This is a mouse.',
                'this is a (\\w+)', 1, 2, 'ie');

 regexp_substr
---------------
 dog
```

REPEAT function

Repeats a string the specified number of times. If the input parameter is numeric, REPEAT treats it as a string.

Synonym for REPLICATE function.

Syntax

```
REPEAT(string, integer)
```

Arguments

string

The first input parameter is the string to be repeated.

integer

The second parameter is an `INTEGER` indicating the number of times to repeat the string.

Return type

VARCHAR

Examples

The following example uses data from the CATEGORY table in the TICKIT sample database. For more information, see Sample database.

To repeat the value of the CATID column in the CATEGORY table three times, use the following example.

```
SELECT catid, REPEAT(catid,3)
```

```
FROM category
ORDER BY 1,2;

+-------+--------+
| catid | repeat |
+-------+--------+
|     1 |    111 |
|     2 |    222 |
|     3 |    333 |
|     4 |    444 |
|     5 |    555 |
|     6 |    666 |
|     7 |    777 |
|     8 |    888 |
|     9 |    999 |
|    10 | 101010 |
|    11 | 111111 |
+-------+--------+
```

REPLACE function

Replaces all occurrences of a set of characters within an existing string with other specified characters.

REPLACE is similar to the TRANSLATE function and the REGEXP_REPLACE function, except that TRANSLATE makes multiple single-character substitutions and REGEXP_REPLACE lets you search a string for a regular expression pattern, while REPLACE substitutes one entire string with another string.

Syntax

```
REPLACE(string, old_chars, new_chars)
```

Arguments

string

CHAR or VARCHAR string to be searched search

old_chars

CHAR or VARCHAR string to replace.

new_chars

New CHAR or VARCHAR string replacing the *old_string*.

Return type

VARCHAR

If either *old_chars* or *new_chars* is NULL, the return is NULL.

Examples

The following example uses data from the CATEGORY table in the TICKIT sample database. For more information, see Sample database.

To convert the string Shows to Theatre in the CATGROUP field, use the following example.

```
SELECT catid, catgroup, REPLACE(catgroup, 'Shows', 'Theatre')
FROM category
ORDER BY 1,2,3;

+-------+----------+----------+
| catid | catgroup | replace  |
+-------+----------+----------+
|     1 | Sports   | Sports   |
|     2 | Sports   | Sports   |
|     3 | Sports   | Sports   |
|     4 | Sports   | Sports   |
|     5 | Sports   | Sports   |
|     6 | Shows    | Theatre  |
|     7 | Shows    | Theatre  |
|     8 | Shows    | Theatre  |
|     9 | Concerts | Concerts |
|    10 | Concerts | Concerts |
|    11 | Concerts | Concerts |
+-------+----------+----------+
```

REPLICATE function

Synonym for the REPEAT function.

See REPEAT function.

REVERSE function

The REVERSE function operates on a string and returns the characters in reverse order. For example, `reverse('abcde')` returns `edcba`. This function works on numeric and date data types as well as character data types; however, in most cases it has practical value for character strings.

Syntax

```
REVERSE( expression )
```

Argument

expression

An expression with a character, date, timestamp, or numeric data type that represents the target of the character reversal. All expressions are implicitly converted to `VARCHAR` strings. Trailing blanks in `CHAR` strings are ignored.

Return type

VARCHAR

Examples

The following examples use data from the USERS and SALES tables in the TICKIT sample database. For more information, see [Sample database](#).

To select five distinct city names and their corresponding reversed names from the USERS table, use the following example.

```
SELECT DISTINCT city AS cityname, REVERSE(cityname)
FROM users
ORDER BY city LIMIT 5;

+----------+----------+
| cityname | reverse  |
+----------+----------+
| Aberdeen | needrebA |
| Abilene  | enelibA  |
| Ada      | adA      |
```

```
| Agat      | tagA      |
| Agawam    | mawagA    |
+-----------+-----------+
```

To select five sales IDs and their corresponding reversed IDs cast as character strings, use the following example.

```
SELECT salesid, REVERSE(salesid)
FROM sales
ORDER BY salesid DESC LIMIT 5;

+---------+---------+
| salesid | reverse |
+---------+---------+
|  172456 |  654271 |
|  172455 |  554271 |
|  172454 |  454271 |
|  172453 |  354271 |
|  172452 |  254271 |
+---------+---------+
```

RTRIM function

The RTRIM function trims a specified set of characters from the end of a string. Removes the longest string containing only characters in the trim characters list. Trimming is complete when a trim character does not appear in the input string.

Syntax

```
RTRIM( string, trim_chars )
```

Arguments

string

A string column, expression, or string literal to be trimmed.

trim_chars

A string column, expression, or string literal that represents the characters to be trimmed from the end of *string*. If not specified, a space is used as the trim character.

Return type

A string that is the same data type as the *string* argument.

Example

The following example trims leading and trailing blanks from the string `'   abc   '`:

```
select '     abc    ' as untrim, rtrim('     abc    ') as trim;

untrim    | trim
----------+------
   abc    |    abc
```

The following example removes the trailing `'xyz'` strings from the string `'xyzaxyzbxyzcxyz'`. The trailing occurrences of `'xyz'` are removed, but occurrences that are internal within the string are not removed.

```
select 'xyzaxyzbxyzcxyz' as untrim,
rtrim('xyzaxyzbxyzcxyz', 'xyz') as trim;

     untrim      |   trim
-----------------+-----------
 xyzaxyzbxyzcxyz | xyzaxyzbxyzc
```

The following example removes the trailing parts from the string `'setuphistorycassettes'` that match any of the characters in the *trim_chars* list `'tes'`. Any `t`, `e`, or `s` that occur before another character that is not in the *trim_chars* list at the ending of the input string are removed.

```
SELECT rtrim('setuphistorycassettes', 'tes');

     rtrim
-----------------
 setuphistoryca
```

The following example trims the characters 'Park' from the end of VENUENAME where present:

```
select venueid, venuename, rtrim(venuename, 'Park')
from venue
order by 1, 2, 3
limit 10;
```

```
venueid |         venuename          |          rtrim
--------+----------------------------+-------------------------
      1 | Toyota Park                | Toyota
      2 | Columbus Crew Stadium      | Columbus Crew Stadium
      3 | RFK Stadium                | RFK Stadium
      4 | CommunityAmerica Ballpark  | CommunityAmerica Ballp
      5 | Gillette Stadium           | Gillette Stadium
      6 | New York Giants Stadium    | New York Giants Stadium
      7 | BMO Field                  | BMO Field
      8 | The Home Depot Center      | The Home Depot Cente
      9 | Dick's Sporting Goods Park | Dick's Sporting Goods
     10 | Pizza Hut Park             | Pizza Hut
```

Note that RTRIM removes any of the characters `P`, `a`, `r`, or `k` when they appear at the end of a VENUENAME.

SOUNDEX function

The SOUNDEX function returns the American Soundex value consisting of the first letter of the input string followed by a 3–digit encoding of the sounds that represent the English pronunciation of the string that you specify. For example, `Smith` and `Smyth` have the same Soundex value.

Syntax

```
SOUNDEX(string)
```

Arguments

string

You specify a `CHAR` or `VARCHAR` string that you want to convert to an American Soundex code value.

Return type

VARCHAR(4)

Usage notes

The SOUNDEX function converts only English alphabetical lowercase and uppercase ASCII characters, including a–z and A–Z. SOUNDEX ignores other characters. SOUNDEX returns a single Soundex value for a string of multiple words separated by spaces.

```
SELECT SOUNDEX('AWS Amazon');

+---------+
| soundex |
+---------+
| A252    |
+---------+
```

SOUNDEX returns an empty string if the input string doesn't contain any English letters.

```
SELECT SOUNDEX('+-*/%');

+---------+
| soundex |
+---------+
|         |
+---------+
```

Examples

To return the Soundex value for `Amazon`, use the following example.

```
SELECT SOUNDEX('Amazon');

+---------+
| soundex |
+---------+
| A525    |
+---------+
```

To return the Soundex value for `smith` and `smyth`, use the following example. Note that the Soundex values are the same.

```
SELECT SOUNDEX('smith'), SOUNDEX('smyth');

+-------+-------+
| smith | smyth |
+-------+-------+
| S530  | S530  |
+-------+-------+
```

SPLIT_PART function

Splits a string on the specified delimiter and returns the part at the specified position.

Syntax

```
SPLIT_PART(string, delimiter, position)
```

Arguments

string

A string column, expression, or string literal to be split. The string can be CHAR or VARCHAR.

delimiter

The delimiter string indicating sections of the input *string*.

If *delimiter* is a literal, enclose it in single quotation marks.

position

Position of the portion of *string* to return (counting from 1). Must be an integer greater than 0. If *position* is larger than the number of string portions, SPLIT_PART returns an empty string. If *delimiter* is not found in *string*, then the returned value contains the contents of the specified part, which might be the entire *string* or an empty value.

Return type

A CHAR or VARCHAR string, the same as the *string* parameter.

Examples

The following example splits a string literal into parts using the $ delimiter and returns the second part.

```
select split_part('abc$def$ghi','$',2)

split_part
----------
def
```

The following example splits a string literal into parts using the $ delimiter. It returns an empty string because part 4 is not found.

```
select split_part('abc$def$ghi','$',4)

split_part
----------

```

The following example splits a string literal into parts using the # delimiter. It returns the entire string, which is the first part, because the delimiter is not found.

```
select split_part('abc$def$ghi','#',1)

split_part
------------
abc$def$ghi
```

The following example splits the timestamp field LISTTIME into year, month, and day components.

```
select listtime, split_part(listtime,'-',1) as year,
split_part(listtime,'-',2) as month,
split_part(split_part(listtime,'-',3),' ',1) as day
from listing limit 5;

      listtime       | year | month | day
---------------------+------+-------+------
 2008-03-05 12:25:29 | 2008 | 03    | 05
 2008-09-09 08:03:36 | 2008 | 09    | 09
 2008-09-26 05:43:12 | 2008 | 09    | 26
 2008-10-04 02:00:30 | 2008 | 10    | 04
 2008-01-06 08:33:11 | 2008 | 01    | 06
```

The following example selects the LISTTIME timestamp field and splits it on the `'-'` character to get the month (the second part of the LISTTIME string), then counts the number of entries for each month:

```
select split_part(listtime,'-',2) as month, count(*)
from listing
group by split_part(listtime,'-',2)
order by 1, 2;
```

```
 month | count
-------+-------
    01 | 18543
    02 | 16620
    03 | 17594
    04 | 16822
    05 | 17618
    06 | 17158
    07 | 17626
    08 | 17881
    09 | 17378
    10 | 17756
    11 | 12912
    12 | 4589
```

STRPOS function

Returns the position of a substring within a specified string.

See CHARINDEX function and POSITION function for similar functions.

Syntax

```
STRPOS(string, substring )
```

Arguments

string

The first input parameter is the CHAR or VARCHAR string to be searched.

substring

The second parameter is the substring to search for within the *string*.

Return type

INTEGER

The STRPOS function returns an INTEGER corresponding to the position of the *substring* (one-based, not zero-based). The position is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters.

Usage notes

STRPOS returns `0` if the *substring* is not found within the *string*.

```
SELECT STRPOS('dogfish', 'fist');

+--------+
| strpos |
+--------+
|      0 |
+--------+
```

Examples

To show the position of `fish` within `dogfish`, use the following example.

```
SELECT STRPOS('dogfish', 'fish');

+--------+
| strpos |
+--------+
|      4 |
+--------+
```

The following example uses data from the SALES table in the TICKIT sample database. For more information, see Sample database.

To return the number of sales transactions with a COMMISSION over 999.00 from the SALES table, use the following example.

```
SELECT DISTINCT STRPOS(commission, '.'),
COUNT (STRPOS(commission, '.'))
FROM sales
WHERE STRPOS(commission, '.') > 4
GROUP BY STRPOS(commission, '.')
ORDER BY 1, 2;

+--------+-------+
| strpos | count |
+--------+-------+
|      5 |   629 |
+--------+-------+
```

STRTOL function

Converts a string expression of a number of the specified base to the equivalent integer value. The converted value must be within the signed 64-bit range.

Syntax

```
STRTOL(num_string, base)
```

Arguments

num_string

String expression of a number to be converted. If *num_string* is empty (`''`) or begins with the null character (`'\0'`), the converted value is `0`. If *num_string* is a column containing a NULL value, STRTOL returns `NULL`. The string can begin with any amount of white space, optionally followed by a single plus '+' or minus '-' sign to indicate positive or negative. The default is '+'. If *base* is `16`, the string can optionally begin with '`0x`'.

base

`INTEGER` between 2 and 36.

Return type

BIGINT

If *num_string* is null, the function returns `NULL`.

Examples

To convert string and base value pairs to integers, use the following examples.

```
SELECT STRTOL('0xf',16);

+--------+
| strtol |
+--------+
|     15 |
+--------+
```

```
SELECT STRTOL('abcd1234',16);

+------------+
|   strtol   |
+------------+
| 2882343476 |
+------------+

SELECT STRTOL('1234567', 10);

+---------+
| strtol  |
+---------+
| 1234567 |
+---------+

SELECT STRTOL('1234567', 8);

+--------+
| strtol |
+--------+
| 342391 |
+--------+

SELECT STRTOL('110101', 2);

+--------+
| strtol |
+--------+
|     53 |
+--------+

SELECT STRTOL('\0', 2);

+--------+
| strtol |
+--------+
|      0 |
+--------+
```

SUBSTRING function

Returns the subset of a string based on the specified start position.

If the input is a character string, the start position and number of characters extracted are based on characters, not bytes, so that multi-byte characters are counted as single characters. If the input is a binary expression, the start position and extracted substring are based on bytes. You can't specify a negative length, but you can specify a negative starting position.

Syntax

```
SUBSTRING(character_string FROM start_position [ FOR number_characters ] )
```

```
SUBSTRING(character_string, start_position, number_characters )
```

```
SUBSTRING(binary_expression, start_byte, number_bytes )
```

```
SUBSTRING(binary_expression, start_byte )
```

Arguments

character_string

The string to be searched. Non-character data types are treated like a string.

start_position

The position within the string to begin the extraction, starting at 1. The *start_position* is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. This number can be negative.

number_characters

The number of characters to extract (the length of the substring). The *number_characters* is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. This number cannot be negative.

binary_expression

The binary_expression of data type VARBYTE to be searched.

start_byte

The position within the binary expression to begin the extraction, starting at 1. This number can be negative.

number_bytes

The number of bytes to extract, that is, the length of the substring. This number can't be negative.

Return type

VARCHAR or VARBYTE depending on the input.

Usage Notes

Following are some examples of how you can use *start_position* and *number_characters* to extract substrings from various positions in a string.

The following example returns a four-character string beginning with the sixth character.

```
select substring('caterpillar',6,4);
substring
-----------
pill
(1 row)
```

If the *start_position* + *number_characters* exceeds the length of the *string*, SUBSTRING returns a substring starting from the *start_position* until the end of the string. For example:

```
select substring('caterpillar',6,8);
substring
-----------
pillar
(1 row)
```

If the `start_position` is negative or 0, the SUBSTRING function returns a substring beginning at the first character of string with a length of `start_position` + `number_characters` -1. For example:

```
select substring('caterpillar',-2,6);
substring
-----------
cat
(1 row)
```

If `start_position` + `number_characters` -1 is less than or equal to zero, SUBSTRING returns an empty string. For example:

```
select substring('caterpillar',-5,4);
substring
-----------

(1 row)
```

Examples

The following example returns the month from the LISTTIME string in the LISTING table:

```
select listid, listtime,
substring(listtime, 6, 2) as month
from listing
order by 1, 2, 3
limit 10;

 listid |      listtime       | month
--------+---------------------+-------
      1 | 2008-01-24 06:43:29 | 01
      2 | 2008-03-05 12:25:29 | 03
      3 | 2008-11-01 07:35:33 | 11
      4 | 2008-05-24 01:18:37 | 05
      5 | 2008-05-17 02:29:11 | 05
      6 | 2008-08-15 02:08:13 | 08
      7 | 2008-11-15 09:38:15 | 11
      8 | 2008-11-09 05:07:30 | 11
      9 | 2008-09-09 08:03:36 | 09
     10 | 2008-06-17 09:44:54 | 06
(10 rows)
```

The following example is the same as above, but uses the FROM...FOR option:

```
select listid, listtime,
substring(listtime from 6 for 2) as month
from listing
order by 1, 2, 3
limit 10;

 listid |      listtime       | month
```

```
--------+---------------------+-------
      1 | 2008-01-24 06:43:29 | 01
      2 | 2008-03-05 12:25:29 | 03
      3 | 2008-11-01 07:35:33 | 11
      4 | 2008-05-24 01:18:37 | 05
      5 | 2008-05-17 02:29:11 | 05
      6 | 2008-08-15 02:08:13 | 08
      7 | 2008-11-15 09:38:15 | 11
      8 | 2008-11-09 05:07:30 | 11
      9 | 2008-09-09 08:03:36 | 09
     10 | 2008-06-17 09:44:54 | 06
(10 rows)
```

You can't use SUBSTRING to predictably extract the prefix of a string that might contain multi-byte characters because you need to specify the length of a multi-byte string based on the number of bytes, not the number of characters. To extract the beginning segment of a string based on the length in bytes, you can CAST the string as VARCHAR(*byte_length*) to truncate the string, where *byte_length* is the required length. The following example extracts the first 5 bytes from the string `'Fourscore and seven'`.

```
select cast('Fourscore and seven' as varchar(5));

varchar
-------
Fours
```

The following example shows a negative start position of a binary value `abc`. Because the start position is -3, the substring is extracted from the beginning of the binary value. The result is automatically shown as the hexadecimal representation of the binary substring.

```
select substring('abc'::varbyte, -3);

 substring
-----------
 616263
```

The following example shows a 1 for the start position of a binary value `abc`. Because because there is no length specified, the string is extracted from the start position to the end of the string. The result is automatically shown as the hexadecimal representation of the binary substring.

```
select substring('abc'::varbyte, 1);
```

```
 substring
-----------
 616263
```

The following example shows a 3 for the start position of a binary value `abc`. Because because there is no length specified, the string is extracted from the start position to the end of the string. The result is automatically shown as the hexadecimal representation of the binary substring.

```
select substring('abc'::varbyte, 3);

 substring
-----------
 63
```

The following example shows a 2 for the start position of a binary value `abc`. The string is extracted from the start position to position 10, but the end of the string is at position 3. The result is automatically shown as the hexadecimal representation of the binary substring.

```
select substring('abc'::varbyte, 2, 10);

 substring
-----------
 6263
```

The following example shows a 2 for the start position of a binary value `abc`. The string is extracted from the start position for 1 byte. The result is automatically shown as the hexadecimal representation of the binary substring.

```
select substring('abc'::varbyte, 2, 1);

 substring
-----------
 62
```

The following example returns the first name `Ana` which appears after the last space in the input string `Silva, Ana`.

```
select reverse(substring(reverse('Silva, Ana'), 1, position(' ' IN reverse('Silva,
 Ana'))))
```

```
 reverse
-----------
 Ana
```

TEXTLEN function

Synonym of LEN function.

See LEN function.

TRANSLATE function

For a given expression, replaces all occurrences of specified characters with specified substitutes. Existing characters are mapped to replacement characters by their positions in the *characters_to_replace* and *characters_to_substitute* arguments. If more characters are specified in the *characters_to_replace* argument than in the *characters_to_substitute* argument, the extra characters from the *characters_to_replace* argument are omitted in the return value.

TRANSLATE is similar to the REPLACE function and the REGEXP_REPLACE function, except that REPLACE substitutes one entire string with another string and REGEXP_REPLACE lets you search a string for a regular expression pattern, while TRANSLATE makes multiple single-character substitutions.

If any argument is null, the return is `NULL`.

Syntax

```
TRANSLATE( expression, characters_to_replace, characters_to_substitute )
```

Arguments

expression

The expression to be translated.

characters_to_replace

A string containing the characters to be replaced.

characters_to_substitute

A string containing the characters to substitute.

Return type

VARCHAR

Examples

To replace several characters in a string, use the following example.

```
SELECT TRANSLATE('mint tea', 'inea', 'osin');

+-----------+
| translate |
+-----------+
| most tin  |
+-----------+
```

The following examples use data from the USERS table in the TICKIT sample database. For more information, see Sample database.

To replace the at sign (@) with a period for all values in a column, use the following example.

```
SELECT email, TRANSLATE(email, '@', '.') as obfuscated_email
FROM users LIMIT 10;

+---------------------------------------+---------------------------------------+
|                 email                 |           obfuscated_email            |
+---------------------------------------+---------------------------------------+
| Cum@accumsan.com                      | Cum.accumsan.com                      |
| lorem.ipsum@Vestibulumante.com        | lorem.ipsum.Vestibulumante.com        |
| non.justo.Proin@ametconsectetuer.edu  | non.justo.Proin.ametconsectetuer.edu  |
| non.ante.bibendum@porttitortellus.org | non.ante.bibendum.porttitortellus.org |
| eros@blanditatnisi.org                | eros.blanditatnisi.org                |
| augue@Donec.ca                        | augue.Donec.ca                        |
| cursus@pedeacurna.edu                 | cursus.pedeacurna.edu                 |
| at@Duis.com                           | at.Duis.com                           |
| quam@facilisisvitaeorci.ca            | quam.facilisisvitaeorci.ca            |
| mi.lorem@nunc.edu                     | mi.lorem.nunc.edu                     |
+---------------------------------------+---------------------------------------+
```

To replace spaces with underscores and strips out periods for all values in a column, use the following example.

```
SELECT city, TRANSLATE(city, ' .', '_')
```

```
FROM users
WHERE city LIKE 'Sain%' OR city LIKE 'St%'
GROUP BY city
ORDER BY city;

+-----------------+----------------+
|      city       |   translate    |
+-----------------+----------------+
| Saint Albans    | Saint_Albans   |
| Saint Cloud     | Saint_Cloud    |
| Saint Joseph    | Saint_Joseph   |
| Saint Louis     | Saint_Louis    |
| Saint Paul      | Saint_Paul     |
| St. George      | St_George      |
| St. Marys       | St_Marys       |
| St. Petersburg  | St_Petersburg  |
| Stafford        | Stafford       |
| Stamford        | Stamford       |
| Stanton         | Stanton        |
| Starkville      | Starkville     |
| Statesboro      | Statesboro     |
| Staunton        | Staunton       |
| Steubenville    | Steubenville   |
| Stevens Point   | Stevens_Point  |
| Stillwater      | Stillwater     |
| Stockton        | Stockton       |
| Sturgis         | Sturgis        |
+-----------------+----------------+
```

TRIM function

Trims a string by blanks or specified characters.

Syntax

```
TRIM( [ BOTH | LEADING | TRAILING ] [trim_chars FROM ] string )
```

Arguments

BOTH | LEADING | TRAILING

(Optional) Specifies where to trim characters from. Use BOTH to remove leading and trailing characters, use LEADING to remove leading characters only, and use TRAILING to remove trailing characters only. If this parameter is omitted, both leading and trailing characters are trimmed.

trim_chars

(Optional) The characters to be trimmed from the string. If this parameter is omitted, blanks are trimmed.

string

The string to be trimmed.

Return type

The TRIM function returns a VARCHAR or CHAR string. If you use the TRIM function with a SQL command, Amazon Redshift implicitly converts the results to VARCHAR. If you use the TRIM function in the SELECT list for a SQL function, Amazon Redshift does not implicitly convert the results, and you might need to perform an explicit conversion to avoid a data type mismatch error. See the CAST function and CONVERT function functions for information about explicit conversions.

Examples

To trim both leading and trailing blanks from the string   dog   , use the following example.

```
SELECT TRIM('    dog    ');

+-------+
| btrim |
+-------+
| dog   |
+-------+
```

To trim both leading and trailing blanks from the string   dog   , use the following example.

```
SELECT TRIM(BOTH FROM '    dog    ');

+-------+
| btrim |
+-------+
| dog   |
+-------+
```

To remove the leading double quotation marks from the string "dog", use the following example.

```
SELECT TRIM(LEADING '"' FROM'"dog"');

+-------+
| ltrim |
+-------+
| dog"  |
+-------+
```

To remove the trailing double quotation marks from the string "dog", use the following example.

```
SELECT TRIM(TRAILING '"' FROM'"dog"');

+-------+
| rtrim |
+-------+
| "dog  |
+-------+
```

TRIM removes any of the characters in *trim_chars* when they appear at the beginning or end of *string*. The following example trims the characters 'C', 'D', and 'G' when they appear at the beginning or end of VENUENAME, which is a VARCHAR column. For more information, see Sample database.

```
SELECT venueid, venuename, TRIM('CDG' FROM venuename)
FROM venue
WHERE venuename LIKE '%Park'
ORDER BY 2
LIMIT 7;

+---------+----------------------------+---------------------------+
| venueid |         venuename          |           btrim           |
+---------+----------------------------+---------------------------+
|     121 | AT&T Park                  | AT&T Park                 |
|     109 | Citizens Bank Park         | itizens Bank Park         |
|     102 | Comerica Park              | omerica Park              |
|       9 | Dick's Sporting Goods Park | ick's Sporting Goods Park |
|      97 | Fenway Park                | Fenway Park               |
|     112 | Great American Ball Park   | reat American Ball Park   |
|     114 | Miller Park                | Miller Park               |
```

```
+---------+----------------------------+---------------------------+
```

UPPER function

Converts a string to uppercase. UPPER supports UTF-8 multibyte characters, up to a maximum of four bytes per character.

Syntax

```
UPPER(string)
```

Arguments

string

The input parameter is a VARCHAR string or any other data type, such as CHAR, that can be implicitly converted to VARCHAR.

Return type

The UPPER function returns a character string that is the same data type as the input string. For example, the function will return a VARCHAR string if the input is a VARCHAR string.

Examples

The following example uses data from the CATEGORY table in the TICKIT sample database. For more information, see [Sample database](https://docs.aws.amazon.com/redshift/latest/dg/c_sampledb.html).

To convert the CATNAME field to uppercase, use the following.

```
SELECT catname, UPPER(catname)
FROM category
ORDER BY 1,2;

+-----------+-----------+
|  catname  |   upper   |
+-----------+-----------+
| Classical | CLASSICAL |
| Jazz      | JAZZ      |
| MLB       | MLB       |
```

```
| MLS        | MLS        |
| Musicals   | MUSICALS   |
| NBA        | NBA        |
| NFL        | NFL        |
| NHL        | NHL        |
| Opera      | OPERA      |
| Plays      | PLAYS      |
| Pop        | POP        |
+-----------+-----------+
```

SUPER type information functions

Following, you can find a description for the type information functions for SQL that Amazon Redshift supports to derive the dynamic information from inputs of the SUPER data type.

Topics

DECIMAL_PRECISION function

Checks the precision of the maximum total number of decimal digits to be stored. This number includes both the left and right digits of the decimal point. The range of the precision is from 1 to 38, with a default of 38.

Syntax

```
DECIMAL_PRECISION(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

INTEGER

Examples

To apply the DECIMAL_PRECISION function to the table t, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (3.14159);

SELECT DECIMAL_PRECISION(s) FROM t;

+-------------------+
| decimal_precision |
+-------------------+
|                 6 |
+-------------------+
```

DECIMAL_SCALE function

Checks the number of decimal digits to be stored to the right of the decimal point. The range of the scale is from 0 to the precision point, with a default of 0.

Syntax

```
DECIMAL_SCALE(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

INTEGER

Examples

To apply the DECIMAL_SCALE function to the table t, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (3.14159);

SELECT DECIMAL_SCALE(s) FROM t;

+---------------+
| decimal_scale |
+---------------+
|             5 |
+---------------+
```

IS_ARRAY function

Checks whether a variable is an array. The function returns `true` if the variable is an array. The function also includes empty arrays. Otherwise, the function returns `false` for all other values, including null.

Syntax

```
IS_ARRAY(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if [1,2] is an array using the IS_ARRAY function, use the following example.

```
SELECT IS_ARRAY(JSON_PARSE('[1,2]'));

+----------+
| is_array |
+----------+
| true     |
+----------+
```

IS_BIGINT function

Checks whether a value is a BIGINT. The IS_BIGINT function returns true for numbers of scale 0 in the 64-bit range. Otherwise, the function returns false for all other values, including null and floating point numbers.

The IS_BIGINT function is a superset of IS_INTEGER.

Syntax

```
IS_BIGINT(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if 5 is a BIGINT using the IS_BIGINT function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (5);

SELECT s, IS_BIGINT(s) FROM t;

+---+-----------+
| s | is_bigint |
+---+-----------+
| 5 | true      |
+---+-----------+
```

IS_BOOLEAN function

Checks whether a value is a BOOLEAN. The IS_BOOLEAN function returns true for constant JSON Booleans. The function returns false for any other values, including null.

Syntax

```
IS_BOOLEAN(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if TRUE is a BOOLEAN using the IS_BOOLEAN function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (TRUE);

SELECT s, IS_BOOLEAN(s) FROM t;

+------+------------+
|  s   | is_boolean |
+------+------------+
| true | true       |
+------+------------+
```

IS_CHAR function

Checks whether a value is a CHAR. The IS_CHAR function returns `true` for strings that have only ASCII characters, because the CHAR type can store only characters that are in the ASCII format. The function returns `false` for any other values.

Syntax

```
IS_CHAR(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if `t` is a CHAR using the IS_CHAR function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES ('t');

SELECT s, IS_CHAR(s) FROM t;
```

```
+-----+---------+
|  s  | is_char |
+-----+---------+
| "t" | true    |
+-----+---------+
```

IS_DECIMAL function

Checks whether a value is a DECIMAL. The IS_DECIMAL function returns true for numbers that are not floating points. The function returns false for any other values, including null.

The IS_DECIMAL function is a superset of IS_BIGINT.

Syntax

```
IS_DECIMAL(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if 1.22 is a DECIMAL using the IS_DECIMAL function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (1.22);

SELECT s, IS_DECIMAL(s) FROM t;

+------+------------+
|  s   | is_decimal |
+------+------------+
| 1.22 | true       |
+------+------------+
```

IS_FLOAT function

Checks whether a value is a floating point number. The IS_FLOAT function returns `true` for floating point numbers (`FLOAT4` and `FLOAT8`). The function returns `false` for any other values.

The set of IS_DECIMAL the set of IS_FLOAT are disjoint.

Syntax

```
IS_FLOAT(super_expression)
```

Arguments

super_expression

A `SUPER` expression or column.

Return type

`BOOLEAN`

Examples

To check if `2.22::FLOAT` is a `FLOAT` using the IS_FLOAT function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES(2.22::FLOAT);

SELECT s, IS_FLOAT(s) FROM t;

+---------+----------+
|    s    | is_float |
+---------+----------+
| 2.22e+0 | true     |
+---------+----------+
```

IS_INTEGER function

Returns `true` for numbers of scale 0 in the 32-bit range, and `false` for anything else (including null and floating point numbers).

The IS_INTEGER function is a superset of the IS_SMALLINT function.

Syntax

```
IS_INTEGER(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if 5 is an INTEGER using the IS_INTEGER function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (5);

SELECT s, IS_INTEGER(s) FROM t;

+---+------------+
| s | is_integer |
+---+------------+
| 5 | true       |
+---+------------+
```

IS_OBJECT function

Checks whether a variable is an object. The IS_OBJECT function returns true for objects, including empty objects. The function returns false for any other values, including null.

Syntax

```
IS_OBJECT(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if `{"name": "Joe"}` is an object using the IS_OBJECT function, use the following example.

```
CREATE TABLE t(s super);

INSERT INTO t VALUES (JSON_PARSE('{"name": "Joe"}'));

SELECT s, IS_OBJECT(s) FROM t;

+----------------+-----------+
|       s        | is_object |
+----------------+-----------+
| {"name":"Joe"} | true      |
+----------------+-----------+
```

IS_SCALAR function

Checks whether a variable is a scalar. The IS_SCALAR function returns `true` for any value that is not an array or an object. The function returns `false` for any other values, including null.

The set of IS_ARRAY, IS_OBJECT, and IS_SCALAR cover all values except nulls.

Syntax

```
IS_SCALAR(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if `{"name": "Joe"}` is a scalar using the IS_SCALAR function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (JSON_PARSE('{"name": "Joe"}'));

SELECT s, IS_SCALAR(s.name) FROM t;

+----------------+-----------+
|       s        | is_scalar |
+----------------+-----------+
| {"name":"Joe"} | true      |
+----------------+-----------+
```

IS_SMALLINT function

Checks whether a variable is a `SMALLINT`. The IS_SMALLINT function returns `true` for numbers of scale 0 in the 16-bit range. The function returns `false` for any other values, including null and floating point numbers.

Syntax

```
IS_SMALLINT(super_expression)
```

Arguments

super_expression

A `SUPER` expression or column.

Return

BOOLEAN

Examples

To check if 5 is a SMALLINT using the IS_SMALLINT function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES (5);

SELECT s, IS_SMALLINT(s) FROM t;

+---+-------------+
| s | is_smallint |
+---+-------------+
| 5 | true        |
+---+-------------+
```

IS_VARCHAR function

Checks whether a variable is a VARCHAR. The IS_VARCHAR function returns `true` for all strings. The function returns `false` for any other values.

The IS_VARCHAR function is a superset of the IS_CHAR function.

Syntax

```
IS_VARCHAR(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

BOOLEAN

Examples

To check if `abc` is a VARCHAR using the IS_VARCHAR function, use the following example.

```
CREATE TABLE t(s SUPER);

INSERT INTO t VALUES ('abc');

SELECT s, IS_VARCHAR(s) FROM t;

+-------+------------+
|   s   | is_varchar |
+-------+------------+
| "abc" | true       |
+-------+------------+
```

JSON_SIZE function

The JSON_SIZE function returns the number of bytes in the given SUPER expression when serialized into a string.

Syntax

```
JSON_SIZE(super_expression)
```

Arguments

super_expression

A SUPER constant or expression.

Return type

INTEGER

The JSON_SIZE function returns an INTEGER indicating the number of bytes in the input string. This value is different from the number of characters. For example, the UTF-8 character #, a black dot, is 3 bytes in size even though it is 1 character.

Usage notes

JSON_SIZE(x) is functionally identical to OCTET_LENGTH(JSON_SERIALIZE). However, note that JSON_SERIALIZE returns an error when the provided SUPER expression would exceed the VARCHAR limit of the system when serialized. JSON_SIZE does not have this limitation.

Examples

To return the length of a SUPER value serialized to a string, use the following example.

```
SELECT JSON_SIZE(JSON_PARSE('[10001,10002,"#"]'));

+-----------+
| json_size |
+-----------+
|        19 |
+-----------+
```

Note that the provided SUPER expression is 17 characters long, but # is a 3-byte character, so JSON_SIZE returns 19.

JSON_TYPEOF function

The JSON_TYPEOF scalar function returns a VARCHAR with values boolean, number, string, object, array, or null, depending on the dynamic type of the SUPER value.

Syntax

```
JSON_TYPEOF(super_expression)
```

Arguments

super_expression

A SUPER expression or column.

Return type

VARCHAR

Examples

To check the type of JSON for the array [1,2] using the JSON_TYPEOF function, use the following example.

```
SELECT JSON_TYPEOF(ARRAY(1,2));
```

```
+-------------+
| json_typeof |
+-------------+
| array       |
+-------------+
```

To check the type of JSON for the object `{"name":"Joe"}` using the JSON_TYPEOF function, use the following example.

```
SELECT JSON_TYPEOF(JSON_PARSE('{"name":"Joe"}'));

+-------------+
| json_typeof |
+-------------+
| object      |
+-------------+
```

SIZE

Returns the binary in-memory size of a SUPER type constant or expression as an `INTEGER`.

Syntax

```
SIZE(super_expression)
```

Arguments

super_expression

A SUPER type constant or expression.

Return type

`INTEGER`

Examples

To use SIZE to get the in-memory size of several SUPER type expressions, use the following example.

```
CREATE TABLE test_super_size(a SUPER);

INSERT INTO test_super_size
VALUES
  (null),
  (TRUE),
  (JSON_PARSE('[0,1,2,3]')),
  (JSON_PARSE('{"a":0,"b":1,"c":2,"d":3}'))
;

SELECT a, SIZE(a)
FROM test_super_size
ORDER BY 2, 1;

+---------------------------+------+
|             a             | size |
+---------------------------+------+
| true                      |    4 |
| NULL                      |    4 |
| [0,1,2,3]                 |   23 |
| {"a":0,"b":1,"c":2,"d":3} |   52 |
+---------------------------+------+
```

VARBYTE functions and operators

Amazon Redshift functions and operators that support the VARBYTE data type include:

- VARBYTE operators
- FROM_HEX
- FROM_VARBYTE
- GETBIT
- TO_HEX
- TO_VARBYTE
- CONCAT
- LEN
- LENGTH function
- OCTET_LENGTH
- SUBSTRING function

VARBYTE operators

The following table lists the VARBYTE operators. The operator works with binary value of data type VARBYTE. If one or both inputs is null, the result is null.

Supported operators

Operator	Description	Return type
<	Less than	BOOLEAN
<=	Less than or equal	BOOLEAN
=	Equal	BOOLEAN
>	Greater than	BOOLEAN
>=	Greater than or equal	BOOLEAN
!= or <>	Not equal	BOOLEAN
||	Concatenation	VARBYTE
+	Concatenation	VARBYTE
~	Bitwise not	VARBYTE
&	Bitwise and	VARBYTE
|	Bitwise or	VARBYTE
#	Bitwise xor	VARBYTE

Examples

In the following examples, the value of `'a'::VARBYTE` is 61 and the value of `'b'::VARBYTE` is 62. The `::` casts the strings into the `VARBYTE` data type. For more information about casting data types, see CAST.

To compare if `'a'` is less than `'b'` using the < operator, use the following example.

```
SELECT 'a'::VARBYTE < 'b'::VARBYTE AS less_than;

+-----------+
| less_than |
+-----------+
| true      |
+-----------+
```

To compare if `'a'` equals `'b'` using the = operator, use the following example.

```
SELECT 'a'::VARBYTE = 'b'::VARBYTE AS equal;

+-------+
| equal |
+-------+
| false |
+-------+
```

To concatenate two binary values using the `||` operator, use the following example.

```
SELECT 'a'::VARBYTE || 'b'::VARBYTE AS concat;

+--------+
| concat |
+--------+
|   6162 |
+--------+
```

To concatenate two binary values using the + operator, use the following example.

```
SELECT 'a'::VARBYTE + 'b'::VARBYTE AS concat;

+--------+
```

```
| concat |
+--------+
|   6162 |
+--------+
```

To negate each bit of the input binary value using the FROM_VARBYTE function, use the following example. The string `'a'` evaluates to `01100001`. For more information, see FROM_VARBYTE.

```
SELECT FROM_VARBYTE(~'a'::VARBYTE, 'binary');

+--------------+
| from_varbyte |
+--------------+
|     10011110 |
+--------------+
```

To apply the & operator on the two input binary values, use the following example. The string `'a'` evaluates to `01100001` and `'b'` evaluates to `01100010`.

```
SELECT FROM_VARBYTE('a'::VARBYTE & 'b'::VARBYTE, 'binary');

+--------------+
| from_varbyte |
+--------------+
|     01100000 |
+--------------+
```

FROM_HEX function

FROM_HEX converts a hexadecimal to a binary value.

Syntax

```
FROM_HEX(hex_string)
```

Arguments

hex_string

Hexadecimal string of data type `VARCHAR` or `TEXT` to be converted. The format must be a literal value.

Return type

VARBYTE

Examples

To convert the hexadecimal representation of '6162' to a binary value, use the following example. The result is automatically shown as the hexadecimal representation of the binary value.

```
SELECT FROM_HEX('6162');

+----------+
| from_hex |
+----------+
|     6162 |
+----------+
```

FROM_VARBYTE function

FROM_VARBYTE converts a binary value to a character string in the specified format.

Syntax

```
FROM_VARBYTE(binary_value, format)
```

Arguments

binary_value

A binary value of data type VARBYTE.

format

The format of the returned character string. Case insensitive valid values are hex, binary, utf8 (also utf-8 and utf_8), and base64.

Return type

VARCHAR

Examples

To convert the binary value 'ab' to hexadecimal, use the following example.

```
SELECT FROM_VARBYTE('ab', 'hex');

+--------------+
| from_varbyte |
+--------------+
|         6162 |
+--------------+
```

To return the binary representation of `'4d'`, use the following example. The binary representation of `'4d'` is the character string `01001101`.

```
SELECT FROM_VARBYTE(FROM_HEX('4d'), 'binary');

+--------------+
| from_varbyte |
+--------------+
|     01001101 |
+--------------+
```

GETBIT function

GETBIT returns the bit value of a binary value at the specified index.

Syntax

```
GETBIT(binary_value, index)
```

Arguments

binary_value

A binary value of data type `VARBYTE`.

index

An index number of the bit in the binary value that is returned. The binary value is a 0-based bit array that is indexed from the rightmost bit (least significant bit) to the leftmost bit (most significant bit).

Return type

`INTEGER`

Examples

To return the bit at index 2 of the binary value `from_hex('4d')`, use the following example. The binary representation of `'4d'` is `01001101`.

```
SELECT GETBIT(FROM_HEX('4d'), 2);

+--------+
| getbit |
+--------+
|      1 |
+--------+
```

To return the bit at eight index locations of the binary value returned by `from_hex('4d')`, use the following example. The binary representation of `'4d'` is `01001101`.

```
SELECT GETBIT(FROM_HEX('4d'), 7), GETBIT(FROM_HEX('4d'), 6),
  GETBIT(FROM_HEX('4d'), 5), GETBIT(FROM_HEX('4d'), 4),
  GETBIT(FROM_HEX('4d'), 3), GETBIT(FROM_HEX('4d'), 2),
  GETBIT(FROM_HEX('4d'), 1), GETBIT(FROM_HEX('4d'), 0);

+--------+--------+--------+--------+--------+--------+--------+--------+
| getbit | getbit | getbit | getbit | getbit | getbit | getbit | getbit |
+--------+--------+--------+--------+--------+--------+--------+--------+
|      0 |      1 |      0 |      0 |      1 |      1 |      0 |      1 |
+--------+--------+--------+--------+--------+--------+--------+--------+
```

TO_HEX function

TO_HEX converts a number or binary value to a hexadecimal representation.

Syntax

```
TO_HEX(value)
```

Arguments

value

Either a number or binary value (VARBYTE) to be converted.

Return type

VARCHAR

Examples

To convert a number to its hexadecimal representation, use the following example.

```
SELECT TO_HEX(2147676847);

+----------+
|  to_hex  |
+----------+
| 8002f2af |
+----------+
```

To convert the VARBYTE representation of 'abc' to a hexadecimal number, use the followign example.

```
SELECT TO_HEX('abc'::VARBYTE);

+--------+
| to_hex |
+--------+
| 616263 |
+--------+
```

To create a table, insert the VARBYTE representation of 'abc' to a hexadecimal number, and select the column with the value, use the following example.

```
CREATE TABLE t (vc VARCHAR);
INSERT INTO t SELECT TO_HEX('abc'::VARBYTE);
SELECT vc FROM t;

+--------+
|   vc   |
+--------+
| 616263 |
+--------+
```

To show that when casting a VARBYTE value to VARCHAR the format is UTF-8, use the following example.

```
CREATE TABLE t (vc VARCHAR);
INSERT INTO t SELECT 'abc'::VARBYTE::VARCHAR;

SELECT vc FROM t;

+-----+
| vc  |
+-----+
| abc |
+-----+
```

TO_VARBYTE function

TO_VARBYTE converts a string in a specified format to a binary value.

Syntax

```
TO_VARBYTE(string, format)
```

Arguments

string

A CHAR or VARCHAR string.

format

The format of the input string. Case insensitive valid values are `hex`, `binary`, `utf8` (also `utf-8` and `utf_8`), and `base64`.

Return type

VARBYTE

Examples

To convert the hex 6162 to a binary value, use the following example. The result is automatically shown as the hexadecimal representation of the binary value.

```
SELECT TO_VARBYTE('6162', 'hex');
```

```
+------------+
| to_varbyte |
+------------+
|       6162 |
+------------+
```

To return the binary representation of 4d, use the following example. The binary representation of '4d' is 01001101.

```
SELECT TO_VARBYTE('01001101', 'binary');

+------------+
| to_varbyte |
+------------+
|         4d |
+------------+
```

To convert the string 'a' in UTF-8 to a binary value, use the following example. The result is automatically shown as the hexadecimal representation of the binary value.

```
SELECT TO_VARBYTE('a', 'utf8');

+------------+
| to_varbyte |
+------------+
|         61 |
+------------+
```

To convert the string '4' in hexadecimal to a binary value, use the following example. If the hexadecimal string length is an odd number, then a 0 is prepended to form a valid hexadecimal number.

```
SELECT TO_VARBYTE('4', 'hex');

+------------+
| to_varbyte |
+------------+
|         04 |
+------------+
```

Window functions

By using window functions, you can create analytic business queries more efficiently. Window functions operate on a partition or "window" of a result set, and return a value for every row in that window. In contrast, non-windowed functions perform their calculations with respect to every row in the result set. Unlike group functions that aggregate result rows, window functions retain all rows in the table expression.

The values returned are calculated by using values from the sets of rows in that window. For each row in the table, the window defines a set of rows that is used to compute additional attributes. A window is defined using a window specification (the OVER clause), and is based on three main concepts:

- *Window partitioning,* which forms groups of rows (PARTITION clause)
- *Window ordering*, which defines an order or sequence of rows within each partition (ORDER BY clause)
- *Window frames*, which are defined relative to each row to further restrict the set of rows (ROWS specification)

Window functions are the last set of operations performed in a query except for the final ORDER BY clause. All joins and all WHERE, GROUP BY, and HAVING clauses are completed before the window functions are processed. Therefore, window functions can appear only in the select list or ORDER BY clause. You can use multiple window functions within a single query with different frame clauses. You can also use window functions in other scalar expressions, such as CASE.

Window functions can't be nested. For example, an aggregate function SUM can appear inside a window function SUM, but a window function SUM can't appear inside another window function SUM. The following is not supported because a window function is nested in another window function.

```
SELECT SUM(SUM(selectcol) OVER (PARTITION BY ordercol)) OVER (Partition by ordercol)
 FROM t;
```

Window function syntax summary

Window functions follow a standard syntax, which is as follows.

```
function (expression) OVER (
```

```
[ PARTITION BY expr_list ]
[ ORDER BY order_list [ frame_clause ] ] )
```

Here, *function* is one of the functions described in this section.

The *expr_list* is as follows.

```
expression | column_name [, expr_list ]
```

The *order_list* is as follows.

```
expression | column_name [ ASC | DESC ]
[ NULLS FIRST | NULLS LAST ]
[, order_list ]
```

The *frame_clause* is as follows.

```
ROWS
{ UNBOUNDED PRECEDING | unsigned_value PRECEDING | CURRENT ROW } |

{ BETWEEN
{ UNBOUNDED PRECEDING | unsigned_value { PRECEDING | FOLLOWING } | CURRENT ROW}
AND
{ UNBOUNDED FOLLOWING | unsigned_value { PRECEDING | FOLLOWING } | CURRENT ROW }}
```

Arguments

function

The window function. For details, see the individual function descriptions.

OVER

The clause that defines the window specification. The OVER clause is mandatory for window functions, and differentiates window functions from other SQL functions.

PARTITION BY *expr_list*

(Optional) The PARTITION BY clause subdivides the result set into partitions, much like the GROUP BY clause. If a partition clause is present, the function is calculated for the rows in each partition. If no partition clause is specified, a single partition contains the entire table, and the function is computed for that complete table.

The ranking functions DENSE_RANK, NTILE, RANK, and ROW_NUMBER require a global comparison of all the rows in the result set. When a PARTITION BY clause is used, the query optimizer can run each aggregation in parallel by spreading the workload across multiple slices according to the partitions. If the PARTITION BY clause is not present, the aggregation step must be run serially on a single slice, which can have a significant negative impact on performance, especially for large clusters.

Amazon Redshift doesn't support string literals in PARTITION BY clauses.

ORDER BY *order_list*

(Optional) The window function is applied to the rows within each partition sorted according to the order specification in ORDER BY. This ORDER BY clause is distinct from and completely unrelated to ORDER BY clauses in the *frame_clause*. The ORDER BY clause can be used without the PARTITION BY clause.

For ranking functions, the ORDER BY clause identifies the measures for the ranking values. For aggregation functions, the partitioned rows must be ordered before the aggregate function is computed for each frame. For more about window function types, see Window functions.

Column identifiers or expressions that evaluate to column identifiers are required in the order list. Neither constants nor constant expressions can be used as substitutes for column names.

NULLS values are treated as their own group, sorted and ranked according to the NULLS FIRST or NULLS LAST option. By default, NULL values are sorted and ranked last in ASC ordering, and sorted and ranked first in DESC ordering.

Amazon Redshift doesn't support string literals in ORDER BY clauses.

If the ORDER BY clause is omitted, the order of the rows is nondeterministic.

> **Note**
>
> In any parallel system such as Amazon Redshift, when an ORDER BY clause doesn't produce a unique and total ordering of the data, the order of the rows is nondeterministic. That is, if the ORDER BY expression produces duplicate values (a partial ordering), the return order of those rows might vary from one run of Amazon Redshift to the next. In turn, window functions might return unexpected or inconsistent results. For more information, see Unique ordering of data for window functions.

column_name

Name of a column to be partitioned by or ordered by.

ASC | DESC

Option that defines the sort order for the expression, as follows:

- ASC: ascending (for example, low to high for numeric values and 'A' to 'Z' for character strings). If no option is specified, data is sorted in ascending order by default.
- DESC: descending (high to low for numeric values; 'Z' to 'A' for strings).

NULLS FIRST | NULLS LAST

Option that specifies whether NULLS should be ordered first, before non-null values, or last, after non-null values. By default, NULLS are sorted and ranked last in ASC ordering, and sorted and ranked first in DESC ordering.

frame_clause

For aggregate functions, the frame clause further refines the set of rows in a function's window when using ORDER BY. It enables you to include or exclude sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers.

The frame clause doesn't apply to ranking functions. Also, the frame clause isn't required when no ORDER BY clause is used in the OVER clause for an aggregate function. If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required.

When no ORDER BY clause is specified, the implied frame is unbounded, equivalent to ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING.

ROWS

This clause defines the window frame by specifying a physical offset from the current row.

This clause specifies the rows in the current window or partition that the value in the current row is to be combined with. It uses arguments that specify row position, which can be before or after the current row. The reference point for all window frames is the current row. Each row becomes the current row in turn as the window frame slides forward in the partition.

The frame can be a simple set of rows up to and including the current row.

```
{UNBOUNDED PRECEDING | offset PRECEDING | CURRENT ROW}
```

Or it can be a set of rows between two boundaries.

```
BETWEEN
{ UNBOUNDED PRECEDING | offset { PRECEDING | FOLLOWING } | CURRENT ROW }
AND
{ UNBOUNDED FOLLOWING | offset { PRECEDING | FOLLOWING } | CURRENT ROW }
```

UNBOUNDED PRECEDING indicates that the window starts at the first row of the partition; *offset* PRECEDING indicates that the window starts a number of rows equivalent to the value of offset before the current row. UNBOUNDED PRECEDING is the default.

CURRENT ROW indicates the window begins or ends at the current row.

UNBOUNDED FOLLOWING indicates that the window ends at the last row of the partition; *offset* FOLLOWING indicates that the window ends a number of rows equivalent to the value of offset after the current row.

offset identifies a physical number of rows before or after the current row. In this case, *offset* must be a constant that evaluates to a positive numeric value. For example, 5 FOLLOWING ends the frame five rows after the current row.

Where BETWEEN is not specified, the frame is implicitly bounded by the current row. For example, `ROWS 5 PRECEDING` is equal to `ROWS BETWEEN 5 PRECEDING AND CURRENT ROW`. Also, `ROWS UNBOUNDED FOLLOWING` is equal to `ROWS BETWEEN CURRENT ROW AND UNBOUNDED FOLLOWING`.

Note

You can't specify a frame in which the starting boundary is greater than the ending boundary. For example, you can't specify any of the following frames.

```
between 5 following and 5 preceding
between current row and 2 preceding
between 3 following and current row
```

Unique ordering of data for window functions

If an ORDER BY clause for a window function doesn't produce a unique and total ordering of the data, the order of the rows is nondeterministic. If the ORDER BY expression produces duplicate values (a partial ordering), the return order of those rows can vary in multiple runs. In this case, window functions can also return unexpected or inconsistent results.

For example, the following query returns different results over multiple runs. These different results occur because `order by dateid` doesn't produce a unique ordering of the data for the SUM window function.

```
select dateid, pricepaid,
sum(pricepaid) over(order by dateid rows unbounded preceding) as sumpaid
from sales
group by dateid, pricepaid;

dateid | pricepaid |   sumpaid
--------+-----------+-------------
1827 |   1730.00 |     1730.00
1827 |    708.00 |     2438.00
1827 |    234.00 |     2672.00
...

select dateid, pricepaid,
sum(pricepaid) over(order by dateid rows unbounded preceding) as sumpaid
from sales
group by dateid, pricepaid;

dateid | pricepaid |   sumpaid
--------+-----------+-------------
1827 |    234.00 |      234.00
1827 |    472.00 |      706.00
1827 |    347.00 |     1053.00
...
```

In this case, adding a second ORDER BY column to the window function can solve the problem.

```
select dateid, pricepaid,
sum(pricepaid) over(order by dateid, pricepaid rows unbounded preceding) as sumpaid
from sales
group by dateid, pricepaid;

dateid | pricepaid | sumpaid
--------+-----------+---------
1827 |    234.00 |  234.00
1827 |    337.00 |  571.00
1827 |    347.00 |  918.00
```

```
...
```

Supported functions

Amazon Redshift supports two types of window functions: aggregate and ranking.

Following are the supported aggregate functions:

- AVG window function
- COUNT window function
- CUME_DIST window function
- DENSE_RANK window function
- FIRST_VALUE window function
- LAG window function
- LAST_VALUE window function
- LEAD window function
- LISTAGG window function
- MAX window function
- MEDIAN window function
- MIN window function
- NTH_VALUE window function
- PERCENTILE_CONT window function
- PERCENTILE_DISC window function
- RATIO_TO_REPORT window function
- STDDEV_SAMP and STDDEV_POP window functions (STDDEV_SAMP and STDDEV are synonyms)
- SUM window function
- VAR_SAMP and VAR_POP window functions (VAR_SAMP and VARIANCE are synonyms)

Following are the supported ranking functions:

- DENSE_RANK window function
- NTILE window function
- PERCENT_RANK window function
- RANK window function

- ROW_NUMBER window function

Sample table for window function examples

You can find specific window function examples with each function description. Some of the examples use a table named WINSALES, which contains 11 rows, as shown following.

SALESID	DATEID	SELLERID	BUYERID	QTY	QTY_SHIPPED
30001	8/2/2003	3	B	10	10
10001	12/24/2003	1	C	10	10
10005	12/24/2003	1	A	30	
40001	1/9/2004	4	A	40	
10006	1/18/2004	1	C	10	
20001	2/12/2004	2	B	20	20
40005	2/12/2004	4	A	10	10
20002	2/16/2004	2	C	20	20
30003	4/18/2004	3	B	15	
30004	4/18/2004	3	B	20	
30007	9/7/2004	3	C	30	

The following script creates and populates the sample WINSALES table.

```
CREATE TABLE winsales(
  salesid int,
  dateid date,
  sellerid int,
  buyerid char(10),
  qty int,
```

```
  qty_shipped int);

INSERT INTO winsales VALUES
  (30001, '8/2/2003', 3, 'b', 10, 10),
  (10001, '12/24/2003', 1, 'c', 10, 10),
  (10005, '12/24/2003', 1, 'a', 30, null),
  (40001, '1/9/2004', 4, 'a', 40, null),
  (10006, '1/18/2004', 1, 'c', 10, null),
  (20001, '2/12/2004', 2, 'b', 20, 20),
  (40005, '2/12/2004', 4, 'a', 10, 10),
  (20002, '2/16/2004', 2, 'c', 20, 20),
  (30003, '4/18/2004', 3, 'b', 15, null),
  (30004, '4/18/2004', 3, 'b', 20, null),
  (30007, '9/7/2004', 3, 'c', 30, null);
```

AVG window function

The AVG window function returns the average (arithmetic mean) of the input expression values. The AVG function works with numeric values and ignores NULL values.

Syntax

```
AVG ( [ALL ] expression ) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list
                        frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression for counting. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the AVG function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

The argument types supported by the AVG function are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, and DOUBLE PRECISION.

The return types supported by the AVG function are:

- BIGINT for SMALLINT or INTEGER arguments
- NUMERIC for BIGINT arguments
- DOUBLE PRECISION for floating point arguments

Examples

The following example computes a rolling average of quantities sold by date; order the results by date ID and sales ID:

```
select salesid, dateid, sellerid, qty,
avg(qty) over
(order by dateid, salesid rows unbounded preceding) as avg
from winsales
order by 2,1;

salesid |   dateid   | sellerid | qty | avg
---------+------------+----------+-----+-----
```

```
30001 | 2003-08-02 |        3 |  10 |  10
10001 | 2003-12-24 |        1 |  10 |  10
10005 | 2003-12-24 |        1 |  30 |  16
40001 | 2004-01-09 |        4 |  40 |  22
10006 | 2004-01-18 |        1 |  10 |  20
20001 | 2004-02-12 |        2 |  20 |  20
40005 | 2004-02-12 |        4 |  10 |  18
20002 | 2004-02-16 |        2 |  20 |  18
30003 | 2004-04-18 |        3 |  15 |  18
30004 | 2004-04-18 |        3 |  20 |  18
30007 | 2004-09-07 |        3 |  30 |  19
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

COUNT window function

The COUNT window function counts the rows defined by the expression.

The COUNT function has two variations. COUNT(*) counts all the rows in the target table whether they include nulls or not. COUNT(expression) computes the number of rows with non-NULL values in a specific column or expression.

Syntax

```
COUNT ( * | [ ALL ] expression) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list
                         frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression for counting. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the COUNT function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

The COUNT function supports all argument data types.

The return type supported by the COUNT function is BIGINT.

Examples

The following example shows the sales ID, quantity, and count of all rows from the beginning of the data window:

```
select salesid, qty,
count(*) over (order by salesid rows unbounded preceding) as count
from winsales
order by salesid;

salesid | qty | count
---------+-----+-----
10001 |  10 |   1
10005 |  30 |   2
10006 |  10 |   3
20001 |  20 |   4
```

```
20002 |  20 |   5
30001 |  10 |   6
30003 |  15 |   7
30004 |  20 |   8
30007 |  30 |   9
40001 |  40 |   10
40005 |  10 |   11
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example shows how the sales ID, quantity, and count of non-null rows from the beginning of the data window. (In the WINSALES table, the QTY_SHIPPED column contains some NULLs.)

```
select salesid, qty, qty_shipped,
count(qty_shipped)
over (order by salesid rows unbounded preceding) as count
from winsales
order by salesid;

salesid | qty | qty_shipped | count
---------+-----+-------------+-------
10001 |  10 |          10 |   1
10005 |  30 |             |   1
10006 |  10 |             |   1
20001 |  20 |          20 |   2
20002 |  20 |          20 |   3
30001 |  10 |          10 |   4
30003 |  15 |             |   4
30004 |  20 |             |   4
30007 |  30 |             |   4
40001 |  40 |             |   4
40005 |  10 |          10 |   5
(11 rows)
```

CUME_DIST window function

Calculates the cumulative distribution of a value within a window or partition. Assuming ascending ordering, the cumulative distribution is determined using this formula:

`count of rows with values <= x / count of rows in the window or partition` where *x* equals the value in the current row of the column specified in the ORDER BY clause. The following dataset illustrates use of this formula:

```
Row# Value   Calculation    CUME_DIST
1        2500    (1)/(5)    0.2
2        2600    (2)/(5)    0.4
3        2800    (3)/(5)    0.6
4        2900    (4)/(5)    0.8
5        3100    (5)/(5)    1.0
```

The return value range is >0 to 1, inclusive.

Syntax

```
CUME_DIST ()
OVER (
[ PARTITION BY partition_expression ]
[ ORDER BY order_list ]
)
```

Arguments

OVER

A clause that specifies the window partitioning. The OVER clause cannot contain a window frame specification.

PARTITION BY *partition_expression*

Optional. An expression that sets the range of records for each group in the OVER clause.

ORDER BY *order_list*

The expression on which to calculate cumulative distribution. The expression must have either a numeric data type or be implicitly convertible to one. If ORDER BY is omitted, the return value is 1 for all rows.

If ORDER BY doesn't produce a unique ordering, the order of the rows is nondeterministic. For more information, see Unique ordering of data for window functions.

Return type

FLOAT8

Examples

The following example calculates the cumulative distribution of the quantity for each seller:

```
select sellerid, qty, cume_dist()
over (partition by sellerid order by qty)
from winsales;

sellerid   qty    cume_dist
--------------------------------------------------
1          10.00    0.33
1          10.64    0.67
1          30.37    1
3          10.04    0.25
3          15.15    0.5
3          20.75    0.75
3          30.55    1
2          20.09    0.5
2          20.12    1
4          10.12    0.5
4          40.23    1
```

For a description of the WINSALES table, see Sample table for window function examples.

DENSE_RANK window function

The DENSE_RANK window function determines the rank of a value in a group of values, based on the ORDER BY expression in the OVER clause. If the optional PARTITION BY clause is present, the rankings are reset for each group of rows. Rows with equal values for the ranking criteria receive the same rank. The DENSE_RANK function differs from RANK in one respect: if two or more rows tie, there is no gap in the sequence of ranked values. For example, if two rows are ranked 1, the next rank is 2.

You can have ranking functions with different PARTITION BY and ORDER BY clauses in the same query.

Syntax

```
DENSE_RANK() OVER
(
[ PARTITION BY expr_list ]
```

```
[ ORDER BY order_list ]
)
```

Arguments

( )

The function takes no arguments, but the empty parentheses are required.

OVER

The window clauses for the DENSE_RANK function.

PARTITION BY *expr_list*

(Optional) One or more expressions that define the window.

ORDER BY *order_list*

(Optional) The expression on which the ranking values are based. If no PARTITION BY is specified, ORDER BY uses the entire table. If ORDER BY is omitted, the return value is 1 for all rows.

If ORDER BY doesn't produce a unique ordering, the order of the rows is nondeterministic. For more information, see Unique ordering of data for window functions.

Return type

BIGINT

Examples

The following examples use the sample table for window functions. For more information, see Sample table for window function examples.

The following example orders the table by the quantity sold and assigns both a dense rank and a regular rank to each row. The results are sorted after the window function results are applied.

```
SELECT salesid, qty,
DENSE_RANK() OVER(ORDER BY qty DESC) AS d_rnk,
RANK() OVER(ORDER BY qty DESC) AS rnk
FROM winsales
```

```
ORDER BY 2,1;

+---------+-----+-------+-----+
| salesid | qty | d_rnk | rnk |
+---------+-----+-------+-----+
|   10001 |  10 |     5 |   8 |
|   10006 |  10 |     5 |   8 |
|   30001 |  10 |     5 |   8 |
|   40005 |  10 |     5 |   8 |
|   30003 |  15 |     4 |   7 |
|   20001 |  20 |     3 |   4 |
|   20002 |  20 |     3 |   4 |
|   30004 |  20 |     3 |   4 |
|   10005 |  30 |     2 |   2 |
|   30007 |  30 |     2 |   2 |
|   40001 |  40 |     1 |   1 |
+---------+-----+-------+-----+
```

Note the difference in rankings assigned to the same set of rows when the DENSE_RANK and RANK functions are used side by side in the same query.

The following example partitions the table by sellerid, orders each partition by the quantity, and assigns a dense rank to each row. The results are sorted after the window function results are applied.

```
SELECT salesid, sellerid, qty,
DENSE_RANK() OVER(PARTITION BY sellerid ORDER BY qty DESC) AS d_rnk
FROM winsales
ORDER BY 2,3,1;

+---------+----------+-----+-------+
| salesid | sellerid | qty | d_rnk |
+---------+----------+-----+-------+
|   10001 |        1 |  10 |     2 |
|   10006 |        1 |  10 |     2 |
|   10005 |        1 |  30 |     1 |
|   20001 |        2 |  20 |     1 |
|   20002 |        2 |  20 |     1 |
|   30001 |        3 |  10 |     4 |
|   30003 |        3 |  15 |     3 |
|   30004 |        3 |  20 |     2 |
|   30007 |        3 |  30 |     1 |
|   40005 |        4 |  10 |     2 |
```

```
|   40001 |        4 |  40 |     1 |
+---------+----------+-----+-------+
```

To successfully use the last example, use the following command to insert a row into the WINSALES table. This row has the same buyerid, sellerid, and qtysold as another row. This will cause two rows to tie in the last example and thus will show the difference between the DENSE_RANK and RANK functions.

```
INSERT INTO winsales VALUES(30009, '2/2/2003', 3, 'b', 20, NULL);
```

The following example partitions the table by buyerid and sellerid, orders each partition by the quantity, and assigns both a dense rank and a regular rank to each row. The results are sorted after the window function is applied.

```
SELECT salesid, sellerid, qty, buyerid,
DENSE_RANK() OVER(PARTITION BY buyerid, sellerid ORDER BY qty DESC) AS d_rnk,
RANK() OVER (PARTITION BY buyerid, sellerid ORDER BY qty DESC) AS rnk
FROM winsales
ORDER BY rnk;

+---------+----------+-----+---------+-------+-----+
| salesid | sellerid | qty | buyerid | d_rnk | rnk |
+---------+----------+-----+---------+-------+-----+
|   20001 |        2 |  20 | b       |     1 |   1 |
|   30007 |        3 |  30 | c       |     1 |   1 |
|   10006 |        1 |  10 | c       |     1 |   1 |
|   10005 |        1 |  30 | a       |     1 |   1 |
|   20002 |        2 |  20 | c       |     1 |   1 |
|   30009 |        3 |  20 | b       |     1 |   1 |
|   40001 |        4 |  40 | a       |     1 |   1 |
|   30004 |        3 |  20 | b       |     1 |   1 |
|   10001 |        1 |  10 | c       |     1 |   1 |
|   40005 |        4 |  10 | a       |     2 |   2 |
|   30003 |        3 |  15 | b       |     2 |   3 |
|   30001 |        3 |  10 | b       |     3 |   4 |
+---------+----------+-----+---------+-------+-----+
```

FIRST_VALUE window function

Given an ordered set of rows, FIRST_VALUE returns the value of the specified expression with respect to the first row in the window frame.

For information about selecting the last row in the frame, see LAST_VALUE window function .

Syntax

```
FIRST_VALUE( expression )[ IGNORE NULLS | RESPECT NULLS ]
OVER (
[ PARTITION BY expr_list ]
[ ORDER BY order_list frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

IGNORE NULLS

When this option is used with FIRST_VALUE, the function returns the first value in the frame that is not NULL (or NULL if all values are NULL).

RESPECT NULLS

Indicates that Amazon Redshift should include null values in the determination of which row to use. RESPECT NULLS is supported by default if you do not specify IGNORE NULLS.

OVER

Introduces the window clauses for the function.

PARTITION BY *expr_list*

Defines the window for the function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY clause is specified, ORDER BY sorts the entire table. If you specify an ORDER BY clause, you must also specify a *frame_clause*.

The results of the FIRST_VALUE function depends on the ordering of the data. The results are nondeterministic in the following cases:

- When no ORDER BY clause is specified and a partition contains two different values for an expression

- When the expression evaluates to different values that correspond to the same value in the ORDER BY list.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows in the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Return type

These functions support expressions that use primitive Amazon Redshift data types. The return type is the same as the data type of the *expression*.

Examples

The following examples use the VENUE table from the sample TICKIT data. For more information, see Sample database.

The following example returns the seating capacity for each venue in the VENUE table, with the results ordered by capacity (high to low). The FIRST_VALUE function is used to select the name of the venue that corresponds to the first row in the frame: in this case, the row with the highest number of seats. The results are partitioned by state, so when the VENUESTATE value changes, a new first value is selected. The window frame is unbounded so the same first value is selected for each row in each partition.

For California, `Qualcomm Stadium` has the highest number of seats (`70561`), so this name is the first value for all of the rows in the `CA` partition.

```
select venuestate, venueseats, venuename,
first_value(venuename)
over(partition by venuestate
order by venueseats desc
rows between unbounded preceding and unbounded following)
from (select * from venue where venueseats >0)
order by venuestate;

venuestate | venueseats |           venuename            |         first_value
-----------+------------+--------------------------------
+------------------------------
CA         |      70561 | Qualcomm Stadium               | Qualcomm Stadium
```

```
CA         |      69843 | Monster Park                   | Qualcomm Stadium
CA         |      63026 | McAfee Coliseum                | Qualcomm Stadium
CA         |      56000 | Dodger Stadium                 | Qualcomm Stadium
CA         |      45050 | Angel Stadium of Anaheim       | Qualcomm Stadium
CA         |      42445 | PETCO Park                     | Qualcomm Stadium
CA         |      41503 | AT&T Park                      | Qualcomm Stadium
CA         |      22000 | Shoreline Amphitheatre         | Qualcomm Stadium
CO         |      76125 | INVESCO Field                  | INVESCO Field
CO         |      50445 | Coors Field                    | INVESCO Field
DC         |      41888 | Nationals Park                 | Nationals Park
FL         |      74916 | Dolphin Stadium                | Dolphin Stadium
FL         |      73800 | Jacksonville Municipal Stadium | Dolphin Stadium
FL         |      65647 | Raymond James Stadium          | Dolphin Stadium
FL         |      36048 | Tropicana Field                | Dolphin Stadium
...
```

The following example shows the use of the IGNORE NULLS option and relies on the addition of a new row to the VENUE table:

```
insert into venue values(2000,null,'Stanford','CA',90000);
```

This new row contains a NULL value for the VENUENAME column. Now repeat the FIRST_VALUE query that was shown earlier in this section:

```
select venuestate, venueseats, venuename,
first_value(venuename)
over(partition by venuestate
order by venueseats desc
rows between unbounded preceding and unbounded following)
from (select * from venue where venueseats >0)
order by venuestate;

venuestate | venueseats |         venuename           | first_value
-----------+------------+----------------------------+-------------
CA         |      90000 | NULL                       | NULL
CA         |      70561 | Qualcomm Stadium           | NULL
CA         |      69843 | Monster Park               | NULL
...
```

Because the new row contains the highest VENUESEATS value (`90000`) and its VENUENAME is NULL, the FIRST_VALUE function returns NULL for the CA partition. To ignore rows like this in the function evaluation, add the IGNORE NULLS option to the function argument:

```
select venuestate, venueseats, venuename,
first_value(venuename) ignore nulls
over(partition by venuestate
order by venueseats desc
rows between unbounded preceding and unbounded following)
from (select * from venue where venuestate='CA')
order by venuestate;

venuestate | venueseats |         venuename          |   first_value
------------+------------+----------------------------+------------------
CA         |      90000 | NULL                       | Qualcomm Stadium
CA         |      70561 | Qualcomm Stadium           | Qualcomm Stadium
CA         |      69843 | Monster Park               | Qualcomm Stadium
...
```

LAG window function

The LAG window function returns the values for a row at a given offset above (before) the current row in the partition.

Syntax

```
LAG (value_expr [, offset ])
[ IGNORE NULLS | RESPECT NULLS ]
OVER ( [ PARTITION BY window_partition ] ORDER BY window_ordering )
```

Arguments

value_expr

The target column or expression that the function operates on.

offset

An optional parameter that specifies the number of rows before the current row to return values for. The offset can be a constant integer or an expression that evaluates to an integer. If you do not specify an offset, Amazon Redshift uses 1 as the default value. An offset of `0` indicates the current row.

IGNORE NULLS

An optional specification that indicates that Amazon Redshift should skip null values in the determination of which row to use. Null values are included if IGNORE NULLS is not listed.

Note

You can use an NVL or COALESCE expression to replace the null values with another value. For more information, see NVL and COALESCE functions.

RESPECT NULLS

Indicates that Amazon Redshift should include null values in the determination of which row to use. RESPECT NULLS is supported by default if you do not specify IGNORE NULLS.

OVER

Specifies the window partitioning and ordering. The OVER clause cannot contain a window frame specification.

PARTITION BY *window_partition*

An optional argument that sets the range of records for each group in the OVER clause.

ORDER BY *window_ordering*

Sorts the rows within each partition.

The LAG window function supports expressions that use any of the Amazon Redshift data types. The return type is the same as the type of the *value_expr*.

Examples

The following example shows the quantity of tickets sold to the buyer with a buyer ID of 3 and the time that buyer 3 bought the tickets. To compare each sale with the previous sale for buyer 3, the query returns the previous quantity sold for each sale. Since there is no purchase before 1/16/2008, the first previous quantity sold value is null:

```
select buyerid, saletime, qtysold,
lag(qtysold,1) over (order by buyerid, saletime) as prev_qtysold
from sales where buyerid = 3 order by buyerid, saletime;

buyerid |      saletime       | qtysold | prev_qtysold
---------+---------------------+---------+--------------
3 | 2008-01-16 01:06:09 |       1 |
3 | 2008-01-28 02:10:01 |       1 |            1
```

```
3 | 2008-03-12 10:39:53 |       1 |            1
3 | 2008-03-13 02:56:07 |       1 |            1
3 | 2008-03-29 08:21:39 |       2 |            1
3 | 2008-04-27 02:39:01 |       1 |            2
3 | 2008-08-16 07:04:37 |       2 |            1
3 | 2008-08-22 11:45:26 |       2 |            2
3 | 2008-09-12 09:11:25 |       1 |            2
3 | 2008-10-01 06:22:37 |       1 |            1
3 | 2008-10-20 01:55:51 |       2 |            1
3 | 2008-10-28 01:30:40 |       1 |            2
(12 rows)
```

LAST_VALUE window function

Given an ordered set of rows, The LAST_VALUE function returns the value of the expression with respect to the last row in the frame.

For information about selecting the first row in the frame, see FIRST_VALUE window function .

Syntax

```
LAST_VALUE( expression )[ IGNORE NULLS | RESPECT NULLS ]
OVER (
[ PARTITION BY expr_list ]
[ ORDER BY order_list frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

IGNORE NULLS

The function returns the last value in the frame that is not NULL (or NULL if all values are NULL).

RESPECT NULLS

Indicates that Amazon Redshift should include null values in the determination of which row to use. RESPECT NULLS is supported by default if you do not specify IGNORE NULLS.

OVER

Introduces the window clauses for the function.

PARTITION BY *expr_list*

Defines the window for the function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY clause is specified, ORDER BY sorts the entire table. If you specify an ORDER BY clause, you must also specify a *frame_clause*.

The results depend on the ordering of the data. The results are nondeterministic in the following cases:

- When no ORDER BY clause is specified and a partition contains two different values for an expression
- When the expression evaluates to different values that correspond to the same value in the ORDER BY list.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows in the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Return type

These functions support expressions that use primitive Amazon Redshift data types. The return type is the same as the data type of the *expression*.

Examples

The following examples use the VENUE table from the sample TICKIT data. For more information, see Sample database.

The following example returns the seating capacity for each venue in the VENUE table, with the results ordered by capacity (high to low). The LAST_VALUE function is used to select the name of the venue that corresponds to the last row in the frame: in this case, the row with the least number of seats. The results are partitioned by state, so when the VENUESTATE value changes, a new last value is selected. The window frame is unbounded so the same last value is selected for each row in each partition.

For California, `Shoreline Amphitheatre` is returned for every row in the partition because it has the lowest number of seats (`22000`).

```
select venuestate, venueseats, venuename,
last_value(venuename)
over(partition by venuestate
order by venueseats desc
rows between unbounded preceding and unbounded following)
from (select * from venue where venueseats >0)
order by venuestate;

venuestate | venueseats |           venuename              |          last_value
-----------+------------+--------------------------------
+------------------------------
CA         |      70561 | Qualcomm Stadium                 | Shoreline Amphitheatre
CA         |      69843 | Monster Park                     | Shoreline Amphitheatre
CA         |      63026 | McAfee Coliseum                  | Shoreline Amphitheatre
CA         |      56000 | Dodger Stadium                   | Shoreline Amphitheatre
CA         |      45050 | Angel Stadium of Anaheim         | Shoreline Amphitheatre
CA         |      42445 | PETCO Park                       | Shoreline Amphitheatre
CA         |      41503 | AT&T Park                        | Shoreline Amphitheatre
CA         |      22000 | Shoreline Amphitheatre           | Shoreline Amphitheatre
CO         |      76125 | INVESCO Field                    | Coors Field
CO         |      50445 | Coors Field                      | Coors Field
DC         |      41888 | Nationals Park                   | Nationals Park
FL         |      74916 | Dolphin Stadium                  | Tropicana Field
FL         |      73800 | Jacksonville Municipal Stadium | Tropicana Field
FL         |      65647 | Raymond James Stadium            | Tropicana Field
FL         |      36048 | Tropicana Field                  | Tropicana Field
...
```

LEAD window function

The LEAD window function returns the values for a row at a given offset below (after) the current row in the partition.

Syntax

```
LEAD (value_expr [, offset ])
```

```
[ IGNORE NULLS | RESPECT NULLS ]
OVER ( [ PARTITION BY window_partition ] ORDER BY window_ordering )
```

Arguments

value_expr

The target column or expression that the function operates on.

offset

An optional parameter that specifies the number of rows below the current row to return values for. The offset can be a constant integer or an expression that evaluates to an integer. If you do not specify an offset, Amazon Redshift uses 1 as the default value. An offset of `0` indicates the current row.

IGNORE NULLS

An optional specification that indicates that Amazon Redshift should skip null values in the determination of which row to use. Null values are included if IGNORE NULLS is not listed.

> **Note**
>
> You can use an NVL or COALESCE expression to replace the null values with another value. For more information, see NVL and COALESCE functions.

RESPECT NULLS

Indicates that Amazon Redshift should include null values in the determination of which row to use. RESPECT NULLS is supported by default if you do not specify IGNORE NULLS.

OVER

Specifies the window partitioning and ordering. The OVER clause cannot contain a window frame specification.

PARTITION BY *window_partition*

An optional argument that sets the range of records for each group in the OVER clause.

ORDER BY *window_ordering*

Sorts the rows within each partition.

The LEAD window function supports expressions that use any of the Amazon Redshift data types. The return type is the same as the type of the *value_expr*.

Examples

The following example provides the commission for events in the SALES table for which tickets were sold on January 1, 2008 and January 2, 2008 and the commission paid for ticket sales for the subsequent sale. The following example uses the TICKIT sample database. For more information, see Sample database.

```
SELECT eventid, commission, saletime, LEAD(commission, 1) over ( ORDER BY saletime ) AS
 next_comm
FROM sales
WHERE saletime BETWEEN '2008-01-09 00:00:00' AND '2008-01-10 12:59:59'
LIMIT 10;

+---------+------------+---------------------+-----------+
| eventid | commission |      saletime       | next_comm |
+---------+------------+---------------------+-----------+
|    1664 |       13.2 | 2008-01-09 01:00:21 |      69.6 |
|     184 |       69.6 | 2008-01-09 01:00:36 |     116.1 |
|    6870 |      116.1 | 2008-01-09 01:02:37 |      11.1 |
|    3718 |       11.1 | 2008-01-09 01:05:19 |     205.5 |
|    6772 |      205.5 | 2008-01-09 01:14:04 |      38.4 |
|    3074 |       38.4 | 2008-01-09 01:26:50 |     209.4 |
|    5254 |      209.4 | 2008-01-09 01:29:16 |      26.4 |
|    3724 |       26.4 | 2008-01-09 01:40:09 |      57.6 |
|    5303 |       57.6 | 2008-01-09 01:40:21 |      51.6 |
|    3678 |       51.6 | 2008-01-09 01:42:54 |      43.8 |
+---------+------------+---------------------+-----------+
```

The following example provides the maximum difference for the commision for events in the SALES table for and the commission paid for ticket sales for the subsequent sale for the same event. This example shows how to use LEAD with a GROUP BY clause. Since window functions aren't allowed in aggregate clauses, this example uses a subquery. The following example uses the TICKIT sample database. For more information, see Sample database.

```
SELECT eventid, eventname, max(next_comm_diff) as max_commission_difference
FROM
(
    SELECT sales.eventid, eventname, commission - LEAD(commission, 1) over (ORDER BY
 sales.eventid, saletime) AS next_comm_diff
```

```
    FROM sales JOIN event ON sales.eventid = event.eventid
)
GROUP BY eventid, eventname
ORDER BY eventid

LIMIT 10

| eventid | eventname                    | max_commission_difference |
+---------+------------------------------+---------------------------+
| 1       | Gotterdammerung              | 7.95                      |
| 2       | Boris Godunov                | 227.85                    |
| 3       | Salome                       | 1350.9                    |
| 4       | La Cenerentola (Cinderella)  | 790.05                    |
| 5       | Il Trovatore                 | 214.05                    |
| 6       | L Elisir d Amore             | 510.9                     |
| 7       | Doctor Atomic                | 180.6                     |
| 9       | The Fly                      | 147                       |
| 10      | Rigoletto                    | 186.6                     |
+---------+------------------------------+---------------------------+
```

LISTAGG window function

For each group in a query, the LISTAGG window function orders the rows for that group according to the ORDER BY expression, then concatenates the values into a single string.

Syntax

```
LISTAGG( [DISTINCT] expression [, 'delimiter' ] )
[ WITHIN GROUP (ORDER BY order_list) ]
OVER ( [PARTITION BY partition_expression] )
```

Arguments

DISTINCT

(Optional) A clause that eliminates duplicate values from the specified expression before concatenating. Trailing spaces are ignored, so the strings `'a'` and `'a  '` are treated as duplicates. LISTAGG uses the first value encountered. For more information, see Significance of trailing blanks.

aggregate_expression

Any valid expression (such as a column name) that provides the values to aggregate. NULL values and empty strings are ignored.

delimiter

(Optional) The string constant to will separate the concatenated values. The default is NULL.

WITHIN GROUP (ORDER BY *order_list*)

(Optional) A clause that specifies the sort order of the aggregated values. Deterministic only if ORDER BY provides unique ordering. The default is to aggregate all rows and return a single value.

OVER

A clause that specifies the window partitioning. The OVER clause cannot contain a window ordering or window frame specification.

PARTITION BY *partition_expression*

(Optional) Sets the range of records for each group in the OVER clause.

Returns

VARCHAR(MAX). If the result set is larger than the maximum VARCHAR size (64K – 1, or 65535), then LISTAGG returns the following error:

```
Invalid operation: Result size exceeds LISTAGG limit
```

Examples

The following examples uses the WINSALES table. For a description of the WINSALES table, see Sample table for window function examples.

The following example returns a list of seller IDs, ordered by seller ID.

```
select listagg(sellerid)
within group (order by sellerid)
over() from winsales;

  listagg
------------
```

```
 11122333344
...
...
 11122333344
 11122333344
   (11 rows)
```

The following example returns a list of seller IDs for buyer B, ordered by date.

```
select listagg(sellerid)
within group (order by dateid)
over () as seller
from winsales
where buyerid = 'b' ;

  seller
---------
    3233
    3233
    3233
    3233
```

The following example returns a comma-separated list of sales dates for buyer B.

```
select listagg(dateid,',')
within group (order by sellerid desc,salesid asc)
over () as dates
from winsales
where buyerid  = 'b';

             dates
-------------------------------------------
2003-08-02,2004-04-18,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-04-18,2004-02-12
```

The following example uses DISTINCT to return a list of unique sales dates for buyer B.

```
select listagg(distinct dateid,',')
within group (order by sellerid desc,salesid asc)
over () as dates
```

```
from winsales
where buyerid  = 'b';

           dates
--------------------------------
2003-08-02,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-02-12
2003-08-02,2004-04-18,2004-02-12
```

The following example returns a comma-separated list of sales IDs for each buyer ID.

```
select buyerid,
listagg(salesid,',')
within group (order by salesid)
over (partition by buyerid) as sales_id
from winsales
order by buyerid;

+---------+-------------------------+
| buyerid |        sales_id         |
+---------+-------------------------+
| a       | 10005,40001,40005       |
| a       | 10005,40001,40005       |
| a       | 10005,40001,40005       |
| b       | 20001,30001,30003,30004 |
| b       | 20001,30001,30003,30004 |
| b       | 20001,30001,30003,30004 |
| b       | 20001,30001,30003,30004 |
| c       | 10001,10006,20002,30007 |
| c       | 10001,10006,20002,30007 |
| c       | 10001,10006,20002,30007 |
| c       | 10001,10006,20002,30007 |
+---------+-------------------------+
```

MAX window function

The MAX window function returns the maximum of the input expression values. The MAX function works with numeric values and ignores NULL values.

Syntax

```
MAX ( [ ALL ] expression ) OVER
```

```
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression. ALL is the default. DISTINCT is not supported.

OVER

A clause that specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the MAX function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

Accepts any data type as input. Returns the same data type as *expression*.

Examples

The following example shows the sales ID, quantity, and maximum quantity from the beginning of the data window:

```
select salesid, qty,
max(qty) over (order by salesid rows unbounded preceding) as max
from winsales
order by salesid;

salesid | qty | max
---------+-----+-----
10001 |  10 |  10
10005 |  30 |  30
10006 |  10 |  30
20001 |  20 |  30
20002 |  20 |  30
30001 |  10 |  30
30003 |  15 |  30
30004 |  20 |  30
30007 |  30 |  30
40001 |  40 |  40
40005 |  10 |  40
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example shows the salesid, quantity, and maximum quantity in a restricted frame:

```
select salesid, qty,
max(qty) over (order by salesid rows between 2 preceding and 1 preceding) as max
from winsales
order by salesid;

salesid | qty | max
---------+-----+-----
10001 |  10 |
10005 |  30 |  10
10006 |  10 |  30
20001 |  20 |  30
20002 |  20 |  20
30001 |  10 |  20
30003 |  15 |  20
30004 |  20 |  15
30007 |  30 |  20
40001 |  40 |  30
40005 |  10 |  40
```

```
(11 rows)
```

MEDIAN window function

Calculates the median value for the range of values in a window or partition. NULL values in the range are ignored.

MEDIAN is an inverse distribution function that assumes a continuous distribution model.

Syntax

```
MEDIAN ( median_expression )
OVER ( [ PARTITION BY partition_expression ] )
```

Arguments

median_expression

An expression, such as a column name, that provides the values for which to determine the median. The expression must have either a numeric or datetime data type or be implicitly convertible to one.

OVER

A clause that specifies the window partitioning. The OVER clause cannot contain a window ordering or window frame specification.

PARTITION BY *partition_expression*

Optional. An expression that sets the range of records for each group in the OVER clause.

Data types

The return type is determined by the data type of *median_expression*. The following table shows the return type for each *median_expression* data type.

Input Type	Return Type
INT2, INT4, INT8, NUMERIC, DECIMAL	DECIMAL
FLOAT, DOUBLE	DOUBLE

Input Type	Return Type
DATE	DATE

Usage notes

If the *median_expression* argument is a DECIMAL data type defined with the maximum precision of 38 digits, it is possible that MEDIAN will return either an inaccurate result or an error. If the return value of the MEDIAN function exceeds 38 digits, the result is truncated to fit, which causes a loss of precision. If, during interpolation, an intermediate result exceeds the maximum precision, a numeric overflow occurs and the function returns an error. To avoid these conditions, we recommend either using a data type with lower precision or casting the *median_expression* argument to a lower precision.

For example, a SUM function with a DECIMAL argument returns a default precision of 38 digits. The scale of the result is the same as the scale of the argument. So, for example, a SUM of a DECIMAL(5,2) column returns a DECIMAL(38,2) data type.

The following example uses a SUM function in the *median_expression* argument of a MEDIAN function. The data type of the PRICEPAID column is DECIMAL (8,2), so the SUM function returns DECIMAL(38,2).

```
select salesid, sum(pricepaid), median(sum(pricepaid))
over() from sales where salesid < 10 group by salesid;
```

To avoid a potential loss of precision or an overflow error, cast the result to a DECIMAL data type with lower precision, as the following example shows.

```
select salesid, sum(pricepaid), median(sum(pricepaid)::decimal(30,2))
over() from sales where salesid < 10 group by salesid;
```

Examples

The following example calculates the median sales quantity for each seller:

```
select sellerid, qty, median(qty)
over (partition by sellerid)
from winsales
```

```
order by sellerid;


sellerid qty median
---------------------------
1  10 10.0
1  10 10.0
1  30 10.0
2  20 20.0
2  20 20.0
3  10 17.5
3  15 17.5
3  20 17.5
3  30 17.5
4  10 25.0
4  40 25.0
```

For a description of the WINSALES table, see [Sample table for window function examples](#).

MIN window function

The MIN window function returns the minimum of the input expression values. The MIN function works with numeric values and ignores NULL values.

Syntax

```
MIN ( [ ALL ] expression ) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the MIN function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

Accepts any data type as input. Returns the same data type as *expression*.

Examples

The following example shows the sales ID, quantity, and minimum quantity from the beginning of the data window:

```
select salesid, qty,
min(qty) over
(order by salesid rows unbounded preceding)
from winsales
order by salesid;

salesid | qty | min
---------+-----+-----
10001 |  10 |  10
10005 |  30 |  10
10006 |  10 |  10
20001 |  20 |  10
20002 |  20 |  10
```

```
30001 |  10 |  10
30003 |  15 |  10
30004 |  20 |  10
30007 |  30 |  10
40001 |  40 |  10
40005 |  10 |  10
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example shows the sales ID, quantity, and minimum quantity in a restricted frame:

```
select salesid, qty,
min(qty) over
(order by salesid rows between 2 preceding and 1 preceding) as min
from winsales
order by salesid;

salesid | qty | min
---------+-----+-----
10001 |  10 |
10005 |  30 |  10
10006 |  10 |  10
20001 |  20 |  10
20002 |  20 |  10
30001 |  10 |  20
30003 |  15 |  10
30004 |  20 |  10
30007 |  30 |  15
40001 |  40 |  20
40005 |  10 |  30
(11 rows)
```

NTH_VALUE window function

The NTH_VALUE window function returns the expression value of the specified row of the window frame relative to the first row of the window.

Syntax

```
NTH_VALUE (expr, offset)
[ IGNORE NULLS | RESPECT NULLS ]
```

```
OVER
( [ PARTITION BY window_partition ]
[ ORDER BY window_ordering
                        frame_clause ] )
```

Arguments

expr

The target column or expression that the function operates on.

offset

Determines the row number relative to the first row in the window for which to return the expression. The *offset* can be a constant or an expression and must be a positive integer that is greater than 0.

IGNORE NULLS

An optional specification that indicates that Amazon Redshift should skip null values in the determination of which row to use. Null values are included if IGNORE NULLS is not listed.

RESPECT NULLS

Indicates that Amazon Redshift should include null values in the determination of which row to use. RESPECT NULLS is supported by default if you do not specify IGNORE NULLS.

OVER

Specifies the window partitioning, ordering, and window frame.

PARTITION BY *window_partition*

Sets the range of records for each group in the OVER clause.

ORDER BY *window_ordering*

Sorts the rows within each partition. If ORDER BY is omitted, the default frame consists of all rows in the partition.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows in the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

The NTH_VALUE window function supports expressions that use any of the Amazon Redshift data types. The return type is the same as the type of the *expr*.

Examples

The following example shows the number of seats in the third largest venue in California, Florida, and New York compared to the number of seats in the other venues in those states:

```
select venuestate, venuename, venueseats,
nth_value(venueseats, 3)
ignore nulls
over(partition by venuestate order by venueseats desc
rows between unbounded preceding and unbounded following)
as third_most_seats
from (select * from venue where venueseats > 0 and
venuestate in('CA', 'FL', 'NY'))
order by venuestate;

venuestate |           venuename            | venueseats | third_most_seats
------------+--------------------------------+------------+------------------
CA         | Qualcomm Stadium               |      70561 |            63026
CA         | Monster Park                   |      69843 |            63026
CA         | McAfee Coliseum                |      63026 |            63026
CA         | Dodger Stadium                 |      56000 |            63026
CA         | Angel Stadium of Anaheim       |      45050 |            63026
CA         | PETCO Park                     |      42445 |            63026
CA         | AT&T Park                      |      41503 |            63026
CA         | Shoreline Amphitheatre         |      22000 |            63026
FL         | Dolphin Stadium                |      74916 |            65647
FL         | Jacksonville Municipal Stadium |      73800 |            65647
FL         | Raymond James Stadium          |      65647 |            65647
FL         | Tropicana Field                |      36048 |            65647
NY         | Ralph Wilson Stadium           |      73967 |            20000
NY         | Yankee Stadium                 |      52325 |            20000
NY         | Madison Square Garden          |      20000 |            20000
(15 rows)
```

NTILE window function

The NTILE window function divides ordered rows in the partition into the specified number of ranked groups of as equal size as possible and returns the group that a given row falls into.

Syntax

```
NTILE (expr)
OVER (
[ PARTITION BY expression_list ]
[ ORDER BY order_list ]
)
```

Arguments

expr

The number of ranking groups and must result in a positive integer value (greater than 0) for each partition. The *expr* argument must not be nullable.

OVER

A clause that specifies the window partitioning and ordering. The OVER clause cannot contain a window frame specification.

PARTITION BY *window_partition*

Optional. The range of records for each group in the OVER clause.

ORDER BY *window_ordering*

Optional. An expression that sorts the rows within each partition. If the ORDER BY clause is omitted, the ranking behavior is the same.

If ORDER BY does not produce a unique ordering, the order of the rows is nondeterministic. For more information, see Unique ordering of data for window functions.

Return type

BIGINT

Examples

The following example ranks into four ranking groups the price paid for Hamlet tickets on August 26, 2008. The result set is 17 rows, divided almost evenly among the rankings 1 through 4:

```
select eventname, caldate, pricepaid, ntile(4)
over(order by pricepaid desc) from sales, event, date
```

```
where sales.eventid=event.eventid and event.dateid=date.dateid and eventname='Hamlet'
and caldate='2008-08-26'
order by 4;

eventname |  caldate   | pricepaid | ntile
-----------+------------+-----------+-------
Hamlet    | 2008-08-26 |   1883.00 |     1
Hamlet    | 2008-08-26 |   1065.00 |     1
Hamlet    | 2008-08-26 |    589.00 |     1
Hamlet    | 2008-08-26 |    530.00 |     1
Hamlet    | 2008-08-26 |    472.00 |     1
Hamlet    | 2008-08-26 |    460.00 |     2
Hamlet    | 2008-08-26 |    355.00 |     2
Hamlet    | 2008-08-26 |    334.00 |     2
Hamlet    | 2008-08-26 |    296.00 |     2
Hamlet    | 2008-08-26 |    230.00 |     3
Hamlet    | 2008-08-26 |    216.00 |     3
Hamlet    | 2008-08-26 |    212.00 |     3
Hamlet    | 2008-08-26 |    106.00 |     3
Hamlet    | 2008-08-26 |    100.00 |     4
Hamlet    | 2008-08-26 |     94.00 |     4
Hamlet    | 2008-08-26 |     53.00 |     4
Hamlet    | 2008-08-26 |     25.00 |     4
(17 rows)
```

PERCENT_RANK window function

Calculates the percent rank of a given row. The percent rank is determined using this formula:

`(x - 1) / (the number of rows in the window or partition - 1)`

where *x* is the rank of the current row. The following dataset illustrates use of this formula:

```
Row# Value Rank Calculation PERCENT_RANK
1 15 1 (1-1)/(7-1) 0.0000
2 20 2 (2-1)/(7-1) 0.1666
3 20 2 (2-1)/(7-1) 0.1666
4 20 2 (2-1)/(7-1) 0.1666
5 30 5 (5-1)/(7-1) 0.6666
6 30 5 (5-1)/(7-1) 0.6666
7 40 7 (7-1)/(7-1) 1.0000
```

The return value range is 0 to 1, inclusive. The first row in any set has a PERCENT_RANK of 0.

Syntax

```
PERCENT_RANK ()
OVER (
[ PARTITION BY partition_expression ]
[ ORDER BY order_list ]
)
```

Arguments

( )

The function takes no arguments, but the empty parentheses are required.

OVER

A clause that specifies the window partitioning. The OVER clause cannot contain a window frame specification.

PARTITION BY *partition_expression*

Optional. An expression that sets the range of records for each group in the OVER clause.

ORDER BY *order_list*

Optional. The expression on which to calculate percent rank. The expression must have either a numeric data type or be implicitly convertible to one. If ORDER BY is omitted, the return value is 0 for all rows.

If ORDER BY does not produce a unique ordering, the order of the rows is nondeterministic. For more information, see [Unique ordering of data for window functions](#).

Return type

FLOAT8

Examples

The following example calculates the percent rank of the sales quantities for each seller:

```
select sellerid, qty, percent_rank()
over (partition by sellerid order by qty)
from winsales;
```

```
sellerid qty  percent_rank
----------------------------------------
1  10.00  0.0
1  10.64  0.5
1  30.37  1.0
3  10.04  0.0
3  15.15  0.33
3  20.75  0.67
3  30.55  1.0
2  20.09  0.0
2  20.12  1.0
4  10.12  0.0
4  40.23  1.0
```

For a description of the WINSALES table, see Sample table for window function examples.

PERCENTILE_CONT window function

PERCENTILE_CONT is an inverse distribution function that assumes a continuous distribution model. It takes a percentile value and a sort specification, and returns an interpolated value that would fall into the given percentile value with respect to the sort specification.

PERCENTILE_CONT computes a linear interpolation between values after ordering them. Using the percentile value `(P)` and the number of not null rows `(N)` in the aggregation group, the function computes the row number after ordering the rows according to the sort specification. This row number `(RN)` is computed according to the formula `RN = (1+ (P*(N-1))`. The final result of the aggregate function is computed by linear interpolation between the values from rows at row numbers `CRN = CEILING(RN)` and `FRN = FLOOR(RN)`.

The final result will be as follows.

If `(CRN = FRN = RN)` then the result is `(value of expression from row at RN)`

Otherwise the result is as follows:

`(CRN - RN) * (value of expression for row at FRN) + (RN - FRN) * (value of expression for row at CRN)`.

You can specify only the PARTITION clause in the OVER clause. If PARTITION is specified, for each row, PERCENTILE_CONT returns the value that would fall into the specified percentile among a set of values within a given partition.

Syntax

```
PERCENTILE_CONT ( percentile )
WITHIN GROUP (ORDER BY expr)
OVER (  [ PARTITION BY expr_list ]  )
```

Arguments

percentile

Numeric constant between 0 and 1. Nulls are ignored in the calculation.

WITHIN GROUP (ORDER BY *expr*)

Specifies numeric or date/time values to sort and compute the percentile over.

OVER

Specifies the window partitioning. The OVER clause cannot contain a window ordering or window frame specification.

PARTITION BY *expr*

Optional argument that sets the range of records for each group in the OVER clause.

Returns

The return type is determined by the data type of the ORDER BY expression in the WITHIN GROUP clause. The following table shows the return type for each ORDER BY expression data type.

Input Type	Return Type
INT2, INT4, INT8, NUMERIC, DECIMAL	DECIMAL
FLOAT, DOUBLE	DOUBLE
DATE	DATE
TIMESTAMP	TIMESTAMP

Usage notes

If the ORDER BY expression is a DECIMAL data type defined with the maximum precision of 38 digits, it is possible that PERCENTILE_CONT will return either an inaccurate result or an error. If the return value of the PERCENTILE_CONT function exceeds 38 digits, the result is truncated to fit, which causes a loss of precision. If, during interpolation, an intermediate result exceeds the maximum precision, a numeric overflow occurs and the function returns an error. To avoid these conditions, we recommend either using a data type with lower precision or casting the ORDER BY expression to a lower precision.

For example, a SUM function with a DECIMAL argument returns a default precision of 38 digits. The scale of the result is the same as the scale of the argument. So, for example, a SUM of a DECIMAL(5,2) column returns a DECIMAL(38,2) data type.

The following example uses a SUM function in the ORDER BY clause of a PERCENTILE_CONT function. The data type of the PRICEPAID column is DECIMAL (8,2), so the SUM function returns DECIMAL(38,2).

```
select salesid, sum(pricepaid), percentile_cont(0.6)
within group (order by sum(pricepaid) desc) over()
from sales where salesid < 10 group by salesid;
```

To avoid a potential loss of precision or an overflow error, cast the result to a DECIMAL data type with lower precision, as the following example shows.

```
select salesid, sum(pricepaid), percentile_cont(0.6)
within group (order by sum(pricepaid)::decimal(30,2) desc) over()
from sales where salesid < 10 group by salesid;
```

Examples

The following examples uses the WINSALES table. For a description of the WINSALES table, see Sample table for window function examples.

```
select sellerid, qty, percentile_cont(0.5)
within group (order by qty)
over() as median from winsales;

 sellerid | qty | median
----------+-----+--------
```

```
        1 |  10 |   20.0
        1 |  10 |   20.0
        3 |  10 |   20.0
        4 |  10 |   20.0
        3 |  15 |   20.0
        2 |  20 |   20.0
        3 |  20 |   20.0
        2 |  20 |   20.0
        3 |  30 |   20.0
        1 |  30 |   20.0
        4 |  40 |   20.0
(11 rows)
```

```
select sellerid, qty, percentile_cont(0.5)
within group (order by qty)
over(partition by sellerid) as median from winsales;

 sellerid | qty | median
----------+-----+--------
        2 |  20 |   20.0
        2 |  20 |   20.0
        4 |  10 |   25.0
        4 |  40 |   25.0
        1 |  10 |   10.0
        1 |  10 |   10.0
        1 |  30 |   10.0
        3 |  10 |   17.5
        3 |  15 |   17.5
        3 |  20 |   17.5
        3 |  30 |   17.5
(11 rows)
```

The following example calculates the PERCENTILE_CONT and PERCENTILE_DISC of the ticket sales for sellers in Washington state.

```
SELECT sellerid, state, sum(qtysold*pricepaid) sales,
percentile_cont(0.6) within group (order by sum(qtysold*pricepaid::decimal(14,2) )
 desc) over(),
percentile_disc(0.6) within group (order by sum(qtysold*pricepaid::decimal(14,2) )
 desc) over()
from sales s, users u
where s.sellerid = u.userid and state = 'WA' and sellerid < 1000
group by sellerid, state;
```

```
 sellerid | state |  sales  | percentile_cont | percentile_disc
----------+-------+---------+-----------------+-----------------
      127 | WA    | 6076.00 |         2044.20 |         1531.00
      787 | WA    | 6035.00 |         2044.20 |         1531.00
      381 | WA    | 5881.00 |         2044.20 |         1531.00
      777 | WA    | 2814.00 |         2044.20 |         1531.00
       33 | WA    | 1531.00 |         2044.20 |         1531.00
      800 | WA    | 1476.00 |         2044.20 |         1531.00
        1 | WA    | 1177.00 |         2044.20 |         1531.00
(7 rows)
```

PERCENTILE_DISC window function

PERCENTILE_DISC is an inverse distribution function that assumes a discrete distribution model. It takes a percentile value and a sort specification and returns an element from the given set.

For a given percentile value P, PERCENTILE_DISC sorts the values of the expression in the ORDER BY clause and returns the value with the smallest cumulative distribution value (with respect to the same sort specification) that is greater than or equal to P.

You can specify only the PARTITION clause in the OVER clause.

Syntax

```
PERCENTILE_DISC ( percentile )
WITHIN GROUP (ORDER BY expr)
OVER (  [ PARTITION BY expr_list ]  )
```

Arguments

percentile

Numeric constant between 0 and 1. Nulls are ignored in the calculation.

WITHIN GROUP (ORDER BY *expr*)

Specifies numeric or date/time values to sort and compute the percentile over.

OVER

Specifies the window partitioning. The OVER clause cannot contain a window ordering or window frame specification.

PARTITION BY *expr*

Optional argument that sets the range of records for each group in the OVER clause.

Returns

The same data type as the ORDER BY expression in the WITHIN GROUP clause.

Examples

The following examples use the WINSALES table. For a description of the WINSALES table, see [Sample table for window function examples](#).

```
SELECT sellerid, qty, PERCENTILE_DISC(0.5)
WITHIN GROUP (ORDER BY qty)
OVER() AS MEDIAN FROM winsales;

+----------+-----+--------+
| sellerid | qty | median |
+----------+-----+--------+
| 3        | 10  | 20     |
| 1        | 10  | 20     |
| 1        | 10  | 20     |
| 4        | 10  | 20     |
| 3        | 15  | 20     |
| 2        | 20  | 20     |
| 2        | 20  | 20     |
| 3        | 20  | 20     |
| 1        | 30  | 20     |
| 3        | 30  | 20     |
| 4        | 40  | 20     |
+----------+-----+--------+

SELECT sellerid, qty, PERCENTILE_DISC(0.5)
WITHIN GROUP (ORDER BY qty)
OVER(PARTITION BY sellerid) AS MEDIAN FROM winsales;

+----------+-----+--------+
| sellerid | qty | median |
+----------+-----+--------+
| 4        | 10  | 10     |
| 4        | 40  | 10     |
| 3        | 10  | 15     |
```

```
| 3        | 15  | 15     |
| 3        | 20  | 15     |
| 3        | 30  | 15     |
| 2        | 20  | 20     |
| 2        | 20  | 20     |
| 1        | 10  | 10     |
| 1        | 10  | 10     |
| 1        | 30  | 10     |
+----------+-----+--------+
```

To find PERCENTILE_DISC(0.25) and PERCENTILE_DISC(0.75) for the quantity when partitioned by the seller ID, use the following examples.

```
SELECT sellerid, qty, PERCENTILE_DISC(0.25)
WITHIN GROUP (ORDER BY qty)
OVER(PARTITION BY sellerid) AS quartile1 FROM winsales;

+----------+-----+-----------+
| sellerid | qty | quartile1 |
+----------+-----+-----------+
| 4        | 10  | 10        |
| 4        | 40  | 10        |
| 2        | 20  | 20        |
| 2        | 20  | 20        |
| 3        | 10  | 10        |
| 3        | 15  | 10        |
| 3        | 20  | 10        |
| 3        | 30  | 10        |
| 1        | 10  | 10        |
| 1        | 10  | 10        |
| 1        | 30  | 10        |
+----------+-----+-----------+

SELECT sellerid, qty, PERCENTILE_DISC(0.75)
WITHIN GROUP (ORDER BY qty)
OVER(PARTITION BY sellerid) AS quartile3 FROM winsales;

+----------+-----+-----------+
| sellerid | qty | quartile3 |
+----------+-----+-----------+
| 3        | 10  | 20        |
| 3        | 15  | 20        |
| 3        | 20  | 20        |
```

```
| 3        | 30  | 20         |
| 4        | 10  | 40         |
| 4        | 40  | 40         |
| 2        | 20  | 20         |
| 2        | 20  | 20         |
| 1        | 10  | 30         |
| 1        | 10  | 30         |
| 1        | 30  | 30         |
+----------+-----+-----------+
```

RANK window function

The RANK window function determines the rank of a value in a group of values, based on the ORDER BY expression in the OVER clause. If the optional PARTITION BY clause is present, the rankings are reset for each group of rows. Rows with equal values for the ranking criteria receive the same rank. Amazon Redshift adds the number of tied rows to the tied rank to calculate the next rank and thus the ranks might not be consecutive numbers. For example, if two rows are ranked 1, the next rank is 3.

RANK differs from the DENSE_RANK window function in one respect: For DENSE_RANK, if two or more rows tie, there is no gap in the sequence of ranked values. For example, if two rows are ranked 1, the next rank is 2.

You can have ranking functions with different PARTITION BY and ORDER BY clauses in the same query.

Syntax

```
RANK () OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list ]
)
```

Arguments

( )

The function takes no arguments, but the empty parentheses are required.

OVER

The window clauses for the RANK function.

PARTITION BY *expr_list*

Optional. One or more expressions that define the window.

ORDER BY *order_list*

Optional. Defines the columns on which the ranking values are based. If no PARTITION BY is specified, ORDER BY uses the entire table. If ORDER BY is omitted, the return value is 1 for all rows.

If ORDER BY does not produce a unique ordering, the order of the rows is nondeterministic. For more information, see Unique ordering of data for window functions.

Return type

INTEGER

Examples

The following example orders the table by the quantity sold (default ascending), and assign a rank to each row. A rank value of 1 is the highest ranked value. The results are sorted after the window function results are applied:

```
select salesid, qty,
rank() over (order by qty) as rnk
from winsales
order by 2,1;

salesid | qty | rnk
--------+-----+-----
10001 |  10 |  1
10006 |  10 |  1
30001 |  10 |  1
40005 |  10 |  1
30003 |  15 |  5
20001 |  20 |  6
20002 |  20 |  6
30004 |  20 |  6
10005 |  30 |  9
30007 |  30 |  9
40001 |  40 |  11
(11 rows)
```

Note that the outer ORDER BY clause in this example includes columns 2 and 1 to make sure that Amazon Redshift returns consistently sorted results each time this query is run. For example, rows with sales IDs 10001 and 10006 have identical QTY and RNK values. Ordering the final result set by column 1 ensures that row 10001 always falls before 10006. For a description of the WINSALES table, see Sample table for window function examples.

In the following example, the ordering is reversed for the window function (`order by qty desc`). Now the highest rank value applies to the largest QTY value.

```
select salesid, qty,
rank() over (order by qty desc) as rank
from winsales
order by 2,1;

 salesid | qty | rank
---------+-----+-----
   10001 |  10 |   8
   10006 |  10 |   8
   30001 |  10 |   8
   40005 |  10 |   8
   30003 |  15 |   7
   20001 |  20 |   4
   20002 |  20 |   4
   30004 |  20 |   4
   10005 |  30 |   2
   30007 |  30 |   2
   40001 |  40 |   1
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example partitions the table by SELLERID and order each partition by the quantity (in descending order) and assign a rank to each row. The results are sorted after the window function results are applied.

```
select salesid, sellerid, qty, rank() over
(partition by sellerid
order by qty desc) as rank
from winsales
order by 2,3,1;

salesid | sellerid | qty | rank
```

```
--------+----------+-----+-----
  10001 |        1 |  10 |  2
  10006 |        1 |  10 |  2
  10005 |        1 |  30 |  1
  20001 |        2 |  20 |  1
  20002 |        2 |  20 |  1
  30001 |        3 |  10 |  4
  30003 |        3 |  15 |  3
  30004 |        3 |  20 |  2
  30007 |        3 |  30 |  1
  40005 |        4 |  10 |  2
  40001 |        4 |  40 |  1
(11 rows)
```

RATIO_TO_REPORT window function

Calculates the ratio of a value to the sum of the values in a window or partition. The ratio to report value is determined using the formula:

`value of` *ratio_expression* `argument for the current row / sum of` *ratio_expression* `argument for the window or partition`

The following dataset illustrates use of this formula:

```
Row# Value Calculation RATIO_TO_REPORT
1 2500 (2500)/(13900) 0.1798
2 2600 (2600)/(13900) 0.1870
3 2800 (2800)/(13900) 0.2014
4 2900 (2900)/(13900) 0.2086
5 3100 (3100)/(13900) 0.2230
```

The return value range is 0 to 1, inclusive. If *ratio_expression* is NULL, then the return value is `NULL`. If a value in *partition_expression* is unique, then function will return 1 for that value.

Syntax

```
RATIO_TO_REPORT ( ratio_expression )
OVER ( [ PARTITION BY partition_expression ] )
```

Arguments

ratio_expression

An expression, such as a column name, that provides the value for which to determine the ratio. The expression must have either a numeric data type or be implicitly convertible to one.

You cannot use any other analytic function in *ratio_expression*.

OVER

A clause that specifies the window partitioning. The OVER clause cannot contain a window ordering or window frame specification.

PARTITION BY *partition_expression*

Optional. An expression that sets the range of records for each group in the OVER clause.

Return type

FLOAT8

Examples

The following examples use the WINSALES table. For a information about how to create the WINSALES table, see Sample table for window function examples.

The following example calculates the ratio-to-report value of each row of a seller's quantity to the total of all seller's quantities.

```
select sellerid, qty, ratio_to_report(qty)
over()
from winsales
order by sellerid;

sellerid  qty    ratio_to_report
--------------------------------------
1         30     0.13953488372093023
1         10     0.046511627906976744
1         10     0.046511627906976744
2         20     0.09302325581395349
2         20     0.09302325581395349
```

```
3          30     0.13953488372093023
3          20     0.09302325581395349
3          15     0.06976744186046512
3          10     0.04651162790697674
4          10     0.04651162790697674
4          40     0.18604651162790697
```

The following example calculates the ratios of the sales quantities for each seller by partition.

```
select sellerid, qty, ratio_to_report(qty)
over(partition by sellerid)
from winsales;

sellerid   qty    ratio_to_report
-------------------------------------------
2          20     0.5
2          20     0.5
4          40     0.8
4          10     0.2
1          10     0.2
1          30     0.6
1          10     0.2
3          10     0.13333333333333333
3          15     0.2
3          20     0.26666666666666666
3          30     0.4
```

ROW_NUMBER window function

Assigns an ordinal number of the current row within a group of rows, counting from 1, based on the ORDER BY expression in the OVER clause. If the optional PARTITION BY clause is present, the ordinal numbers are reset for each group of rows. Rows with equal values for the ORDER BY expressions receive the different row numbers nondeterministically.

Syntax

```
ROW_NUMBER() OVER(
  [ PARTITION BY expr_list ]
  [ ORDER BY order_list ]
)
```

Arguments

( )

The function takes no arguments, but the empty parentheses are required.

OVER

The window function clause for the ROW_NUMBER function.

PARTITION BY *expr_list*

Optional. One or more column expressions that divide the results into sets of rows.

ORDER BY *order_list*

Optional. One or more column expressions that defines the order of rows within a set. If no PARTITION BY is specified, ORDER BY uses the entire table.

If ORDER BY does not produce a unique ordering or is omitted, the order of the rows is nondeterministic. For more information, see Unique ordering of data for window functions.

Return type

BIGINT

Examples

The following examples use the `WINSALES` table. For a description of the `WINSALES` table, see Sample table for window function examples.

The following example orders the table by QTY (in ascending order), then assigns a row number to each row. The results are sorted after the window function results are applied.

```
SELECT salesid, sellerid, qty,
ROW_NUMBER() OVER(
   ORDER BY qty ASC) AS row
FROM winsales
ORDER BY 4,1;

salesid   sellerid   qty   row
---------+----------+-----+-----
   30001 |        3 |  10 |   1
```

```
   10001 |        1 |  10 |   2
   10006 |        1 |  10 |   3
   40005 |        4 |  10 |   4
   30003 |        3 |  15 |   5
   20001 |        2 |  20 |   6
   20002 |        2 |  20 |   7
   30004 |        3 |  20 |   8
   10005 |        1 |  30 |   9
   30007 |        3 |  30 |  10
   40001 |        4 |  40 |  11
```

The following example partitions the table by SELLERID and orders each partition by QTY (in ascending order), then assigns a row number to each row. The results are sorted after the window function results are applied.

```
SELECT salesid, sellerid, qty,
ROW_NUMBER() OVER(
  PARTITION BY sellerid
  ORDER BY qty ASC) AS row_by_seller
FROM winsales
ORDER BY 2,4;

 salesid | sellerid | qty | row_by_seller
---------+----------+-----+-----
   10001 |        1 |  10 |   1
   10006 |        1 |  10 |   2
   10005 |        1 |  30 |   3
   20001 |        2 |  20 |   1
   20002 |        2 |  20 |   2
   30001 |        3 |  10 |   1
   30003 |        3 |  15 |   2
   30004 |        3 |  20 |   3
   30007 |        3 |  30 |   4
   40005 |        4 |  10 |   1
   40001 |        4 |  40 |   2
```

The following example shows the results when not using the optional clauses.

```
SELECT salesid, sellerid, qty, ROW_NUMBER() OVER() AS row
FROM winsales
ORDER BY 4,1;
```

```
salesid   sellerid   qty   row
---------+----------+-----+-----
   30001 |        3 |  10 |   1
   10001 |        1 |  10 |   2
   10005 |        1 |  30 |   3
   40001 |        4 |  40 |   4
   10006 |        1 |  10 |   5
   20001 |        2 |  20 |   6
   40005 |        4 |  10 |   7
   20002 |        2 |  20 |   8
   30003 |        3 |  15 |   9
   30004 |        3 |  20 |  10
   30007 |        3 |  30 |  11
```

STDDEV_SAMP and STDDEV_POP window functions

The STDDEV_SAMP and STDDEV_POP window functions return the sample and population standard deviation of a set of numeric values (integer, decimal, or floating-point). See also STDDEV_SAMP and STDDEV_POP functions.

STDDEV_SAMP and STDDEV are synonyms for the same function.

Syntax

```
STDDEV_SAMP | STDDEV | STDDEV_POP
( [ ALL ] expression ) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list
                        frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

The argument types supported by the STDDEV functions are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, and DOUBLE PRECISION.

Regardless of the data type of the expression, the return type of a STDDEV function is a double precision number.

Examples

The following example shows how to use STDDEV_POP and VAR_POP functions as window functions. The query computes the population variance and population standard deviation for PRICEPAID values in the SALES table.

```
select salesid, dateid, pricepaid,
round(stddev_pop(pricepaid) over
(order by dateid, salesid rows unbounded preceding)) as stddevpop,
round(var_pop(pricepaid) over
(order by dateid, salesid rows unbounded preceding)) as varpop
from sales
order by 2,1;
```

```
salesid | dateid | pricepaid | stddevpop | varpop
--------+--------+-----------+-----------+---------
  33095 |   1827 |    234.00 |         0 |       0
  65082 |   1827 |    472.00 |       119 |   14161
  88268 |   1827 |    836.00 |       248 |   61283
  97197 |   1827 |    708.00 |       230 |   53019
 110328 |   1827 |    347.00 |       223 |   49845
 110917 |   1827 |    337.00 |       215 |   46159
 150314 |   1827 |    688.00 |       211 |   44414
 157751 |   1827 |   1730.00 |       447 |  199679
 165890 |   1827 |   4192.00 |      1185 | 1403323
...
```

The sample standard deviation and variance functions can be used in the same way.

SUM window function

The SUM window function returns the sum of the input column or expression values. The SUM function works with numeric values and ignores NULL values.

Syntax

```
SUM ( [ ALL ] expression ) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list
                        frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the SUM function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

The argument types supported by the SUM function are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, and DOUBLE PRECISION.

The return types supported by the SUM function are:

- BIGINT for SMALLINT or INTEGER arguments
- NUMERIC for BIGINT arguments
- DOUBLE PRECISION for floating-point arguments

Examples

The following example creates a cumulative (rolling) sum of sales quantities ordered by date and sales ID:

```
select salesid, dateid, sellerid, qty,
sum(qty) over (order by dateid, salesid rows unbounded preceding) as sum
from winsales
order by 2,1;

salesid |   dateid   | sellerid | qty | sum
---------+------------+----------+-----+-----
30001 | 2003-08-02 |        3 |  10 |  10
```

```
10001 | 2003-12-24 |        1 |  10 |  20
10005 | 2003-12-24 |        1 |  30 |  50
40001 | 2004-01-09 |        4 |  40 |  90
10006 | 2004-01-18 |        1 |  10 | 100
20001 | 2004-02-12 |        2 |  20 | 120
40005 | 2004-02-12 |        4 |  10 | 130
20002 | 2004-02-16 |        2 |  20 | 150
30003 | 2004-04-18 |        3 |  15 | 165
30004 | 2004-04-18 |        3 |  20 | 185
30007 | 2004-09-07 |        3 |  30 | 215
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example creates a cumulative (rolling) sum of sales quantities by date, partition the results by seller ID, and order the results by date and sales ID within the partition:

```
select salesid, dateid, sellerid, qty,
sum(qty) over (partition by sellerid
order by dateid, salesid rows unbounded preceding) as sum
from winsales
order by 2,1;

salesid |   dateid   | sellerid | qty | sum
---------+------------+----------+-----+-----
30001 | 2003-08-02 |        3 |  10 |  10
10001 | 2003-12-24 |        1 |  10 |  10
10005 | 2003-12-24 |        1 |  30 |  40
40001 | 2004-01-09 |        4 |  40 |  40
10006 | 2004-01-18 |        1 |  10 |  50
20001 | 2004-02-12 |        2 |  20 |  20
40005 | 2004-02-12 |        4 |  10 |  50
20002 | 2004-02-16 |        2 |  20 |  40
30003 | 2004-04-18 |        3 |  15 |  25
30004 | 2004-04-18 |        3 |  20 |  45
30007 | 2004-09-07 |        3 |  30 |  75
(11 rows)
```

The following example numbers all of the rows sequentially in the result set, ordered by the SELLERID and SALESID columns:

```
select salesid, sellerid, qty,
```

```
sum(1) over (order by sellerid, salesid rows unbounded preceding) as rownum
from winsales
order by 2,1;

salesid | sellerid |  qty | rownum
--------+----------+------+--------
10001 |        1 |   10 |      1
10005 |        1 |   30 |      2
10006 |        1 |   10 |      3
20001 |        2 |   20 |      4
20002 |        2 |   20 |      5
30001 |        3 |   10 |      6
30003 |        3 |   15 |      7
30004 |        3 |   20 |      8
30007 |        3 |   30 |      9
40001 |        4 |   40 |     10
40005 |        4 |   10 |     11
(11 rows)
```

For a description of the WINSALES table, see Sample table for window function examples.

The following example numbers all rows sequentially in the result set, partition the results by SELLERID, and order the results by SELLERID and SALESID within the partition:

```
select salesid, sellerid, qty,
sum(1) over (partition by sellerid
order by sellerid, salesid rows unbounded preceding) as rownum
from winsales
order by 2,1;

salesid | sellerid | qty | rownum
---------+----------+-----+--------
10001 |        1 |  10 |      1
10005 |        1 |  30 |      2
10006 |        1 |  10 |      3
20001 |        2 |  20 |      1
20002 |        2 |  20 |      2
30001 |        3 |  10 |      1
30003 |        3 |  15 |      2
30004 |        3 |  20 |      3
30007 |        3 |  30 |      4
40001 |        4 |  40 |      1
40005 |        4 |  10 |      2
```

```
(11 rows)
```

VAR_SAMP and VAR_POP window functions

The VAR_SAMP and VAR_POP window functions return the sample and population variance of a set of numeric values (integer, decimal, or floating-point). See also VAR_SAMP and VAR_POP functions.

VAR_SAMP and VARIANCE are synonyms for the same function.

Syntax

```
VAR_SAMP | VARIANCE | VAR_POP
( [ ALL ] expression ) OVER
(
[ PARTITION BY expr_list ]
[ ORDER BY order_list
                        frame_clause ]
)
```

Arguments

expression

The target column or expression that the function operates on.

ALL

With the argument ALL, the function retains all duplicate values from the expression. ALL is the default. DISTINCT is not supported.

OVER

Specifies the window clauses for the aggregation functions. The OVER clause distinguishes window aggregation functions from normal set aggregation functions.

PARTITION BY *expr_list*

Defines the window for the function in terms of one or more expressions.

ORDER BY *order_list*

Sorts the rows within each partition. If no PARTITION BY is specified, ORDER BY uses the entire table.

frame_clause

If an ORDER BY clause is used for an aggregate function, an explicit frame clause is required. The frame clause refines the set of rows in a function's window, including or excluding sets of rows within the ordered result. The frame clause consists of the ROWS keyword and associated specifiers. See Window function syntax summary.

Data types

The argument types supported by the VARIANCE functions are SMALLINT, INTEGER, BIGINT, NUMERIC, DECIMAL, REAL, and DOUBLE PRECISION.

Regardless of the data type of the expression, the return type of a VARIANCE function is a double precision number.

System administration functions

Topics

Amazon Redshift supports several system administration functions.

CHANGE_QUERY_PRIORITY

CHANGE_QUERY_PRIORITY enables superusers to modify the priority of a query that is either running or waiting in workload management (WLM).

This function enables superusers to immediately change the priority of any query in the system. Only one query, user, or session can run with the priority `CRITICAL`.

Syntax

```
CHANGE_QUERY_PRIORITY(query_id, priority)
```

Arguments

query_id

The query identifier of the query whose priority is changed. Requires an INTEGER value.

priority

The new priority to be assigned to the query. This argument must be a string with the value CRITICAL, HIGHEST, HIGH, NORMAL, LOW, or LOWEST.

Return Type

None

Examples

To show the column query_priority in the STV_WLM_QUERY_STATE system table, use the following example.

```
SELECT query, service_class, query_priority, state
FROM stv_wlm_query_state WHERE service_class = 101;

+-------+---------------+----------------+---------+
| query | service_class | query_priority |  state  |
+-------+---------------+----------------+---------+
|  1076 |           101 | Lowest         | Running |
|  1075 |           101 | Lowest         | Running |
+-------+---------------+----------------+---------+
```

To show the results of a superuser running the function change_query_priority to change the priority to CRITICAL, use the following example.

```
SELECT CHANGE_QUERY_PRIORITY(1076, 'Critical');

+--------------------------------------------------------------------------------+
|                              change_query_priority                             |
+--------------------------------------------------------------------------------+
```

```
| Succeeded to change query priority. Priority changed from Lowest to Critical. |
+-------------------------------------------------------------------------------+
```

CHANGE_SESSION_PRIORITY

CHANGE_SESSION_PRIORITY enables superusers to immediately change the priority of any session in the system. Only one session, user, or query can run with the priority `CRITICAL`.

Syntax

```
CHANGE_SESSION_PRIORITY(pid, priority)
```

Arguments

pid

The process identifier of the session whose priority is changed. The value `-1` refers to the current session. Requires an `INTEGER` value.

priority

The new priority to be assigned to the session. This argument must be a string with the value `CRITICAL`, `HIGHEST`, `HIGH`, `NORMAL`, `LOW`, or `LOWEST`.

Return type

None

Examples

To return the process identifier of the server process handling the current session, use the following example.

```
SELECT pg_backend_pid();

+----------------+
| pg_backend_pid |
+----------------+
|          30311 |
+----------------+
```

In this example, the priority is changed to `LOWEST` for the current session.

```
SELECT CHANGE_SESSION_PRIORITY(30311, 'Lowest');

+---------------------------------------------------------------------------------------
+
|                                  change_session_priority
 |
+---------------------------------------------------------------------------------------
+
| Succeeded to change session priority. Changed session (pid:30311) priority to lowest.
 |
+---------------------------------------------------------------------------------------
+
```

In this example, the priority is changed to `HIGH` for the current session.

```
SELECT CHANGE_SESSION_PRIORITY(-1, 'High');

+-----------------------------------------------------------------------------------------------
+
|                                       change_session_priority
           |
+-----------------------------------------------------------------------------------------------
+
| Succeeded to change session priority. Changed session (pid:30311) priority from
 lowest to high. |
+-----------------------------------------------------------------------------------------------
+
```

To create a stored procedure that changes a session priority, use the following example. Permission to run this stored procedure is granted to the database user `test_user`.

```
CREATE OR REPLACE PROCEDURE sp_priority_low(pid IN int, result OUT varchar)
AS $$
BEGIN
  SELECT CHANGE_SESSION_PRIORITY(pid, 'low') into result;
END;
$$ LANGUAGE plpgsql
SECURITY DEFINER;
GRANT EXECUTE ON PROCEDURE sp_priority_low(int) TO test_user;
```

Then the database user named `test_user` calls the procedure.

```
CALL sp_priority_low(pg_backend_pid());

+-------------------------------------------------------+
|                        result                         |
+-------------------------------------------------------+
| Success. Change session (pid:13155) priority to low. |
+-------------------------------------------------------+
```

CHANGE_USER_PRIORITY

CHANGE_USER_PRIORITY enables superusers to modify the priority of all queries issued by a user that are either running or waiting in workload management (WLM). Only one user, session, or query can run with the priority `CRITICAL`.

Syntax

```
CHANGE_USER_PRIORITY(user_name, priority)
```

Arguments

user_name

The database user name whose query priority is changed.

priority

The new priority to be assigned to all queries issued by `user_name`. This argument must be a string with the value `CRITICAL`, `HIGHEST`, `HIGH`, `NORMAL`, `LOW`, `LOWEST`, or `RESET`. Only superusers can change the priority to `CRITICAL`. Changing the priority to `RESET` removes the priority setting for `user_name`.

Return type

None

Examples

To change the priority for the user `analysis_user` to `LOWEST`, use the following example.

```
SELECT CHANGE_USER_PRIORITY('analysis_user', 'lowest');
```

```
+-------------------------------------------------------------------------------------+
|                                 change_user_priority                                |
+-------------------------------------------------------------------------------------+
| Succeeded to change user priority. Changed user (analysis_user) priority to lowest. |
+-------------------------------------------------------------------------------------+
```

To change the priority to `LOW`, use the following example.

```
SELECT CHANGE_USER_PRIORITY('analysis_user', 'low');

+----------------------------------------------------------------------------------------------
+
|                                      change_user_priority
        |
+----------------------------------------------------------------------------------------------
+
| Succeeded to change user priority. Changed user (analysis_user) priority from Lowest
 to low. |
+----------------------------------------------------------------------------------------------
+
```

To reset the priority, use the following example.

```
SELECT CHANGE_USER_PRIORITY('analysis_user', 'reset');

+-------------------------------------------------------+
|                  change_user_priority                 |
+-------------------------------------------------------+
| Succeeded to reset priority for user (analysis_user). |
+-------------------------------------------------------+
```

CURRENT_SETTING

CURRENT_SETTING returns the current value of the specified configuration parameter.

This function is equivalent to the SHOW command.

Syntax

```
current_setting('parameter')
```

The following statement returns the current value of the specified session context variable.

```
current_setting('variable_name')
current_setting('variable_name'[, error_if_undefined])
```

Arguments

parameter

Parameter value to display. For a list of configuration parameters, see Configuration reference

variable_name

The name of the variable to display. This must be a string constant for session context variables.

error_if_undefined

(Optional) A boolean value that specifies the behavior if the variable name doesn't exist. When error_if_undefined is set to TRUE, which is the default, Amazon Redshift throws an error. When error_if_undefined is set to FALSE, Amazon Redshift returns NULL. Amazon Redshift supports the *error_if_undefined* parameter only for session context variables. This can't be used when the input is a configuration parameter.

Return type

Returns a CHAR or VARCHAR string.

Examples

To return the current setting for the query_group parameter, use the following example.

```
SELECT CURRENT_SETTING('query_group');

+-----------------+
| current_setting |
+-----------------+
| unset           |
+-----------------+
```

To return the current setting for the variable app_context.user_id, use the following example.

```
SELECT CURRENT_SETTING('app_context.user_id', FALSE);
```

PG_CANCEL_BACKEND

Cancels a query. PG_CANCEL_BACKEND is functionally equivalent to the CANCEL command. You can cancel queries currently being run by your user. Superusers can cancel any query.

Syntax

```
pg_cancel_backend( pid )
```

Arguments

pid

The process ID (PID) of the query to be canceled. You cannot cancel a query by specifying a query ID; you must specify the query's process ID. Requires an `INTEGER` value.

Return type

None

Usage notes

If queries in multiple sessions hold locks on the same table, you can use the PG_TERMINATE_BACKEND function to terminate one of the sessions, which forces any currently running transactions in the terminated session to release all locks and roll back the transaction. Query the PG__LOCKS catalog table to view currently held locks. If you cannot cancel a query because it is in transaction block (BEGIN … END), you can terminate the session in which the query is running by using the PG_TERMINATE_BACKEND function.

Examples

To cancel a currently running query, first retrieve the process ID for the query that you want to cancel. To determine the process IDs for all currently running queries, run the following command.

```
SELECT pid, TRIM(starttime) AS start,
duration, TRIM(user_name) AS user,
SUBSTRING(query,1,40) AS querytxt
FROM stv_recents
WHERE status = 'Running';
```

```
+-----+------------------------+----------+--------+-----------------------------+
| pid |       starttime        | duration |  user  |          querytxt           |
+-----+------------------------+----------+--------+-----------------------------+
| 802 | 2013-10-14 09:19:03.55 |      132 | dwuser | select venuename from venue |
| 834 | 2013-10-14 08:33:49.47 |  1250414 | dwuser | select * from listing;      |
| 964 | 2013-10-14 08:30:43.29 |   326179 | dwuser | select sellerid from sales  |
+-----+------------------------+----------+--------+-----------------------------+
```

To cancel the query with process ID 802, use the following example.

```
SELECT PG_CANCEL_BACKEND(802);
```

PG_TERMINATE_BACKEND

Terminates a session. You can terminate a session owned by your user. A superuser can terminate any session.

Syntax

```
pg_terminate_backend( pid )
```

Arguments

pid

The process ID of the session to be terminated. Requires an `INTEGER` value.

Return type

None

Usage notes

If you are close to reaching the limit for concurrent connections, use PG_TERMINATE_BACKEND to terminate idle sessions and free up the connections. For more information, see Limits in Amazon Redshift.

If queries in multiple sessions hold locks on the same table, you can use PG_TERMINATE_BACKEND to terminate one of the sessions, which forces any currently running transactions in the terminated session to release all locks and roll back the transaction. Query the PG_LOCKS catalog table to view currently held locks.

If a query is not in a transaction block (BEGIN … END), you can cancel the query by using the CANCEL command or the PG_CANCEL_BACKEND function.

Examples

To query the SVV_TRANSACTIONS table to view all locks in effect for current transactions, use the following example.

```
SELECT * FROM svv_transactions;

+-----------+--------+-------+------+---------------------+-----------------
+---------------------+----------+---------+
| txn_owner | txn_db |  xid  | pid  |      txn_start      |    lock_mode    |
 lockable_object_type | relation | granted |
+-----------+--------+-------+------+---------------------+-----------------
+---------------------+----------+---------+
| rsuser    | dev    | 96178 | 8585 | 2017-04-12 20:13:07 | AccessShareLock | relation
            |    51940 | true    |
| rsuser    | dev    | 96178 | 8585 | 2017-04-12 20:13:07 | AccessShareLock | relation
            |    52000 | true    |
| rsuser    | dev    | 96178 | 8585 | 2017-04-12 20:13:07 | AccessShareLock | relation
            |   108623 | true    |
| rsuser    | dev    | 96178 | 8585 | 2017-04-12 20:13:07 | ExclusiveLock   |
 transactionid        |          | true    |
+-----------+--------+-------+------+---------------------+-----------------
+---------------------+----------+---------+
```

TO terminate the session holding the locks, use the following example.

```
SELECT PG_TERMINATE_BACKEND(8585);
```

REBOOT_CLUSTER

Reboot the Amazon Redshift cluster without closing the connections to the cluster. You must be a database superuser to run this command.

After this soft reboot has completed, the Amazon Redshift cluster returns an error to the user application and requires the user application to resubmit any transactions or queries interrupted by the soft reboot.

Syntax

```
SELECT REBOOT_CLUSTER();
```

SET_CONFIG

Sets a configuration parameter to a new setting.

This function is equivalent to the SET command in SQL.

Syntax

```
SET_CONFIG('parameter', 'new_value' , is_local)
```

The following statement sets a session context variable to a new setting.

```
set_config('variable_name', 'new_value' , is_local)
```

Arguments

parameter

Parameter to set.

variable_name

The name of the variable to set.

new_value

New value of the parameter.

is_local

If true, parameter value applies only to the current transaction. Valid values are `true` or `1` and `false` or `0`.

Return type

Returns a CHAR or VARCHAR string.

Examples

To set the value of the `query_group` parameter to `test` for the current transaction only, use the following example.

```
SELECT SET_CONFIG('query_group', 'test', true);

+------------+
| set_config |
+------------+
| test       |
+------------+
```

To set session context variables, use the following example.

```
SELECT SET_CONFIG(‘app.username’, ‘cuddy’, FALSE);
```

System information functions

Amazon Redshift supports numerous system information functions.

Topics

- LAST_USER_QUERY_ID
- PG_BACKEND_PID
- PG_GET_COLS
- PG_GET_GRANTEE_BY_IAM_ROLE
- PG_GET_IAM_ROLE_BY_USER
- PG_GET_LATE_BINDING_VIEW_COLS
- PG_GET_SESSION_ROLES
- PG_LAST_COPY_COUNT
- PG_LAST_COPY_ID
- PG_LAST_UNLOAD_ID
- PG_LAST_QUERY_ID
- PG_LAST_UNLOAD_COUNT
- SLICE_NUM Function
- USER
- ROLE_IS_MEMBER_OF
- USER_IS_MEMBER_OF
- VERSION

CURRENT_AWS_ACCOUNT

Returns the AWS account associated with the Amazon Redshift cluster that submitted a query.

Syntax

```
current_aws_account
```

Return type

Returns an integer.

Example

The following query returns the name of the current database.

```
select user, current_aws_account;
```

```
current_user | current_account
-------------+---------------
dwuser       | 987654321

(1 row)
```

CURRENT_DATABASE

Returns the name of the database where you are currently connected.

Syntax

```
current_database()
```

Return type

Returns a CHAR or VARCHAR string.

Example

The following query returns the name of the current database.

```
select current_database();

current_database
------------------
tickit
(1 row)
```

CURRENT_NAMESPACE

Returns the cluster namespace of the current Amazon Redshift cluster. Amazon Redshift cluster namespace is the unique ID of the Amazon Redshift cluster.

Syntax

```
current_namespace
```

Return type

Returns a CHAR or VARCHAR string.

Example

The following query returns the name of the current namespace.

```
select user, current_namespace;
current_user | current_namespace
-------------+------------------------------------
dwuser       | 86b5169f-01dc-4a6f-9fbb-e2e24359e9a8

(1 row)
```

CURRENT_SCHEMA

Returns the name of the schema at the front of the search path. This schema will be used for any tables or other named objects that are created without specifying a target schema.

Syntax

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view.

```
current_schema()
```

Return type

CURRENT_SCHEMA returns a CHAR or VARCHAR string.

Examples

The following query returns the current schema:

```
select current_schema();

current_schema
----------------
public
(1 row)
```

CURRENT_SCHEMAS

Returns an array of the names of any schemas in the current search path. The current search path is defined in the search_path parameter.

Syntax

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view.

```
current_schemas(include_implicit)
```

Argument

include_implicit

If true, specifies that the search path should include any implicitly included system schemas. Valid values are `true` and `false`. Typically, if `true`, this parameter returns the `pg_catalog` schema in addition to the current schema.

Return type

Returns a CHAR or VARCHAR string.

Examples

The following example returns the names of the schemas in the current search path, not including implicitly included system schemas:

```
select current_schemas(false);

current_schemas
-----------------
{public}
(1 row)
```

The following example returns the names of the schemas in the current search path, including implicitly included system schemas:

```
select current_schemas(true);

current_schemas
---------------------
{pg_catalog,public}
(1 row)
```

CURRENT_SESSION_ARN

Returns the ARN of the currently authorized global user. Global users present with the same identity across Redshift accounts, clusters, and Serverless workgroups. Global users log in through IAM Identity Center, or through IAM-based session authentication. Data lake users are global AWS users.

This function is typically used in the context of using multi-dialect AWS Glue views. For more information about identity management with IAM Identity Center and Redshift, see Connect Redshift with IAM Identity Center to give users a single sign-on experience. For more information about multi-dialect Glue views Creating views in the AWS Glue Data Catalog.

Syntax

```
current_session_arn()
```

Return type

Returns a VARCHAR string of the globally authenticated user or a null value.

Usage notes

Local users aren't supported and result in a null response.

Example

The following query returns the name of the current session ARN:

```
SELECT current_session_arn();

current_session_arn
--------------
arn:aws:iam::123456789012:user/user
```

```
(1 row)
```

CURRENT_USER

Returns the user name of the current "effective" user of the database, as applicable to checking permissions. Usually, this user name will be the same as the session user; however, this can occasionally be changed by superusers.

> **Note**
>
> Do not use trailing parentheses when calling CURRENT_USER.

Syntax

```
current_user
```

Return type

CURRENT_USER returns a NAME data type and can be cast as a CHAR or VARCHAR string.

Usage notes

If a stored procedure was created using the SECURITY DEFINER option of the CREATE_PROCEDURE command, when invoking the CURRENT_USER function from within the stored procedure, Amazon Redshift returns the user name of the owner of the stored procedure.

Example

The following query returns the name of the current database user:

```
select current_user;

current_user
--------------
dwuser
(1 row)
```

CURRENT_USER_ID

Returns the unique identifier for the Amazon Redshift user logged in to the current session.

Syntax

```
CURRENT_USER_ID
```

Return type

The CURRENT_USER_ID function returns an integer.

Examples

The following example returns the user name and current user ID for this session:

```
select user, current_user_id;

 current_user | current_user_id
--------------+-----------------
   dwuser     |               1
(1 row)
```

DEFAULT_IAM_ROLE

Returns the default IAM role currently associated with the Amazon Redshift cluster. The function returns none if there isn't any default IAM role associated.

Syntax

```
select default_iam_role();
```

Return type

Returns a VARCHAR string.

Example

The following example returns the default IAM role currently associated with the specified Amazon Redshift cluster,

```
select default_iam_role();
              default_iam_role
-----------------------------------------------
 arn:aws:iam::123456789012:role/myRedshiftRole
(1 row)
```

GET_MOUNTED_ROLE

When invoked as part of a multi-dialect AWS Glue view, it allows returning the IAM role used to mount the Lake Formation schema or database. Multi-dialect means that the SQL is supported across multiple query engines, such as Amazon EMR and Redshift. For more information about multi-dialect Glue views, see Creating views in the AWS Glue Data Catalog.

Syntax

```
get_mounted_role()
```

Return type

Returns a VARCHAR string or a null value.

Usage notes

This function returns null for any use case outside of an external Lake Formation view.

Example

The following query returns the identity to mount the Lake Formation resource.

```
CREATE EXTERNAL PROTECTED VIEW external_schema.remote_view AS
SELECT mycol, get_mounted_role() FROM external_schema.remote_table;

mycol | get_mounted_role
----------------------------
1       arn:aws:iam::123456789012:role/salesrole
(1 row)
```

HAS_ASSUMEROLE_PRIVILEGE

Returns Boolean `true` (`t`) if the specified user has the specified IAM role with the privilege to run the specified command. The function returns `false` (`f`) if the user doesn't have the specified IAM role with the privilege to run the specified command. For more information about privileges, see GRANT.

Syntax

```
has_assumerole_privilege( [ user, ] iam_role_arn, cmd_type)
```

Arguments

user

The name of the user to check for IAM role privileges. The default is to check the current user. Superusers and users can use this function. However, users can only view their own privileges.

iam_role_arn

The IAM role that has been granted the command privileges.

cmd_type

The command for which access has been granted. Valid values are the following:

- COPY
- UNLOAD
- EXTERNAL FUNCTION
- CREATE MODEL

Return type

BOOLEAN

Example

The following query confirms that the user `reg_user1` has the privilege for the `Redshift-S3-Read` role to run the COPY command.

```
select has_assumerole_privilege('reg_user1', 'arn:aws:iam::123456789012:role/Redshift-S3-Read', 'copy');
```

```
has_assumerole_privilege
------------------------
true
(1 row)
```

HAS_DATABASE_PRIVILEGE

Returns `true` if the user has the specified privilege for the specified database. For more information about privileges, see GRANT.

Syntax

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view.

```
has_database_privilege( [ user, ] database, privilege)
```

Arguments

user

The name of the user to check for database privileges. The default is to check the current user.

database

The database associated with the privilege.

privilege

The privilege to check. Valid values are the following:

- CREATE
- TEMPORARY
- TEMP

Return type

Returns a CHAR or VARCHAR string.

Example

The following query confirms that the GUEST user has the TEMP privilege on the TICKIT database.

```
select has_database_privilege('guest', 'tickit', 'temp');

has_database_privilege
------------------------
true
(1 row)
```

HAS_SCHEMA_PRIVILEGE

Returns `true` if the user has the specified privilege for the specified schema. For more information about privileges, see GRANT.

Syntax

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view.

```
has_schema_privilege( [ user, ] schema, privilege)
```

Arguments

user

The name of the user to check for schema privileges. The default is to check the current user.

schema

The schema associated with the privilege.

privilege

The privilege to check. Valid values are the following:

- CREATE
- USAGE
- ALTER
- DROP

Return type

Returns a CHAR or VARCHAR string.

Example

The following query confirms that the GUEST user has the CREATE privilege on the PUBLIC schema:

```
select has_schema_privilege('guest', 'public', 'create');

has_schema_privilege
----------------------
true
(1 row)
```

HAS_TABLE_PRIVILEGE

Returns `true` if the user has the specified privilege for the specified table and returns `false` otherwise.

Syntax

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view. For more information about privileges, see GRANT.

```
has_table_privilege( [ user, ] table, privilege)
```

Arguments

user

The name of the user to check for table privileges. The default is to check the current user.

table

Table associated with the privilege.

privilege

Privilege to check. Valid values are the following:

- SELECT
- INSERT
- UPDATE
- DELETE

- DROP
- REFERENCES

Return type

BOOLEAN

Examples

The following query finds that the GUEST user doesn't have SELECT privilege on the LISTING table.

```
select has_table_privilege('guest', 'listing', 'select');

has_table_privilege
---------------------
false
```

The following query lists table privileges, including select, insert, update, and delete, using output from the pg_tables and pg_user catalog tables. This is a sample only. You might have to specify a schema name and table names from your database. For more information, see Querying the catalog tables.

```
SELECT
     tablename
     ,usename
     ,HAS_TABLE_PRIVILEGE(users.usename, tablename, 'select') AS sel
     ,HAS_TABLE_PRIVILEGE(users.usename, tablename, 'insert') AS ins
     ,HAS_TABLE_PRIVILEGE(users.usename, tablename, 'update') AS upd
     ,HAS_TABLE_PRIVILEGE(users.usename, tablename, 'delete') AS del
FROM
(SELECT * from pg_tables
WHERE schemaname = 'public' and tablename in ('event','listing')) as tables
,(SELECT * FROM pg_user) AS users;

tablename | usename    |  sel   |  ins  |  upd  | del
----------+------------+--------+-------+-------+-------
event     |  john      |  true  | true  | true  | true
event     |  sally     |  false | false | false | false
event     |  elsa      |  false | false | false | false
listing   |  john      |  true  | true  | true  | true
listing   |  sally     |  false | false | false | false
```

```
listing    |  elsa      |  false | false | false | false
```

The previous query also contains a cross join. For more information, see JOIN examples. To query tables that are not in the `public` schema, remove the `schemaname` condition from the WHERE clause and use the following example prior to your query.

```
SET SEARCH_PATH to 'schema_name';
```

LAST_USER_QUERY_ID

Returns the query ID of the most recently completed user query in the current session. If no queries have been run in the current session, last_user_query_id returns -1. The function does not return the query ID for queries that run exclusively on the leader node. For more information, see Leader node–only functions.

Syntax

```
last_user_query_id()
```

Return type

Returns an integer.

Example

The following query returns the ID of the latest query run by a user completed in the current session.

```
select last_user_query_id();
```

Results are the following.

```
last_user_query_id
-----------------------
    5437
(1 row)
```

The following query returns the query ID and text of the most recently completed query run by a user in the current session.

```
select query_id, query_text from sys_query_history where query_id =
 last_user_query_id();
```

Results are the following.

```
 query_id, query_text
---------
+----------------------------------------------------------------------------------------------------
 5556975 | select last_user_query_id() limit 100 --RequestID=<unique request ID>;
 TraceID=<unique trace ID>
```

PG_BACKEND_PID

Returns the process ID (PID) of the server process handling the current session.

Note

The PID is not globally unique. It can be reused over time.

Syntax

```
pg_backend_pid()
```

Return type

Returns an integer.

Example

You can correlate PG_BACKEND_PID with log tables to retrieve information for the current session. For example, the following query returns the query ID and a portion of the query text for queries completed in the current session.

```
select query, substring(text,1,40)
from stl_querytext
where pid =  PG_BACKEND_PID()
order by query desc;

 query |                  substring
-------+------------------------------------------
```

```
 14831 | select query, substring(text,1,40) from
 14827 | select query, substring(path,0,80) as pa
 14826 | copy category from 's3://dw-tickit/manif
 14825 | Count rows in target table
 14824 | unload ('select * from category') to 's3
(5 rows)
```

You can correlate PG_BACKEND_PID with the pid column in the following log tables (exceptions are noted in parentheses):

- STL_CONNECTION_LOG
- STL_DDLTEXT
- STL_ERROR
- STL_QUERY
- STL_QUERYTEXT
- STL_SESSIONS (process)
- STL_TR_CONFLICT
- STL_UTILITYTEXT
- STV_ACTIVE_CURSORS
- STV_INFLIGHT
- STV_LOCKS (lock_owner_pid)
- STV_RECENTS (process_id)

PG_GET_COLS

Returns the column metadata for a table or view definition.

Syntax

```
pg_get_cols('name')
```

Arguments

name

The name of an Amazon Redshift table or view. For more information, see Names and identifiers.

Return type

VARCHAR

Usage notes

The PG_GET_COLS function returns one row for each column in the table or view definition. The row contains a comma-separated list with the schema name, relation name, column name, data type, and column number. The formatting of the result of the SQL depends on the SQL client used.

Examples

The following examples return results for a view named `SALES_VW` in schema `public` and table table named `sales` in schema `mytickit1` that are created by the user in the connected database `dev`.

The following example returns the column metadata for a view named `SALES_VW`.

```
select pg_get_cols('sales_vw');

pg_get_cols
-----------------------------------------------------------
(public,sales_vw,salesid,integer,1)
(public,sales_vw,listid,integer,2)
(public,sales_vw,sellerid,integer,3)
(public,sales_vw,buyerid,integer,4)
(public,sales_vw,eventid,integer,5)
(public,sales_vw,dateid,smallint,6)
(public,sales_vw,qtysold,smallint,7)
(public,sales_vw,pricepaid,"numeric(8,2)",8)
(public,sales_vw,commission,"numeric(8,2)",9)
(public,sales_vw,saletime,"timestamp without time zone",10)
```

The following example returns the column metadata for the `SALES_VW` view in table format.

```
select * from pg_get_cols('sales_vw')
cols(view_schema name, view_name name, col_name name, col_type varchar, col_num int);

view_schema | view_name | col_name   | col_type                      | col_num
------------+-----------+------------+-------------------------------+--------
public      | sales_vw  | salesid    | integer                       |       1
public      | sales_vw  | listid     | integer                       |       2
```

```
public       | sales_vw  | sellerid   | integer                     |       3
public       | sales_vw  | buyerid    | integer                     |       4
public       | sales_vw  | eventid    | integer                     |       5
public       | sales_vw  | dateid     | smallint                    |       6
public       | sales_vw  | qtysold    | smallint                    |       7
public       | sales_vw  | pricepaid  | numeric(8,2)                |       8
public       | sales_vw  | commission | numeric(8,2)                |       9
public       | sales_vw  | saletime   | timestamp without time zone |      10
```

The following example returns the column metadata for the `SALES` table in schema `mytickit1`in table format.

```
select * from pg_get_cols('"mytickit1"."sales"')
cols(view_schema name, view_name name, col_name name, col_type varchar, col_num int);

view_schema | view_name | col_name   | col_type                    | col_num
------------+-----------+------------+-----------------------------+--------
mytickit1   | sales     | salesid    | integer                     |       1
mytickit1   | sales     | listid     | integer                     |       2
mytickit1   | sales     | sellerid   | integer                     |       3
mytickit1   | sales     | buyerid    | integer                     |       4
mytickit1   | sales     | eventid    | integer                     |       5
mytickit1   | sales     | dateid     | smallint                    |       6
mytickit1   | sales     | qtysold    | smallint                    |       7
mytickit1   | sales     | pricepaid  | numeric(8,2)                |       8
mytickit1   | sales     | commission | numeric(8,2)                |       9
mytickit1   | sales     | saletime   | timestamp without time zone |      10
```

PG_GET_GRANTEE_BY_IAM_ROLE

Returns all users and groups granted a specified IAM role.

Syntax

```
pg_get_grantee_by_iam_role('iam_role_arn')
```

Arguments

iam_role_arn

The IAM role for which to return the users and groups that have been granted this role.

Return type

VARCHAR

Usage notes

The PG_GET_GRANTEE_BY_IAM_ROLE function returns one row for each user or group. Each row contains the grantee name, grantee type, and granted privilege. The possible values for the grantee type are p for public, u for user, and g for group.

You must be a superuser to use this function.

Example

The following example indicates that the IAM role `Redshift-S3-Write` is granted to `group1` and `reg_user1`. Users in `group_1` can specify the role only for COPY operations, and user `reg_user1` can specify the role only to perform UNLOAD operations.

```
select pg_get_grantee_by_iam_role('arn:aws:iam::123456789012:role/Redshift-S3-Write');
```

```
  pg_get_grantee_by_iam_role
-----------------------------
 (group_1,g,COPY)
 (reg_user1,u,UNLOAD)
```

The following example of the PG_GET_GRANTEE_BY_IAM_ROLE function formats the result as a table.

```
select grantee, grantee_type, cmd_type FROM
 pg_get_grantee_by_iam_role('arn:aws:iam::123456789012:role/Redshift-S3-Write')
 res_grantee(grantee text, grantee_type text, cmd_type text) ORDER BY 1,2,3;
```

```
  grantee  | grantee_type | cmd_type
-----------+--------------+----------
 group_1   | g            | COPY
 reg_user1 | u            | UNLOAD
```

PG_GET_IAM_ROLE_BY_USER

Returns all IAM roles and command privileges granted to a user.

Syntax

```
pg_get_iam_role_by_user('name')
```

Arguments

name

The name of the user for which to return IAM roles.

Return type

VARCHAR

Usage notes

The PG_GET_IAM_ROLE_BY_USER function returns one row for each set of roles and command privileges. The row contains a comma-separated list with the user name, IAM role, and command.

A value of `default` in the result indicates that the user can specify any available role to perform the displayed command.

You must be a superuser to use this function.

Example

The following example indicates that user `reg_user1` can specify any available IAM role to perform COPY operations. The user can also specify the `Redshift-S3-Write` role for UNLOAD operations.

```
select pg_get_iam_role_by_user('reg_user1');
```

```
                             pg_get_iam_role_by_user
---------------------------------------------------------------------------------
 (reg_user1,default,COPY)
 (reg_user1,arn:aws:iam::123456789012:role/Redshift-S3-Write,COPY|UNLOAD)
```

The following example of the PG_GET_IAM_ROLE_BY_USER function formats the result as a table.

```
select username, iam_role, cmd FROM pg_get_iam_role_by_user('reg_user1')
 res_iam_role(username text, iam_role text, cmd text);
```

```
 username  |                      iam_role                      | cmd
-----------+----------------------------------------------------+------
 reg_user1 | default                                            | None
 reg_user1 | arn:aws:iam::123456789012:role/Redshift-S3-Read | COPY
```

PG_GET_LATE_BINDING_VIEW_COLS

Returns the column metadata for all late-binding views in the database. For more information, see Late-binding views

Syntax

```
pg_get_late_binding_view_cols()
```

Return type

VARCHAR

Usage notes

The `PG_GET_LATE_BINDING_VIEW_COLS` function returns one row for each column in late-binding views. The row contains a comma-separated list with the schema name, relation name, column name, data type, and column number.

Example

The following example returns the column metadata for all late-binding views.

```
select pg_get_late_binding_view_cols();

pg_get_late_binding_view_cols
------------------------------------------------------------
(public,myevent,eventname,"character varying(200)",1)
(public,sales_lbv,salesid,integer,1)
(public,sales_lbv,listid,integer,2)
(public,sales_lbv,sellerid,integer,3)
(public,sales_lbv,buyerid,integer,4)
(public,sales_lbv,eventid,integer,5)
(public,sales_lbv,dateid,smallint,6)
(public,sales_lbv,qtysold,smallint,7)
```

```
(public,sales_lbv,pricepaid,"numeric(8,2)",8)
(public,sales_lbv,commission,"numeric(8,2)",9)
(public,sales_lbv,saletime,"timestamp without time zone",10)
(public,event_lbv,eventid,integer,1)
(public,event_lbv,venueid,smallint,2)
(public,event_lbv,catid,smallint,3)
(public,event_lbv,dateid,smallint,4)
(public,event_lbv,eventname,"character varying(200)",5)
(public,event_lbv,starttime,"timestamp without time zone",6)
```

The following example returns the column metadata for all late-binding views in table format.

```
select * from pg_get_late_binding_view_cols() cols(view_schema name, view_name name,
 col_name name, col_type varchar, col_num int);
view_schema | view_name | col_name   | col_type                    | col_num
------------+-----------+------------+-----------------------------+--------
public      | sales_lbv | salesid    | integer                     |       1
public      | sales_lbv | listid     | integer                     |       2
public      | sales_lbv | sellerid   | integer                     |       3
public      | sales_lbv | buyerid    | integer                     |       4
public      | sales_lbv | eventid    | integer                     |       5
public      | sales_lbv | dateid     | smallint                    |       6
public      | sales_lbv | qtysold    | smallint                    |       7
public      | sales_lbv | pricepaid  | numeric(8,2)                |       8
public      | sales_lbv | commission | numeric(8,2)                |       9
public      | sales_lbv | saletime   | timestamp without time zone |      10
public      | event_lbv | eventid    | integer                     |       1
public      | event_lbv | venueid    | smallint                    |       2
public      | event_lbv | catid      | smallint                    |       3
public      | event_lbv | dateid     | smallint                    |       4
public      | event_lbv | eventname  | character varying(200)      |       5
public      | event_lbv | starttime  | timestamp without time zone |       6
```

PG_GET_SESSION_ROLES

Returns session roles of the currently logged in user. Session roles of a user are the groups defined by an identity provider (IdP) for the logged in user. For example, an identity provider (IdP) such as Microsoft Azure Active Directory (Azure AD) verifies the identity of the user and provides any external groups the user is part of during the user login process. These external groups are transformed into Amazon Redshift roles and are available during the current session. These roles are called session roles. An administrator can grant privileges to a session role similar to other Amazon Redshift roles. For information about using roles, see Role-based access control (RBAC).

For information about managing identities with an identity provider (IdP), see Native identity provider (IdP) federation for Amazon Redshift in the *Amazon Redshift Management Guide*.

To view the roles defined in the Amazon Redshift catalog, query the system view SVV_ROLES.

Syntax

```
pg_get_session_roles()
```

Return type

A set of rows that consists of two values. The first value has two parts separated by a colon(:) that contains an `idp-namespace:role-name`. The `idp-namespace` is the namespace of the identity provider (IdP). The `role-name` is the name of the external group in the identity provider (IdP). The second value contains a `role-id` which is the role identifier.

Usage notes

The `PG_GET_SESSION_ROLES` function returns one row for each returned session role.

Examples

The following example returns one row for each role from the Azure Active Directory IdP. The returned columns are cast to `sess_roles` with columns `name` and `roleid`. Each `name` consists of the Azure Active Directory namespace and a group name in Azure Active Directory.

```
SELECT * FROM pg_get_session_roles() AS sess_roles(name name, roleid integer);

name                  roleid
--------------------------------
my_aad:test_group_1   106204
my_aad:test_group_2   106205
my_aad:test_group_3   106206
my_aad:test_group_4   106207
my_aad:test_group_5   106208
```

The following example returns one row for each IAM group that the currently logged in IAM user is a member of. The returned columns are cast to `sess_roles` with columns `name` and `roleid`. Each `name` consists of the IAM namespace and IAM group name.

```
SELECT * FROM pg_get_session_roles() AS sess_roles(name name, roleid integer);
```

```
name                     roleid
--------------------------------
IAM:myGroup              110332
```

PG_LAST_COPY_COUNT

Returns the number of rows that were loaded by the last COPY command run in the current session. PG_LAST_COPY_COUNT is updated with the last COPY ID, which is the query ID of the last COPY that began the load process, even if the load failed. The query ID and COPY ID are updated when the COPY command begins the load process.

If the COPY fails because of a syntax error or because of insufficient privileges, the COPY ID is not updated and PG_LAST_COPY_COUNT returns the count for the previous COPY. If no COPY commands were run in the current session, or if the last COPY failed during loading, PG_LAST_COPY_COUNT returns 0. For more information, see PG_LAST_COPY_ID.

Syntax

```
pg_last_copy_count()
```

Return type

Returns BIGINT.

Example

The following query returns the number of rows loaded by the latest COPY command in the current session.

```
select pg_last_copy_count();

pg_last_copy_count
--------------------
             192497
(1 row)
```

PG_LAST_COPY_ID

Returns the query ID of the most recently completed COPY command in the current session. If no COPY commands have been run in the current session, PG_LAST_COPY_ID returns -1.

The value for PG_LAST_COPY_ID is updated when the COPY command begins the load process. If the COPY fails because of invalid load data, the COPY ID is updated, so you can use PG_LAST_COPY_ID when you query STL_LOAD_ERRORS table. If the COPY transaction is rolled back, the COPY ID is not updated.

The COPY ID is not updated if the COPY command fails because of an error that occurs before the load process begins, such as a syntax error, access error, invalid credentials, or insufficient privileges. The COPY ID is not updated if the COPY fails during the analyze compression step, which begins after a successful connection, but before the data load.

Syntax

```
pg_last_copy_id()
```

Return type

Returns an integer.

Example

The following query returns the query ID of the latest COPY command in the current session.

```
select pg_last_copy_id();

pg_last_copy_id
---------------
          5437
(1 row)
```

The following query joins STL_LOAD_ERRORS to STL_LOADERROR_DETAIL to view the details errors that occurred during the most recent load in the current session:

```
select d.query, substring(d.filename,14,20),
d.line_number as line,
substring(d.value,1,16) as value,
substring(le.err_reason,1,48) as err_reason
from stl_loaderror_detail d, stl_load_errors le
where d.query = le.query
and d.query = pg_last_copy_id();

 query |    substring      | line |  value   |                    err_reason
```

```
-------+-------------------+------+----------
+---------------------------------------------
    558| allusers_pipe.txt |  251 | 251      | String contains invalid or unsupported
 UTF8 code
    558| allusers_pipe.txt |  251 | ZRU29FGR | String contains invalid or unsupported
 UTF8 code
    558| allusers_pipe.txt |  251 | Kaitlin  | String contains invalid or unsupported
 UTF8 code
    558| allusers_pipe.txt |  251 | Walter   | String contains invalid or unsupported
 UTF8 code
```

PG_LAST_UNLOAD_ID

Returns the query ID of the most recently completed UNLOAD command in the current session. If no UNLOAD commands have been run in the current session, PG_LAST_UNLOAD_ID returns -1.

The value for PG_LAST_UNLOAD_ID is updated when the UNLOAD command begins the load process. If the UNLOAD fails because of invalid load data, the UNLOAD ID is updated, so you can use the UNLOAD ID for further investigation. If the UNLOAD transaction is rolled back, the UNLOAD ID is not updated.

The UNLOAD ID is not updated if the UNLOAD command fails because of an error that occurs before the load process begins, such as a syntax error, access error, invalid credentials, or insufficient privileges.

Syntax

```
PG_LAST_UNLOAD_ID()
```

Return type

Returns an integer.

Example

The following query returns the query ID of the latest UNLOAD command in the current session.

```
select PG_LAST_UNLOAD_ID();

PG_LAST_UNLOAD_ID
---------------
```

```
           5437
(1 row)
```

PG_LAST_QUERY_ID

Returns the query ID of the most recently completed query in the current session. If no queries have been run in the current session, PG_LAST_QUERY_ID returns -1. PG_LAST_QUERY_ID does not return the query ID for queries that run exclusively on the leader node. For more information, see Leader node–only functions.

Syntax

```
pg_last_query_id()
```

Return type

Returns an integer.

Example

The following query returns the ID of the latest query completed in the current session.

```
select pg_last_query_id();
```

Results are the following.

```
pg_last_query_id
----------------
           5437
(1 row)
```

The following query returns the query ID and text of the most recently completed query in the current session.

```
select query, trim(querytxt) as sqlquery
from stl_query
where query = pg_last_query_id();
```

Results are the following.

```
query | sqlquery
------+--------------------------------------------------
 5437 | select name, loadtime from stl_file_scan where loadtime > 1000000;
(1 rows)
```

PG_LAST_UNLOAD_COUNT

Returns the number of rows that were unloaded by the last UNLOAD command completed in the current session. PG_LAST_UNLOAD_COUNT is updated with the query ID of the last UNLOAD, even if the operation failed. The query ID is updated when the UNLOAD is completed. If the UNLOAD fails because of a syntax error or because of insufficient privileges, PG_LAST_UNLOAD_COUNT returns the count for the previous UNLOAD. If no UNLOAD commands were completed in the current session, or if the last UNLOAD failed during the unload operation, PG_LAST_UNLOAD_COUNT returns 0.

Syntax

```
pg_last_unload_count()
```

Return type

Returns BIGINT.

Example

The following query returns the number of rows unloaded by the latest UNLOAD command in the current session.

```
select pg_last_unload_count();

pg_last_unload_count
--------------------
              192497
(1 row)
```

SLICE_NUM Function

Returns an integer corresponding to the slice number in the cluster where the data for a row is located. SLICE_NUM takes no parameters.

Syntax

```
SLICE_NUM()
```

Return type

The SLICE_NUM function returns an integer.

Examples

The following example shows which slices contain data for the first ten EVENT rows in the EVENTS table:

```
select distinct eventid, slice_num() from event order by eventid limit 10;

 eventid | slice_num
---------+-----------
       1 |         1
       2 |         2
       3 |         3
       4 |         0
       5 |         1
       6 |         2
       7 |         3
       8 |         0
       9 |         1
      10 |         2
(10 rows)
```

The following example returns a code (10000) to show that a query without a FROM statement runs on the leader node:

```
select slice_num();
slice_num
-----------
10000
(1 row)
```

USER

Synonym for CURRENT_USER. See CURRENT_USER.

ROLE_IS_MEMBER_OF

Returns true if the role is a member of another role. Superusers can check the membership of all roles. Regular users who have the ACCESS SYSTEM TABLE permission can check all users' membership. Otherwise, regular users can only check roles to which they have access. Amazon Redshift errors out if the provided roles don't exist or the current user doesn't have access to the role.

Syntax

```
role_is_member_of( role_name,  granted_role_name)
```

Arguments

role_name

The name of the role.

granted_role_name

The name of the granted role.

Return type

Returns a BOOLEAN.

Example

The following query confirms that the role isn't a member of role1 nor role2.

```
SELECT role_is_member_of('role1', 'role2');

 role_is_member_of
-------------------
             False
```

USER_IS_MEMBER_OF

Returns true if the user is a member of a role or group. Superusers can check the membership of all users. Regular users who are members of the sys:secadmin or sys:superuser role can check all users' membership. Otherwise, regular users can only check themselves. Amazon Redshift sends an error if the provided identities don't exist or the current user doesn't have access to the role.

Syntax

```
user_is_member_of( user_name,  role_name | group_name)
```

Arguments

user_name

The name of the user.

role_name

The name of the role.

group_name

The name of the group.

Return type

Returns a BOOLEAN.

Example

The following query confirms that the user isn't a member of role1.

```
SELECT user_is_member_of('reguser', 'role1');

 user_is_member_of
-------------------
           False
```

VERSION

The VERSION function returns details about the currently installed release, with specific Amazon Redshift version information at the end.

> **Note**
>
> This is a leader-node function. This function returns an error if it references a user-created table, an STL or STV system table, or an SVV or SVL system view.

Syntax

```
VERSION()
```

Return type

Returns a CHAR or VARCHAR string.

Examples

The following example shows the cluster version information of the current cluster:

```
select version();
```

```
version
------------------------------------------------------------------------------------------------------

PostgreSQL 8.0.2 on i686-pc-linux-gnu, compiled by GCC gcc (GCC) 3.4.2 20041017 (Red
Hat 3.4.2-6.fc3), Redshift 1.0.12103
```

Where `1.0.12103` is the cluster version number.

> **Note**
>
> To force your cluster to update to the latest cluster version, adjust your maintenance window.

Reserved words

The following is a list of Amazon Redshift reserved words. You can use the reserved words with delimited identifiers (double quotation marks).

> **Note**
>
> While START and CONNECT are not reserved words, use delimited identifiers or AS if you're using START and CONNECT as table aliases in your query to avoid failure at runtime.

For more information, see Names and identifiers.

```
AES128
AES256
ALL
ALLOWOVERWRITE
ANALYSE
ANALYZE
AND
ANY
ARRAY
AS
ASC
AUTHORIZATION
AZ64
BACKUP
BETWEEN
BINARY
BLANKSASNULL
BOTH
BYTEDICT
BZIP2
CASE
CAST
CHECK
COLLATE
COLUMN
CONSTRAINT
CREATE
CREDENTIALS
CROSS
CURRENT_DATE
CURRENT_TIME
CURRENT_TIMESTAMP
CURRENT_USER
CURRENT_USER_ID
DEFAULT
DEFERRABLE
DEFLATE
DEFRAG
DELTA
DELTA32K
DESC
DISABLE
```

```
DISTINCT
DO
ELSE
EMPTYASNULL
ENABLE
ENCODE
ENCRYPT
ENCRYPTION
END
EXCEPT
EXPLICIT
FALSE
FOR
FOREIGN
FREEZE
FROM
FULL
GLOBALDICT256
GLOBALDICT64K
GRANT
GROUP
GZIP
HAVING
IDENTITY
IGNORE
ILIKE
IN
INITIALLY
INNER
INTERSECT
INTERVAL
INTO
IS
ISNULL
JOIN
LEADING
LEFT
LIKE
LIMIT
LOCALTIME
LOCALTIMESTAMP
LUN
LUNS
LZO
```

```
LZOP
MINUS
MOSTLY16
MOSTLY32
MOSTLY8
NATURAL
NEW
NOT
NOTNULL
NULL
NULLS
OFF
OFFLINE
OFFSET
OID
OLD
ON
ONLY
OPEN
OR
ORDER
OUTER
OVERLAPS
PARALLEL
PARTITION
PERCENT
PERMISSIONS
PIVOT
PLACING
PRIMARY
RAW
READRATIO
RECOVER
REFERENCES
REJECTLOG
RESORT
RESPECT
RESTORE
RIGHT
SELECT
SESSION_USER
SIMILAR
SNAPSHOT
SOME
```

```
SYSDATE
SYSTEM
TABLE
TAG
TDES
TEXT255
TEXT32K
THEN
TIMESTAMP
TO
TOP
TRAILING
TRUE
TRUNCATECOLUMNS
UNION
UNIQUE
UNNEST
UNPIVOT
USER
USING
VERBOSE
WALLET
WHEN
WHERE
WITH
WITHOUT
```

System tables and views reference

Amazon Redshift has many system tables and views that contain information about how the system is functioning. You can query these system tables and views the same way that you would query any other database tables. This section shows some sample system table queries and explains:

- How different types of system tables and views are generated
- What types of information you can obtain from these tables
- How to join Amazon Redshift system tables to catalog tables
- How to manage the growth of system table log files

Some system tables can only be used by AWS staff for diagnostic purposes. The following sections discuss the system tables that can be queried for useful information by system administrators or other database users.

> **Note**
>
> System tables are not included in automated or manual cluster backups (snapshots). STL system views retain seven days of log history. Retaining logs doesn't require any customer action, but if you want to store log data for more than 7 days, you have to periodically copy it to other tables or unload it to Amazon S3.

Topics

- System catalog tables

Types of system tables and views

There are several types of system tables and views:

- SVV views contain information about database objects with references to transient STV tables.
- SYS views are used to monitor query and workload usage for provisioned clusters and serverless workgroups.
- STL views are generated from logs that have been persisted to disk to provide a history of the system.
- STV tables are virtual system tables that contain snapshots of the current system data. They are based on transient in-memory data and are not persisted to disk-based logs or regular tables.
- SVCS views provide details about queries on both the main and concurrency scaling clusters.
- SVL views provide details about queries on main clusters.

System tables and views do not use the same consistency model as regular tables. It is important to be aware of this issue when querying them, especially for STV tables and SVV views. For example, given a regular table t1 with a column c1, you would expect that the following query to return no rows:

```
select * from t1
where c1 > (select max(c1) from t1)
```

However, the following query against a system table might well return rows:

```
select * from stv_exec_state
where currenttime > (select max(currenttime) from stv_exec_state)
```

The reason this query might return rows is that currenttime is transient and the two references in the query might not return the same value when evaluated.

On the other hand, the following query might well return no rows:

```
select * from stv_exec_state
where currenttime = (select max(currenttime) from stv_exec_state)
```

Visibility of data in system tables and views

> **Note**
>
> Amazon Redshift automatically masks certain system table columns when logging information about queries made to Data Catalog views to prevent exposure of sensitive metadata. For more information, see Secure logging in the *Amazon Redshift Management Guide*.

There are two classes of visibility for data in system tables and views: visible to users and visible to superusers.

Only users with superuser privileges can see the data in those tables that are in the superuser-visible category. Regular users can see data in the user-visible tables. To give a regular user access to superuser-visible tables, grant SELECT privilege on that table to the regular user. For more information, see GRANT.

By default, in most user-visible tables, rows generated by another user are invisible to a regular user. If a regular user is given SYSLOG ACCESS UNRESTRICTED, that user can see all rows in user-visible tables, including rows generated by another user. For more information, see ALTER USER or CREATE USER. All rows in SVV_TRANSACTIONS are visible to all users. For more information about data visibility, see the AWS re:Post knowledge base article How can I allow Amazon Redshift database regular users permission to view data in system tables from other users for my cluster?.

For metadata views, Amazon Redshift doesn't allow visibility to users that are granted SYSLOG ACCESS UNRESTRICTED.

> **Note**
>
> Giving a user unrestricted access to system tables gives the user visibility to data generated by other users. For example, STL_QUERY and STL_QUERY_TEXT contain the full text of INSERT, UPDATE, and DELETE statements, which might contain sensitive user-generated data.

A superuser can see all rows in all tables. To give a regular user access to superuser-visible tables, GRANT SELECT privilege on that table to the regular user.

Filtering system-generated queries

The query-related system tables and views, such as SVL_QUERY_SUMMARY, SVL_QLOG, and others, usually contain a large number of automatically generated statements that Amazon Redshift uses to monitor the status of the database. These system-generated queries are visible to a superuser, but are seldom useful. To filter them out when selecting from a system table or system view that uses the `userid` column, add the condition `userid > 1` to the WHERE clause. For example:

```
select * from svl_query_summary where userid > 1
```

Migrating provisioned-only queries to SYS monitoring view queries

Migrating from provisioned clusters to Amazon Redshift Serverless

If you're migrating a provisioned cluster to Amazon Redshift Serverless, you may have queries using the following system views, which only store data from provisioned clusters.

- All STL views
- All STV views
- All SVCS views
- All SVL views
- Some SVV views
  - For a full list of SVV views unsupported in Amazon Redshift Serverless, see the list at the bottom of Monitoring queries and workloads with Amazon Redshift Serverless in the *Amazon Redshift Management Guide*.

To keep using your queries, refit them to use columns defined in the SYS monitoring views that correspond to the columns in your provisioned-only views. To see the mapping relation between the provisioned-only views and the SYS monitoring views, go to System view mapping for migrating to SYS monitoring views

Updating queries while staying on a provisioned cluster

If you're not migrating to Amazon Redshift Serverless, you might still want to update your existing queries. The SYS monitoring views are designed for ease of use and reduced complexity, providing a complete array of metrics for effective monitoring and troubleshooting. Using SYS views such as SYS_QUERY_HISTORY and SYS_QUERY_DETAIL that consolidate the information of multiple provisioned-only views, you can streamline your queries.

Improving query identifier tracking using the SYS monitoring views

SYS monitoring views such as such as SYS_QUERY_HISTORY and SYS_QUERY_DETAIL contain the query_id column, which holds the identifier for users' queries. Similarly, provisioned-only views such as STL_QUERY and SVL_QLOG contain the query column, which also holds the query identifiers. However, the query identifiers recorded in the SYS system views are different from those recorded in the provisioned-only views.

The difference between the SYS views' query_id column values and the provisioned-only views' query column values is as follows:

- In SYS views, the query_id column records user-submitted queries in their original form. The Amazon Redshift optimizer might break them down into child queries for improved performance, but a single query you run will still only have a single row in SYS_QUERY_HISTORY. If you want to see the individual child queries, you can find them in SYS_QUERY_DETAIL.
- In provisioned-only views, the query column records queries at the child query level. If the Amazon Redshift optimizer rewrites your original query into multiple child queries, there will be multiple rows in STL_QUERY with differing query identifier values for a single query you run.

When you migrate your monitoring and diagnostic queries from provisioned-only views to SYS views, consider this difference and edit your queries accordingly. For more information on how Amazon Redshift processes queries, see Query planning and execution workflow.

Example

For an example of how Amazon Redshift records queries differently in provisioned-only and SYS monitoring views, see the following sample query. This is the query written as you would run it in Amazon Redshift.

```
SELECT
  s_name
  , COUNT(*) AS numwait
FROM
  supplier,
  lineitem l1,
  orders,
  nation
WHERE    s_suppkey = l1.l_suppkey
         AND o_orderkey = l1.l_orderkey
         AND o_orderstatus = 'F'
         AND l1.l_receiptdate > l1.l_commitdate
         AND EXISTS (SELECT
                       *
                     FROM
                       lineitem l2
                     WHERE  l2.l_orderkey = l1.l_orderkey
                            AND l2.l_suppkey <> l1.l_suppkey )
         AND NOT EXISTS (SELECT
                           *
                         FROM
                           lineitem l3
                         WHERE  l3.l_orderkey = l1.l_orderkey
                                AND l3.l_suppkey <> l1.l_suppkey
                                AND l3.l_receiptdate > l3.l_commitdate )
         AND s_nationkey = n_nationkey
         AND n_name = 'UNITED STATES'
GROUP BY
  s_name
ORDER BY
  numwait DESC
  , s_name LIMIT 100;
```

Under the hood the Amazon Redshift query optimizer rewrites the above user-submitted query into 5 child queries.

The first child query creates a temporary table to materialize a subquery.

```
CREATE TEMP TABLE volt_tt_606590308b512(l_orderkey
                                        , l_suppkey
                                        , s_name   ) AS SELECT
                                                         l1.l_orderkey
                                                         , l1.l_suppkey
```

```
                                                              , public.supplier.s_name
                                                            FROM
                                                              public.lineitem AS l1,
                                                              public.nation,
                                                              public.orders,
                                                              public.supplier
                                                            WHERE  l1.l_commitdate <
 l1.l_receiptdate
                                                                   AND l1.l_orderkey =
 public.orders.o_orderkey
                                                                   AND l1.l_suppkey =
 public.supplier.s_suppkey
                                                                   AND public.nation.n_name
 = 'UNITED STATES'::CHAR(8)
                                                                   AND
 public.nation.n_nationkey = public.supplier.s_nationkey
                                                                   AND
 public.orders.o_orderstatus = 'F'::CHAR(1);
```

The second child query collects statistics from the temporary table.

```
padb_fetch_sample: select count(*) from volt_tt_606590308b512;
```

The third child query creates another temporary table to materialize another subquery, referencing the temporary table created above.

```
CREATE TEMP TABLE volt_tt_606590308c2ef(l_orderkey
                                        , l_suppkey) AS (SELECT

 volt_tt_606590308b512.l_orderkey
                                                                ,
 volt_tt_606590308b512.l_suppkey
                                                             FROM
                                                               public.lineitem AS l2,
                                                               volt_tt_606590308b512
                                                             WHERE  l2.l_suppkey <>
 volt_tt_606590308b512.l_suppkey
                                                                    AND l2.l_orderkey =
 volt_tt_606590308b512.l_orderkey)
                                                                    EXCEPT distinct (SELECT
 volt_tt_606590308b512.l_orderkey, volt_tt_606590308b512.l_suppkey
                                                                    FROM public.lineitem AS
 l3, volt_tt_606590308b512
```

```
                                                              WHERE l3.l_commitdate <
 l3.l_receiptdate
                                                                AND l3.l_suppkey <>
 volt_tt_606590308b512.l_suppkey
                                                                AND l3.l_orderkey =
 volt_tt_606590308b512.l_orderkey);
```

The fourth child query again collects the temporary table's statistics.

```
padb_fetch_sample: select count(*) from volt_tt_606590308c2ef
```

The last child query uses the temporary tables created above to generate the output.

```
SELECT
  volt_tt_606590308b512.s_name AS s_name
  , COUNT(*) AS numwait
FROM
  volt_tt_606590308b512,
  volt_tt_606590308c2ef
WHERE    volt_tt_606590308b512.l_orderkey = volt_tt_606590308c2ef.l_orderkey
         AND volt_tt_606590308b512.l_suppkey = volt_tt_606590308c2ef.l_suppkey
GROUP BY
  1
ORDER BY
  2 DESC
  , 1 ASC LIMIT 100;
```

In the provisioned-only system view STL_QUERY, Amazon Redshift records five rows at the child query level, as follows:

```
SELECT userid, xid, pid, query, querytxt::varchar(100);
FROM stl_query
WHERE xid = 48237350
ORDER BY xid, starttime;

 userid |   xid    |    pid     |  query   |
    querytxt
--------+----------+------------+----------
+---------------------------------------------------------------------------------------------------
    101 | 48237350 | 1073840810 | 12058151 | CREATE TEMP TABLE
 volt_tt_606590308b512(l_orderkey, l_suppkey, s_name) AS SELECT l1.l_orderkey, l1.l
```

```
    101 | 48237350 | 1073840810 | 12058152 | padb_fetch_sample: select count(*) from
 volt_tt_606590308b512
    101 | 48237350 | 1073840810 | 12058156 | CREATE TEMP TABLE
 volt_tt_606590308c2ef(l_orderkey, l_suppkey) AS (SELECT volt_tt_606590308b512.l_or
    101 | 48237350 | 1073840810 | 12058168 | padb_fetch_sample: select count(*) from
 volt_tt_606590308c2ef
    101 | 48237350 | 1073840810 | 12058170 | SELECT s_name , COUNT(*) AS numwait FROM
 supplier, lineitem l1, orders, nation WHERE s_suppkey = l1.
(5 rows)
```

In the SYS monitoring view SYS_QUERY_HISTORY, Amazon Redshift records the query as follows:

```
SELECT user_id, transaction_id, session_id, query_id, query_text::varchar(100)
FROM sys_query_history
WHERE transaction_id = 48237350
ORDER BY start_time;

 user_id | transaction_id | session_id | query_id |
         query_text
---------+----------------+------------+----------
+-----------------------------------------------------------------------------------------
     101 |       48237350 | 1073840810 | 12058149 | SELECT s_name , COUNT(*) AS numwait
 FROM supplier, lineitem l1, orders, nation WHERE s_suppkey = l1.
```

In SYS_QUERY_DETAIL, you can find child query-level details using the query_id value from SYS_QUERY_HISTORY. The child_query_sequence column shows the order the child queries are executed in. For more information on the columns in SYS_QUERY_DETAIL, see SYS_QUERY_DETAIL.

```
select user_id,
       query_id,
       child_query_sequence,
       stream_id,
       segment_id,
       step_id,
       start_time,
       end_time,
       duration,
       blocks_read,
       blocks_write,
       local_read_io,
       remote_read_io,
       data_skewness,
       time_skewness,
```

```
       is_active,
       spilled_block_local_disk,
       spilled_block_remote_disk
from sys_query_detail
where query_id = 12058149
      and step_id = -1
order by query_id,
         child_query_sequence,
         stream_id,
         segment_id,
         step_id;

 user_id | query_id | child_query_sequence | stream_id | segment_id | step_id |
       start_time          |          end_time           | duration | blocks_read |
 blocks_write | local_read_io | remote_read_io | data_skewness | time_skewness |
 is_active | spilled_block_local_disk | spilled_block_remote_disk
---------+----------+----------------------+-----------+------------+---------
+----------------------------+----------------------------+----------+-------------
+--------------+---------------+----------------+---------------+---------------
+-----------+--------------------------+--------------------------
     101 | 12058149 |                    1 |         0 |          0 |      -1 |
 2023-09-27 15:40:38.512415 | 2023-09-27 15:40:38.533333 |    20918 |           0 |
         0 |             0 |              0 |             0 |            44 | f
 |                        0 |                          0
     101 | 12058149 |                    1 |         1 |          1 |      -1 |
 2023-09-27 15:40:39.931437 | 2023-09-27 15:40:39.972826 |    41389 |          12 |
         0 |            12 |              0 |             0 |            77 | f
 |                        0 |                          0
     101 | 12058149 |                    1 |         2 |          2 |      -1 |
 2023-09-27 15:40:40.584412 | 2023-09-27 15:40:40.613982 |    29570 |          32 |
         0 |            32 |              0 |             0 |            25 | f
 |                        0 |                          0
     101 | 12058149 |                    1 |         2 |          3 |      -1 |
 2023-09-27 15:40:40.582038 | 2023-09-27 15:40:40.615758 |    33720 |           0 |
         0 |             0 |              0 |             0 |             1 | f
 |                        0 |                          0
     101 | 12058149 |                    1 |         3 |          4 |      -1 |
 2023-09-27 15:40:46.668766 | 2023-09-27 15:40:46.705456 |    36690 |          24 |
         0 |            15 |              0 |             0 |            17 | f
 |                        0 |                          0
     101 | 12058149 |                    1 |         4 |          5 |      -1 |
 2023-09-27 15:40:46.707209 | 2023-09-27 15:40:46.709176 |     1967 |           0 |
         0 |             0 |              0 |             0 |            18 | f
 |                        0 |                          0
```

```
    101 | 12058149 |                    1 |         4 |          6 |       -1 |
 2023-09-27 15:40:46.70656  | 2023-09-27 15:40:46.71289  |     6330 |            0 |
        0 |              0 |                0 |              0 |              0 | f
 |                       0 |                         0
    101 | 12058149 |                    1 |         5 |          7 |       -1 |
 2023-09-27 15:40:46.71405  | 2023-09-27 15:40:46.714343 |      293 |            0 |
        0 |              0 |                0 |              0 |              0 | f
 |                       0 |                         0
    101 | 12058149 |                    2 |         0 |          0 |       -1 |
 2023-09-27 15:40:52.083907 | 2023-09-27 15:40:52.087854 |     3947 |            0 |
        0 |              0 |                0 |              0 |             35 | f
 |                       0 |                         0
    101 | 12058149 |                    2 |         1 |          1 |       -1 |
 2023-09-27 15:40:52.089632 | 2023-09-27 15:40:52.091129 |     1497 |            0 |
        0 |              0 |                0 |              0 |             11 | f
 |                       0 |                         0
    101 | 12058149 |                    2 |         1 |          2 |       -1 |
 2023-09-27 15:40:52.089008 | 2023-09-27 15:40:52.091306 |     2298 |            0 |
        0 |              0 |                0 |              0 |              0 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         0 |          0 |       -1 |
 2023-09-27 15:40:56.882013 | 2023-09-27 15:40:56.897282 |    15269 |            0 |
        0 |              0 |                0 |              0 |             29 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         1 |          1 |       -1 |
 2023-09-27 15:40:59.718554 | 2023-09-27 15:40:59.722789 |     4235 |            0 |
        0 |              0 |                0 |              0 |             13 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         2 |          2 |       -1 |
 2023-09-27 15:40:59.800382 | 2023-09-27 15:40:59.807388 |     7006 |            0 |
        0 |              0 |                0 |              0 |             58 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         3 |          3 |       -1 |
 2023-09-27 15:41:06.488685 | 2023-09-27 15:41:06.493825 |     5140 |            0 |
        0 |              0 |                0 |              0 |             56 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         3 |          4 |       -1 |
 2023-09-27 15:41:06.486206 | 2023-09-27 15:41:06.497756 |    11550 |            0 |
        0 |              0 |                0 |              0 |              2 | f
 |                       0 |                         0
    101 | 12058149 |                    3 |         4 |          5 |       -1 |
 2023-09-27 15:41:06.499201 | 2023-09-27 15:41:06.500851 |     1650 |            0 |
        0 |              0 |                0 |              0 |             15 | f
 |                       0 |                         0
```

```
    101 | 12058149 |                    3 |          4 |           6 |       -1 |
 2023-09-27 15:41:06.498609 | 2023-09-27 15:41:06.500949 |     2340 |            0 |
        0 |              0 |                0 |               0 |               0 | f
 |                       0 |                           0
    101 | 12058149 |                    3 |          5 |           7 |       -1 |
 2023-09-27 15:41:06.502945 | 2023-09-27 15:41:06.503282 |      337 |            0 |
        0 |              0 |                0 |               0 |               0 | f
 |                       0 |                           0
    101 | 12058149 |                    4 |          0 |           0 |       -1 |
 2023-09-27 15:41:06.62899  | 2023-09-27 15:41:06.631452 |     2462 |            0 |
        0 |              0 |                0 |               0 |              22 | f
 |                       0 |                           0
    101 | 12058149 |                    4 |          1 |           1 |       -1 |
 2023-09-27 15:41:06.632313 | 2023-09-27 15:41:06.63391  |     1597 |            0 |
        0 |              0 |                0 |               0 |              20 | f
 |                       0 |                           0
    101 | 12058149 |                    4 |          1 |           2 |       -1 |
 2023-09-27 15:41:06.631726 | 2023-09-27 15:41:06.633813 |     2087 |            0 |
        0 |              0 |                0 |               0 |               0 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          0 |           0 |       -1 |
 2023-09-27 15:41:12.571974 | 2023-09-27 15:41:12.584234 |    12260 |            0 |
        0 |              0 |                0 |               0 |              39 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          0 |           1 |       -1 |
 2023-09-27 15:41:12.569815 | 2023-09-27 15:41:12.585391 |    15576 |            0 |
        0 |              0 |                0 |               0 |               4 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          1 |           2 |       -1 |
 2023-09-27 15:41:13.758513 | 2023-09-27 15:41:13.76401  |     5497 |            0 |
        0 |              0 |                0 |               0 |              39 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          1 |           3 |       -1 |
 2023-09-27 15:41:13.749    | 2023-09-27 15:41:13.772987 |    23987 |            0 |
        0 |              0 |                0 |               0 |              32 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          2 |           4 |       -1 |
 2023-09-27 15:41:13.799526 | 2023-09-27 15:41:13.813506 |    13980 |            0 |
        0 |              0 |                0 |               0 |              62 | f
 |                       0 |                           0
    101 | 12058149 |                    5 |          2 |           5 |       -1 |
 2023-09-27 15:41:13.798823 | 2023-09-27 15:41:13.813651 |    14828 |            0 |
        0 |              0 |                0 |               0 |               0 | f
 |                       0 |                           0
```

```
(28 rows)
```

System table query, process, and session ids

When analyzing query, process, and session ids that appear in system tables, be aware of the following:

- The query id value (in columns such as `query_id` and `query`) can be reused over time.
- The process id or session id value (in columns such as `process_id`, `pid`, and `session_id`) can be reused over time.
- The transaction id value (in columns such as `transaction_id` and `xid`) is unique.

SVV metadata views

SVV views are system views in Amazon Redshift that contain information about database objects. Note that although they store information such as user permissions or table names, they're not meant for joining with user-created relations.

> **Note**
>
> Amazon Redshift reports a WARNING, not an ERROR, if a database response fails for any reason. Amazon Redshift doesn't send ERROR messages when you're querying objects in a datashare.

Topics

- SVV_QUERY_STATE
- SVV_REDSHIFT_COLUMNS
- SVV_REDSHIFT_DATABASES
- SVV_REDSHIFT_FUNCTIONS
- SVV_REDSHIFT_SCHEMA_QUOTA
- SVV_REDSHIFT_SCHEMAS
- SVV_REDSHIFT_TABLES
- SVV_RELATION_PRIVILEGES
- SVV_RLS_APPLIED_POLICY
- SVV_RLS_ATTACHED_POLICY
- SVV_RLS_POLICY
- SVV_RLS_RELATION
- SVV_ROLE_GRANTS
- SVV_ROLES
- SVV_SCHEMA_PRIVILEGES
- SVV_SCHEMA_QUOTA_STATE
- SVV_SYSTEM_PRIVILEGES
- SVV_TABLE_INFO
- SVV_TABLES
- SVV_TRANSACTIONS
- SVV_USER_GRANTS
- SVV_USER_INFO
- SVV_VACUUM_PROGRESS
- SVV_VACUUM_SUMMARY

SVV_ACTIVE_CURSORS

SVV_ACTIVE_CURSORS displays details for currently open cursors. For more information, see DECLARE.

SVV_ACTIVE_CURSORS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views. A user can only view cursors opened by that user. A superuser can view all cursors.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user who created the cursor.
cursor_name	varchar(128)	The name of the cursor.
transaction_id	bigint(128)	The ID of the transaction.
session_id	integer	The ID of the process with the active cursor.
declare_time	timestamp	The time the cursor was declared.
total_bytes	bigint	The size of the cursor result set, in bytes.
total_rows	bigint	The number of rows in the cursor result set.
fetched_rows	bigint	The number of rows currently fetched from the cursor result set.
cursor_storage_limit_used_percent	integer	The percentage of disk space currently used by the cursor.

SVV_ALL_COLUMNS

Use SVV_ALL_COLUMNS to view a union of columns from Amazon Redshift tables as shown in SVV_REDSHIFT_COLUMNS and the consolidated list of all external columns from all external tables. For information about Amazon Redshift columns, see SVV_REDSHIFT_COLUMNS.

SVV_ALL_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database.
schema_name	varchar(128)	The name of the schema.
table_name	varchar(128)	The name of the table.
column_name	varchar(128)	The name of the column.
ordinal_position	integer	The position of the column in the table.
column_default	varchar(4000)	The default value of the column.
is_nullable	varchar(3)	A value that indicates whether the column is nullable. Possible values are yes and no.
data_type	varchar(128)	The data type of the column.
character_maximum_length	integer	The maximum number of characters in the column.
numeric_precision	integer	The numeric precision.
numeric_scale	integer	The numeric scale.
remarks	varchar(256)	Remarks.

Sample queries

The following example returns the output of SVV_ALL_COLUMNS.

```
SELECT *
FROM svv_all_columns
WHERE database_name = 'tickit_db'
    AND TABLE_NAME = 'tickit_sales_redshift'
ORDER BY COLUMN_NAME,
    SCHEMA_NAME
LIMIT 5;

 database_name | schema_name |     table_name        | column_name | ordinal_position
 | column_default | is_nullable | data_type | character_maximum_length |
 numeric_precision | numeric_scale | remarks
 --------------+-------------+----------------------+-------------+------------------
+----------------+-------------+-----------+-------------------------
+-------------------+--------------+---------
   tickit_db    |    public    | tickit_sales_redshift |    buyerid   |        4          |
                |      NO      |  integer  |                            |         32
   |       0        |
   tickit_db    |    public    | tickit_sales_redshift | commission   |        9          |
                |     YES      |  numeric  |                            |          8
   | 2          |
   tickit_db    |    public    | tickit_sales_redshift |    dateid    |        7          |
                |      NO      |  smallint |                            |         16
   |       0        |
   tickit_db    |    public    | tickit_sales_redshift |   eventid    |        5          |
                |      NO      |  integer  |                            |         32
   |       0        |
   tickit_db    |    public    | tickit_sales_redshift |    listid    |        2          |
                |      NO      |  integer  |                            |         32
   |       0        |
```

SVV_ALL_SCHEMAS

Use SVV_ALL_SCHEMAS to view a union of Amazon Redshift schemas as shown in SVV_REDSHIFT_SCHEMAS and the consolidated list of all external schemas from all databases. For more information about Amazon Redshift schemas, see SVV_REDSHIFT_SCHEMAS.

SVV_ALL_SCHEMAS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where the schema exists.
schema_name	varchar(128)	The name of the schema.
schema_owner	integer	The user ID of the schema owner. For information about user IDs, see PG_USER_INFO.
schema_type	varchar(128)	The type of the schema. Possible values are external, local, and shared schemas.
schema_acl	varchar(128)	The string that defines the permissions for the specified user or user group for the schema.
source_database	varchar(128)	The name of the source database for external schema.
schema_option	varchar(256)	The options of the schema. This is an external schema attribute.

Sample query

The following example returns the output of SVV_ALL_SCHEMAS.

```
SELECT *
FROM svv_all_schemas
WHERE database_name = 'tickit_db'
ORDER BY database_name,
    SCHEMA_NAME;
```

```
 database_name |     schema_name      | schema_owner | schema_type | schema_acl |
 source_database | schema_option
---------------+--------------------+-------------+------------+-----------
+----------------+---------------
   tickit_db   |       public       |       1      |   shared    |            |
            |
```

SVV_ALL_TABLES

Use SVV_ALL_TABLES to view a union of Amazon Redshift tables as shown in SVV_REDSHIFT_TABLES and the consolidated list of all external tables from all external schemas. For information about Amazon Redshift tables, see SVV_REDSHIFT_TABLES.

SVV_ALL_TABLES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where the table exists.
schema_name	varchar(128)	The schema name for the table.
table_name	varchar(128)	The name of the table.
table_acl	varchar(128)	The string that defines the permission for the specified user or user group for the table.
table_type	varchar(128)	The type of the table. Possible values are views, base tables, external tables, and shared tables.
remarks	varchar(256)	Remarks.

Sample queries

The following example returns the output of SVV_ALL_TABLES.

```
SELECT *
FROM svv_all_tables
WHERE database_name = 'tickit_db'
ORDER BY TABLE_NAME,
    SCHEMA_NAME
LIMIT 5;

 database_name | schema_name |        table_name        | table_type | table_acl |
 remarks
---------------+-------------+--------------------------+------------+-----------
+---------
   tickit_db   |    public   | tickit_category_redshift |    TABLE   |            |
   tickit_db   |    public   |   tickit_date_redshift   |    TABLE   |            |
   tickit_db   |    public   |   tickit_event_redshift  |    TABLE   |            |
   tickit_db   |    public   | tickit_listing_redshift  |    TABLE   |            |
   tickit_db   |    public   |   tickit_sales_redshift  |    TABLE   |            |
```

If the table_acl value is null, no access privileges have been explicitly granted to the corresponding table.

SVV_ALTER_TABLE_RECOMMENDATIONS

Records the current Amazon Redshift Advisor recommendations for tables. This view shows recommendations for all tables, whether they are defined for automatic optimization or not. To view if a table is defined for automatic optimization, see SVV_TABLE_INFO. Entries appear only for tables visible in the current session's database. After a recommendation has been applied (either by Amazon Redshift or by you), it no longer appears in the view.

SVV_ALTER_TABLE_RECOMMENDATIONS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
type	character (30)	The type of recommendation. Possible values are distkey and sortkey.
database	character (128)	The database name.
table_id	integer	The table identifier.
group_id	integer	The group number of a set of recommendations. All recommend ations in a group should be applied to see the maximum benefit. Possible values are -1 for a sort key recommendation, and a number larger than zero for a distribution key recommendation.
ddl	character (1024)	The SQL statement that must run to apply the recommendation.
auto_eligible	character (1)	The value indicates if the recommendation is eligible for Amazon Redshift to run automatically. If this value is `t`, then the indication is true, if `f` then false.

Sample queries

In the following example, the rows in the result show recommendations for distribution key and sort key. The rows also show whether the recommendations are eligible for Amazon Redshift to automatically apply them.

```
select type, database, table_id, group_id, ddl, auto_eligible
from svv_alter_table_recommendations;
```

```
 type      | database | table_id | group_id | ddl

                     | auto_eligible
```

```
diststyle | db0      | 117884   | 2         | ALTER TABLE "sch"."dp21235_tbl_1" ALTER
DISTSTYLE KEY DISTKEY "c0"
                     | f
diststyle | db0      | 117892   | 2         | ALTER TABLE "sch"."dp21235_tbl_1" ALTER
DISTSTYLE KEY DISTKEY "c0"
                     | f
diststyle | db0      | 117885   | 1         | ALTER TABLE "sch"."catalog_returns"
ALTER DISTSTYLE KEY DISTKEY "cr_sold_date_sk", ALTER COMPOUND SORTKEY
("cr_sold_date_sk","cr_returned_time_sk") | t
sortkey   | db0      | 117890   | -1        | ALTER TABLE "sch"."customer_addresses"
ALTER COMPOUND SORTKEY ("ca_address_sk")
                      | t
```

SVV_ATTACHED_MASKING_POLICY

Use SVV_ATTACHED_MASKING_POLICY to view all the relations and roles/users with policies attached on the currently connected database.

Only superusers and users with the `sys:secadmin` role can view SVV_ATTACHED_MASKING_POLICY. Regular users will see 0 rows.

Table columns

Column name	Data type	Description
policy_name	text	The name of the masking policy attached to the table.
schema_name	text	The schema of the table to which the policy is attached.
table_name	text	The name of the table to which the policy is attached.
table_type	text	The type of the table to which the policy is attached.
grantor	text	The name of the user that attached the policy.

Column name	Data type	Description
grantee	text	The name of the user/role to whom the policy is attached.
grantee_type	text	The type of grantee. This can be *role*, *user*, or *public*.
priority	int	The priority of the attached policy.
input_columns	text	The input column attributes of the attached policy.
output_columns	text	The output column attributes of the attached policy.
is_masking_datashare_on	boolean	Whether the table to which the policy is attached is DDM-protected over datashares.

Internal functions

SVV_ATTACHED_MASKING_POLICY supports the following internal functions:

mask_get_policy_for_role_on_column

Get the highest priority policy that applies to a given column/role pair.

Syntax

```
mask_get_policy_for_role_on_column
                        (relschema,
                        relname,
                        colname,
                        rolename);
```

Parameters

relschema

The name of the schema the policy is in.

relname

The name of the table the policy is in.

colname

The name of the column the policy is attached to.

rolename

The name of the role the policy is attached to.

mask_get_policy_for_user_on_column

Get the highest priority policy that applies to a given column/user pair.

Syntax

```
mask_get_policy_for_user_on_column
                        (relschema,
                        relname,
                        colname,
                        username);
```

Parameters

relschema

The name of the schema the policy is in.

relname

The name of the table the policy is in.

colname

The name of the column the policy is attached to.

rolename

The name of the user the policy is attached to.

SVV_COLUMNS

Use SVV_COLUMNS to view catalog information about the columns of local and external tables and views, including late-binding views.

SVV_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

The SVV_COLUMNS view joins table metadata from the System catalog tables (tables with a PG prefix) and the SVV_EXTERNAL_COLUMNS system view. The system catalog tables describe Amazon Redshift database tables. SVV_EXTERNAL_COLUMNS describes external tables that are used with Amazon Redshift Spectrum.

All users can see all rows from the system catalog tables. Regular users can see column definitions from the SVV_EXTERNAL_COLUMNS view only for external tables to which they have been granted access. Although regular users can see table metadata in the system catalog tables, they can only select data from user-defined tables if they own the table or have been granted access.

Table columns

Column name	Data type	Description
table_catalog	text	The name of the catalog where the table is.
table_schema	text	The schema name for the table.
table_name	text	The name of the table.
column_name	text	The name of the column.
ordinal_position	int	The position of the column in the table.

Column name	Data type	Description
column_default	text	The default value of the column.
is_nullable	text	A value that indicates whether the column is nullable.
data_type	text	The data type of the column.
character_maximum_length	int	The maximum number of characters in the column.
numeric_precision	int	The numeric precision. If the data_type column is numeric, this column returns the number of significant digits in the entire value.
numeric_precision_radix	int	The numeric precision radix. If the data_type column is numeric, this column returns the base of the columns numeric_precision and numeric_scale.
numeric_scale	int	The numeric scale. If the data_type column is numeric, this column returns the number of significant digits in the decimal value.
datetime_precision	int	The datetime precision.
interval_type	text	The interval type.
interval_precision	text	The interval precision.

Column name	Data type	Description
character_set_catalog	text	The character set catalog.
character_set_schema	text	The character set schema.
character_set_name	text	The character set name.
collation_catalog	text	The collation catalog.
collation_schema	text	The collation schema.
collation_name	text	The collation name.
domain_name	text	The domain name.
remarks	text	Remarks.

SVV_COLUMN_PRIVILEGES

Use SVV_COLUMN_PRIVILEGES to view the column permissions that are explicitly granted to users, roles, and groups in the current database.

SVV_COLUMN_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
namespace_name	text	The name of the namespace where a specified relation exists.
relation_name	text	The name of the relation.

Column name	Data type	Description
column_name	text	The name of the column.
privilege_type	text	The type of the permission. Possible values are SELECT or UPDATE.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group or public.

Sample query

The following example displays the result of the SVV_COLUMN_PRIVILEGES.

```
SELECT
 namespace_name,relation_name,COLUMN_NAME,privilege_type,identity_name,identity_type
FROM svv_column_privileges WHERE relation_name = 'lineitem';

 namespace_name | relation_name | column_name | privilege_type | identity_name |
 identity_type
----------------+---------------+-------------+----------------+---------------
+----------------
    public      |   lineitem    | l_orderkey  |     SELECT     |    reguser    |
 user
    public      |   lineitem    | l_orderkey  |     SELECT     |     role1     |
 role
    public      |   lineitem    | l_partkey   |     SELECT     |    reguser    |
 user
    public      |   lineitem    | l_partkey   |     SELECT     |     role1     |
 role
```

SVV_COPY_JOB_INTEGRATIONS

Use SVV_COPY_JOB_INTEGRATIONS to view details of S3 event integrations.

This view contains the S3 event integrations that have been created.

SVV_COPY_JOB_INTEGRATIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
job_owner	integer	The identifier of the owner of the job.
channel_arn	name	The integration identifier.
bucket	text	The Amazon S3 bucket name associated with the integrati on.
channel state	name	The state of the integrati on. Valid values: `Pending`, `Established` , and `Inactive` .
db_name	name	The database name of the dependent object.
job_name	text	The name of the job.
job_state	integer	The state of the job. Valid values: `0` for active, 1 for pending.

The following example returns S3 integrations for the current database.

```
SELECT * FROM SVV_COPY_JOB_INTEGRATIONS WHERE db_name = pg_catalog.current_database();
```

SVV_DATABASE_PRIVILEGES

Use SVV_DATABASE_PRIVILEGES to view the database permissions that are explicitly granted to users, roles, and groups in your Amazon Redshift cluster.

SVV_DATABASE_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
database_name	text	The name of the database.
privilege_type	text	The type of the permission. For permissions with a privilege_scope of database, possible values are USAGE, CREATE, TEMPORARY, TEMP, and ALTER. For privilege_scope values other than database, possible values include any permission type available on the permission's scope.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_option	boolean	A value that indicates whether the user can grant the permission to other users and roles. It is always false for the role and group identity type.

Column name	Data type	Description
privilege_scope	text	The scope of the permission specified in privilege_type. Possible values are as follows: • DATABASE • SCHEMAS • TABLES • FUNCTIONS • LANGUAGES For information on scoped permissions, go to Scoped permissions.

Sample query

The following example displays the result of the SVV_DATABASE_PRIVILEGES.

```
SELECT database_name,privilege_type,identity_name,identity_type,admin_option FROM
 svv_database_privileges
WHERE database_name = 'test_db';

 database_name | privilege_type | identity_name | identity_type | admin_option
---------------+----------------+---------------+---------------+--------------
     test_db   |      CREATE    |     reguser   |      user     |     False
     test_db   |      CREATE    |      role1    |      role     |     False
     test_db   |      TEMP      |      public   |      public   |     False
     test_db   |      TEMP      |      role1    |      role     |     False
```

SVV_DATASHARE_PRIVILEGES

Use SVV_DATASHARE_PRIVILEGES to view the datashare permissions that are explicitly granted to users, roles, and groups in your Amazon Redshift cluster.

SVV_DATASHARE_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
datashare _name	text	The name of the datashare.
privilege _type	text	The type of the permission. Possible values are ALTER or SHARE.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_ name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_opt ion	boolean	A value that indicates whether the user can grant the permission to other users and roles. It is always false for the role and group identity type.

Sample query

The following example displays the result of the SVV_DATASHARE_PRIVILEGES.

```
SELECT datashare_name,privilege_type,identity_name,identity_type,admin_option FROM
 svv_datashare_privileges
WHERE datashare_name = 'demo_share';

 datashare_name | privilege_type |  identity_name | identity_type | admin_option
----------------+----------------+----------------+---------------+--------------
   demo_share   |     ALTER      |    superuser   |     user      |   False
   demo_share   |     ALTER      |    reguser     |     user      |   False
```

SVV_DATASHARES

Use SVV_DATASHARES to view a list of datashares created on the cluster, and datashares shared with the cluster.

SVV_DATASHARES is visible to the following users:

- Superusers
- Datashare owners
- Users with ALTER or USAGE permissions on a datashare

Other users can't see any rows. For information on the ALTER and USAGE permissions, see GRANT.

Table columns

Column name	Data type	Description
share_name	varchar(128)	The name of a datashare.
share_id	integer	The ID of the datashare.
share_owner	integer	The owner of the datashare.
source_database	varchar(128)	The source database for this datashare.
consumer_database	varchar(128)	The consumer database that is created from this datashare.
share_type	varchar(8)	The type of the datashare. Possible values are INBOUND and OUTBOUND.
createdate	timestamp without time zone	The date when datashare was created.
is_publicaccessible	boolean	The property that specifies whether a datashare can be

Column name	Data type	Description
		shared to a publicly accessible cluster.
share_acl	varchar(256)	The string that defines the permissions for the specified user or user group for the datashare.
producer_account	varchar(16)	The ID for the datashare producer account.
producer_namespace	varchar(64)	The unique cluster identifie r for the datashare producer cluster.
managed_by	varchar(64)	The property that specifies the AWS service that manages the datashare.

Usage notes

Retrieving additional metadata – Using the integer returned in the `share_owner` column, you can join with `usesysid` in SVL_USER_INFO to get data about the datashare owner. This includes the name and additional properties.

Sample query

The following example returns the output for SVV_DATASHARES.

```
SELECT share_owner, source_database, share_type, is_publicaccessible
FROM svv_datashares
WHERE share_name LIKE 'tickit_datashare%'
AND source_database = 'dev';

  share_owner | source_database | share_type  | is_publicaccessible
--------------+-----------------+-------------+----------------------
     100      |       dev       |   OUTBOUND  |        True
```

```
(1 rows)
```

The following example returns the output for SVV_DATASHARES for outbound datashares.

```
SELECT share_name, share_owner, btrim(source_database), btrim(consumer_database),
 share_type, is_publicaccessible, share_acl, btrim(producer_account),
 btrim(producer_namespace), btrim(managed_by) FROM svv_datashares WHERE share_type =
 'OUTBOUND';

   share_name   | share_owner | source_database | consumer_database | share_type |
 is_publicaccessible | share_acl | producer_account|        producer_namespace
   | managed_by
----------------+-------------+-----------------+-------------------
+------------+---------------------+-----------+-----------------
+--------------------------------------+------------
    salesshare  |      1      |       dev       |                    |  OUTBOUND  |
   True         |           |   123456789012  | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d |

 marketingshare |      1      |       dev       |                    |  OUTBOUND  |
   True         |           |   123456789012  | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d |
```

The following example returns the output for SVV_DATASHARES for inbound datashares.

```
SELECT share_name, share_owner, btrim(source_database), btrim(consumer_database),
 share_type, is_publicaccessible, share_acl, btrim(producer_account),
 btrim(producer_namespace), btrim(managed_by) FROM svv_datashares WHERE share_type =
 'INBOUND';

  share_name    | share_owner | source_database | consumer_database | share_type |
 is_publicaccessible | share_acl | producer_account |        producer_namespace
    | managed_by
----------------+-------------+-----------------+-------------------
+------------+---------------------+-----------+------------------
+--------------------------------------+------------
  salesshare    |             |                 |                    |  INBOUND   |
   False         |           |  123456789012    | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d
 |
 marketingshare |             |                 |                    |  INBOUND   |
  False         |           |  123456789012    | 13b8833d-17c6-4f16-8fe4-1a018f5ed00d |
 ADX
```

SVV_DATASHARE_CONSUMERS

Use SVV_DATASHARE_CONSUMERS to view a list of consumers for a datashare created on a cluster.

SVV_DATASHARE_CONSUMERS is visible to the following users:

- Superusers
- Datashare owners
- Users with ALTER or USAGE permissions on a datashare

Other users can't see any rows. For information on the ALTER and USAGE permissions, see GRANT.

Table columns

Column name	Data type	Description
share_name	varchar(128)	The name of the datashare.
consumer_account	varchar(16)	The account ID for the datashare consumer.
consumer_namespace	varchar(64)	The unique cluster identifier of the datashare consumer cluster.
share_date	timestamp without time zone	The date that the datashare was shared.

Sample query

The following example returns the output for SVV_DATASHARE_CONSUMERS.

```
SELECT count(*)
FROM svv_datashare_consumers
WHERE share_name LIKE 'tickit_datashare%';

1
```

SVV_DATASHARE_OBJECTS

Use SVV_DATASHARE_OBJECTS to view a list of objects in all datashares created on the cluster or shared with the cluster.

SVV_DATASHARE_OBJECTS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about viewing a list of datashares, see SVV_DATASHARES.

Table columns

Column name	Data type	Description
share_type	varchar(8)	The type of the specified datashare. Possible values are OUTBOUND and INBOUND.
share_name	varchar(128)	The name of the datashare.
object_type	varchar(64)	The type of a specified object. Possible values are schemas, tables, views, late binding views, materialized views, and functions.
object_name	varchar(512)	The name of the object. The object name extends to include the schema name, such as schema1.t1.
producer_account	varchar(16)	The ID for the datashare producer account.
producer_namespace	varchar(64)	The unique cluster identifie r for the datashare producer cluster.
include_new	boolean	The property that specifies whether to add any future

Column name	Data type	Description
		tables, views, or SQL user-defined functions (UDFs) created in the specified schema to the datashare. This parameter is only relevant for OUTBOUND datashares and only for schema types in the datashare.

Sample query

The following examples return the output for SVV_DATASHARE_OBJECTS.

```
SELECT share_type,
    btrim(share_name)::varchar(16) AS share_name,
    object_type,
    object_name
FROM svv_datashare_objects
WHERE share_name LIKE 'tickit_datashare%'
AND object_name LIKE '%tickit%'
ORDER BY object_name
LIMIT 5;

 share_type |     share_name     | object_type |          object_name
------------+--------------------+-------------+---------------------------------
 OUTBOUND   |  tickit_datashare  |    table    |  public.tickit_category_redshift
 OUTBOUND   |  tickit_datashare  |    table    |  public.tickit_date_redshift
 OUTBOUND   |  tickit_datashare  |    table    |  public.tickit_event_redshift
 OUTBOUND   |  tickit_datashare  |    table    |  public.tickit_listing_redshift
 OUTBOUND   |  tickit_datashare  |    table    |  public.tickit_sales_redshift
```

```
SELECT * FROM SVV_DATASHARE_OBJECTS WHERE share_name like 'sales%';

share_type | share_name | object_type | object_name  | producer_account |
 producer_namespace          | include_new
-----------+------------+-------------+-------------+-----------------
+-------------------------------------+-------------
```

```
OUTBOUND   | salesshare | schema       | public       | 123456789012     |
13b8833d-17c6-4f16-8fe4-1a018f5ed00d |      t
OUTBOUND   | salesshare | table        | public.sales | 123456789012     |
13b8833d-17c6-4f16-8fe4-1a018f5ed00d |
```

SVV_DEFAULT_PRIVILEGES

Use SVV_DEFAULT_PRIVILEGES to view the default privileges that a user has access to in an Amazon Redshift cluster.

SVV_DEFAULT_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see default permissions granted to them.

Table columns

Column name	Data type	Description
schema_name	text	The name of the schema.
object_type	text	The object type. Possible values are RELATION, FUNCTION, or PROCEDURE.
owner_id	integer	The owner ID. Possible value is the user ID.
owner_name	text	The name of the owner.
owner_type	text	The owner type. Possible value is user.
privilege_type	text	The privilege type. Possible values are INSERT, SELECT, UPDATE, DELETE, RULE, REFERENCES TRIGGER, DROP, and EXECUTE.
grantee_id	integer	The grantee ID. Possible values are user ID, role ID, and group ID.

Column name	Data type	Description
grantee_type	text	The grantee type. Possible values are user, role, and public.
admin_option	boolean	The value that indicates whether the user can grant permissions to other users and roles. It is always false for role and group type.

Sample query

The following example returns the output for SVV_DEFAULT_PRIVILEGES.

```
SELECT * from svv_default_privileges;

 schema_name |    object_type     | owner_id | owner_name | owner_type | privilege_type
 | grantee_id | grantee_name | grantee_type | admin_option
-------------+-------------------+--------- +------------+------------+----------------
+------------+--------------+-------------+-------------+
   public    |      RELATION      |    106   |     u1     |    user    |     UPDATE
 |      107    |      u2      |     user    |      f      |
   public    |      RELATION      |    106   |     u1     |    user    |     SELECT
 |      107    |      u2      |     user    |      f      |
```

SVV_DISKUSAGE

Amazon Redshift creates the SVV_DISKUSAGE system view by joining the STV_TBL_PERM and STV_BLOCKLIST tables. The SVV_DISKUSAGE view contains information about data allocation for the tables in a database.

Use aggregate queries with SVV_DISKUSAGE, as the following examples show, to determine the number of disk blocks allocated per database, table, slice, or column. Each data block uses 1 MB. You can also use STV_PARTITIONS to view summary information about disk utilization.

SVV_DISKUSAGE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Note

This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
db_id	integer	Database ID.
name	character (72)	Table name.
slice	integer	Data slice allocated to the table.
col	integer	Zero-based index for the column. Every table you create has three hidden columns appended to it: INSERT_XID, DELETE_XID, and ROW_ID (OID). A table with 3 user-defined columns contains 6 actual columns, and the user-defined columns are internally numbered as 0, 1, and 2. The INSERT_XID, DELETE_XID, and ROW_ID columns are numbered 3, 4, and 5, respectively, in this example.
tbl	integer	Table ID.
blocknum	integer	ID for the data block.
num_values	integer	Number of values contained on the block.
minvalue	bigint	Minimum value contained on the block.
maxvalue	bigint	Maximum value contained on the block.
sb_pos	integer	Internal identifier for the position of the super block on disk.
pinned	integer	Whether or not the block is pinned into memory as part of pre-load. 0 = false; 1 = true. Default is false.

Column name	Data type	Description
on_disk	integer	Whether or not the block is automatically stored on disk. 0 = false; 1 = true. Default is false.
modified	integer	Whether or not the block has been modified. 0 = false; 1 = true. Default is false.
hdr_modified	integer	Whether or not the block header has been modified. 0 = false; 1 = true. Default is false.
unsorted	integer	Whether or not a block is unsorted. 0 = false; 1 = true. Default is true.
tombstone	integer	For internal use.
preferred_diskno	integer	Disk number that the block should be on, unless the disk has failed. Once the disk has been fixed, the block will move back to this disk.
temporary	integer	Whether or not the block contains temporary data, such as from a temporary table or intermediate query results. 0 = false; 1 = true. Default is false.
newblock	integer	Indicates whether or not a block is new (true) or was never committed to disk (false). 0 = false; 1 = true.

Sample queries

SVV_DISKUSAGE contains one row per allocated disk block, so a query that selects all the rows potentially returns a very large number of rows. We recommend using only aggregate queries with SVV_DISKUSAGE.

Return the highest number of blocks ever allocated to column 6 in the USERS table (the EMAIL column):

```
select db_id, trim(name) as tablename, max(blocknum)
from svv_diskusage
where name='users' and col=6
group by db_id, name;
```

```
db_id  | tablename | max
--------+-----------+-----
175857 | users     |   2
(1 row)
```

The following query returns similar results for all of the columns in a large 10-column table called SALESNEW. (The last three rows, for columns 10 through 12, are for the hidden metadata columns.)

```
select db_id, trim(name) as tablename, col, tbl, max(blocknum)
from svv_diskusage
where name='salesnew'
group by db_id, name, col, tbl
order by db_id, name, col, tbl;

db_id  | tablename  | col |  tbl   | max
--------+------------+-----+--------+-----
175857 | salesnew   |   0 | 187605 | 154
175857 | salesnew   |   1 | 187605 | 154
175857 | salesnew   |   2 | 187605 | 154
175857 | salesnew   |   3 | 187605 | 154
175857 | salesnew   |   4 | 187605 | 154
175857 | salesnew   |   5 | 187605 |  79
175857 | salesnew   |   6 | 187605 |  79
175857 | salesnew   |   7 | 187605 | 302
175857 | salesnew   |   8 | 187605 | 302
175857 | salesnew   |   9 | 187605 | 302
175857 | salesnew   |  10 | 187605 |   3
175857 | salesnew   |  11 | 187605 |   2
175857 | salesnew   |  12 | 187605 | 296
(13 rows)
```

SVV_EXTERNAL_COLUMNS

Use SVV_EXTERNAL_COLUMNS to view details for columns in external tables. Use SVV_EXTERNAL_COLUMNS also for cross-database queries to view details on all columns from the table on unconnected databases that users have access to.

SVV_EXTERNAL_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
redshift_database_name	text	The name of the local Amazon Redshift database.
schemaname	text	The name of the Amazon Redshift external schema for the external table.
tablename	text	The name of the external table.
columnname	text	The name of the column.
external_type	text	The data type of the column.
columnnum	integer	The external column number, starting from 1.
part_key	integer	If the column is a partition key, the order of the key. If the column isn't a partition, the value is **`0`**.
is_nullable	text	Defines whether a column is nullable or not. Some values are `true`, `false`, or " " empty string that represents no information.

SVV_EXTERNAL_DATABASES

Use SVV_EXTERNAL_DATABASES to view details for external databases.

SVV_EXTERNAL_DATABASES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
eskind	integer	The type of the external catalog for the database; **1** indicates a data catalog, **2** indicates a Hive metastore.
esoptions	text	Details of the catalog where the database resides.
databasename	text	The name of the database in the external catalog.
location	text	The location of the database.
parameters	text	Database parameters.

SVV_EXTERNAL_PARTITIONS

Use SVV_EXTERNAL_PARTITIONS to view details for partitions in external tables.

SVV_EXTERNAL_PARTITIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views..

Table columns

Column name	Data type	Description
schemaname	text	The name of the Amazon Redshift external schema for the external table with the specified partitions.
tablename	text	The name of the external table.
values	text	Values for the partition.

Column name	Data type	Description
location	text	The location of the partition. The column size is limited to 128 characters. Longer values are truncated.
input_format	text	The input format.
output_format	text	The output format.
serialization_lib	text	The serialization library.
serde_par ameters	text	SerDe parameters.
compressed	integer	A value that indicates whether the partition is compressed; **1** indicates compressed, **0** indicates not compressed.
parameters	text	Partition properties.

SVV_EXTERNAL_SCHEMAS

Use SVV_EXTERNAL_SCHEMAS to view information about external schemas. For more information, see CREATE EXTERNAL SCHEMA.

SVV_EXTERNAL_SCHEMAS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
esoid	oid	External schema ID.
eskind	smallint	The type of the external catalog for the external schema: 1 indicates a data catalog, 2 indicates a Hive metastore , 3 indicates a federated query to Aurora PostgreSQL or Amazon RDS PostgreSQL, 4 indicates a schema for a

Column name	Data type	Description
		local Amazon Redshift database, 5 indicates a schema for a remote Amazon Redshift database, 6 indicates a schema for a system table, 8 indicates a schema for remote MySQL databases, 9 indicates a schema for an Amazon Kinesis data stream, and 10 indicates an Amazon Managed Streaming for Apache Kafka data stream.
schemaname	name	External schema name.
esowner	integer	User ID of the external schema owner.
databasename	text	External database name.
esoptions	text	External schema options.

Example

The following example shows details for external schemas.

```
select * from svv_external_schemas;

esoid  | eskind | schemaname | esowner | databasename | esoptions

-------+--------+------------+---------+--------------
+---------------------------------------------------------------
100133 |      1 | spectrum   |     100 | redshift     |
 {"IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
```

SVV_EXTERNAL_TABLES

Use SVV_EXTERNAL_TABLES to view details for external tables; for more information, see CREATE EXTERNAL SCHEMA. Use SVV_EXTERNAL_TABLES also for cross-database queries to view metadata on all tables on unconnected databases that users have access to.

SVV_EXTERNAL_TABLES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
redshift_database_name	text	The name of the local Amazon Redshift database.
schemaname	text	The name of the Amazon Redshift external schema for the external table.
tablename	text	The name of the external table.
tabletype	text	The type of table. Some values are TABLE, VIEW, MATERIALIZED VIEW, or " " empty string that represents no information.
location	text	The location of the table.
input_format	text	The input format
output_format	text	The output format.
serialization_lib	text	The serialization library.
serde_parameters	text	SerDe parameters.
compressed	integer	A value that indicates whether the table is compressed; **1** indicates compressed, **0** indicates not compressed.
parameters	text	Table properties.

Example

The following example shows details svv_external_tables with a predicate on the external schema used by a federated query.

```
select schemaname, tablename from svv_external_tables where schemaname = 'apg_tpch';
schemaname  | tablename
------------+-----------
apg_tpch    | customer
apg_tpch    | lineitem
apg_tpch    | nation
apg_tpch    | orders
apg_tpch    | part
apg_tpch    | partsupp
apg_tpch    | region
apg_tpch    | supplier
(8 rows)
```

SVV_FUNCTION_PRIVILEGES

Use SVV_FUNCTION_PRIVILEGES to view the function permissions that are explicitly granted to users, roles, and groups in the current database.

SVV_FUNCTION_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
namespace_name	text	The name of the namespace where a specified function exists.
function_name	text	The name of the function.

Column name	Data type	Description
argument_types	text	The string that represents the type of input argument for a function.
privilege_type	text	The type of the permission. Possible value is EXECUTE.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_option	boolean	A value that indicates whether the user can grant the permission to other users and roles. It is always false for the role and group identity type.

Sample query

The following example displays the result of the SVV_FUNCTION_PRIVILEGES.

```
SELECT
 namespace_name,function_name,argument_types,privilege_type,identity_name,identity_type,admin_o
 FROM svv_function_privileges
WHERE identity_name IN ('role1', 'reguser');

 namespace_name | function_name |       argument_types       | privilege_type |
 identity_name | identity_type | admin_option
----------------+---------------+----------------------------+----------------
+----------------+---------------+--------------
    public      | test_func1    | integer                    |    EXECUTE     |
 role1     |     role       |  False
    public      | test_func2    | integer, character varying |    EXECUTE     |
 reguser    |     user       |  False
```

SVV_GEOGRAPHY_COLUMNS

Use SVV_GEOGRAPHY_COLUMNS to view the list of GEOGRAPHY columns in your data warehouse. This list of columns includes columns from datashares.

SVV_GEOGRAPHY_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
f_table_catalog	varchar(128)	The name of the database where the table with the GEOGRAPHY column exists.
f_table_schema	varchar(128)	The name of the schema where the table with the GEOGRAPHY column exists.
f_table_name	varchar(128)	The name of the table where the GEOGRAPHY column exists.
f_geography_column	varchar(128)	The name of the GEOGRAPHY column.
coord_dimension	integer	The number of dimensions of the GEOGRAPHY data.
srid	integer	The spatial reference system identifier (SRID) of the GEOGRAPHY data.
type	varchar(128)	The spatial geography data type name.

Sample query

The following example displays the result of the SVV_GEOGRAPHY_COLUMNS.

```
SELECT * FROM svv_geography_columns;
```

```
f_table_catalog  | f_table_schema  | f_table_name  | f_geography_column  |
 coord_dimension | srid |  type
-----------------+-----------------+--------------+---------------------
+-----------------+------+--------------
dev              | public          | spatial_test  | test_geography      | 2
    | 0     | GEOGRAPHY
```

SVV_GEOMETRY_COLUMNS

Use SVV_GEOMETRY_COLUMNS to view the list of GEOMETRY columns in your data warehouse. This list of columns includes columns from datashares.

SVV_GEOMETRY_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
f_table_catalog	varchar(128)	The name of the database where the table with the GEOMETRY column exists.
f_table_schema	varchar(128)	The name of the schema where the table with the GEOMETRY column exists.
f_table_name	varchar(128)	The name of the table where the GEOMETRY column exists.
f_geometry_column	varchar(128)	The name of the GEOMETRY column.
coord_dimension	integer	The number of dimensions of the GEOMETRY data.
srid	integer	The spatial reference system identifier (SRID) of the GEOMETRY olumn.

Column name	Data type	Description
type	varchar(128)	The spatial geometry type name.

Sample query

The following example displays the result of the SVV_GEOMETRY_COLUMNS.

```
SELECT * FROM svv_geometry_columns;

f_table_catalog  | f_table_schema  | f_table_name  | f_geometry_column   |
 coord_dimension | srid |   type
-----------------+-----------------+---------------+--------------------
+-----------------+------+--------------
dev              | public          | accomodations | shape               | 2
    | 0    | GEOMETRY
dev              | public          | zipcode       | wkb_geometry        | 2
    | 0    | GEOMETRY
```

SVV_IAM_PRIVILEGES

Use SVV_IAM_PRIVILEGES to view explicitly granted IAM privileges on users, roles and groups.

SVV_IAM_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see entries they have access to.

Table columns

Column name	Data type	Description
iam_arn	text	Name of the namespace.

Column name	Data type	Description
command_type	text	Privilege types. Possible values are COPY, UNLOAD, CREATE MODEL, or EXTERNAL FUNCTION.
identity_id	integer	Identity ID. Possible values are user ID, role ID, or group ID.
identity_name	text	Identity name.
identity_type	text	Identity type. Possible values are user, role, group, or public.

Sample queries

The following example shows the results of SVV_IAM_PRIVILEGES.

```
SELECT * from SVV_IAM_PRIVILEGES ORDER BY IDENTITY_ID;
       iam_arn        | command_type | identity_id | identity_name | identity_type
----------------------+--------------+-------------+---------------+---------------
 default-aws-iam-role | COPY         |           0 | public        | public
 default-aws-iam-role | UNLOAD       |           0 | public        | public
 default-aws-iam-role | CREATE MODEL |           0 | public        | public
 default-aws-iam-role | EXFUNC       |           0 | public        | public
 default-aws-iam-role | COPY         |         106 | u1            | user
 default-aws-iam-role | UNLOAD       |         106 | u1            | user
 default-aws-iam-role | CREATE MODEL |         106 | u1            | user
 default-aws-iam-role | EXFUNC       |         106 | u1            | user
 default-aws-iam-role | COPY         |      118413 | r1            | role
 default-aws-iam-role | UNLOAD       |      118413 | r1            | role
 default-aws-iam-role | CREATE MODEL |      118413 | r1            | role
 default-aws-iam-role | EXFUNC       |      118413 | r1            | role
(12 rows)
```

SVV_IDENTITY_PROVIDERS

The SVV_IDENTITY_PROVIDERS view returns the name and additional properties for identity providers. For more information about how to create an identity provider, see CREATE IDENTITY PROVIDER.

SVV_IDENTITY_PROVIDERS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
uid	integer	The unique ID of the registere d identity provider.
name	text	The identity provider name.
type	text	The identity provider type.
instanceid	text	The unique differentiator between instances of the same type.
namespc	text	The namespace prefix of the identity provider.
params	text	The JSON object with parameters for the identity provider.
enabled	bool	Indicates if the identity provider is enabled.

Sample queries

To view identity provider properties, run a query like the following after creating identity providers.

```
SELECT name, type, instanceid, namespc, params, enabled
FROM svv_identity_providers
```

```
ORDER BY 1;
```

The sample output includes param descriptions.

```
       name        | type   |                instanceid                | namespc |
                                                 params                                                  

                          | enabled
------------------+-------+--------------------------------------+---------
+---------------------------------------------------------------------------------------------------------
+---------
 rs5517_azure_idp | azure | e40d4bb2-7670-44ae-bfb8-5db013221d73 | abc     |
 {"issuer":"https://login.microsoftonline.com/e40d4bb2-7670-44ae-bfb8-5db013221d73/
v2.0", "client_id":"871c010f-5e61-4fb1-83ac-98610a7e9110", "client_secret":,
 "audience":["https://analysis.windows.net/powerbi/connector/AmazonRedshift", "https://
analysis.windows.net/powerbi/connector/AWSRDS"]} | t
(1 row)
```

SVV_INTEGRATION

SVV_INTEGRATION displays details about the configuration of integrations.

SVV_INTEGRATION is visible only to superusers. For more information, see Visibility of data in system tables and views.

For information about zero-ETL integrations, see Zero-ETL integrations.

Table columns

Column name	Data type	Description
integration_id	character (128)	The identifier associated with the integration.
target_database	character (128)	The database in Amazon Redshift that receives the integration data.
source	character (128)	The source data for the integration. Possible types include `MySQL`, `PostgreSQL`, and `S3_EVENT_NOTIFICATIONS`.

Column name	Data type	Description
state	character (128)	The state of the integration. Possible values include `PendingDbConnectState` , `SchemaDiscoveryState` , `CdcRefreshState` , and `ErrorState` .
current_lag	bigint	The current lag time (milliseconds) between the source and destination of the integration.
last_replicated_checkpoint	character (128)	The last replicated checkpoint.
total_tables_replicated	integer	The number of total tables currently in the replicated state.
total_tables_failed	integer	The number of total tables currently in the failed state.
creation_time	timestamp	The time (UTC) when the integration is created. It is defined as the time when the target database is created from the integration.
refresh_interval	integer	The approximate time interval, in seconds, to refresh data from the zero-ETL source to the target database.
source_database	character (128)	The name of the source database.
is_history_mode	boolean	A TRUE value indicates that history mode is on. A FALSE indicates that history mode is off.

Sample queries

The following SQL command displays the currently defined integrations.

```
select * from svv_integration;
```

```
           integration_id              | target_database | source |      state
    | current_lag |      last_replicated_checkpoint      | total_tables_replicated |
  total_tables_failed |       creation_time        |  refresh_interval  | source_database
  | is_history_mode
--------------------------------------+-----------------+--------+-----------------
+-------------+--------------------------------------+------------------------
+---------------------+----------------------------+--------------------
+----------------+----------------
  99108e72-1cfd-414f-8cc0-0216acefac77 |     perfdb      |  MySQL | CdcRefreshState |
  56606106   | {"txn_seq":9834,"txn_id":126597515} |           152            |
 0         | 2023-09-19 21:05:27.520299|      720           + mysourceetl     | f
```

SVV_INTEGRATION_TABLE_MAPPING

SVV_INTEGRATION_TABLE_MAPPING displays the mapping of source database, schema, table, column, and data type to the target when the identifier value of those fields are different.

Note

This view is only populated for the following types of zero-ETL integrations:

- AWS Glue third-party applications to Amazon SageMaker Lakehouse
- Amazon DynamoDB to Amazon SageMaker Lakehouse

For more information, see Zero-ETL integrations in the *AWS Glue Developer Guide*.

The transformation of identifier values from source to target follow the following rules:

- An upper case letter is converted to lower case.
- A character that is not a lowercase letter, a digit, or underscore (_) is converted to an underscore (_).
- If there is a conflict with a existing identifier value, then an Universally Unique Identifier (UUID) is appended to the new identifier.
- If the source identifier value is an Amazon Redshift keyword, then the suffix `_redshift` is appended to the new identifier.

After transformation, a character must be a lowercase letter, a digit, or underscore (_) and match the regex pattern `[a-z0-9_]`. The following examples demonstrate the conversion rules:

Source	Target	Notes
foo	foo	No transformation
Bar	bar	
fooBar	foobar	
foo1	foo1	No transformation
foo_1	foo_1	No transformation
Bar@1	bar_1	
foo_bar@	foo_bar_	
case	case_redshift	

SVV_INTEGRATION_TABLE_MAPPING is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about zero-ETL integrations, see Zero-ETL integrations in the *Amazon Redshift Management Guide*.

Table columns

Column name	Data type	Description
integration_id	character (128)	The identifier associated with the integration.
source_database	character (128)	The name of the database in the source.

Column name	Data type	Description
target_database	character (128)	The database in Amazon Redshift that receives the integration data.
source_schema_name	character (128)	The name of the schema in the source.
target_schema_name	character (128)	The schema in Amazon Redshift that receives the integration data.
source_table_name	character (128)	The name of the table in the source.
target_table_name	character (128)	The table in Amazon Redshift that receives the integration data.
source_column_name	character (128)	The name of the column in the source.
target_column_name	character (128)	The column in Amazon Redshift that receives the integration data.
source_data_type	character (128)	The data type of the column in the source.
target_data_type	character (128)	The data type of the column in Amazon Redshift that receives the integration data.

Sample queries

The following SQL command displays mapping of metadata values from source to target.

```
select * from svv_integration_table_mapping;

           integration_id              | source_database | target_database |
 source_schema_name | target_schema_name | source_table_name | target_table_name |
--------------------------------------+-----------------+-----------------
+---------------------+--------------------+---------------------------------------+
```

```
 99108e72-1cfd-414f-8cc0-0216acefac77 |     mydatabase  |  mydatabase      |  myschema
        | myschema           | Mytable            | mytable           |


                                    | source_column_name | target_column_name |
 source_data_type | target_data_type |
                                    +--------------------+-------------------
+------------------+-----------------+
                                    | Mycolumnname       | mycolumnname       |
 Mydatatype       | mydatatype       |
```

SVV_INTEGRATION_TABLE_STATE

SVV_INTEGRATION_TABLE_STATE displays details about table-level integration information.

SVV_INTEGRATION_TABLE_STATE is visible only to superusers. For more information, see Visibility of data in system tables and views.

For more information, see Zero-ETL integrations.

Table columns

Column name	Data type	Description
integration_id	character(128)	The identifier associated with the integration.
target_database	character(128)	The name of the Amazon Redshift database.
schema_name	character(128)	The name of the Amazon Redshift schema.
table_name	character(128)	The name of the table.
table_state	character(128)	The state of the table. Possible values are `Synced`, `Failed`, `Deleted`, `ResyncRequired` , `ResyncInitiated` and `DroppedSource` . The `DroppedSource` state indicates that the source of a history mode table was dropped at the source.
table_last_replicated_checkpoint	character(128)	The current synced log coordinates.

Column name	Data type	Description
reason	character(256)	The reason for the last state transition. Common reasons can be unsupported data types in tables, tables don't have primary keys. To learn more about how to troublesh oot common issues, see Troubleshooting zero-ETL integrations in Amazon Redshift.
last_updated_times tamp	timestamp without time zone	The time (UTC) when the table is last updated.
table_rows	bigint	The total number of rows in the table.
table_size	bigint	The size of the table in megabytes (MB).
is_history_mode	boolean	A TRUE value indicates that history mode is on. A FALSE indicates that history mode is off.

Sample queries

The following SQL command displays the columns of the log of integrations.

```
select * from svv_integration_table_state;

          integration_id              | target_database | schema_name |     table_name
   | table_state  |table_last_replicated_checkpoint | reason | last_updated_timestamp
   |table_rows   | table_size | is_history_mode
--------------------------------------+----------------+-------------
+-------------------+-------------+----------------------------------+--------
+----------------------------+-----------+-----------+----------------
 4798e675-8f9f-4686-b05f-92c538e19629 |  sample_test2    |    sample   |
 SampleTestChannel |    Synced     |   {"txn_seq":3,"txn_id":3122}   |         |
 2023-05-12 12:40:30.656625 | 2          |    16       | f
```

SVV_INTERLEAVED_COLUMNS

Use the SVV_INTERLEAVED_COLUMNS view to help determine whether a table that uses interleaved sort keys should be reindexed using VACUUM REINDEX. For more information about how to determine how often to run VACUUM and when to run a VACUUM REINDEX, see Minimizing vacuum times.

SVV_INTERLEAVED_COLUMNS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
tbl	integer	Table ID.
col	integer	Zero-based index for the column.
interleaved_skew	numeric(9,2)	Ratio that indicates of the amount of skew present in the interleaved sort key columns for a table. A value of 1.00 indicates no skew, and larger values indicate more skew. Tables with a large skew should be reindexed with the VACUUM REINDEX command.
last_reindex	timestamp	Time when the last VACUUM REINDEX was run for the specified table. This value is NULL if a table has never been reindexed or if the underlying system log table, STL_VACUUM, has been rotated since the last reindex.

Sample queries

To identify tables that might need to be reindexed, run the following query.

```
select tbl as tbl_id, stv_tbl_perm.name as table_name,
col, interleaved_skew, last_reindex
from svv_interleaved_columns, stv_tbl_perm
where svv_interleaved_columns.tbl = stv_tbl_perm.id
and interleaved_skew is not null;

 tbl_id | table_name | col | interleaved_skew | last_reindex
--------+------------+-----+------------------+--------------------
 100068 | lineorder  |   0 |             3.65 | 2015-04-22 22:05:45
 100068 | lineorder  |   1 |             2.65 | 2015-04-22 22:05:45
 100072 | customer   |   0 |             1.65 | 2015-04-22 22:05:45
```

```
 100072 | lineorder  |   1 |             1.00 | 2015-04-22 22:05:45
(4 rows)
```

SVV_LANGUAGE_PRIVILEGES

Use SVV_LANGUAGE_PRIVILEGES to view the language permissions that are explicitly granted to users, roles, and groups in the current database.

SVV_LANGUAGE_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
language_name	text	The name of the language.
privilege_type	text	The type of the permission. Possible value is USAGE.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_option	boolean	A value that indicates whether the user can grant the permission to other users and roles. It is always false for the role and group identity type.

Sample query

The following example displays the result of the SVV_LANGUAGE_PRIVILEGES.

```
SELECT language_name,privilege_type,identity_name,identity_type,admin_option FROM
 svv_language_privileges
WHERE identity_name IN ('role1', 'reguser');

 language_name | privilege_type | identity_name | identity_type | admin_option
---------------+----------------+---------------+---------------+---------------
   exfunc      |      USAGE     |    reguser    |     user      |    False
   exfunc      |      USAGE     |     role1     |     role      |    False
   plpythonu   |      USAGE     |    reguser    |     user      |    False
```

SVV_MASKING_POLICY

Use SVV_MASKING_POLICY to view all masking policies created on the cluster.

Only superusers and users with the `sys:secadmin` role can view SVV_MASKING_POLICY. Regular users will see 0 rows.

Table columns

Column name	Data type	Description
policy_database	text	The name of the database in which the masking policy was created.
policy_name	text	The name of the masking policy.
input_columns	text	The attributes provided in the WITH clause of CREATE POLICY statement.
policy_expression	text	The masking expression used in the policy.

Column name	Data type	Description
policy_modified_by	text	The name of the user who last modified the policy.
policy_modified_time	timestamp	The timestamp of when the policy was created or last modified.

SVV_ML_MODEL_INFO

State information about the current state of the machine learning model.

SVV_ML_MODEL_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	char(128)	The database of the model.
schema_name	char(128)	The schema of the model.
user_name	char(128)	The owner of the model.
model_name	char(128)	The name of the model.
life_cycle	char(20)	The lifecycle status of the model.
is_refreshable	integer	The state of the model whether it is refreshab le if original tables and columns in the training query still exist and the user still has the permissions to them. Possible values are: 1 (refreshable) and 0 (not refreshable).
model_state	char(128)	The current state of the model.

Sample query

The following query displays the current state of machine learning models.

```
SELECT schema_name, model_name, model_state
FROM svv_ml_model_info;

 schema_name |        model_name            |             model_state
-------------+------------------------------+--------------------------------------
 public      | customer_churn_auto_model    | Train Model On SageMaker In Progress
 public      | customer_churn_xgboost_model | Model is Ready
(2 row)
```

SVV_ML_MODEL_PRIVILEGES

Use SVV_ML_MODEL_PRIVILEGES to view the machine learning model permissions that are explicitly granted to users, roles, and groups in the cluster.

SVV_ML_MODEL_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
namespace_name	text	The name of the namespace where a specified machine learning model exists.
model_name	text	The name of the machine learning model.
model_version	integer	The version number of the model.
privilege_type	text	The type of the permission. Possible value is EXECUTE.

Column name	Data type	Description
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_option	boolean	A value that indicates whether the user can grant the permissio n to other users and roles. It is always false for the role and group identity type.

Sample query

The following example displays the result of the SVV_ML_MODEL_PRIVILEGES.

```
SELECT
 namespace_name,model_name,model_version,privilege_type,identity_name,identity_type,admin_optio
 FROM svv_ml_model_privileges
WHERE model_name = 'test_model';

 namespace_name | model_name | model_version | privilege_type |  identity_name |
 identity_type | admin_option
----------------+------------+---------------+----------------+----------------
+---------------+--------------
      public    | test_model |       1       |    EXECUTE     |     reguser    |
 user      |    False
      public    | test_model |       1       |    EXECUTE     |     role1      |
 role      |    False
```

SVV_MV_DEPENDENCY

The SVV_MV_DEPENDENCY table shows the dependencies of materialized views on other materialized views within Amazon Redshift.

For more information about materialized views, see Materialized views in Amazon Redshift.

SVV_MV_DEPENDENCY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	char(128)	The database that contains the specified materialized view.
schema_name	char(128)	The schema of the materialized view.
name	char(128)	The name of the materialized view.
dependent _database _name	char(128)	The materialized view database on which this materialized view depends.
dependent _schema_name	char(128)	The materialized view schema on which this materialized view depends.
dependent _name	char(128)	The name of the materialized view on which this materialized view depends.

Sample query

The following query returns an output row that indicates that the materialized view `mv_over_foo` uses the materialized view `mv_foo` in its definition as a dependency.

```
CREATE SCHEMA test_ivm_setup;
CREATE TABLE test_ivm_setup.foo(a INT);
CREATE MATERIALIZED VIEW test_ivm_setup.mv_foo AS SELECT * FROM test_ivm_setup.foo;
```

```
CREATE MATERIALIZED VIEW test_ivm_setup.mv_over_foo AS SELECT * FROM
 test_ivm_setup.mv_foo;

SELECT * FROM svv_mv_dependency;

 database_name | schema_name          | name        | dependent_database_name |
 dependent_schema_name      | dependent_name
---------------+----------------------+-------------+------------------------
+-------------------------+----------
 dev           | test_ivm_setup       | mv_over_foo |                     dev |
 test_ivm_setup            | mv_foo
```

SVV_MV_INFO

The SVV_MV_INFO table contains a row for every materialized view, whether the data is stale, and state information.

For more information about materialized views, see Materialized views in Amazon Redshift.

SVV_MV_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	char(128)	The database that contains the materialized view.
schema_name	char(128)	The schema of the database.
user_name	char(128)	The user who owns the materialized view.
name	char(128)	The materialized view name.
is_stale	char(1)	A `t` indicates that the materialized view is stale. A *stale* materialized view is one where the base tables have been updated but the materialized view hasn't been refreshed. This information might not be accurate if a refresh hasn't been run since the last restart.

Column name	Data type	Description
state	integer	The state of the materialized view as follows: • 0 – The materialized view is fully recomputed when refreshed. • 1 – The materialized view is incremental. • 101 – The materialized view can't be refreshed due to a dropped column. This constraint applies even if the column isn't used in the materialized view. • 102 – The materialized view can't be refreshed due to a changed column type. This constrain t applies even if the column isn't used in the materialized view. • 103 – The materialized view can't be refreshed due to a renamed table. • 104 – The materialized view can't be refreshed due to a renamed column. This constraint applies even if the column isn't used in the materialized view. • 105 – The materialized view can't be refreshed due to a renamed schema.
autorewrite	char(1)	A `t` indicates that the materialized view is eligible for automatic rewriting of queries.
autorefresh	char(1)	A `t` indicates that the materialized view can be automatically refreshed.

Sample query

To view the state of all materialized views, run the following query.

```
select * from svv_mv_info;
```

This query returns the following sample output.

```
database_name |        schema_name        | user_name |   name   |  is_stale | state |
 autorefresh | autorewrite
--------------+-------------------------+-----------+---------+----------+-------
+-------------+----------------
 dev          | test_ivm_setup            | catch-22  | mv       |  f        |     1 |
       1 |          0
 dev          | test_ivm_setup            | lotr      | old_mv  |  t        |     1 |
       0 |          1
```

SVV_QUERY_INFLIGHT

Use the SVV_QUERY_INFLIGHT view to determine what queries are currently running on the database. This view joins STV_INFLIGHT to STL_QUERYTEXT. SVV_QUERY_INFLIGHT does not show leader-node only queries. For more information, see Leader node–only functions.

SVV_QUERY_INFLIGHT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
slice	integer	Slice where the query is running.
query	integer	Query ID. Can be used to join various other system tables and views.

Column name	Data type	Description
pid	integer	Process ID. All of the queries in a session are run in the same process, so this value remains constant if you run a series of queries in the same session. You can use this column to join to the STL_ERROR table.
starttime	timestamp	Time that the query started.
suspended	integer	Whether the query is suspended: **0** = false; **1** = true.
text	character(200)	Query text, in 200-character increments.
sequence	integer	Sequence number for segments of query statements.

Sample queries

The sample output below shows two queries currently running, the SVV_QUERY_INFLIGHT query itself and query 428, which is split into three rows in the table. (The starttime and statement columns are truncated in this sample output.)

```
select slice, query, pid, starttime, suspended, trim(text) as statement, sequence
from svv_query_inflight
order by query, sequence;

slice|query| pid  |      starttime       |suspended| statement | sequence
-----+-----+------+----------------------+---------+-----------+---------
1012 | 428 | 1658 | 2012-04-10 13:53:... |       0 | select ...|    0
1012 | 428 | 1658 | 2012-04-10 13:53:... |       0 | enueid ...|    1
1012 | 428 | 1658 | 2012-04-10 13:53:... |       0 | atname,...|    2
1012 | 429 | 1608 | 2012-04-10 13:53:... |       0 | select ...|    0
(4 rows)
```

SVV_QUERY_STATE

Use SVV_QUERY_STATE to view information about the runtime of currently running queries.

The SVV_QUERY_STATE view contains a data subset of the STV_EXEC_STATE table.

SVV_QUERY_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Note

This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
query	integer	Query ID. Can be used to join various other system tables and views.
seg	integer	Number of the query segment that is running. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process.
step	integer	Number of the query step that is running. A step is the smallest unit of query runtime. Each step represents a discrete unit of work, such as scanning a table, returning results, or sorting data.
maxtime	interval	Maximum amount of time (in microseconds) for this step to run.
avgtime	interval	Average time (in microseconds) for this step to run.
rows	bigint	Number of rows produced by the step that is running.
bytes	bigint	Number of bytes produced by the step that is running.
cpu	bigint	For internal use.

Column name	Data type	Description
memory	bigint	For internal use.
rate_row	double precision	Rows-per-second rate since the query started, computed by summing the rows and dividing by the number of seconds from when the query started to the current time.
rate_byte	double precision	Bytes-per-second rate since the query started, computed by summing the bytes and dividing by the number of seconds from when the query started to the current time.
label	character(25)	Query label: a name for the step, such as `scan` or `sort`.
is_diskbased	character(1)	Whether this step of the query is running as a disk-based operation: true (**`t`**) or false (**`f`**). Only certain steps, such as hash, sort, and aggregate steps, can go to disk. Many types of steps are always performed in memory.
workmem	bigint	Amount of working memory (in bytes) assigned to the query step.
num_part	integer	Number of partitions a hash table is divided into during a hash step. A positive number in this column does not imply that the hash step runs as a disk-based operation. Check the value in the IS_DISKBASED column to see if the hash step was disk-based.
is_rrscan	character(1)	If true (**`t`**), indicates that range-restricted scan was used on the step. Default is false (**`f`**).
is_delayed_scan	character(1)	If true (**`t`**), indicates that delayed scan was used on the step. Default is false (**`f`**).

Sample queries

Determining the processing time of a query by step

The following query shows how long each step of the query with query ID 279 took to run and how many data rows Amazon Redshift processed:

```
select query, seg, step, maxtime, avgtime, rows, label
from svv_query_state
where query = 279
order by query, seg, step;
```

This query retrieves the processing information about query 279, as shown in the following sample output:

```
query |   seg   | step | maxtime | avgtime |  rows   | label
------+---------+------+---------+---------+---------+-------------------
  279 |       3 |    0 | 1658054 | 1645711 | 1405360 | scan
  279 |       3 |    1 | 1658072 | 1645809 |       0 | project
  279 |       3 |    2 | 1658074 | 1645812 | 1405434 | insert
  279 |       3 |    3 | 1658080 | 1645816 | 1405437 | distribute
  279 |       4 |    0 | 1677443 | 1666189 | 1268431 | scan
  279 |       4 |    1 | 1677446 | 1666192 | 1268434 | insert
  279 |       4 |    2 | 1677451 | 1666195 |       0 | aggr
(7 rows)
```

Determining if any active queries are currently running on disk

The following query shows if any active queries are currently running on disk:

```
select query, label, is_diskbased from svv_query_state
where is_diskbased = 't';
```

This sample output shows any active queries currently running on disk:

```
 query | label        | is_diskbased
-------+--------------+--------------
1025   | hash tbl=142 |      t
(1 row)
```

SVV_REDSHIFT_COLUMNS

Use SVV_REDSHIFT_COLUMNS to view a list of all columns that a user has access to. This set of columns includes the columns on the cluster and the columns from datashares provided by remote clusters.

SVV_REDSHIFT_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where the table containing the columns exists.
schema_name	varchar(128)	The name of the schema for the table.
table_name	varchar(128)	The name of the table.
column_name	varchar(128)	The name of a column.
ordinal_position	integer	The position of the column in the table.
data_type	varchar(32)	The data type of the column.
column_default	varchar(4000)	The default value of the column.
is_nullable	varchar(3)	A value that defines whether a column is nullable. Possible values are `yes`, no, and " " (an empty string that represents no information).
encoding	varchar(128)	The encoding type of the column.
distkey	boolean	A value that is true if this column is the distribution key for the table, and false otherwise.
sortkey	integer	A value that specifies the order of the column in the sort key.

Column name	Data type	Description
		If the table uses a compound sort key, then all columns that are part of the sort key have a positive value that indicates the position of the column in the sort key. If the table uses an interleaved sort key, then each column that is part of the sort key has a value that is alternately positive or negative. Here, the absolute value indicates the position of the column in the sort key. If `sortkey` is 0, the column isn't part of a sort key.
column_acl	varchar(128)	A string that defines the permissions for the specified user or user group for the column.
remarks	varchar(256)	Remarks.

Sample query

The following example returns the output of SVV_REDSHIFT_COLUMNS.

```
SELECT *
FROM svv_redshift_columns
WHERE database_name = 'tickit_db'
    AND TABLE_NAME = 'tickit_sales_redshift'
ORDER BY COLUMN_NAME,
    TABLE_NAME,
    database_name
```

```
LIMIT 5;

database_name | schema_name |        table_name        | column_name | ordinal_position |
 data_type | column_default | is_nullable | encoding | distkey | sortkey | column_acl
 | remarks
--------------+-------------+------------------------+-------------+-----------------
+-----------+---------------+-------------+----------+---------+---------
+-------------+--------
   tickit_db  |   public    | tickit_sales_redshift |   buyerid   |        4         |
 integer  |                |     NO      |   az64   | False   |    0    |             |
   tickit_db  |   public    | tickit_sales_redshift | commission |        9         |
 numeric  |     (8,2)      |     YES     |   az64   | False   |    0    |             |
   tickit_db  |   public    | tickit_sales_redshift |    dateid   |        6         |
 smallint |                |     NO      |   none   | False   |    1    |             |
   tickit_db  |   public    | tickit_sales_redshift |   eventid   |        5         |
 integer  |                |     NO      |   az64   | False   |    0    |       |
   tickit_db  |   public    | tickit_sales_redshift |   listid    |        2         |
 integer  |                |     NO      |   az64   | True    |    0    |             |
```

SVV_REDSHIFT_DATABASES

Use SVV_ REDSHIFT_DATABASES to view a list of all the databases that a user has access to. This includes the databases on the cluster and the databases created from datashares provided by remote clusters.

SVV_REDSHIFT_DATABASES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database.
database_owner	integer	The database owner user ID.
database_type	varchar(32)	The type of database. Possible types are local or shared databases.

Column name	Data type	Description
database_acl	varchar(128)	This information is for internal use only.
database_options	varchar(128)	The properties of the database.
database_isolation_level	varchar(128)	The isolation level of the database. Possible values include: `Snapshot Isolation` and `Serializable`.

Sample query

The following example returns the output for SVV_REDSHIFT_DATABASES.

```
select database_name, database_owner, database_type, database_options,
 database_isolation_level
from  svv_redshift_databases;


database_name | database_owner | database_type | database_options |
 database_isolation_level
--------------+----------------+---------------+------------------+------------------
   dev        |  1             | local         | NULL             | Serializable
```

SVV_REDSHIFT_FUNCTIONS

Use SVV_REDSHIFT_FUNCTIONS to view a list of all functions that a user has access to. This set of functions includes the functions on the cluster and the functions from datashares provided by remote clusters.

SVV_REDSHIFT_FUNCTIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where the cluster that has these functions exists.
schema_name	varchar(128)	The name of the schema that specifies a given function.
function_name	varchar(128)	The name of a specified function.
function_type	varchar(128)	The type of function. Possible values are regular functions , aggregate functions, and stored procedures.
argument_type	varchar(512)	A string that represents the type of a function's input argument.
result_type	varchar(128)	The data type of a function's return value.

Sample query

The following example returns the output of SVV_REDSHIFT_FUNCTIONS.

```
SELECT *
FROM svv_redshift_functions
WHERE database_name = 'tickit_db'
    AND SCHEMA_NAME = 'public'
ORDER BY function_name
LIMIT 5;

database_name | schema_name |       function_name     |  function_type    |
 argument_type   | result_type
```

```
--------------+-------------+-----------------------+------------------
+-----------------+-------------
   tickit_db  |    public   |     shared_function    | REGULAR FUNCTION | integer,
 integer |   integer
```

SVV_REDSHIFT_SCHEMA_QUOTA

Displays the quota and the current disk usage for each schema in a database.

SVV_REDSHIFT_SCHEMA_QUOTA is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

This view is available when querying provisioned clusters or Redshift Serverless workgroups.

Table columns

Column name	Data type	Description
database_name	character(128)	The database that contains the schema.
schema_name	character(128)	The name of the schema.
schema_owner	integer	The internal user ID of the schema owner.
quota	integer	The amount of disk space (in MB) that the schema can use.
disk_usage	integer	The disk space (in MB) that is currently used by the schema.

Sample query

The following example displays the quota and the current disk usage for the schema named `sales_schema`.

```
SELECT TRIM(SCHEMA_NAME) "schema_name", QUOTA, disk_usage FROM
 svv_redshift_schema_quota
```

```
WHERE SCHEMA_NAME = 'sales_schema';


schema_name    | quota | disk_usage
--------------+-------+------------
sales_schema   | 2048  | 30
```

SVV_REDSHIFT_SCHEMAS

Use SVV_REDSHIFT_SCHEMAS to view a list of all schemas that a user has access to. This set of schemas includes the schemas on the cluster and the schemas from datashares provided by remote clusters.

SVV_REDSHIFT_SCHEMAS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where a specified schema exists.
schema_name	varchar(128)	The namespace or schema name.
schema_owner	integer	The internal user ID of the schema owner.
schema_type	varchar(16)	The type of the schema. Possible values are shared and local schemas.
schema_acl	varchar(128)	The string that defines the permissions for the specified user or user group for the schema.

Column name	Data type	Description
schema_option	varchar(128)	The options of the schema.

Sample query

The following example returns the output of SVV_REDSHIFT_SCHEMAS.

```
SELECT *
FROM svv_redshift_schemas
WHERE database_name = 'tickit_db'
ORDER BY database_name,
    SCHEMA_NAME;

database_name |    schema_name     | schema_owner | schema_type | schema_acl |
 schema_option
--------------+--------------------+--------------+-------------+------------
+---------------
   tickit_db  |       public       |       1      |    shared   |            |
```

SVV_REDSHIFT_TABLES

Use SVV_REDSHIFT_TABLES to view a list of all tables that a user has access to. This set of tables includes the tables on the cluster and the tables from datashares provided by remote clusters.

SVV_REDSHIFT_TABLES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database_name	varchar(128)	The name of the database where a specified table exists.
schema_name	varchar(128)	The name the schema for the table.
table_name	varchar(128)	The name of the table.

Column name	Data type	Description
table_type	varchar(128)	The type of table. Possible values are views and tables.
table_acl	varchar(128)	The string that defines the permissions for the specified user or user group for the table.
remarks	varchar(128)	Remarks.
table_owner	varchar(128)	The owner of the table.

Sample query

The following example returns the output of SVV_REDSHIFT_TABLES.

```
SELECT *
FROM svv_redshift_tables
WHERE database_name = 'tickit_db' AND TABLE_NAME LIKE 'tickit_%'
ORDER BY database_name,
TABLE_NAME;

database_name | schema_name |         table_name       | table_type | table_acl |
 remarks | table_owner
--------------+-------------+--------------------------+------------+-----------
+---------+-----------
   tickit_db  |    public   | tickit_category_redshift |    TABLE   |           |
   +
   tickit_db  |    public   |   tickit_date_redshift   |    TABLE   |           |
   +
   tickit_db  |    public   |   tickit_event_redshift  |    TABLE   |           |
   +
   tickit_db  |    public   |  tickit_listing_redshift |    TABLE   |           |
   +
   tickit_db  |    public   |   tickit_sales_redshift  |    TABLE   |           |
   +
   tickit_db  |    public   |   tickit_users_redshift  |    TABLE   |           |
   +
```

```
   tickit_db  |    public    |  tickit_venue_redshift  |    TABLE    |           |
```

If the table_acl value is null, no access privileges have been explicitly granted to the corresponding table.

SVV_RELATION_PRIVILEGES

Use SVV_RELATION_PRIVILEGES to view the relation (tables and views) permissions that are explicitly granted to users, roles, and groups in the current database.

SVV_RELATION_PRIVILEGES is visible to the following users:

- Superusers
- Users with the SYSLOG ACCESS UNRESTRICTED permission

Other users can only see identities they have access to or own. For more information about data visibility, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
namespace _name	text	The name of the namespace where a specified relation exists.
relation_name	text	The name of the relation.
privilege_type	text	The type of the permission. Possible values are INSERT, SELECT, UPDATE, DELETE, REFERENCES, or DROP.
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.

Column name	Data type	Description
admin_option	boolean	A value that indicates whether the user can grant the permission to other users and roles. It is always false for the role and group identity type.

Sample query

The following example displays the result of the SVV_RELATION_PRIVILEGES.

```
SELECT
 namespace_name,relation_name,privilege_type,identity_name,identity_type,admin_option
 FROM svv_relation_privileges
WHERE relation_name = 'orders' AND privilege_type = 'SELECT';

 namespace_name | relation_name | privilege_type |  identity_name | identity_type |
 admin_option
----------------+---------------+----------------+----------------+---------------
+--------------
     public     |    orders     |     SELECT     |    reguser     |     user      |
 False
     public     |    orders     |     SELECT     |     role1      |     role      |
 False
```

SVV_RLS_APPLIED_POLICY

Use SVV_RLS_APPLIED_POLICY to trace the application of RLS policies on queries that reference RLS-protected relations.

SVV_RLS_APPLIED_POLICY is visible to the following users:

- Superusers
- Users with the `sys:operator` role
- Users with the ACCESS SYSTEM TABLE permission

Note that sys:secadmin isn't granted this system permission.

Table columns

Column name	Data type	Description
username	text	The name of the user that ran the query.
query	integer	The ID of the query.
xid	long	The context of the transaction.
pid	integer	The leader process running the query.
recordtime	time	The time when the query was recorded.
command	char(1)	The command for which the RLS policy was applied. Possible values are `k` for unknown, `s` for select, `u` for update, `i` for insert, `y` for utility, and `d` for delete.
datname	text	The name of the database of the relation to which the row-level security policy is attached.
relschema	text	The name of the schema of the relation to which the row-level security policy is attached.
relname	text	The name of the relation to which the row-level security policy is attached.
polname	text	The name of the row-level security policy that is attached to the relation.
poldefault	char(1)	The default setting of the row-level security policy that is attached to the relation. Possible vaules are `f` for false if the default false policy has been applied and `t` for true if the default true policy has been applied.

Sample query

The following example displays the result of the SVV_RLS_APPLIED_POLICY. To query the SVV_RLS_APPLIED_POLICY, you must have the ACCESS SYSTEM TABLE permission.

```
-- Check what RLS policies were applied to the run query.
SELECT username, command, datname, relschema, relname, polname, poldefault
FROM svv_rls_applied_policy
WHERE datname = CURRENT_DATABASE() AND query = PG_LAST_QUERY_ID();

 username | command |  datname   | relschema |          relname          |      polname
  | poldefault
----------+---------+-----------+-----------+---------------------------
+-----------------+------------
   molly  |    s    | tickit_db |   public  | tickit_category_redshift |
 policy_concerts |
```

SVV_RLS_ATTACHED_POLICY

Use SVV_RLS_ATTACHED_POLICY to view a list of all relations and users that have one or more row-level security policies attached on the currently connected database.

Only users with the sys:secadmin role can query this view.

Table columns

Column name	Data type	Description
relschema	text	The name of the schema of the relation to which the row-level security policy is attached.
relname	text	The name of the relation to which the row-level security policy is attached.
relkind	text	The type of the object, such as table.
polname	text	The name of the row-level security policy that is attached to the relation.
grantor	text	The name of the user that has attached this policy.

Column name	Data type	Description
grantee	text	The name of the user or role that this policy has been attached to.
granteekind	text	The type of grantee. Possible values are user or role.
is_pol_on	boolean	The parameter that indicates whether a row-level security policy is turned on or off on a table. Possible values are true and false.
is_rls_on	boolean	The parameter that indicates whether a row-level security is turned on or off on a table. Possible values are true and false.
rls_conjunction_type	character (3)	The parameter that indicates whether relation combine RLS policies with and or or.

Sample query

The following example displays the result of the SVV_RLS_ATTACHED_POLICY.

```
--Inspect the policy in SVV_RLS_ATTACHED_POLICY
SELECT * FROM svv_rls_attached_policy;

 relschema |         relname           | relkind |     polname      | grantor | grantee
 | granteekind | is_pol_on | is_rls_on | rls_conjuntion_type
-----------+---------------------------+---------+------------------+---------+----------
+-------------+-----------+-----------+--------------------
 public    | tickit_category_redshift |  table  | policy_concerts |   bob   |  analyst
 |    role     |    True   |    True   |      and
 public    | tickit_category_redshift |  table  | policy_concerts |   bob   |  dbadmin
 |    role     |    True   |    True   |      and
```

SVV_RLS_POLICY

Use SVV_RLS_POLICY to view a list of all row-level security policies created on the Amazon Redshift cluster.

SVV_RLS_POLICY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
poldb	text	The name of the database in which the row-level security policy is created.
polname	text	The name of the row-level security policy.
polalias	text	The table alias used in the policy definition.
polatts	text	The attributes provided to the policy definition.
polqual	text	The policy condition provided in the USING clause of the CREATE POLICY statement.
polenabled	boolean	Whether the policy is turned on globally.
polmodifiedby	text	The name of the user that created or modified the policy most recently.
polmodifi edtime	timestamp	The timestamp of when the policy is created or last modified.

Sample query

The following example displays the result of the SVV_RLS_POLICY.

```
-- Create some policies.
CREATE RLS POLICY pol1 WITH (a int) AS t USING ( t.a IS NOT NULL );
CREATE RLS POLICY pol2 WITH (c varchar(10)) AS t USING ( c LIKE '%public%');

-- Inspect the policy in SVV_RLS_POLICY
SELECT * FROM svv_rls_policy;

 poldb | polname | polalias |                      polatts                       |
        polqual                | polenabled | polmodifiedby |   polmodifiedtime
-------+---------+----------+---------------------------------------------------
+---------------------------------------+------------+---------------
+---------------------
```

```
my_db | pol1    | t         | [{"colname":"a","type":"integer"}]                |
"t"."a" IS NOT NULL                   | t           | policy_admin  | 2022-02-11
14:40:49
my_db | pol2    | t         | [{"colname":"c","type":"character varying(10)"}] |
"t"."c" LIKE CAST('%public%' AS TEXT) | t           | policy_admin  | 2022-02-11
14:41:28
```

SVV_RLS_RELATION

Use SVV_RLS_RELATION to view a list of all relations that are RLS-protected.

SVV_RLS_RELATION is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
datname	text	The name of the database containing the relation.
relschema	text	The name of the schema containing the relation.
relname	text	The name of the relation.
relkind	text	The type of the relation, such as tables or views.
is_rls_on	boolean	The parameter that indicates whether the relation is RLS-protected.
is_rls_datashare_on	boolean	The parameter that indicates whether the relation is RLS-protected over datashares.
rls_conjunction_type	character(3)	The parameter that indicates whether relation combine RLS policies with `and` or `or`.
rls_datashare_conjunction_type	character(3)	The parameter that indicates whether relation combine RLS policies with `and` or `or` over datashares.

Sample query

The following example displays the result of the SVV_RLS_RELATION.

```
ALTER TABLE tickit_category_redshift ROW LEVEL SECURITY ON FOR DATASHARES;


--Inspect RLS state on the relations using SVV_RLS_RELATION.
SELECT datname, relschema, relname, relkind, is_rls_on, is_rls_datashare_on FROM
 svv_rls_relation ORDER BY relname;

  datname  | relschema |        relname           | relkind | is_rls_on |
 is_rls_datashare_on | rls_conjunction_type | rls_datashare_conjunction_type
-----------+-----------+--------------------------+---------+-----------
+---------------------+----------------------+--------------------------------
 tickit_db |   public  | tickit_category_redshift |  table  |     t    |           t
       |          and         |              and
(1 row)
```

SVV_ROLE_GRANTS

Use SVV_ROLE_GRANTS to view a list of roles that are explicitly granted roles in the cluster.

SVV_ROLE_GRANTS is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
role_id	integer	The ID of the role.
role_name	text	The name of the role.
granted_role_id	integer	The ID for the granted role.

Column name	Data type	Description
granted_role_name	text	The name for the granted role.

Sample query

The following example returns the output of SVV_ROLE_GRANTS.

```
GRANT ROLE role1 TO ROLE role2;
GRANT ROLE role2 TO ROLE role3;

SELECT role_name, granted_role_name FROM svv_role_grants;

 role_name |  granted_role_name
-----------+--------------------
   role2   |      role1
   role3   |      role2
(2 rows)
```

SVV_ROLES

Use SVV_ROLES to view role information.

This table is visible to all users.

Table columns

Column name	Data type	Description
role_id	integer	The role ID.
role_name	text	The name of the role.
role_owner	text	The name of the role owner.
external_id	text	The unique identifier of the role in the third-party identity provider.

Sample query

The following example returns the output of SVV_ROLES.

```
SELECT role_name,role_owner FROM svv_roles WHERE role_name IN ('role1', 'role2');

 role_name | role_owner
-----------+------------
   role1   | superuser
   role2   | superuser
```

SVV_SCHEMA_PRIVILEGES

Use SVV_SCHEMA_PRIVILEGES to view the schema permissions that are explicitly granted to users, roles, and groups in the current database.

SVV_SCHEMA_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
namespace_name	text	The name of the namespace where a specified schema exists.
privilege_type	text	The type of the permission. For permissions with a privilege_scope of schema, possible values are CREATE, USAGE, and ALTER. For privilege_scope values other than schema, possible values include any permission type available on the permission's scope.

Column name	Data type	Description
identity_id	integer	The ID of the identity. Possible values are user ID, role ID, or group ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user, role, group, or public.
admin_option	boolean	A value that indicates whether the user can grant the permissio n to other users and roles. It is always false for the role and group identity type.
privilege_scope	text	The scope of the permission specified in privilege_type. Possible values are as follows: • SCHEMA • TABLES • FUNCTIONS For information on scoped permissions, go to [Scoped permissions]().

Sample query

The following example displays the result of the SVV_SCHEMA_PRIVILEGES.

```
SELECT namespace_name,privilege_type,identity_name,identity_type,admin_option FROM
 svv_schema_privileges
WHERE namespace_name = 'test_schema1';
```

```
 namespace_name | privilege_type |  identity_name | identity_type | admin_option
----------------+----------------+----------------+---------------+--------------
 test_schema1   |    USAGE       |     reguser    |     user      |    False
 test_schema1   |    USAGE       |     role1      |     role      |    False
```

SVV_SCHEMA_QUOTA_STATE

Displays the quota and the current disk usage for each schema.

Regular users can see information for schemas for which they have USAGE permission. Superusers can see information for all schemas in the current database.

SVV_SCHEMA_QUOTA_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
schema_id	integer	The namespace or schema ID.
schema_name	character (128)	The namespace or schema name.
schema_owner	integer	The internal user ID of the schema owner.
quota	integer	The amount of disk space (in MB) that the schema can use.
disk_usage	integer	The disk space (in MB) that is currently used by the schema.
disk_usage_pct	double precision	The disk space percentage that is currently used by the schema out of the configured quota.

Sample query

The following example displays the quota and the current disk usage for the schema.

```
SELECT TRIM(SCHEMA_NAME) "schema_name", QUOTA, disk_usage, disk_usage_pct FROM
 svv_schema_quota_state
WHERE SCHEMA_NAME = 'sales_schema';
schema_name   | quota | disk_usage | disk_usage_pct
--------------+-------+------------+----------------
sales_schema  | 2048  | 30         | 1.46
(1 row)
```

SVV_SYSTEM_PRIVILEGES

SVV_SYSTEM_PRIVILEGES is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see identities they have access to or own.

Table columns

Column name	Data type	Description
system_privilege	text	The name of the system permission.
identity_id	integer	The ID of the identity. Possible values are user ID or role ID.
identity_name	text	The name of the identity.
identity_type	text	The type of the identity. Possible values are user or role.

Sample query

The following example displays the result for the specified parameters.

```
SELECT system_privilege,identity_name,identity_type FROM svv_system_privileges
WHERE system_privilege = 'ALTER TABLE' AND identity_name = 'sys:superuser';

 system_privilege | identity_name | identity_type
------------------+---------------+---------------
   ALTER TABLE    | sys:superuser |     role
```

SVV_TABLE_INFO

Shows summary information for tables in the database. The view filters system tables and shows only user-defined tables.

You can use the SVV_TABLE_INFO view to diagnose and address table design issues that can influence query performance. This includes issues with compression encoding, distribution keys, sort style, data distribution skew, table size, and statistics. The SVV_TABLE_INFO view doesn't return any information for empty tables.

The SVV_TABLE_INFO view summarizes information from the STV_BLOCKLIST, STV_NODE_STORAGE_CAPACITY, STV_TBL_PERM, and STV_SLICES system tables and from the PG_DATABASE, PG_ATTRIBUTE, PG_CLASS, PG_NAMESPACE, and PG_TYPE catalog tables.

SVV_TABLE_INFO is visible only to superusers. For more information, see Visibility of data in system tables and views. To permit a user to query the view, grant SELECT permission on SVV_TABLE_INFO to the user.

Table columns

Column name	Data type	Description
database	text	Database name.
schema	text	Schema name.
table_id	oid	Table ID.
table	text	Table name.

Column name	Data type	Description
encoded	text	Value that indicates whether any column has compression encoding defined.
diststyle	text	Distribution style or distribution key column, if key distribution is defined. Possible values include `EVEN`, `KEY(`*`column`*`)`, `ALL`, `AUTO(ALL)` , `AUTO(EVEN)` , and `AUTO(KEY(` *`column`*`))`.
sortkey1	text	First column in the sort key, if a sort key is defined. Possible values include *`column`*, `AUTO(SORTKEY)` , and `AUTO(SORTKEY(` *`column`*`))`.
max_varchar	integer	Size of the largest column that uses a VARCHAR data type.
sortkey1_enc	character(32)	Compression encoding of the first column in the sort key, if a sort key is defined.
sortkey_num	integer	Number of columns defined as sort keys.
size	bigint	Size of the table, in 1-MB data blocks.
pct_used	numeric(10,4)	Percent of available space that is used by the table.

Column name	Data type	Description
empty	bigint	For internal use. This column is no longer used and will be removed in a future release.
unsorted	numeric(5,2)	Percent of unsorted rows in the table.
stats_off	numeric(5,2)	Number that indicates how stale the table's statistics are; 0 is current, 100 is out of date.
tbl_rows	numeric(38,0)	Total number of rows in the table. This value includes rows marked for deletion, but not yet vacuumed.
skew_sortkey1	numeric(19,2)	Ratio of the size of the largest non-sort key column to the size of the first column of the sort key, if a sort key is defined. Use this value to evaluate the effectiveness of the sort key.
skew_rows	numeric(19,2)	Ratio of the number of rows in the slice with the most rows to the number of rows in the slice with the fewest rows.
estimated_visible_rows	numeric(38,0)	The estimated rows in the table. This value does not include rows marked for deletion.

Column name	Data type	Description
risk_event	text	Risk information about a table. The field is separated into parts: `risk_type |xid|timestamp` • The `risk_type` , where 1 indicates that a `COPY command with the EXPLICIT_IDS option` ran. Amazon Redshift no longer checks the uniqueness of IDENTITY columns in the table. For more information, see EXPLICIT_IDS. • The transaction ID, `xid`, that introduced the risk. • The `timestamp` when the COPY command ran. The following example shows the values in the field. `1|1107|2019-06-22 07:16:11.292952`
vacuum_sort_benefit	numeric(12,2)	The estimated maximum percentage improvement of scan query performance when you run vacuum sort.

Column name	Data type	Description
create_time	timestamp without time zone	The timestamp for when the table was created.

Sample queries

The following example shows encoding, distribution style, sorting, and data skew for all user-defined tables in the database. Here, "table" must be enclosed in double quotation marks because it is a reserved word.

```
select "table", encoded, diststyle, sortkey1, skew_sortkey1, skew_rows
from svv_table_info
order by 1;

table           | encoded | diststyle       | sortkey1     | skew_sortkey1 | skew_rows
---------------+---------+-----------------+--------------+---------------+----------
category        | N       | EVEN            |              |               |
date            | N       | ALL             | dateid       |          1.00 |
event           | Y       | KEY(eventid)    | dateid       |          1.00 |      1.02
listing         | Y       | KEY(listid)     | dateid       |          1.00 |      1.01
sales           | Y       | KEY(listid)     | dateid       |          1.00 |      1.02
users           | Y       | KEY(userid)     | userid       |          1.00 |      1.01
venue           | N       | ALL             | venueid      |          1.00 |
(7 rows)
```

SVV_TABLES

Use SVV_TABLES to view tables in local and external catalogs.

SVV_TABLES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
table_catalog	text	The name of the catalog where the table exists.

Column name	Data type	Description
table_schema	text	The name the schema for the table.
table_name	text	The name of the table.
table_type	text	The type of table. Possible values are views, external tables, and base tables.
remarks	text	Remarks.

SVV_TRANSACTIONS

Records information about transactions that currently hold locks on tables in the database. Use the SVV_TRANSACTIONS view to identify open transactions and lock contention issues. For more information about locks, see Managing concurrent write operations and LOCK.

SVV_TRANSACTIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
txn_owner	text	Name of the owner of the transaction.
txn_db	text	Name of the database associated with the transacti on.
xid	bigint	Transaction ID.
pid	integer	Process ID associated with the lock.
txn_start	timestamp	Start time of the transaction.

Column name	Data type	Description
lock_mode	text	Name of the lock mode held or requested by this process. If `lock_mode` is `Exclusive Lock` and `granted` is true (`t`), then this transaction ID is an open transaction.
lockable_object_type	text	Type of object requesting or holding the lock, either `relation` if it is a table or `transactionid` if it is a transaction.
relation	integer	Table ID for the table (relation) acquiring the lock. This value is NULL if `lockable_object_type` is `transactionid` .
granted	boolean	Value that indicates whether that the lock has been granted (`t`) or is pending (`f`) .

Sample queries

The following command shows all active transactions and the locks requested by each transaction.

```
select * from svv_transactions;

 txn_
 lockable_
 owner | txn_db |  xid   |  pid  |         txn_start          |      lock_mode      |
 object_type    | relation | granted
-------+--------+--------+-------+----------------------------+--------------------
+----------------+----------+---------
 root   | dev    | 438484 | 22223 | 2016-03-02 18:42:18.862254 | AccessShareLock     |
 relation       |   100068 | t
```

```
 root  | dev    | 438484 | 22223 | 2016-03-02 18:42:18.862254 | ExclusiveLock       |
 transactionid  |          | t
 root  | tickit | 438490 | 22277 | 2016-03-02 18:42:48.084037 | AccessShareLock     |
 relation       |    50860 | t
 root  | tickit | 438490 | 22277 | 2016-03-02 18:42:48.084037 | AccessShareLock     |
 relation       |    52310 | t
 root  | tickit | 438490 | 22277 | 2016-03-02 18:42:48.084037 | ExclusiveLock       |
 transactionid  |          | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | AccessExclusiveLock |
 relation       |   100068 | f
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | RowExclusiveLock    |
 relation       |    16688 | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | AccessShareLock     |
 relation       |   100064 | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | AccessExclusiveLock |
 relation       |   100166 | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | AccessExclusiveLock |
 relation       |   100171 | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | AccessExclusiveLock |
 relation       |   100190 | t
 root  | dev    | 438505 | 22378 | 2016-03-02 18:43:27.611292 | ExclusiveLock       |
 transactionid  |          | t
(12 rows)

(12 rows)
```

SVV_USER_GRANTS

Use SVV_USER_GRANTS to view the list of users that are explicitly granted roles in the cluster.

SVV_USER_GRANTS is visible to the following users:

- Superusers
- Users with the ACCESS SYSTEM TABLE permission

Other users can only see roles that are explicitly granted to them.

Table columns

Column name	Data type	Description
user_id	integer	The user ID for the user.
user_name	text	The name of the user.
role_id	integer	The role ID for the granted role.
role_name	text	The role name for the granted role.
admin_option	boolean	A value that indicates whether the user can grant the role to other users and roles.

Sample queries

The following queries grant roles to users and show the list of users that are explicitly granted roles.

```
GRANT ROLE role1 TO reguser;
GRANT ROLE role2 TO reguser;
GRANT ROLE role1 TO superuser;
GRANT ROLE role2 TO superuser;

SELECT user_name,role_name,admin_option FROM svv_user_grants;

 user_name | role_name | admin_option
-----------+-----------+--------------
 superuser |  role1    | False
 reguser   |  role1    | False
 superuser |  role2    | False
  reguser  |  role2    | False
```

SVV_USER_INFO

You can retrieve data about Amazon Redshift database users with the SVV_USER_INFO view.

SVV_USER_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_name	text	The user name for the role.
user_id	integer	The user ID for the user.
createdb	boolean	A value that indicates whether the user has permissions to create databases.
superuser	boolean	A value that indicates whether the user is a superuser.
catalog_update	boolean	A value that indicates whether the user can update system catalogs.
connection_limit	text	The number of connections that the user can open.
syslog_access	text	A value that indicates whether the user has access to the system logs. The two possible values are `RESTRICTED` and `UNRESTRICTED`. `RESTRICTED` means that users that are not superusers can see their own records. `UNRESTRICTED` means that user that are not superusers can see all records in the system views and tables to which they have `SELECT` privileges.
last_ddl_timestamp	timestamp	The timestamp for the last data definition language (DDL) create statement run by the user.
session_timeout	integer	The maximum time in seconds that a session remains inactive or idle before timing out. 0 indicates that no timeout is set. For information about the cluster's idle or inactive timeout setting, see Quotas and limits in Amazon Redshift in the *Amazon Redshift Management Guide*.

Column name	Data type	Description
external_user_id	text	Unique identifier of the user in the third-party identity provider.

Sample queries

The following command retrieves user information from SVV_USER_INFO.

```
SELECT * FROM SVV_USER_INFO;
```

SVV_VACUUM_PROGRESS

This view returns an estimate of how much time it will take to complete a vacuum operation that is currently in progress.

SVV_VACUUM_PROGRESS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_VACUUM_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For information about SVV_VACUUM_SUMMARY, see SVV_VACUUM_SUMMARY.

For information about SVL_VACUUM_PERCENTAGE, see SVL_VACUUM_PERCENTAGE.

> **Note**
>
> This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
table_name	text	Name of the table currently being vacuumed, or the table that was last vacuumed if no operation is in progress.
status	text	Description of the current activity being done as part of the vacuum operation: • Initialize • Sort • Merge • Delete • Select • Failed • Complete • Skipped • Building INTERLEAVED SORTKEY order
time_remaining_estimate	text	Estimated time left for the current vacuum operation to complete, in minutes and seconds: **`5m 10s`**, for example. An estimated time is not returned until the vacuum completes its first sort operation. If no vacuum is in progress, the last vacuum that was performed is displayed with **`Completed`** in the STATUS column and an empty TIME_REMAINING_ESTIMATE column. The estimate typically becomes more accurate as the vacuum progresses.

Sample queries

The following queries, run a few minutes apart, show that a large table named SALESNEW is being vacuumed.

```
select * from svv_vacuum_progress;
```

```
table_name    |              status             | time_remaining_estimate
--------------+---------------------------------+-------------------------
salesnew      |  Vacuum: initialize salesnew  |
(1 row)
...
select * from svv_vacuum_progress;

table_name   |         status         | time_remaining_estimate
-------------+------------------------+-------------------------
salesnew     |  Vacuum salesnew sort  | 33m 21s
(1 row)
```

The following query shows that no vacuum operation is currently in progress. The last table to be vacuumed was the SALES table.

```
select * from svv_vacuum_progress;

table_name   |  status   | time_remaining_estimate
-------------+----------+-------------------------
  sales      | Complete |
(1 row)
```

SVV_VACUUM_SUMMARY

The SVV_VACUUM_SUMMARY view joins the STL_VACUUM, STL_QUERY, and STV_TBL_PERM tables to summarize information about vacuum operations logged by the system. The view returns one row per table per vacuum transaction. The view records the elapsed time of the operation, the number of sort partitions created, the number of merge increments required, and deltas in row and block counts before and after the operation was performed.

SVV_VACUUM_SUMMARY is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_VACUUM_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For information about SVV_VACUUM_PROGRESS, see SVV_VACUUM_PROGRESS.

For information about SVL_VACUUM_PERCENTAGE, see SVL_VACUUM_PERCENTAGE.

Note

This view is only available when querying provisioned clusters.

Table columns

Column name	Data type	Description
table_name	text	Name of the vacuumed table.
xid	bigint	Transaction ID of the VACUUM operation.
sort_partitions	bigint	Number of sorted partitions created during the sort phase of the vacuum operation.
merge_increments	bigint	Number of merge increments required to complete the merge phase of the vacuum operation.
elapsed_time	bigint	Elapsed runtime of the vacuum operation (in microseconds).
row_delta	bigint	Difference in the total number of table rows before and after the vacuum.
sortedrow_delta	bigint	Difference in the number of sorted table rows before and after the vacuum.
block_delta	integer	Difference in block count for the table before and after the vacuum.
max_merge_partitions	integer	This column is used for performance analysis and represents the maximum number of partitions that vacuum can process for the table per merge phase iteration. (Vacuum sorts the unsorted region into one or more sorted partitions. Depending on the number of columns in the table and the current Amazon Redshift configuration, the merge phase can process a maximum number of partitions in a single merge iteration. The merge phase will still work if the number of

Column name	Data type	Description
		sorted partitions exceeds the maximum number of merge partitions, but more merge iterations will be required.)

Sample query

The following query returns statistics for vacuum operations on three different tables. The SALES table was vacuumed twice.

```
select table_name, xid, sort_partitions as parts, merge_increments as merges,
elapsed_time, row_delta, sortedrow_delta as sorted_delta, block_delta
from svv_vacuum_summary
order by xid;

table_  | xid  |parts|merges| elapsed_ | row_    | sorted_ | block_
name    |      |     |      | time     | delta   | delta   | delta
--------+------+-----+------+----------+---------+---------+--------
users   | 2985 |   1 |    1 | 61919653 |       0 |   49990 |      20
category| 3982 |   1 |    1 | 24136484 |       0 |      11 |       0
sales   | 3992 |   2 |    1 | 71736163 |       0 | 1207192 |      32
sales   | 4000 |   1 |    1 | 15363010 | -851648 | -851648 |    -140
(4 rows)
```

SYS monitoring views

Monitoring views are system views in Amazon Redshift that are used to monitor query and workload resource usage of provisioned clusters and serverless workgroups. These views are located in the `pg_catalog` schema. To display the information provided by these views, run SQL SELECT statements.

Unless noted otherwise, these views are available for Amazon Redshift clusters and Amazon Redshift Serverless workgroups.

SYS_SERVERLESS_USAGE gathers usage data for Amazon Redshift Serverless only.

Topics

- SYS_ANALYZE_COMPRESSION_HISTORY
- SYS_ANALYZE_HISTORY
- SYS_APPLIED_MASKING_POLICY_LOG
- SYS_AUTO_TABLE_OPTIMIZATION
- SYS_CHILD_QUERY_TEXT
- SYS_CONNECTION_LOG
- SYS_COPY_JOB
- SYS_COPY_JOB_DETAIL
- SYS_COPY_JOB_INFO
- SYS_COPY_REPLACEMENTS
- SYS_DATASHARE_CHANGE_LOG
- SYS_DATASHARE_CROSS_REGION_USAGE
- SYS_DATASHARE_USAGE_CONSUMER
- SYS_DATASHARE_USAGE_PRODUCER
- SYS_EXTERNAL_QUERY_DETAIL
- SYS_EXTERNAL_QUERY_ERROR
- SYS_INTEGRATION_ACTIVITY
- SYS_INTEGRATION_TABLE_ACTIVITY
- SYS_INTEGRATION_TABLE_STATE_CHANGE
- SYS_LOAD_DETAIL
- SYS_LOAD_ERROR_DETAIL
- SYS_LOAD_HISTORY
- SYS_MV_REFRESH_HISTORY
- SYS_MV_STATE
- SYS_PROCEDURE_CALL
- SYS_PROCEDURE_MESSAGES
- SYS_QUERY_DETAIL
- SYS_QUERY_EXPLAIN
- SYS_QUERY_HISTORY
- SYS_QUERY_TEXT

SYS_ANALYZE_COMPRESSION_HISTORY

Records details for compression analysis operations during COPY or ANALYZE COMPRESSION commands.

SYS_ANALYZE_COMPRESSION_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user who generated the entry.
start_time	timestamp	The time when the compression analysis operation started.
transaction_id	bigint	The transaction ID of the compression analysis operation.

Column name	Data type	Description
table_id	integer	The table ID of the table that was analyzed.
table_name	character(128)	The name of the table that was analyzed.
column_position	integer	The index of the column in the table that was analyzed to determine the compression encoding.
old_encoding	character(15)	The encoding type before compression analysis.
new_encoding	character(15)	The encoding type after compression analysis.
mode	character(14)	The possible values are: **PRESET** Specifies that the `new_encoding` is determined by the Amazon Redshift COPY command based on the column data type. No data is sampled. **ON** Specifies that the `new_encoding` is determined by the Amazon Redshift COPY command based on an analysis of sample data. **ANALYZE ONLY** Specifies that the `new_encoding` is determined by the Amazon Redshift ANALYZE COMPRESSION command based on an analysis of sample data. However, the encoding type of the analyzed column is not changed.

Sample queries

The following example inspects the details of compression analysis on the `lineitem` table by the last COPY command run in the same session.

```
select transaction_id, table_id, btrim(table_name) as table_name, column_position,
 old_encoding, new_encoding, mode
from sys_analyze_compression_history
where transaction_id = (select transaction_id from sys_query_history where query_id =
 pg_last_copy_id()) order by column_position;

 transaction_id  |  table_id   | table_name | column_position |  old_encoding   |
 new_encoding   |      mode
-----------------+-------------+------------+-----------------+-----------------
+-----------------+-------------
      8196       |   248126    | lineitem   |        0        | mostly32        |
 mostly32        | ON
      8196       |   248126    | lineitem   |        1        | mostly32        | lzo
          | ON
      8196       |   248126    | lineitem   |        2        | lzo             |
 delta32k        | ON
      8196       |   248126    | lineitem   |        3        | delta           | delta
          | ON
      8196       |   248126    | lineitem   |        4        | bytedict        |
 bytedict        | ON
      8196       |   248126    | lineitem   |        5        | mostly32        |
 mostly32        | ON
      8196       |   248126    | lineitem   |        6        | delta           | delta
          | ON
      8196       |   248126    | lineitem   |        7        | delta           | delta
          | ON
      8196       |   248126    | lineitem   |        8        | lzo             | zstd
          | ON
      8196       |   248126    | lineitem   |        9        | runlength       | zstd
          | ON
      8196       |   248126    | lineitem   |       10        | delta           | lzo
          | ON
      8196       |   248126    | lineitem   |       11        | delta           | delta
          | ON
      8196       |   248126    | lineitem   |       12        | delta           | delta
          | ON
      8196       |   248126    | lineitem   |       13        | bytedict        | zstd
          | ON
```

```
       8196         |    248126     | lineitem    |         14          | bytedict          | zstd
            | ON
       8196         |    248126     | lineitem    |         15          | text255           | zstd
            | ON
(16 rows)
```

SYS_ANALYZE_HISTORY

Logs details for ANALYZE operations.

SYS_ANALYZE_HISTORY is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user who generated the entry.
transaction_id	long	The transaction ID.
database_name	char(30)	The name of the database.
table_name	char(30)	The name of the table.
table_id	integer	The ID of the table.
is_automatic	char(1)	The value is true (t) if the operation included an Amazon Redshift ANALYZE operation by default. The value is false (f) if the ANALYZE command was run explicitly.
status	char(15)	The result of the analyze command. Possible values are Full, Skipped, and PredicateColumn.
start_time	timestamp	The time in UTC of when the ANALYZE operation started running.

Column name	Data type	Description
end_time	timestamp	The time in UTC of when the ANALYZE operation finished running.
rows	double	The total number of rows in the table
modified_rows	double	The total number of rows that were modified since the last ANALYZE operation.
analyze_threshold_percent	integer	The value of the analyze_threshold_percent parameter.
last_analyze_time	timestamp	The time in UTC of when the table was previously analyzed.

Sample queries

```
 user_id | transaction_id | database_name | schema_name |      table_name     |
 table_id | is_automatic | Status |          start_time          |           end_time
     | rows | modified_rows | analyze_threshold_percent |  last_analyze_time
---------+----------------+---------------+-------------+--------------------
+----------+--------------+--------+----------------------------+----------
+-----------------+------+---------------+--------------------------
+---------------------
     101 |           8006 |           dev |      public | test_table_562bf8dc
 |   110427 |            f |   Full | 2023-09-21 18:33:08.504646 | 2023-09-21
 18:33:24.296498 |    5 |             5 |                         0 | 2000-01-01
 00:00:00
```

SYS_APPLIED_MASKING_POLICY_LOG

Use SYS_APPLIED_MASKING_POLICY_LOG to trace the application of dynamic data masking policies on queries that reference DDM-protected relations.

SYS_APPLIED_MASKING_POLICY_LOG is visible to the following users:

- Superusers
- Users with the `sys:operator` role
- Users with the ACCESS SYSTEM TABLE permission

Regular users will see 0 rows.

Note that SYS_APPLIED_MASKING_POLICY_LOG isn't visible to users with the `sys:secadmin` role.

For more information on dynamic data masking, go to Dynamic data masking.

Table columns

Column name	Data type	Description
policy_name	text	The name of the masking policy.
user_id	text	The ID of the user who ran the query.
record_time	timestamp	The time that the system view entry was recorded.
session_id	int	The process ID.
transaction_id	long	The transaction ID.
query_id	int	The query ID.
database_name	text	The name of the database on which the query was run.
relation_name	text	The name of the table that the masking policy is applied to.
schema_name	text	The name of the schema that the table is in.
attachment_id	long	The attached masking policy's ID.

Column name	Data type	Description
relation_kind	text	The type of the relation that the masking policy is applied to. Possible values are `TABLE`, `VIEW`, `LATE BINDING VIEW`, and `MATERIALIZED VIEW` .

Sample queries

The following example shows that the `mask_credit_card_full` masking policy is attached to the `credit_db.public.credit_cards` table.

```
select policy_name, database_name, relation_name, schema_name, relation_kind
from sys_applied_masking_policy_log;

policy_name           | database_name | relation_name | schema_name | relation_kind
----------------------+---------------+---------------+-------------+---------------
mask_credit_card_full | credit_db     | credit_cards  | public      | table

(1 row)
```

SYS_AUTO_TABLE_OPTIMIZATION

Records automated actions taken by Amazon Redshift on tables defined for automatic optimization.

SYS_AUTO_TABLE_OPTIMIZATION is visible only to superusers. For more information, see [Visibility of data in system tables and views](#).

Table columns

Column name	Data type	Description
transaction_id	long	The transaction identifier.

Column name	Data type	Description
session_id	int	The session identifier of the process that executed the alter command.
table_id	int	The table identifier.
alter_table_type	character (32)	The type of recommendation. Possible values are `distkey`, `sortkey`, and `encode`.
status	character (128)	The completion status of the recommendation. Possible values are `Start`, `Complete`, `Skipped`, `Abort`, `Checkpoint` , and `Failed`.
event_time	timestamp	The timestamp of the status column.
alter_from	character (200)	The previous distribution style and sort keys of the table before applying the recommendation. The value is truncated into 200-character increments.

Sample queries

In the following example, the rows in the result show actions taken by Amazon Redshift.

```
SELECT table_id, alter_table_type, status, event_time, alter_from
FROM SYS_AUTO_TABLE_OPTIMIZATION;

 table_id |  alter_table_type   |                        status
 |         event_time          |  alter_from
----------+---------------------+-----------------------------------------------------------
+-----------------------------+-----------------
   118082 | sortkey             | Start
 | 2020-08-22 19:42:20.727049  |
   118078 | sortkey             | Start
 | 2020-08-22 19:43:54.728819  |
   118082 | sortkey             | Start
 | 2020-08-22 19:42:52.690264  |
   118072 | sortkey             | Start
 | 2020-08-22 19:44:14.793572  |
```

```
   118082 | sortkey                | Failed
 | 2020-08-22 19:42:20.728917  |
   118078 | sortkey                | Complete
 | 2020-08-22 19:43:54.792705  |  SORTKEY: None;
   118086 | sortkey                | Complete
 | 2020-08-22 19:42:00.72635   |  SORTKEY: None;
   118082 | sortkey                | Complete
 | 2020-08-22 19:43:34.728144  |  SORTKEY: None;
   118072 | sortkey                | Skipped:Retry exceeds the maximum limit for a table.
 | 2020-08-22 19:44:46.706155  |
   118086 | sortkey                | Start
 | 2020-08-22 19:42:00.685255  |
   118082 | sortkey                | Start
 | 2020-08-22 19:43:34.69531   |
   118072 | sortkey                | Start
 | 2020-08-22 19:44:46.703331  |
   118082 | sortkey                | Checkpoint: progress 14.755079%
 | 2020-08-22 19:42:52.692828  |
   118072 | sortkey                | Failed
 | 2020-08-22 19:44:14.796071  |
   116723 | sortkey                | Abort:This table is not AUTO.
 | 2020-10-28 05:12:58.479233  |
   110203 | distkey                | Abort:This table is not AUTO.
 | 2020-10-28 05:45:54.67259   |
```

SYS_CHILD_QUERY_TEXT

Returns the SQL text of a child query.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The user query ID
child_query_sequence	integer	The sequence of the rewritten user query, starting with 1.
sequence	integer	The sequence number for this query piece.

Column name	Data type	Description
text	character (200)	The first 200 characters of the text of the SQL query.

Sample queries

In the following example, the rows in the result show actions taken by Amazon Redshift.

```
SELECT * from sys_child_query_text where query_id = '34487366' order by
 child_query_sequence asc, sequence asc;

user_id | query_id | child_query_sequence | sequence | text
--------|----------|----------------------|----------|-------------------------------------------
100     | 34899339 |   1                  |    0     |  /* RQEV2-aY6ZZ1ZpQK */\nwith
 venue as (\n    select venueid,\n            venuename,\n            venuestate\n
 from venue\n), event as (\n    select eventid,\n            venueid,\n            date

100     | 34899339 |   1                  |    1     |  id,\n            eventname\n
  from event\n    where eventname like '3 Doors Down'\n), users as (\n    select userid
\n    from users\n), sales as (\n    select salesid,\n            pricepaid,
100     | 34899339 |   1                  |    2     |  \n            eventid,\n
      buyerid\n    from sales\n)\nselect e.eventname,\n        v.venuename,\n
 count(distinct(u.userid)) as unique_customers,\n        sum(s.pricepaid) as total_sal

100     | 34899339 |   1                  |    3     |  es\nfrom venue as v inner join
 event e on v.venueid = e.venueid\ninner join sales s on e.eventid = s.eventid inner
 join users u on s.buyerid = u.userid\ngroup by 1,2\norder by 4 desc limit 100
```

SYS_CONNECTION_LOG

Logs authentication attempts and connections and disconnections.

SYS_CONNECTION_LOG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
event	character(50)	Connection or authentication event.
record_time	timestamp	Time the event occurred.
remote_host	character(45)	Name or IP address of remote host.
remote_port	character(32)	Port number for remote host.
session_id	integer	Process ID associated with the statement.
database_name	character(50)	Database name.
user_name	character(50)	Username.
auth_method	character(32)	Authentication method.
duration	integer	Duration of connection in microseconds.
ssl_version	character(50)	Secure Sockets Layer (SSL) version. This column is empty when SSL is disabled.
ssl_cipher	character(128)	SSL cipher.
mtu	integer	Maximum transmission unit (MTU).
ssl_compression	character(64)	SSL compression type.
ssl_expansion	character(64)	SSL expansion type.

Column name	Data type	Description
iam_auth_guid	character(36)	The IAM authentication ID for the CloudTrail request.
application_name	character(250)	The initial or updated name of the application for a session.
driver_version	character(64)	The version of ODBC or JDBC driver that connects to your Amazon Redshift cluster from your third-party SQL client tools.
os_version	character(64)	The version of the operating system that is on the client machine that connects to your Amazon Redshift cluster.
plugin_name	character(32)	The name of the plugin used to connect to your Amazon Redshift cluster.
protocol_version	integer	The internal protocol version that the Amazon Redshift driver uses when establishing its connection with the server. The protocol versions are negotiated between the driver and server. The version describes the features available. Valid values include: • 0 (BASE_SERVER_PROTOCOL_VERSION) • 1 (EXTENDED_RESULT_METADATA_SERVER_PROTOCOL_VERSION) – To save a round trip per query, the server sends extra result set metadata information. • 2 (BINARY_PROTOCOL_VERSION) – Depending on the data type of the result set, the server sends data in binary format. • 3 (EXTENDED2_RESULT_METADATA_SERVER_PROTOCOL_VERSION) – The server sends case sensitivity (collation) information of a column.
global_session_id	character(36)	The globally unique identifier for the current session. The session ID persists through node failure restarts.

Sample queries

To view the details for open connections, run the following query.

```
select record_time, user_name, database_name, remote_host, remote_port
from sys_connection_log
where event = 'initiating session'
and session_id not in
(select session_id from sys_connection_log
where event = 'disconnecting session')
order by 1 desc;

record_time         | user_name    | database_name    | remote_host    | remote_port

--------------------+-------------+-----------------+---------------
+--------------------------------
2014-11-06 20:30:06 | rdsdb       | dev             | [local]        |

2014-11-06 20:29:37 | test001     | test            | 10.49.42.138   | 11111

2014-11-05 20:30:29 | rdsdb       | dev             | 10.49.42.138   | 33333

2014-11-05 20:28:35 | rdsdb       | dev             | [local]        |
(4 rows)
```

The following example reflects a failed authentication attempt and a successful connection and disconnection.

```
select event, record_time, remote_host, user_name
from sys_connection_log order by record_time;

            event      |         record_time        |  remote_host  | user_name

-----------------------+----------------------------+---------------+---------
authentication failure | 2012-10-25 14:41:56.96391  | 10.49.42.138  | john

authenticated          | 2012-10-25 14:42:10.87613  | 10.49.42.138  | john

initiating session     | 2012-10-25 14:42:10.87638  | 10.49.42.138  | john

disconnecting session  | 2012-10-25 14:42:19.95992  | 10.49.42.138  | john
```

```
(4 rows)
```

The following example shows the version of the ODBC driver, the operating system on the client machine, and the plugin used to connect to the Amazon Redshift cluster. In this example, the plugin used is for standard ODBC driver authentication using a login name and password.

```
select driver_version, os_version, plugin_name from sys_connection_log;

driver_version                          |  os_version                        |
 plugin_name
----------------------------------------+-----------------------------------
+--------------------
Amazon Redshift ODBC Driver 1.4.15.0001 | Darwin 18.7.0 x86_64               | none
Amazon Redshift ODBC Driver 1.4.15.0001 | Linux 4.15.0-101-generic x86_64    | none
```

The following example shows the version of the operating system on the client machine, the driver version, and the protocol version.

```
select os_version, driver_version, protocol_version from sys_connection_log;

os_version                      |  driver_version              | protocol_version
--------------------------------+------------------------------+--------------------
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
```

SYS_COPY_JOB

Use SYS_COPY_JOB to view details of COPY JOB commands.

This view contains the COPY JOB commands that have been created.

SYS_COPY_JOB is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
job_id	bigint	The copy job identifier.

Column name	Data type	Description
job_name	character(128)	The name of the copy job.
iam_role	character(128)	The IAM role specified in the COPY statement.
job_text	character(256)	The parameters of the COPY statement.
is_auto	integer	Indicates whether the COPY JOB is automatically run by Amazon Redshift. A 1 indicates true, `0` indicates false.
on_error_suspend	integer	This information is for internal use only.

SYS_COPY_JOB_DETAIL

Use SYS_COPY_JOB_DETAIL to view details of COPY JOB commands.

This view contains the COPY JOB commands that have been created. If COPY JOB attempts to load a file and it fails to load, the file is skipped on future automatic COPY JOB attempts.

SYS_COPY_JOB_DETAIL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user that owns the job.
database_name	text	The name of the database containing the job.

Column name	Data type	Description
job_id	integer	The copy job identifier.
job_name	text	The name of the copy job.
file_location	text	The Amazon S3 bucket name for the entry.
file_name	text	The Amazon S3 key name for the entry.
file_size	bigint	The size of the entry in bytes.
file_etag	text	The Amazon S3 entity tag (ETag) for the entry.
job_text	character(256)	The parameters of the COPY statement.
modification_time	timestamp	The time (UTC) at which the S3 object was created or modified initiating ingestion. In S3 listing mode, this is the object modification time. For notification mode, this is the time the notification event occurred.
enqueue_time	timestamp	The time (UTC) at which the entry was added to the ingestion queue.
status	char(1)	The status of the entry. Valid values: P for pending ingestion, I for ingested, E for error ingesting, and U for unknown (indicating some kind of unexpected state).

The following example returns one row where for ingested entries.

```
SELECT * FROM SYS_COPY_JOB_DETAIL WHERE status ilike '%ingested%' limit 1;


user_id | 100
database_name | dev
job_name | many_job_4_3
job_id | 110702
file_location | saral-sqs-system4623202051-0
file_name | frenzy-9/4623202051/file_0_107
file_size | 11302
file_etag | 51b2d78ac5b5aecf4ee6f8374815ad19
modification_time | 2024-07-15 20:43:14
enqueue_time | 2024-07-15 20:44:24
status | Ingested
```

SYS_COPY_JOB_INFO

Use SYS_COPY_JOB_INFO to view messages logged about a COPY JOB.

This view contains information about errors in a COPY JOB that has run.

SYS_COPY_JOB_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
job_id	bigint	The copy job identifier.
job_name	character(128)	The name of the copy job.
database_name	character(128)	The name of the database.
record_time	timestamp	The time (UTC) when the message was logged.
message	chaacter(512)	This message of the logged event for a COPY JOB.

SYS_COPY_REPLACEMENTS

Displays a log that records when invalid UTF-8 characters were replaced by the COPY command with the ACCEPTINVCHARS option. A log entry is added to SYS_COPY_REPLACEMENTS for each of the first 100 rows on each node slice that required at least one replacement.

You can use this view to see information about serverless workgroups and provisioned clusters.

SYS_COPY_REPLACEMENTS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	ID of the user who generated the query.
query_id	bigint	The query ID. The column used to join other system tables and views.
table_id	integer	The table ID.
file_name	character (256)	The complete path to the input file for the COPY command.
column_name	character (127)	The first field that contains an invalid UTF-8 character.
line_number	bigint	The line number in the input data file that containes an invalid UTF-8 character. -1 indicates that the line number is not available, such as when copying from a columnar data file.
raw_line	character (1024)	The raw load data that contains an invalid UTF-8 character.

Sample queries

The following example returns replacements for the most recent COPY operation.

```
select query_idp, table_id, file_name, line_number, colname
from sys_copy_replacements
where query = pg_last_copy_id();


 query_id | table_id |   file_name                                                 |
 line_number | column_name
 ---------+----------+-------------------------------------------------------------
+-------------+--------
    96    |    26    | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt                   |
 123 | city
    96    |    26    | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt                   |
 456 | city
    96    |    26    | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt                   |
 789 | city
    96    |    26    | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt                   |
 012 | city
    96    |    26    | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt                   |
 119 | city
...
```

SYS_DATASHARE_CHANGE_LOG

Records the consolidated view for tracking changes to datashares on both producer and consumer clusters.

SYS_DATASHARE_CHANGE_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user taking the action.
user_name	varchar(128)	The name of the user taking the action.
session_id	integer	The ID of the session.

Column name	Data type	Description
transaction_id	bigint	The ID of the transaction.
share_id	integer	The ID of the datashare affected.
share_name	varchar(128)	The name of the datashare.
source_database_id	integer	The ID of the database to which the datashare belongs.
source_database_name	varchar(128)	The name of the database to which the datashare belongs.
consumer_database_id	integer	The ID of the database imported from the datashare.
consumer_database_name	varchar(128)	The name of the database imported from the datashare.
arn	varchar(192)	The ARN of the resource backing the imported database.
record_time	timestamp	The timestamp of the action.
action	varchar(128)	The action being run. Possible values are CREATE DATASHARE, DROP DATASHARE, GRANT ALTER, REVOKE ALTER, GRANT SHARE, REVOKE SHARE, ALTER ADD, ALTER REMOVE, ALTER SET, GRANT USAGE, REVOKE USAGE, CREATE DATABASE, GRANT, or REVOKE USAGE on a shared database, DROP SHARED DATABASE, ALTER SHARED DATABASE.
status	integer	The status of the action. Possible values are SUCCESS and ERROR-ERROR CODE.

Column name	Data type	Description
share_object_type	varchar(64)	The type of database object that was added to or removed from the datashare. Possible values are schemas, tables, columns, functions, and views. This is a field for the producer cluster.
share_object_id	integer	The ID of database object that was added to or removed from the datashare. This is a field for the producer cluster.
share_object_name	varchar(128)	The name of database object that was added to or removed from the datashare. This is a field for the producer cluster.
target_user_type	varchar(16)	The type of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.
target_user_id	integer	The ID of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.
target_user_name	varchar(128)	The name of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.
consumer_account	varchar(16)	The account ID of the data consumer. This is a field for the producer cluster.
consumer_namespace	varchar(64)	The namespace of the data consumer account. This is a field for the producer cluster.
producer_account	varchar(16)	The account ID of the producer account that the datashare belongs to. This is a field for the consumer cluster.
producer_namespace	varchar(64)	The namespace of the product account that the datashare belongs to. This is a field for the consumer cluster.
attribute_name	varchar(64)	The name of an attribute of the datashare or shared database.
attribute_value	varchar(128)	The value of an attribute of the datashare or shared database.

Column name	Data type	Description
message	varchar(512)	The error message when an action fails.

Sample queries

The following example shows a SYS_DATASHARE_CHANGE_LOG view.

```
SELECT DISTINCT action
FROM sys_datashare_change_log
WHERE share_object_name LIKE 'tickit%';

         action
 -----------------------
  "ALTER DATASHARE ADD"
```

SYS_DATASHARE_CROSS_REGION_USAGE

Use the SYS_DATASHARE_CROSS_REGION_USAGE view to get a summary of cross-Region data transferred usage caused by cross-Region datasharing query. SYS_DATASHARE_CROSS_REGION_USAGE aggregates details at the segment level.

SYS_DATASHARE_CROSS_REGION_USAGE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
query_id	integer	The ID of the query. Use this value to join other system tables and views.
child_query_sequence	integer	The sequence of the rewritten user query, starting with 1.

Column name	Data type	Description
segment_id	bigint	The number of the segment. A query consists of multiple segments, and each segment consists of one or more steps.
start_time	time	The time in UTC that the data transfer began.
end_time	time	The time in UTC that the data transfer ended.
transferred_data	bigint	The number of bytes of data transferred from a producer Region to a consumer Region.
source_region	char(25)	The producer Region that the query transferred data from.

Sample queries

The following example shows a SYS_DATASHARE_CROSS_REGION_USAGE view.

```
SELECT query_id, segment_id, transferred_data, source_region
from sys_datashare_cross_region_usage
where query_id = pg_last_query_id()
order by query_id, segment_id;

  query_id | segment_id | transferred_data | source_region
-----------+------------+------------------+---------------
    200048 |          2 |          4194304 |    us-west-1
    200048 |          2 |          4194304 |    us-east-2
```

SYS_DATASHARE_USAGE_CONSUMER

Records the activity and usage of datashares. This view is only relevant on the consumer cluster.

SYS_DATASHARE_USAGE_CONSUMER is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user issuing the request.
session_id	integer	The ID of the leader process running the query.
transaction_id	bigint	The context of the current transaction.
request_id	varchar(50)	The unique ID of the requested API call.
request_type	varchar(25)	The type of the request made to the producer cluster.
transaction_uid	varchar(50)	The unique ID of the transaction.
record_time	timestamp	The time when the action is recorded.
status	integer	The status of the requested API call.
error_message	varchar(512)	The message for an error.

Sample queries

The following example shows the SYS_DATASHARE_USAGE_CONSUMER view.

```
SELECT request_type, status, trim(error) AS error
FROM sys_datashare_usage_consumer

  request_type  | status | error_message
----------------+--------+---------------
 "GET RELATION" |   0    |
```

SYS_DATASHARE_USAGE_PRODUCER

Records the activity and usage of datashares. This view is only relevant on the producer cluster.

SYS_DATASHARE_USAGE_PRODUCER is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
share_id	integer	The object ID (OID) of the datashare.
share_name	varchar(128)	The name of the datashare.
request_id	varchar(50)	The unique ID of the requested API call.
request_type	varchar(25)	The type of the request made to the producer cluster.
object_type	varchar(64)	The type of the object being shared from the datashare. Possible values are schemas, tables, columns, functions, and views.
object_oid	integer	The ID of the object being shared from the datashare.
object_name	varchar(128)	The name of the object being shared from the datashare.
consumer_account	varchar(16)	The account of the consumer account that the datashare is shared to.
consumer_namespace	varchar(64)	The namespace of the consumer account that the datashare is shared to.

Column name	Data type	Description
consumer_transaction_uid	varchar(50)	The unique transaction ID of the statement on the consumer cluster.
record_time	timestamp	The time when the action is recorded.
status	integer	The status of the datashare.
error_message	varchar(512)	The message for an error.
consumer_region	char(64)	The Region that the consumer cluster is in.

Sample queries

The following example shows the SYS_DATASHARE_USAGE_PRODUCER view.

```
SELECT DISTINCT
FROM sys_datashare_usage_producer
WHERE object_name LIKE 'tickit%';

   request_type
 ------------------
   "GET RELATION"
```

SYS_EXTERNAL_QUERY_DETAIL

Use SYS_EXTERNAL_QUERY_DETAIL to view details for queries at a segment level. Each row represents a segment from a particular WLM query with details like the number of rows processed, number of bytes processed, and partition info of external tables in Amazon S3. Each row in this view will also have a corresponding entry in the SYS_QUERY_DETAIL view, except this view has more detail information related to external query processing.

SYS_EXTERNAL_QUERY_DETAIL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The query identifier of the external query.
transaction_id	bigint	The transaction identifier.
child_query_sequence	integer	The sequence of the rewritten user query. Starts with 0, similar to segment_id.
segment_id	integer	The segment identifier of the query segment.
source_type	character(32)	The data source type of the query, it could be S3 for Redshift Spectrum, PG for federated query.
start_time	timestamp	The time when the query began.
end_time	timestamp	The time when the query completed.
duration	bigint	The amount of time (microsec onds) spent on the query.
total_partitions	integer	The number of partitions an Amazon S3 query required.
qualified_partitions	integer	The number of partitions an Amazon S3 query scanned.

Column name	Data type	Description
scanned_files	bigint	The number of Amazon S3 files scanned.
returned_rows	bigint	The number of scanned rows for an Amazon S3 query, or the number of returned rows for a federated query.
returned_bytes	bigint	The number of scanned bytes for an Amazon S3 query, or the number of returned bytes for a federated query.
file_format	text	The file format of Amazon S3 files.
file_location	text	The Amazon S3 location of external table.
external_query_text	text	The segment level query text for a federated query.
warning_message	character(4000)	The warning message displayed when the query runs.
table_name	character(136)	The table name of the step that is being operated.
is_recursive	character(1)	Indicates whether there is recursive scan for subfolders.
is_nested	character(1)	Indicates whether the nested column data type is accessed.
s3list_time	bigint	The duration of file listing in milliseconds.

Column name	Data type	Description
get_partition_time	long	Time spent to list and qualify partitions for a given external object from the AWS Glue Data Catalog and Apache Hive.

Sample queries

The following query shows the external query details.

```
SELECT query_id,
       segment_id,
       start_time,
       end_time,
       total_partitions,
       qualified_partitions,
       scanned_files,
       returned_rows,
       returned_bytes,
       trim(external_query_text) query_text,
       trim(file_location) file_location
FROM sys_external_query_detail
ORDER BY query_id, start_time DESC
LIMIT 2;
```

Sample output.

```
 query_id | segment_id |         start_time         |          end_time
   | total_partitions | qualified_partitions | scanned_files | returned_rows |
 returned_bytes | query_text | file_location
----------+------------+----------------------------+----------------------------
+------------------+----------------------+---------------+---------------
+----------------+-----------+---------------
   763251 |          0 | 2022-02-15 22:32:23.312448 | 2022-02-15 22:32:24.036023 |
          3 |                    3 |             3 |         38203 |        2683414 |
          |
```

```
    763254 |          0 | 2022-02-15 22:32:40.17103  | 2022-02-15 22:32:40.839313 |
            3 |                      3 |               3 |           38203 |          2683414 |
            |
```

SYS_EXTERNAL_QUERY_ERROR

You can query the system view SYS_EXTERNAL_QUERY_ERROR to get information about Redshift Spectrum scan errors. SYS_EXTERNAL_QUERY_ERROR displays a sample of logged errors. The default is 10 entries per query.

SYS_EXTERNAL_QUERY_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user that generated this row.
query_id	bigint	The query identifier of the query that generated this row.
file_location	char(256)	The location of the data being queried.
rowid	char(2100)	The location of the error within the file. The `rowid` parts are separated with a `:` (colon) and additional parts might be added in the future. `row_offset :row_group :row_id` A row_offset is the offset (in bytes) of the row within the file and is set to `-1` for unsupported file formats. A table is divided into row_groups, and each group has rows with distinct row_ids.
column_name	char(127)	The name of the column returned by the query.

Column name	Data type	Description
original_value	char(1024)	Original value queried.
modified_value	char(1024)	Modified value returned based on the data handling configuration option specified in the query.
trigger	char(128)	Data handling option specified in the query.
action	char(128)	Action associated with the data handling option specified in the query.
action_value	char(128)	Value of action parameter associated with the data handling option specified in the query.
error_code	integer	Result code of the data handling option specified in the query.

Sample query

The following query returns the list of rows for which data handling operations were performed.

```
SELECT * FROM sys_external_query_error;
```

The query returns results similar to the following.

```
  user_id   query_id  file_location                                 rowid
 column_name          original_value            modified_value      trigger
 action              action_value               error_code
     100     1574007   s3://spectrum-uddh/league/spi_global_rankings.0:0
 league_name          Barclays Premier League    Barclays Premier Lea UNSPECIFIED
 TRUNCATE                                         156
     100     1574007   s3://spectrum-uddh/league/spi_global_rankings.0:0
 league_nspi          34595                      32767                UNSPECIFIED
 OVERFLOW_VALUE                                   199
```

```
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:1
league_nspi            34151                      32767                UNSPECIFIED
OVERFLOW_VALUE                                     199
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:2
league_name            Barclays Premier League    Barclays Premier Lea UNSPECIFIED
TRUNCATE                                           156
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:2
league_nspi            33223                      32767                UNSPECIFIED
OVERFLOW_VALUE                                     199
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:3
league_name            Barclays Premier League    Barclays Premier Lea UNSPECIFIED
TRUNCATE                                           156
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:3
league_nspi            32808                      32767                UNSPECIFIED
OVERFLOW_VALUE                                     199
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:4
league_nspi            32790                      32767                UNSPECIFIED
OVERFLOW_VALUE                                     199
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:5
league_name            Spanish Primera Division   Spanish Primera Divi UNSPECIFIED
TRUNCATE                                           156
    100     1574007    s3://spectrum-uddh/league/spi_global_rankings.0:6
league_name            Spanish Primera Division   Spanish Primera Divi UNSPECIFIED
TRUNCATE                                           156
```

SYS_INTEGRATION_ACTIVITY

SYS_INTEGRATION_ACTIVITY displays details about completed integration runs.

SYS_INTEGRATION_ACTIVITY is visible only to superusers. For more information, see Visibility of data in system tables and views.

For information about zero-ETL integrations, see Working with zero-ETL integrations in the Amazon Redshift Management Guide.

Table columns

Column name	Data type	Description
integration_id	character (128)	The identifier associated with the integration.

Column name	Data type	Description
target_database	character (128)	The database in Amazon Redshift that receives the integration data.
source	character (128)	The source data for the integration. Possible types includes `MySQL` and `PostgreSQL` .
checkpoint_name	character (128)	The name of the checkpoint replicating binlog coordinates.
checkpoint_type	character (16)	The type of checkpoint. Possible values include: `snapshot`, `cdc`.
checkpoint_bytes	bigint	The number of bytes in this checkpoint.
last_commit_timestamp	timestamp	The timestamp when last commited in this checkpoint.
modified_tables	integer	The number of tables modified in the checkpoint.
integration_start_time	time	The time (UTC) when integration started for this checkpoint.
integration_end_time	time	The time (UTC) when integration ended for this checkpoint.

Sample queries

The following SQL command displays the log of integrations.

```
select * from sys_integration_activity;

          integration_id              | target_database | source |
   checkpoint_name                    | checkpoint_type  | checkpoint_bytes |
 last_commit_timestamp    | modified_tables |    integration_start_time    |
 integration_end_time
--------------------------------------+-----------------+--------
+------------------------------------------+-----------------+-----------------
```

```
+-------------------------+-----------------+----------------------------
+----------------------------
 76b15917-afae-4447-b7fd-08e2a5acce7b |   demo1         | MySQL  | checkpoints/
checkpoint_3_241_3_510.json     |        cdc        |        762        | 2023-05-10
 23:00:14.201 |         1        | 2023-05-10 23:00:45.054265 | 2023-05-10
 23:00:46.339826
 76b15917-afae-4447-b7fd-08e2a5acce7b |   demo1         | MySQL  | checkpoints/
checkpoint_3_16329_3_17839.json |        cdc        |       13488       | 2023-05-11
 01:33:57.411 |         2        | 2023-05-11 02:19:09.440121 | 2023-05-11
 02:19:16.090492
 76b15917-afae-4447-b7fd-08e2a5acce7b |   demo1         | MySQL  | checkpoints/
checkpoint_3_5103_3_5532.json   |        cdc        |        1657       | 2023-05-10
 23:13:14.205 |         2        | 2023-05-10 23:13:23.545487 | 2023-05-10
 23:13:25.652144
```

SYS_INTEGRATION_TABLE_ACTIVITY

SYS_INTEGRATION_TABLE_ACTIVITY displays details of insert, delete, and update activity of zero-ETL integrations. There is one row added for each completed ingestion.

A superuser can see all rows in this table.

For more information, see zero-ETL integrations.

Table columns

Column name	Data type	Description
integration_id	character (128)	The identifier associated with the integration.
checkpoint_name	character (128)	The name of the checkpoint.
target_database	character (128)	The name of the Amazon Redshift database.
schema_name	character (128)	The name of the Amazon Redshift schema.

Column name	Data type	Description
table_name	character (128)	The name of the table.
table_id	integer	The identifier of the table.
record_time	timestamp	The time (UTC) when this change completed.
transaction_id	bigint	The transaction identifier.
inserted_rows	bigint	The number of rows inserted by the ingestion.
deleted_rows	bigint	The number of rows deleted by the ingestion.
updated_rows	bigint	The number of rows updated by the ingestion.
bytes_ingested	bigint	The number of bytes ingested.

Sample queries

The following SQL command displays activity of the integration.

```
select * from sys_integration_table_activity;

          integration_id              | checkpoint_name | target_database | schema_name
 |     table_name    | table_id     | record_time                | transaction_id  |
 inserted_rows   | deleted_rows | updated_rows | bytes_ingested
--------------------------------------+-----------------+-----------------
+-------------+------------------+-------------+---------------------------
+-----------------+---------------+-------------+-------------+---------------
 4798e675-8f9f-4686-b05f-92c538e19629 |                 | sample_test2    |    sample
 | SampleTestChannel |  111276      | 2023-05-12 12:40:30.656625 | 7736             |  2
            | 0            | 0            | 125
```

SYS_INTEGRATION_TABLE_STATE_CHANGE

SYS_INTEGRATION_TABLE_STATE_CHANGE displays details about table state change logs for integrations.

A superuser can see all rows in this table.

For more information, see Working with Zero-ETL integrations.

Table columns

Column name	Data type	Description
integration_id	character (128)	The identifier associated with the integration.
database_name	character (128)	The name of the Amazon Redshift database.
schema_name	character (128)	The name of the Amazon Redshift schema.
table_name	character (128)	The name of the table.
new_state	character (128)	The state of the table. Possible values are `Synced`, `ResyncRequired` , `ResyncInitiated` , `Deleted`, `Failed`, and `ResyncDeleted` .
table_last_replicated_checkpoint	character (128)	The current synced log coordinates.
state_change_reason	character (256)	The reason for the last state transition.
record_time	timestamp	The time (UTC) when this record was updated.

Sample queries

The following SQL command displays the log of integrations.

```
select * from sys_integration_table_state_change;

            integration_id             | database_name | schema_name | table_name
 | new_state |  table_last_replicated_checkpoint   | state_change_reason |
 record_time
```

```
---------------------------------------+----------------+--------------+------------
+-----------+--------------------------------------+---------------------
+-----------------------------
 99108e72-1cfd-414f-8cc0-0216acefac77 | perfdb        | sbtest80t3s | sbtest79    |
 Synced    | {"txn_seq":9834,"txn_id":126597515} |                     | 2023-09-20
 19:39:50.087868
 99108e72-1cfd-414f-8cc0-0216acefac77 | perfdb        | sbtest80t3s | sbtest56    |
 Synced    | {"txn_seq":9834,"txn_id":126597515} |                     | 2023-09-20
 19:39:45.54005
 99108e72-1cfd-414f-8cc0-0216acefac77 | perfdb        | sbtest80t3s | sbtest50    |
 Synced    | {"txn_seq":9834,"txn_id":126597515} |                     | 2023-09-20
 19:40:20.362504
 99108e72-1cfd-414f-8cc0-0216acefac77 | perfdb        | sbtest80t3s | sbtest18    |
 Synced    | {"txn_seq":9834,"txn_id":126597515} |                     | 2023-09-20
 19:40:32.544084
 99108e72-1cfd-414f-8cc0-0216acefac77 | perfdb        | sbtest40t3s | sbtest23    |
 Synced    | {"txn_seq":9834,"txn_id":126597515} |                     | 2023-09-20
 15:49:05.186209
```

SYS_LOAD_DETAIL

Returns information to track or troubleshoot a data load.

This view records the progress of each data file as it is loaded into a database table.

This view is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	ID of the user who generated the entry.
query_id	integer	Query ID.
file_name	character(256)	File name to be loaded.
bytes_scanned	integer	The number of bytes scanned from the file in Amazon S3.

Column name	Data type	Description
lines_scanned	integer	Number of lines scanned from the load file. This number may not match the number of rows that are actually loaded. For example, the load may scan but tolerate a number of bad records, based on the MAXERROR option in the COPY command.
record_time	timestamp	Time that this entry was last updated.
splits_scanned	Number of splits of this file.	Number of splits of this file.
start_time	timestamp	Time that this file processing started.
end_time	timestamp	Time that this file processing finished.

Sample queries

The following example returns details for the last COPY operation.

```
select query_id, trim(file_name) as file, record_time
from sys_load_detail
where query_id = pg_last_copy_id();

 query_id |               file               |          record_time
----------+----------------------------------+----------------------------
 28554    | s3://dw-tickit/category_pipe.txt | 2013-11-01 17:14:52.648486
(1 row)
```

The following query contains entries for a fresh load of the tables in the TICKIT database:

```
select query_id, trim(file_name), record_time
from sys_load_detail
where file_name like '%tickit%' order by query_id;

 query_id |           btrim          |          record_time
----------+--------------------------+----------------------------
 22475    | tickit/allusers_pipe.txt | 2013-02-08 20:58:23.274186
```

```
 22478    | tickit/venue_pipe.txt    | 2013-02-08 20:58:25.070604
 22480    | tickit/category_pipe.txt | 2013-02-08 20:58:27.333472
 22482    | tickit/date2008_pipe.txt | 2013-02-08 20:58:28.608305
 22485    | tickit/allevents_pipe.txt| 2013-02-08 20:58:29.99489
 22487    | tickit/listings_pipe.txt | 2013-02-08 20:58:37.632939
 22593    | tickit/allusers_pipe.txt | 2013-02-08 21:04:08.400491
 22596    | tickit/venue_pipe.txt    | 2013-02-08 21:04:10.056055
 22598    | tickit/category_pipe.txt | 2013-02-08 21:04:11.465049
 22600    | tickit/date2008_pipe.txt | 2013-02-08 21:04:12.461502
 22603    | tickit/allevents_pipe.txt| 2013-02-08 21:04:14.785124
 22605    | tickit/listings_pipe.txt | 2013-02-08 21:04:20.170594

(12 rows)
```

The fact that a record is written to the log file for this system view does not mean that the load committed successfully as part of its containing transaction. To verify load commits, query the STL_UTILITYTEXT view and look for the COMMIT record that corresponds with a COPY transaction. For example, this query joins SYS_LOAD_DETAIL and STL_QUERY based on a subquery against STL_UTILITYTEXT:

```
select l.query_id,rtrim(l.file_name),q.transaction_id
from sys_load_detail l, sys_query_text q
where l.query_id=q.query_id
and exists
(select xid from stl_utilitytext where xid=q.transaction_id and
 rtrim("text")='COMMIT');

 query_id |           rtrim            |  transaction_id
----------+----------------------------+-----------------
 22600    | tickit/date2008_pipe.txt   | 68311
 22480    | tickit/category_pipe.txt   | 68066
  7508    | allusers_pipe.txt          | 23365
  7552    | category_pipe.txt          | 23415
  7576    | allevents_pipe.txt         | 23429
  7516    | venue_pipe.txt             | 23390
  7604    | listings_pipe.txt          | 23445
 22596    | tickit/venue_pipe.txt      | 68309
 22605    | tickit/listings_pipe.txt   | 68316
 22593    | tickit/allusers_pipe.txt   | 68305
 22485    | tickit/allevents_pipe.txt  | 68071
  7561    | allevents_pipe.txt         | 23429
  7541    | category_pipe.txt          | 23415
  7558    | date2008_pipe.txt          | 23428
```

```
 22478    | tickit/venue_pipe.txt     | 68065
   526    | date2008_pipe.txt         |  2572
  7466    | allusers_pipe.txt         | 23365
 22482    | tickit/date2008_pipe.txt  | 68067
 22598    | tickit/category_pipe.txt  | 68310
 22603    | tickit/allevents_pipe.txt | 68315
 22475    | tickit/allusers_pipe.txt  | 68061
   547    | date2008_pipe.txt         |  2572
 22487    | tickit/listings_pipe.txt  | 68072
  7531    | venue_pipe.txt            | 23390
  7583    | listings_pipe.txt         | 23445
(25 rows)
```

SYS_LOAD_ERROR_DETAIL

Use SYS_LOAD_ERROR_DETAIL to view details of COPY command errors. Each row represents a COPY command. It contains both running and finished COPY commands.

SYS_LOAD_ERROR_DETAIL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the copy.
query_id	bigint	The query identifier of the copy.
transaction_id	bigint	The transaction identifier.
session_id	integer	The process identifier of the process running the copy.
database_name	character(64)	The name of the database the user was connected to when the copy was issued.
table_id	integer	The table identifier.

Column name	Data type	Description
start_time	timestamp	The time (UTC) when the copy began.
file_name	character(256)	The complete path to the input file to load.
line_number	bigint	The line number in the load file with the error. When you load a JSON file, the line number of the last line of the JSON object with the error.
column_name	character(127)	The field with the error.
column_type	character(10)	The data type of the field with the error.
column_length	character(10)	The column length, if applicable. This field is populated when the data type has a limit length. For example, for a column with a data type of "character(3)", this column contains the value "3."
position	integer	The position of the error in the field.
error_code	integer	The error code.
error_message	character(512)	The explanation of the error.

Sample queries

The following query shows the load error details of copy command for specific query.

```
SELECT query_id,
       table_id,
       start_time,
       trim(file_name) AS file_name,
       trim(column_name) AS column_name,
       trim(column_type) AS column_type,
       trim(error_message) AS error_message
FROM sys_load_error_detail
WHERE query_id = 762949
ORDER BY start_time
LIMIT 10;
```

Sample output.

```
 query_id | table_id |         start_time         |               file_name
      | column_name | column_type |                 error_message
----------+----------+----------------------------
+------------------------------------------+-------------+-------------
+------------------------------------------------
   762949 |   137885 | 2022-02-15 22:14:46.759151 | s3://load-test/copyfail/
wrong_format_000 | id          | int4        | Invalid digit, Value 'a', Pos 0, Type:
 Integer
   762949 |   137885 | 2022-02-15 22:14:46.759151 | s3://load-test/copyfail/
wrong_format_001 | id          | int4        | Invalid digit, Value 'a', Pos 0, Type:
 Integer
```

SYS_LOAD_HISTORY

Use SYS_LOAD_HISTORY to view details of COPY commands. Each row represents a COPY command with accumulated statistics for some of the fields. It contains both running and finished COPY commands.

SYS_LOAD_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the copy.

Column name	Data type	Description
query_id	bigint	The query identifier of the copy.
transaction_id	bigint	The transaction identifier.
session_id	integer	The process identifier of the process running the copy.
database_name	text	The name of the database the user was connected to when the operation was issued.
status	text	The status of the copy. Valid values are `running`, `completed` , `aborted`.
table_name	text	The name of the table copying into.
start_time	timestamp	The time when the copy began.
end_time	timestamp	The time when the copy completed.
duration	bigint	The amount of time (microsec onds) spent in the COPY command.
data_source	text	The Amazon S3 location of files input to copy.
file_format	text	The source file format. Formats include csv, txt, json, avro, orc, or parquet.

Column name	Data type	Description
loaded_rows	bigint	The number of rows copied to a table.
loaded_bytes	bigint	The number of bytes copied to a table.
source_file_count	integer	The number of files count in source files.
source_file_bytes	bigint	The number of bytes in source files.
file_count_scanned	integer	The number of scanned files from Amazon S3.
file_bytes_scanned	bigint	The number of bytes scanned from the file in Amazon S3.
error_count	bigint	The number of errors count.
copy_job_id	bigint	The copy job identifier. A `0` indicates no job identifier.

Sample queries

The following query shows the loaded rows, bytes, tables, and datasource of specific copy commands.

```
SELECT query_id,
       table_name,
       data_source,
       loaded_rows,
       loaded_bytes
FROM sys_load_history
WHERE query_id IN (6389,490791,441663,74374,72297)
ORDER BY query_id,
         data_source DESC;
```

Sample output.

```
 query_id |    table_name    |                              data_source
              | loaded_rows | loaded_bytes
----------+-----------------
+------------------------------------------------------------------------+-------------
+---------------
     6389 | store_returns    | s3://load-test/data-sources/tpcds/2.8.0/textfile/1T/
store_returns/    |   287999764 | 1196240296158
    72297 | web_site         | s3://load-test/data-sources/tpcds/2.8.0/textfile/1T/
web_site/         |          54 |          43808
    74374 | ship_mode        | s3://load-test/data-sources/tpcds/2.8.0/textfile/1T/
ship_mode/        |          20 |           1320
   441663 | income_band      | s3://load-test/data-sources/tpcds/2.8.0/textfile/1T/
income_band/      |          20 |           2152
   490791 | customer_address | s3://load-test/data-sources/tpcds/2.8.0/textfile/1T/
customer_address/ |     6000000 |     722924305
```

The following query shows the loaded rows, bytes, tables, and datasource of copy commands.

```
SELECT query_id,
       table_name,
       data_source,
       loaded_rows,
       loaded_bytes
FROM sys_load_history
ORDER BY query_id DESC
LIMIT 10;
```

Sample output.

```
 query_id |       table_name       |                                 data_source
                          | loaded_rows |  loaded_bytes
----------+-----------------------
+------------------------------------------------------------------------------
+-------------+----------------
   491058 | web_site               | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/web_site/             |          54 |          43808
   490947 | web_sales              | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/web_sales/            |   720000376 |  22971988122819
   490923 | web_returns            | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/web_returns/          |    71997522 |     96597496325
```

```
   490918 | web_page                    | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/web_page/                    |        3000 |             1320
   490907 | warehouse                   | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/warehouse/                   |          20 |             1320
   490902 | time_dim                    | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/time_dim/                    |       86400 |             1320
   490876 | store_sales                 | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/store_sales/                 |  2879987999 | 151666241887933
   490870 | store_returns               | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/store_returns/               |   287999764 |   1196405607941
   490865 | store                       | s3://load-test/data-sources/tpcds/2.8.0/
textfile/1T/store/                       |        1002 |          365507
```

The following query shows the daily loaded rows and bytes of the copy command.

```
SELECT date_trunc('day',start_time) AS exec_day,
       SUM(loaded_rows) AS loaded_rows,
       SUM(loaded_bytes) AS loaded_bytes
FROM sys_load_history
GROUP BY exec_day
ORDER BY exec_day DESC;
```

Sample output.

```
      exec_day       | loaded_rows |   loaded_bytes
---------------------+-------------+------------------
 2022-01-20 00:00:00 |  6347386005 |  258329473070606
 2022-01-19 00:00:00 | 19042158015 |  775198502204572
 2022-01-18 00:00:00 | 38084316030 | 1550294469446883
 2022-01-17 00:00:00 | 25389544020 | 1033271084791724
 2022-01-16 00:00:00 | 19042158015 |  775222736252792
 2022-01-15 00:00:00 | 19834245387 |  798122849155598
 2022-01-14 00:00:00 | 75376544688 | 3077040926571384
```

SYS_MV_REFRESH_HISTORY

The results include information about the refresh history of all materialized views. The results include the refresh type, such as manual or auto, and the status of the most recent refresh.

SYS_MV_REFRESH_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the refresh.
session_id	integer	The process identifier for the process running the materiali zed view refresh.
transaction_id	bigint	The transaction identifier.
database_name	char(128)	The database that contains the materialized view.
schema_name	char(128)	The schema of the materiali zed view.
mv_id	bigint	Object ID of the materialized view.
mv_name	char(128)	The materialized view name.
refresh_type	char(32)	The type of refresh, such as manual or auto.
status	text	The status of the refresh. For detailed information about statuses, see the status column for SVL_MV_RE FRESH_STATUS.
start_time	timestamp	The start time of the refresh.
end_time	timestamp	The end time of the refresh.

Column name	Data type	Description
duration	bigint	The amount of time in microseconds it took to refresh the materialized view.

Sample queries

The following query shows the refresh history for materialized views.

```
SELECT user_id,
     session_id,
     transaction_id,
     database_name,
     schema_name,
     mv_id,
     mv_name,
     refresh_type,
     status,
     start_time,
     end_time,
     duration
     from sys_mv_refresh_history;
```

The query returns the following sample output:

```
 user_id | session_id | transaction_id | database_name | schema_name                  |
 mv_id  |  mv_name            |  refresh_type  |  status
                                                                         |  start_time
    |  end_time                  |  duration
---------+------------+---------------+---------------
+----------------------------+--------+--------------------+----------------
+-----------------------------------------------------------------------------------------
+----------------------------+----------------------------+-----------
       1 | 1073815659 |          15066 | dev           | test_stl_mv_refresh_schema
 | 203762 | mv_incremental      | Manual          | MV was already updated
                                                                                 | 2023-10-26
 15:59:20.952179 | 2023-10-26 15:59:20.952866 |      687
       1 | 1073815659 |          15068 | dev           | test_stl_mv_refresh_schema
 | 203771 | mv_nonincremental   | Manual          | MV was already updated
```

```
                                                                        | 2023-10-26
15:59:21.008049 | 2023-10-26 15:59:21.008658 |      609
      1 | 1073815659 |          15070 | dev           | test_stl_mv_refresh_schema
| 203779 | mv_refresh_error   | Manual          | MV was already updated
                                                                        | 2023-10-26
15:59:21.064252 | 2023-10-26 15:59:21.064885 |      633
      1 | 1073815659 |          15074 | dev           | test_stl_mv_refresh_schema
| 203762 | mv_incremental     | Manual          | Refresh successfully updated MV
incrementally                                                           | 2023-10-26
15:59:29.693329 | 2023-10-26 15:59:43.482842 | 13789513
      1 | 1073815659 |          15076 | dev           | test_stl_mv_refresh_schema
| 203771 | mv_nonincremental  | Manual          | Refresh successfully recomputed
MV from scratch                                                         | 2023-10-26
15:59:43.550184 | 2023-10-26 15:59:47.880833 |  4330649
      1 | 1073815659 |          15078 | dev           | test_stl_mv_refresh_schema
| 203779 | mv_refresh_error   | Manual          | Refresh failed due to an internal
error                                                                 | 2023-10-26
15:59:47.949052 | 2023-10-26 15:59:52.494681 |  4545629
      1 | 1073815659 |          15071 | dev           | test_stl_mv_refresh_schema
| 203778 | mv_test            | Manual          | Cascade refresh failed because
materialized view test_stl_mv_refresh_schema.child was not refreshed. | 2023-10-26
15:30:21.432252 | 2023-10-26 15:30:21.432252 |      532
      1 | 1073815659 |          15071 | dev           | test_stl_mv_refresh_schema
| 203761 | child              | Manual          | Refresh failed due to an internal
error.                                                                | 2023-10-26
15:30:21.432252 | 2023-10-26 15:30:21.432252 |      532
      1 | 1073815659 |          15069 | dev           | test_stl_mv_refresh_schema
| 203778 | mv_test            | Manual          | Cascade refresh skipped because
materialized view test_stl_mv_refresh_schema.child was not refreshed.| 2023-10-26
15:21:43.550369 | 2023-10-26 15:21:43.550369 |      633
      1 | 1073815659 |          15069 | dev           | test_stl_mv_refresh_schema
| 203761 | child              | Manual          | Refresh failed due to an internal
error.                                                                | 2023-10-26
15:21:43.550369 | 2023-10-26 15:21:43.550369 |      633
(10 rows)
```

SYS_MV_STATE

The results include information about the state of all materialized views. It includes base table information, schema properties, and information about recent events, like dropping a column.

SYS_MV_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	bigint	The ID of the user who created the event.
transaction_id	bigint	The transaction ID of the event.
database_name	char(128)	The database that contains the materialized view.
event_desc	char(500)	The event that prompted the state change. Example values include the following: • Column type was changed • Column was dropped • Column was renamed • Schema name was changed • Small-table conversion • TRUNCATE • Vacuum Note that there are other possible values for this column.
start_time	timestamp	The start time of the event.
base_table_database_name	char(128)	The database name for the base table.
base_table_schema	char(128)	The schema of the base table.
base_table_name	char(128)	The name of the base table.

Column name	Data type	Description
mv_schema	char(128)	The schema of the materiali zed view.
mv_name	char(128)	The name of the materialized view.
state	character(32)	The changed state of the materialized view, which are as follows: • Recompute • Unrefreshable

Sample queries

The following query shows the materialized view state.

```
select * from sys_mv_state;
```

The query returns the following sample output:

```
 user_id | transaction_id | database_name | event_desc                  | start_time
              | base_table_database_name | base_table_schema | base_table_name     |
 mv_schema  | mv_name                    | state
---------+----------------+---------------+-----------------------------
+----------------------------+-------------------------+-------------------
+--------------------+------------+----------------------------+-------------
 106     | 12720          | tickit_db     | TRUNCATE                    | 2023-07-26
 14:59:12.788268 | tickit_db                 | mv_schema         | test_table_95d6d861 |
 mv_schema    | materialized_view_a1f3f862 | Recompute
 106     | 12724          | tickit_db     | ALTER TABLE ALTER DISTSTYLE | 2023-07-26
 14:59:51.409014 | tickit_db                 | mv_schema         | test_table_58102435 |
 mv_schema    | materialized_view_ca746631 | Recompute
 106     | 12720          | tickit_db     | Column was renamed          | 2023-07-26
 14:59:12.822928 | tickit_db                 | mv_schema         | test_table_95d6d861 |
 mv_schema    | materialized_view_5750a8d4 | Unrefreshable
```

```
106      | 12727            | tickit_db      | Table was renamed            | 2023-07-26
15:00:08.051244 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_5750a8d4 | Unrefreshable
106      | 12720            | tickit_db      | Column was renamed           | 2023-07-26
14:59:12.857755 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_5750a8d4 | Unrefreshable
106      | 12727            | tickit_db      | Table was renamed            | 2023-07-26
15:00:08.051358 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_5ef0d754 | Unrefreshable
106      | 12720            | tickit_db      | TRUNCATE                     | 2023-07-26
14:59:12.788159 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_5750a8d4 | Recompute
106      | 12720            | tickit_db      | Column was renamed           | 2023-07-26
14:59:12.857799 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_a1f3f862 | Unrefreshable
106      | 12720            | tickit_db      | TRUNCATE                     | 2023-07-26
14:59:12.788327 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_5ef0d754 | Recompute
106      | 12727            | tickit_db      | ALTER TABLE ALTER SORTKEY    | 2023-07-26
15:00:08.006235 | tickit_db                | mv_schema         | test_table_58102435 |
mv_schema    | materialized_view_ca746631 | Recompute
106      | 12720            | tickit_db      | Column was renamed           | 2023-07-26
14:59:12.82297  | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_a1f3f862 | Unrefreshable
106      | 12727            | tickit_db      | Table was renamed            | 2023-07-26
15:00:08.051321 | tickit_db                | mv_schema         | test_table_95d6d861 |
mv_schema    | materialized_view_a1f3f862 | Unrefreshable
```

SYS_PROCEDURE_CALL

Use the SYS_PROCEDURE_CALL view to get information about stored procedure calls, including start time, end time, status of a stored procedure call, and call hierarchy for nested stored procedure calls. Each stored procedure call receives a query ID.

SYS_PROCEDURE_CALL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
session_user_id	integer	The identifier of the user who created the session and is the invoker of the top-level stored procedure call.
security_user_id	integer	The identifier of the user whose privileges were used to run the statement within the stored procedure. If the stored procedure was called from the outer DEFINER stored procedure, then this will be the owner user_id of that outer stored procedure.
query_id	integer	The query identifier of the stored procedure call.
query_text	char(4000)	The text of the stored procedure call query.
start_time	timestamp	The time in UTC when the query started running. The timestamp uses six digits of precision for fractiona l seconds, for example. 2009-06-12 11:29:19. 131358.
end_time	timestamp	The time in UTC when the query finished running. The timestamp uses six digits of precision for fractiona l seconds, for example:

Column name	Data type	Description
		2009-06-12 11:29:19.131358.
status	char(10)	The status of the stored procedure call. When the stored procedure was stopped by the system or canceled by the user, the value is canceled. If the stored procedure call runs to completion, the value is success.
caller_procedure_query_id	integer	If the stored procedure call was invoked by another stored procedure call, then this column contains the query ID of the outer call. Otherwise, the field is NULL.

Sample queries

The following query returns a nested stored procedure call hierarchy.

```
select query_id, datediff(seconds, start_time, end_time) as elapsed_time, status,
 trim(query_text) as call, caller_procedure_query_id from sys_procedure_call;
```

Sample output.

```
 query_id | elapsed_time | status  |                       call                       |
 caller_procedure_query_id
----------+--------------+---------+--------------------------------------------------
+---------------------------
     3087 |           18 | success | CALL proc_bd906c98c45443ffa165e9552056902d(1)    |
          3085
     3085 |           18 | success | CALL proc_bd906c98c45443ffa165e9552056902d_2(1); |
```

```
(2 rows)
```

SYS_PROCEDURE_MESSAGES

SYS_PROCEDURE_MESSAGES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
transaction_id	bigint	The transaction identifier.
query_id	integer	The query identifier of the stored procedure call.
record_time	timestamp	The time in UTC when the message was generated.
log_level	char(10)	The log level of the generated message. Possible values are LOG, INFO, NOTICE, WARNING, and EXCEPTION.
message	char(1024)	The text of the generated message.
line_number	integer	The line number of the generated message.

Sample queries

The following query shows sample output of SYS_PROCEDURE_MESSAGES.

```
select transaction_id, query_id, record_time, log_level, trim(message), line_number
 from sys_procedure_messages;
```

```
transaction_id | query_id |         record_time          | log_level |             btrim
        | line_number
```

```
---------------+----------+----------------------------+-----------
+---------------------------+-------------
     25267     |    80562   | 2023-07-17 14:38:31.910136 |   NOTICE   |
 test_notice_msg_b9f1e749  |      8
     25267     |    80562   | 2023-07-17 14:38:31.910002 |    LOG     |
 test_log_msg_833c7420     |      6
     25267     |    80562   | 2023-07-17 14:38:31.910111 |    INFO    |
 test_info_msg_651373d9    |      7
     25267     |    80562   | 2023-07-17 14:38:31.910154 |   WARNING |
 test_warning_msg_831c5747 |      9
(4 rows)
```

SYS_QUERY_DETAIL

Use SYS_QUERY_DETAIL to view details for queries at various metric levels, with each row representing details about a particular WLM query at a given metric level. This view contains many types of queries such as DDL, DML, and utility commands (for example, copy and unload). Some columns might not be relevant depending on the query type. For example, external_scanned_bytes is not relevant to internal tables.

SYS_QUERY_DETAIL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

To verify whether a transaction containing the executed query was successfully committed, you need to perform a join operation between system tables and the `sys_transaction_history` table. For example:

```
SELECT
    th.transaction_id,
    qd.query_id,
    th.status AS transaction_status
FROM
    sys_query_detail qd
LEFT JOIN sys_query_history qh ON qd.query_id = qh.query_id
LEFT JOIN sys_transaction_history th on qh.transaction_id = th.transaction_id;
```

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The query identifier.
child_query_sequence	integer	The sequence of the rewritten user query, starting with 1.
stream_id	integer	The stream identifier of the query stream.
segment_id	integer	The segment identifier of the query running segment.
step_id	integer	The step identifier in a segment.
step_name	text	The step name in a segment. Possible values are `aggregate` , `broadcast` , `delete`, `distribute` , `hash`, `hashjoin`, `insert`, `limit`, `merge`, `nestloop`, `parse`, `return`, `save`, `scan`, `sort`, `sortlimit` , `unique`, and `window`.
table_id	integer	The table identifier for permanent table scans.
table_name	character(136)	The table name of the step that is being operated.
is_rrscan	character	A value that indicates whether a step is a scan

Column name	Data type	Description
		step. True (t) indicates that a range-restricted scan was used.
start_time	timestamp	The time when the query step began. This field is recorded at the segment level, regardless of the value in the `metrics_level` column.
end_time	timestamp	The time when the query step completed. This field is recorded at the segment level, regardless of the value in the `metrics_level` column.
duration	bigint	The amount of time (microseconds) spent on the step. This field is recorded at the segment level, regardless of the value in the `metrics_level` column.
alert	text	The description of the alert event.
input_bytes	bigint	The input bytes for the current step.
input_rows	bigint	The input rows for the current step.
output_bytes	bigint	The output bytes for the current step.

Column name	Data type	Description
output_rows	bigint	The output rows for the current step.
blocks_read	bigint	The number of block the step read.
blocks_write	bigint	The number of block the step wrote.
local_read_IO	bigint	The number of blocks read from local disk cache.
remote_read_IO	bigint	The number of blocks read from remote.
source	text	The type of database object that was scanned. This column only has a value when the row's *step_name* value is `scan`.
data_skewness	integer	The skewness of output rows distribution among all steps. It is a number in the range of 0% to 100%. The larger the number, the more unbalanced is the distribution.
time_skewness	integer	The skewness of execution time distribution among all steps. It is a number in the range of 0% to 100%. The larger the number, the more unbalanced is the distribut ion.

Column name	Data type	Description
is_active	character	The state of the query at the step level. Possible values are ‘t’ that shows the step is actively running or ‘f’ that indicates the step completes running.
spilled_block_local_disk	bigint	The number of blocks spilled to local disk.
spilled_block_remote_disk	bigint	The number of blocks spilled to Amazon Simple Storage Service.
step_attribute	character(64)	Contains information about the associated step. Possible values for scan steps: `multi-dimensional` .
metrics_level	character(64)	The metric level of the query. Possible values are as follows: • child query • stream • segment • step •
plan_parent_id	integer	The identifier of the plan node's parent node. A parent node can have multiple child nodes. For example, a merge join is the parent node of the scans on the joined tables.

Column name	Data type	Description
plan_node_id	integer	The identifier of a plan node that maps to one or more steps in the query.

Usage notes

SYS_QUERY_DETAIL can contain metrics at the step, steam, segment, and child query level. In addition to referencing the metrics_level column, you can see which metric level a given row is showing by referencing the step_id, segment_id, and stream_id fields according to the following table.

Metric level	stream_id value	segment_id value	step_id value
child query	-1	-1	-1
stream	A valid step value	-1	-1
segment	A valid step value	A valid step value	-1
step	A valid step value	A valid step value	A valid step value

Sample queries

The following example returns the output of SYS_QUERY_DETAIL.

The following query shows the query metadata detail at step level, including step name, input_bytes, output_bytes, input_rows, output_rows.

```
SELECT query_id,
       child_query_sequence,
       stream_id,
       segment_id,
       step_id,
       trim(step_name) AS step_name,
       duration,
       input_bytes,
       output_bytes,
```

```
       input_rows,
       output_rows
FROM sys_query_detail
WHERE query_id IN (193929)
ORDER BY query_id,
         stream_id,
         segment_id,
         step_id DESC;
```

Sample output.

```
 query_id | child_query_sequence | stream_id | segment_id | step_id | step_name  |
 duration     | input_bytes | output_bytes | input_rows | output_rows
----------+----------------------+-----------+------------+---------+------------
+-----------------+-------------+--------------+------------+-------------
   193929 |                    2 |         0 |          0 |       3 | hash       |
     37144 |           0 |      9350272 |          0 |      292196
   193929 |                    5 |         0 |          0 |       3 | hash       |
      9492 |           0 |        23360 |          0 |        1460
   193929 |                    1 |         0 |          0 |       3 | hash       |
     46809 |           0 |      9350272 |          0 |      292196
   193929 |                    4 |         0 |          0 |       2 | return     |
      7685 |           0 |          896 |          0 |         112
   193929 |                    1 |         0 |          0 |       2 | project    |
     46809 |           0 |            0 |          0 |      292196
   193929 |                    2 |         0 |          0 |       2 | project    |
     37144 |           0 |            0 |          0 |      292196
   193929 |                    5 |         0 |          0 |       2 | project    |
      9492 |           0 |            0 |          0 |        1460
   193929 |                    3 |         0 |          0 |       2 | return     |
     11033 |           0 |        14336 |          0 |         112
   193929 |                    2 |         0 |          0 |       1 | project    |
     37144 |           0 |            0 |          0 |      292196
   193929 |                    1 |         0 |          0 |       1 | project    |
     46809 |           0 |            0 |          0 |      292196
   193929 |                    5 |         0 |          0 |       1 | project    |
      9492 |           0 |            0 |          0 |        1460
   193929 |                    3 |         0 |          0 |       1 | aggregate  |
     11033 |           0 |       201488 |          0 |          14
   193929 |                    4 |         0 |          0 |       1 | aggregate  |
      7685 |           0 |        28784 |          0 |          14
   193929 |                    5 |         0 |          0 |       0 | scan       |
      9492 |           0 |        23360 |     292196 |        1460
```

```
   193929 |                    4 |          0 |            0 |         0 | scan        |
      7685 |            0 |        1344 |          112 |          112
   193929 |                    2 |          0 |            0 |         0 | scan        |
     37144 |            0 |     7304900 |       292196 |       292196
   193929 |                    3 |          0 |            0 |         0 | scan        |
     11033 |            0 |       13440 |          112 |          112
   193929 |                    1 |          0 |            0 |         0 | scan        |
     46809 |            0 |     7304900 |       292196 |       292196
   193929 |                    5 |          0 |            0 |        -1 |             |
      9492 |        12288 |           0 |            0 |            0
   193929 |                    1 |          0 |            0 |        -1 |             |
     46809 |        16384 |           0 |            0 |            0
   193929 |                    2 |          0 |            0 |        -1 |             |
     37144 |        16384 |           0 |            0 |            0
   193929 |                    4 |          0 |            0 |        -1 |             |
      7685 |        28672 |           0 |            0 |            0
   193929 |                    3 |          0 |            0 |        -1 |             |
     11033 |       114688 |           0 |            0 |            0
```

To view the tables in your database in order from most used to least used, use the following example. Replace *sample_data_dev* with your own database. Note that this query will count queries starting when your cluster is created, but your system view data is not saved when your data warehouse is lacking space.

```
SELECT table_name, COUNT (DISTINCT query_id)
FROM SYS_QUERY_DETAIL
WHERE table_name LIKE 'sample_data_dev%'
GROUP BY table_name
ORDER BY COUNT(*) DESC;

+----------------------------------+-------+
|            table_name            | count |
+----------------------------------+-------+
| sample_data_dev.tickit.venue     |     4 |
| sample_data_dev.myunload1.venue |     3 |
| sample_data_dev.tickit.listing   |     1 |
| sample_data_dev.tickit.category |     1 |
| sample_data_dev.tickit.users     |     1 |
| sample_data_dev.tickit.date      |     1 |
| sample_data_dev.tickit.sales     |     1 |
| sample_data_dev.tickit.event     |     1 |
+----------------------------------+-------+
```

The following example shows the various metric levels for a single WLM query.

```
SELECT query_id, child_query_sequence, stream_id, segment_id, step_id, step_name,
 start_time, end_time, metrics_level
FROM sys_query_detail
WHERE query_id = 1553 AND step_id = -1
ORDER BY stream_id, segment_id, step_id;

 query_id | child_query_sequence | stream_id | segment_id | step_id | step_name |
   start_time          |           end_time           | metrics_level
----------+----------------------+-----------+------------+---------+-----------
+----------------------------+----------------------------+---------------
     1553 |                    1 |        -1 |         -1 |      -1 |           |
 2024-10-17 02:28:49.814721 | 2024-10-17 02:28:49.847838 | child query
     1553 |                    1 |         0 |         -1 |      -1 |           |
 2024-10-17 02:28:49.814721 | 2024-10-17 02:28:49.835609 | stream
     1553 |                    1 |         0 |          0 |      -1 |           |
 2024-10-17 02:28:49.824677 | 2024-10-17 02:28:49.830372 | segment
     1553 |                    1 |         1 |         -1 |      -1 |           |
 2024-10-17 02:28:49.835624 | 2024-10-17 02:28:49.845773 | stream
     1553 |                    1 |         1 |          1 |      -1 |           |
 2024-10-17 02:28:49.84088  | 2024-10-17 02:28:49.842388 | segment
     1553 |                    1 |         1 |          2 |      -1 |           |
 2024-10-17 02:28:49.835926 | 2024-10-17 02:28:49.844396 | segment
     1553 |                    1 |         2 |         -1 |      -1 |           |
 2024-10-17 02:28:49.846949 | 2024-10-17 02:28:49.847838 | stream
     1553 |                    1 |         2 |          3 |      -1 |           |
 2024-10-17 02:28:49.847013 | 2024-10-17 02:28:49.847485 | segment
(8 rows)
```

SYS_QUERY_EXPLAIN

Displays the EXPLAIN plan for a query that has been submitted for execution.

SYS_QUERY_EXPLAIN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The query identifier. Detailed query information is stored in SYS_QUERY_HISTORY.
child_query_sequence	integer	The sequence of the rewritten user query, starting with 1.
plan_node_id	integer	The identifier of a plan node that maps to one or more steps in the query.
plan_parent_id	integer	The identifier of the plan node's parent node. A parent node can have multiple child nodes. For example, a merge join is the parent node of the scans on the joined tables.
plan_node	character(400)	The node text from the EXPLAIN output. Plan nodes that refer to execution on compute nodes are prefixed with XN in the EXPLAIN output.
node_info	character(400)	Qualifier and filter informati on for the plan node. For example, join conditions and WHERE clause restrictions are included in this column.

Sample queries

The following example is the EXPLAIN plan of a single query.

```
SELECT * FROM sys_query_explain WHERE query_id = 612635 ORDER BY plan_node_id;

 userid | query_id | child_query_sequence | plan_node_id | plan_parent_id |


         plan_node

                                          |

                                                                          plan_info




--------+----------+----------------------+--------------+----------------
+------------------------------------------------------------------------------------------------------
+------------------------------------------------------------------------------------------------------
    100 |   612635 |                    1 |            1 |              0 | XN Limit
 (cost=3604047533041.00..3604047533041.25 rows=100 width=20)

                                            |





    100 |   612635 |                    1 |            2 |              1 |   ->  XN
 Merge  (cost=3604047533041.00..3604047533148.02 rows=42809 width=20)

                                             | Merge Key: sum(b.totalprice)





    100 |   612635 |                    1 |            3 |              2 |        ->
 XN Network  (cost=3604047533041.00..3604047533148.02 rows=42809 width=20)
```

```
                                        |   Send to leader

   100 |   612635 |                    1 |             4 |              3 |
  ->  XN Sort  (cost=3604047533041.00..3604047533148.02 rows=42809 width=20)

                                        | Sort Key: sum(b.totalprice)

   100 |   612635 |                    1 |             5 |              4 |
         ->  XN HashAggregate  (cost=2604047529640.76..2604047529747.78 rows=42809
 width=20)

                                             |

   100 |   612635 |                    1 |             6 |              5 |
               ->  XN Hash Join DS_DIST_NONE  (cost=15104956.16..2602364653507.34
 rows=336575226684 width=20)

                                                          | Hash Cond: (("outer".listid =
 "inner".listid) AND ("outer".sellerid = "inner".sellerid))

   100 |   612635 |                    1 |             7 |              6 |
                         ->  XN Seq Scan on listing b  (cost=0.00..7884677.12
```

```
 rows=788467712 width=24)
                                                               |
    100 |    612635 |                       1 |              8 |                 6 |
                      ->  XN Hash  (cost=7063797.76..7063797.76 rows=706379776 width=8)
                                                 |
    100 |    612635 |                       1 |              9 |                 8 |
                                 ->  XN Seq Scan on sales a  (cost=0.00..7063797.76
 rows=706379776 width=8)
                                                           |
(9 rows)
```

SYS_QUERY_HISTORY

Use SYS_QUERY_HISTORY to view details of user queries. Each row represents a user query with accumulated statistics for some of the fields. This view contains many types of queries, such as data definition language (DDL), data manipulation language (DML), copy, unload, and Amazon Redshift Spectrum. It contains both running and finished queries.

SYS_QUERY_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see [Visibility of data in system tables and views](#).

Note

To verify whether a transaction containing the executed query was successfully committed, you need to perform a join operation between system tables and the `sys_transaction_history` table. For example:

```
SELECT
    qh.transaction_id,
    qh.query_id,
    qh.status AS query_status,
    qh.query_type,
    TRIM(qh.query_text) AS query_text,
    th.status AS transaction_status
FROM
    sys_query_history qh
LEFT JOIN
    sys_transaction_history th ON qh.transaction_id = th.transaction_id;
```

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The query identifier.
query_label	character(320)	The short name for the query.
transaction_id	bigint	The transaction identifier.
session_id	integer	The process identifier of the process running the query.
database_name	character(128)	The name of the database the user was connected to when the query was issued.

Column name	Data type	Description
query_type	character(32)	The type of query, such as, SELECT, INSERT, UPDATE, UNLOAD, COPY, COMMAND, DDL, UTILITY, CTAS, and OTHER.
status	character(10)	The status of the query. Valid values: planning, queued, running, returning, failed, canceled, and success.
result_cache_hit	Boolean	Indicates whether the query matches the result cache.
start_time	timestamp	The time when the query began.
end_time	timestamp	The time when the query completed.
elapsed_time	bigint	The total amount of time (microseconds) spent on the query.
queue_time	bigint	The total time (microseconds) spent on the service class query queue.
execution_time	bigint	The total time (microseconds) running in the service class.
error_message	character(512)	The reason a query failed.
returned_rows	bigint	The number of rows returned to the client.

Column name	Data type	Description
returned_bytes	bigint	The number of bytes returned to the client.
query_text	character(4000)	The query string. This string might be truncated.
redshift_version	character(256)	The Amazon Redshift version when the query ran.
usage_limit	character(150)	List of usage limit IDs reached by the query.
compute_type	varchar(32)	Indicates whether the query runs on the main cluster or concurrency scaling cluster. Possible values are `primary` (query runs on the main cluster), `secondary` (query runs on the secondary cluster), or `primary-scale` (query runs on the concurrency cluster). This is only applicable to provisioned cluster.
compile_time	bigint	The total time (microseconds) spent on compilation of the query.
planning_time	bigint	The total time (microseconds) spent on planning of the query.
lock_wait_time	bigint	The total time (microseconds) spent on waiting for relation lock.

Column name	Data type	Description
service_class_id	integer	The service class's ID. For a list of service class IDs, go to WLM service class IDs. This column is only used for queries run on provision ed clusters. For queries run on Redshift Serverless, this column contains -1.
service_class_name	character(64)	The service class name. This column is only used for queries run on provisioned clusters. For queries run on Amazon Redshift Redshift Serverless, this column is empty.

Column name	Data type	Description
query_priority	character(20)	The priority of the queue in which the query ran. Possible values are as follows: • NULL • lowest • low • normal • high • highest NULL means that query priority isn't supported for the query. This column is only used for queries run on provision ed clusters. For queries run on Redshift Serverless, this column is empty.

Column name	Data type	Description
short_query_accelerated	character(10)	Whether the query was accelerated using short query acceleration (SQA). Possible values are as follows: • true • false • NULL This column is only used for queries run on provision ed clusters. For queries run on Redshift Serverless, this column is empty.
user_query_hash	character(40)	The query hash generated from the query, including its query literals. Repeated queries with the same query text will have the same user_query_hash values.
generic_query_hash	character(40)	The query hash generated from the query, excluding its query literals. Repeated queries with the same query text, but different query literals, will have the same generic_query_hash values.
query_hash_version	integer	The version number for the query hash generated from the query.

Column name	Data type	Description
result_cache_query_id	integer	If the query used result caching, this field value is the query ID of the query that was the source of the cached results. If result caching was not used, this field value is `0`.
username	character(128)	The username of the user who submitted the query.

Sample queries

The following query returns running and queued queries.

```
SELECT user_id,
       query_id,
       transaction_id,
       session_id,
       status,
       trim(database_name) AS database_name,
       start_time,
       end_time,
       result_cache_hit,
       elapsed_time,
       queue_time,
       execution_time
FROM sys_query_history
WHERE status IN ('running','queued')
ORDER BY start_time;
```

Sample output.

```
 user_id | query_id | transaction_id | session_id | status  | database_name |
 start_time          |          end_time          | result_cache_hit | elapsed_time |
 queue_time | execution_time
---------+----------+----------------+------------+---------+---------------
+----------------------------+----------------------------+------------------
+--------------+------------+----------------
```

```
     101 |   760705 |         852337 | 1073832321 | running | tpcds_1t      |
 2022-02-15 19:03:19.67849 | 2022-02-15 19:03:19.739811 | f                |
 61321 |          0 |              0
```

The following query returns the query start time, end time, queue time, elapsed time, planning time, and other metadata for a specific query.

```
SELECT user_id,
       query_id,
       transaction_id,
       session_id,
       status,
       trim(database_name) AS database_name,
       start_time,
       end_time,
       result_cache_hit,
       elapsed_time,
       queue_time,
       execution_time,
       planning_time,
       trim(query_text) as query_text
FROM sys_query_history
WHERE query_id = 3093;
```

Sample output.

```
user_id | query_id | transaction_id | session_id |   status   | database_name |
   start_time          |           end_time           | result_cache_hit | elapsed_time |
 queue_time | execution_time | planning_time | query_text
--------+----------+----------------+------------+------------
+---------------+----------------------------+---------------------------
+------------------+-------------+------------+----------------+--------------
+-------------------------------------
    106 |     3093 |          11759 | 1073750146 | success    | dev           |
 2023-03-16 16:53:17.840214 | 2023-03-16 16:53:18.106588 | f                |
 266374 |          0 |         105725 |        136589 | select count(*) from item;
```

The following query lists the 10 most recent SELECT queries.

```
SELECT query_id,
       transaction_id,
       session_id,
```

```
       start_time,
       elapsed_time,
       queue_time,
       execution_time,
       returned_rows,
       returned_bytes
FROM sys_query_history
WHERE query_type = 'SELECT'
ORDER BY start_time DESC limit 10;
```

Sample output.

```
 query_id | transaction_id | session_id |         start_time         | elapsed_time |
 queue_time | execution_time | returned_rows | returned_bytes
----------+----------------+------------+----------------------------+--------------
+------------+----------------+---------------+----------------
   526532 |          61093 | 1073840313 | 2022-02-09 04:43:24.149603 |       520571 |
        0 |         481293 |             1 |           3794
   526520 |          60850 | 1073840313 | 2022-02-09 04:38:27.24875  |       635957 |
        0 |         596601 |             1 |           3679
   526508 |          60803 | 1073840313 | 2022-02-09 04:37:51.118835 |       563882 |
        0 |         503135 |             5 |          17216
   526505 |          60763 | 1073840313 | 2022-02-09 04:36:48.636224 |       649337 |
        0 |         589823 |             1 |            652
   526478 |          60730 | 1073840313 | 2022-02-09 04:36:11.741471 |     14611321 |
        0 |       14544058 |             0 |              0
   526467 |          60636 | 1073840313 | 2022-02-09 04:34:11.91463  |     16711367 |
        0 |       16633767 |             1 |            575
   511617 |         617946 | 1074009948 | 2022-01-20 06:21:54.44481  |      9937090 |
        0 |        9899271 |           100 |          12500
   511603 |         617941 | 1074259415 | 2022-01-20 06:21:45.71744  |      8065081 |
        0 |        7582500 |           100 |           8889
   511595 |         617935 | 1074128320 | 2022-01-20 06:21:44.030876 |      1051270 |
        0 |        1014879 |             1 |             72
   511584 |         617931 | 1074030019 | 2022-01-20 06:21:42.764088 |       609033 |
        0 |         485887 |           100 |           8438
```

The following query shows the daily select query count and average query elapsed time.

```
SELECT date_trunc('day',start_time) AS exec_day,
       status,
       COUNT(*) AS query_cnt,
```

```
       AVG(datediff (microsecond,start_time,end_time)) AS elapsed_avg
FROM sys_query_history
WHERE query_type = 'SELECT'
AND start_time >= '2022-01-14'
AND start_time <= '2022-01-18'
GROUP BY exec_day,
         status
ORDER BY exec_day,
         status;
```

Sample output.

```
      exec_day       | status  | query_cnt | elapsed_avg
---------------------+---------+-----------+------------
 2022-01-14 00:00:00 | success |      5253 |  56608048
 2022-01-15 00:00:00 | success |      7004 |  56995017
 2022-01-16 00:00:00 | success |      5253 |  57016363
 2022-01-17 00:00:00 | success |      5309 |  55236784
 2022-01-18 00:00:00 | success |      8092 |  54355124
```

The following query shows the daily query elapsed time performance.

```
SELECT distinct date_trunc('day',start_time) AS exec_day,
       query_count.cnt AS query_count,
       Percentile_cont(0.5) within group(ORDER BY elapsed_time) OVER (PARTITION BY
 exec_day) AS P50_runtime,
       Percentile_cont(0.8) within group(ORDER BY elapsed_time) OVER (PARTITION BY
 exec_day) AS P80_runtime,
       Percentile_cont(0.9) within group(ORDER BY elapsed_time) OVER (PARTITION BY
 exec_day) AS P90_runtime,
       Percentile_cont(0.99) within group(ORDER BY elapsed_time) OVER (PARTITION BY
 exec_day) AS P99_runtime,
       Percentile_cont(1.0) within group(ORDER BY elapsed_time) OVER (PARTITION BY
 exec_day) AS max_runtime
FROM sys_query_history
LEFT JOIN (SELECT  date_trunc('day',start_time) AS day, count(*) cnt
           FROM sys_query_history
           WHERE query_type = 'SELECT'
           GROUP by 1) query_count
ON date_trunc('day',start_time) = query_count.day
WHERE query_type = 'SELECT'
ORDER BY exec_day;
```

Sample output.

```
     exec_day       | query_count | p50_runtime | p80_runtime | p90_runtime | 
 p99_runtime  | max_runtime
---------------------+-------------+-------------+-------------+-------------
+--------------+--------------
 2022-01-14 00:00:00 |        5253 |  16816922.0 |  69525096.0 | 158524917.8 | 
 486322477.52 | 1582078873.0
 2022-01-15 00:00:00 |        7004 |  15896130.5 |  71058707.0 | 164314568.9 | 
 500331542.07 | 1696344792.0
 2022-01-16 00:00:00 |        5253 |  15750451.0 |  72037082.2 | 159513733.4 | 
 480372059.24 | 1594793766.0
 2022-01-17 00:00:00 |        5309 |  15394513.0 |  68881393.2 | 160254700.0 | 
 493372245.84 | 1521758640.0
 2022-01-18 00:00:00 |        8092 |  15575286.5 |  68485955.4 | 154559572.5 | 
 463552685.39 | 1542783444.0
 2022-01-19 00:00:00 |        5860 |  16648747.0 |  72470482.6 | 166485138.2 | 
 492038228.67 | 1693483241.0
 2022-01-20 00:00:00 |        1751 |  15422072.0 |  69686381.0 | 162315385.0 | 
 497066615.00 | 1439319739.0
 2022-02-09 00:00:00 |          13 |   6382812.0 |  17616161.6 |  21197988.4 | 
 23021343.84 |   23168439.0
```

The following query shows the query type distribution.

```
SELECT query_type,
       COUNT(*) AS query_count
FROM sys_query_history
GROUP BY query_type
ORDER BY query_count DESC;
```

Sample output.

```
 query_type | query_count
------------+-------------
 UTILITY    |      134486
 SELECT     |       38537
 DDL        |        4832
 OTHER      |         768
 LOAD       |         768
 CTAS       |         748
```

```
 COMMAND    |          92
```

The following example shows the difference in query hash results between several queries. Observe the following queries:

```
CREATE TABLE test_table (col1 INT);

INSERT INTO test_table VALUES (1),(2);

SELECT * FROM test_table;

SELECT * FROM test_table;

SELECT col1 FROM test_table;

SELECT * FROM test_table WHERE col1=1;

SELECT * FROM test_table WHERE col1=2;

SELECT query_id, TRIM(user_query_hash) AS user_query_hash, TRIM(generic_query_hash)
 AS generic_query_hash, TRIM(query_text) AS text FROM sys_query_history ORDER BY
 start_time
DESC LIMIT 10;
```

Following is a sample output:

```
query_id | user_query_hash | generic_query_hash | text
---------+-----------------+--------------------+----------
24723049 | oPuFtjEPLTs=    | oPuFtjEPLTs=       | select query_id,
 trim(user_query_hash) as user_query_hash, trim(generic_query_hash) as
 generic_query_hash, query_hash_version, trim(query_text) as text from
 sys_query_history order by start_time\r\ndesc limit 20
24723045 | Gw2Kwdd8m2I=    | IwfRu8/XAKI=       | select * from test_table where col1=2
 limit 100
24723041 | LNw2vx0GDXo=    | IwfRu8/XAKI=       | select * from test_table where col1=1
 limit 100
24723036 | H+qep/c82Y8=    | H+qep/c82Y8=       | select col1 from test_table limit 100
24723033 | H+qep/c82Y8=    | H+qep/c82Y8=       | select * from test_table limit 100
24723029 | H+qep/c82Y8=    | H+qep/c82Y8=       | select * from test_table limit 100
24723023 | 50sirx9E1hU=    | uO36Z1a/QYs=       | insert into test_table values (1),(2)
24723021 | YSVnlivZHeo=    | YSVnlivZHeo=       | create table test_table (col1 int)
```

`SELECT * FROM test_table;` and `SELECT col1 FROM test_table;` have the same user_query_hash value, since test_table has only one column. `SELECT * FROM test_table WHERE col1=1;` and `SELECT * FROM test_table WHERE col1=2;` have different user_query_hash values, but identical generic_query_hash values, since the two queries are identical outside of the query literals 1 and 2.

SYS_QUERY_TEXT

Use SYS_QUERY_TEXT to view the query text of all queries. Each row represents the query text of queries up to 4000 characters starting with sequence number 0. When the query statement contains more than 4000 characters, additional rows are logged for the statement by incrementing the sequence number for each row. This view logs all user query text such as DDL, utility, Amazon Redshift queries, and leader-node only queries.

SYS_QUERY_TEXT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
query_id	bigint	The query identifier.
transaction_id	bigint	The identifier of the transacti on associated with the statement.
session_id	integer	The process identifier of the session running the query.
start_time	timestamp	The time when the query starts.
sequence	integer	When a single statement contains more than 4000 characters, additional rows

Column name	Data type	Description
		are logged for the statement . Sequence 0 is the first row, 1 is the second row, and so on.
text	character (4000)	The text of the SQL query that is in 4000-character increments. This field might contain special character s, such as backslash (\) and newline (\n).

Sample queries

The following query returns running and queued queries.

```
SELECT user_id,
 query_id,
 transaction_id,
 session_id, start_time,
 sequence, trim(text) as text from sys_query_text
 ORDER BY sequence;
```

Sample output.

```
 user_id | query_id | transaction_id | session_id |        start_time          |
 sequence |                                                              text
--------+----------+----------------+------------+----------------------------
+----------
+---------------------------------------------------------------------------------------
   100  |     4    |       1396      | 1073750220 | 2023-04-28 16:44:55.887184 |
   0    | SELECT trim(text) as text, sequence FROM sys_query_text WHERE query_id =
 pg_last_query_id() AND user_id > 1 AND start
_time > '2023-04-28 16:44:55.922705+00:00'::timestamp order by sequence;
```

The following query returns the permissions that have been granted or revoked from groups in your database.

```
SELECT
```

```
    SPLIT_PART(text, ' ', 1) as grantrevoke,
    SPLIT_PART((SUBSTRING(text, STRPOS(UPPER(text), 'GROUP'))), ' ', 2) as group,
    SPLIT_PART((SUBSTRING(text, STRPOS(UPPER(text), ' '))), 'ON', 1) as type,
    SPLIT_PART((SUBSTRING(text, STRPOS(UPPER(text), 'ON'))), ' ', 2) || ' ' ||
 SPLIT_PART((SUBSTRING(text, STRPOS(UPPER(text), 'ON'))), ' ', 3) as entity
FROM SYS_QUERY_TEXT
WHERE (text LIKE 'GRANT%' OR text LIKE 'REVOKE%') AND text LIKE '%GROUP%';

+-------------+----------+--------+----------+
| grantrevoke |  group   |  type  |  entity  |
+-------------+----------+--------+----------+
| GRANT       | bi_group | SELECT | TABLE t1 |
| GRANT       | bi_group | SELECT | TABLE t1 |
| GRANT       | bi_group | SELECT | TABLE t1 |
| GRANT       | bi_group | USAGE  | TABLE t1 |
| GRANT       | bi_group | SELECT | TABLE t1 |
| GRANT       | bi_group | SELECT | TABLE t1 |
+-------------+----------+--------+----------+
```

SYS_RESTORE_LOG

Use SYS_RESTORE_LOG to monitor the migration progress of each table in the cluster during a classic resize to RA3 nodes. It captures the historic throughput of data migration during the resize operation. For more information about classic resize to RA3 nodes, see Classic resize.

SYS_RESTORE_LOG is visible only to superusers.

Table columns

Column name	Data type	Description
event_time	timestamp	A timestamp that indicates when the log entry is recorded.
database_name	char(128)	The name of the database.
schema_name	char(128)	The name of the schema.
table_name	char(128)	The name of the table.

Column name	Data type	Description
table_id	integer	The ID of the table.
action	char(128)	The action taken at the time of the entry. Values can include: Migration started, checkpoint, resumed, completed, cancelled, or reset.
table_size	long	The size of the table.
total_data_processed	long	The size of the data in MB processed up to this point for the table.
delta_data_processed	long	Size of data processed since the last event_time update, in MB. This helps you determine how much of the data has been processed since the previous recorded time interval. You can compare this with the table_size to get a sense of how quickly data processing is going.
message	char(512)	A detailed explanation for the value in the action column.
redistribution_type	char(32)	The redistribution type for the table. Either KEY conversion or an EVEN rebalancing task. For more information about distribut ion styles, see Distribution styles.

Sample queries

The following query calculates the throughput of data processing, using SYS_RESTORE_LOG.

```
SELECT
    ROUND(sum(delta_data_processed) / 1024.0, 2) as data_processed_gb,
    ROUND(datediff(sec, min(event_time), max(event_time)) / 3600.0, 2) as duration_hr,
    ROUND(data_processed_gb/duration_hr, 2) as throughput_gb_per_hr
from sys_restore_log;
```

Sample output.

```
 data_processed_gb | duration_hr | throughput_gb_per_hr
-------------------+-------------+----------------------
              0.91 |        8.37 |                 0.11
(1 row)
```

The following query that shows all redistribution types.

```
SELECT * from sys_restore_log ORDER BY event_time;
```

```
 database_name |     schema_name      |      table_name      | table_id |
 action              | total_data_processed | delta_data_processed |          event_time
        | table_size | message |   redistribution_type
---------------+----------------------+----------------------+----------
+----------------------------+----------------------+----------------------
+----------------------------+------------+---------+--------------------------
 dev           | schemaaaa877096d844d | customer_key         |   106424 |
 Redistribution started      |                    0 |                      | 2024-01-05
 02:18:00.744977 |        325 |         | Restore Distkey Table
 dev           | schemaaaa877096d844d | dp30907_t2_autokey   |   106430 |
 Redistribution started      |                    0 |                      | 2024-01-05
 02:18:02.756675 |         90 |         | Restore Distkey Table
 dev           | schemaaaa877096d844d | dp30907_t2_autokey   |   106430 |
 Redistribution completed    |                   90 |                   90 | 2024-01-05
 02:23:30.643718 |         90 |         | Restore Distkey Table
 dev           | schemaaaa877096d844d | customer_key         |   106424 |
 Redistribution completed    |                  325 |                  325 | 2024-01-05
 02:23:45.998249 |        325 |         | Restore Distkey Table
 dev           | schemaaaa877096d844d | dp30907_t1_even      |   106428 |
 Redistribution started      |                    0 |                      | 2024-01-05
 02:23:46.083849 |         30 |         | Rebalance Disteven Table
```

```
 dev            | schemaaaa877096d844d | dp30907_t5_auto_even |   106436 |
 Redistribution started      |                    0 |                    | 2024-01-05
 02:23:46.855728 |          45 |          | Rebalance Disteven Table
 dev            | schemaaaa877096d844d | dp30907_t5_auto_even |   106436 |
 Redistribution completed    |                   45 |                 45 | 2024-01-05
 02:24:16.343029 |          45 |          | Rebalance Disteven Table
 dev            | schemaaaa877096d844d | dp30907_t1_even      |   106428 |
 Redistribution completed    |                   30 |                 30 | 2024-01-05
 02:24:20.584703 |          30 |          | Rebalance Disteven Table
 dev            | schemaefd028a2a48a4c | customer_even        |   130512 |
 Redistribution started      |                    0 |                    | 2024-01-05
 04:54:55.641741 |         190 |          | Restore Disteven Table
 dev            | schemaefd028a2a48a4c | customer_even        |   130512 |
 Redistribution checkpointed |     29.4342113157737 |     29.4342113157737 | 2024-01-05
 04:55:04.770696 |         190 |          | Restore Disteven Table
(8 rows)
```

SYS_RESTORE_STATE

Use SYS_RESTORE_STATE to monitor the migration progress of each table during a classic resize. This is specifically applicable when the target node type is RA3. For more information about classic resize to RA3 nodes, see Classic resize.

SYS_RESTORE_STATE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the query.
database_name	char(64)	The name of the database of the table.
schema_id	integer	The schema ID of the table.
table_id	integer	The ID of the table.
table_name	char(128)	The name of the table.

Column name	Data type	Description
redistribution_status	char(128)	The status of redistribution progress of the table. Possible values are Completed , In progress, and Pending.
percentage_redistributed	float	The percentage of the redistribution progress of the table. Possible values are from 0 to 100%. For example, a value of 25 indicates that 25% of the data is redistrib uted.
redistribution_type	char(32)	The redistribution type for the table. Either KEY conversion or an EVEN rebalancing task. For more information about distribut ion styles, see Distribution styles.

Sample queries

The following query returns records for running and queued queries.

```
SELECT * FROM sys_restore_state;
```

Sample output.

```
 userid | database_name | schema_id | table_id |   table_name   | redistribution_status
 | precentage_redistributed |    redistribution_type
--------+---------------+-----------+----------+----------------
+------------------------+-------------------------+------------------------
    1   |     test1     |   124865  |  124878  | customer_key_4 |         Pending
 |      0                   |   Rebalance Disteven Table
```

```
    1   |     dev      |   124865  |  124874  | customer_key_3 |         Pending
 |     0                   |  Rebalance Disteven Table
    1   |     dev      |   124865  |  124870  | customer_key_2 |        Completed
 |    100                  |  Rebalance Disteven Table
    1   |     dev      |   124865  |  124866  | customer_key_1 |       In progress
 |    13.52                |  Restore Distkey Table
```

The following gives you the data-processing status.

```
SELECT
    redistribution_status, ROUND(SUM(block_count) / 1024.0, 2) AS total_size_gb
FROM sys_restore_state sys inner join stv_tbl_perm stv
    on sys.table_id = stv.id
GROUP BY sys.redistribution_status;
```

Sample output.

```
 redistribution_status | total_size_gb
-----------------------+---------------
 Completed             |          0.07
 Pending               |          0.71
 In progress           |          0.20
(3 rows)
```

SYS_SCHEMA_QUOTA_VIOLATIONS

Records the occurrence, transaction ID, and other useful information when a schema quota is exceeded. This system table is a translation of STL_SCHEMA_QUOTA_VIOLATIONS.

r_SYS_SCHEMA_QUOTA_VIOLATIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
owner_id	integer	The ID of the schema owner.

Column name	Data type	Description
user_id	integer	The ID of the user who generated the entry.
transacti on_id	bigint	The transaction ID associated with the statement.
session_id	integer	The process ID associated with the statement.
schema_id	integer	The namespace or schema ID.
schema_na me	character (128)	The namespace or schema name.
quota	integer	The amount of disk space (in MB) that the schema can use.
disk_usage	integer	The disk space (in MB) that is currently used by the schema.
record_ti me	timestamp without time zone	The time when the violation occurred.

Sample queries

The following query shows the result of a quota violation:

```
SELECT user_id, TRIM(schema_name) "schema_name", quota, disk_usage, record_time FROM
sys_schema_quota_violations WHERE SCHEMA_NAME = 'sales_schema' ORDER BY timestamp DESC;
```

This query returns the following sample output for the specified schema:

```

user_id| schema_name  | quota | disk_usage | record_time
-------+--------------+-------+------------+----------------------------
104    | sales_schema | 2048  | 2798       | 2020-04-20 20:09:25.494723
(1 row)
```

SYS_SERVERLESS_USAGE

Use SYS_SERVERLESS_USAGE to view details of Amazon Redshift Serverless usage of resources. This system view doesn't apply to provisioned Amazon Redshift clusters.

This view contains the serverless usage summary including how much compute capacity is used to process queries and the amount of Amazon Redshift managed storage used at a 1-minute granularity. The compute capacity is measured in Redshift processing units (RPUs) and metered for the workloads that you run in RPU-seconds on a per-second basis. RPUs are used to process queries on the data loaded in the data warehouse, queried from an Amazon S3 data lake, or accessed from operational databases using a federated query. Amazon Redshift Serverless retains the information in SYS_SERVERLESS_USAGE for 7 days.

For examples on compute cost billing, see Billing for Amazon Redshift Serverless.

SYS_SERVERLESS_USAGE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
start_time	timestamp	The time when the interval began.
end_time	timestamp	The time when the interval completed.
compute_seconds	double precision	The accumulated compute unit (RPU) seconds consumed during this time interval. This value accounts for the base RPU capacity allocated for the account.
compute_capacity	double precision	The average number of compute units (Redshift processing units, or RPUs)

Column name	Data type	Description
		allocated during this time interval. The compute_capacity value can be dynamically changed.
data_storage	integer	The average data storage space in MB used during this time interval. Used data storage can change dynamically as data is loaded or deleted from the database.
cross_region_transferred_data	integer	The accumulated data transferred for cross-Region data sharing in bytes during this time interval.
charged_seconds	integer	The accumulated compute unit (RPU) seconds charged during this time interval. This is computed after transacti ons end, and hence can be 0 while a transaction runs. Use charged_seconds to calculate cost for an Amazon Redshift Serverless workgroup. This value accounts for the RPU capacity allocated for the Amazon Redshift Serverless workgroup.

Usage notes

- There are situations where compute_seconds is 0 but charged_seconds is greater than 0, or vice versa. This is normal behavior resulting from the way data is recorded in the system view. For a more accurate representation of serverless usage details, we recommend aggregating the data.

Example

To get the total charges for RPU hours used for a time interval by querying charged_seconds, run the following query:

```
select trunc(start_time) "Day",
(sum(charged_seconds)/3600::double precision) * <Price for 1 RPU> as cost_incurred
from sys_serverless_usage
group by 1
order by 1
```

Note that there can be idle time during the interval. Idle time doesn't add to RPUs consumed.

SYS_SESSION_HISTORY

Use the SYS_SESSION_HISTORY to view information about the current active sessions and session history.

SYS_SESSION_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	char(50)	The identifier of the user who generated the entry.
session_id	integer	The ID of the session associated with the statement.
database_name	char(50)	The name of the database.

Column name	Data type	Description
status	char	The status of the session. Possible values are `active`, `timed out`, and `closed`.
session_timeout	integer	The maximum time in seconds that a session remains inactive or idle before timing out. 0 indicates that no timeout is set.
start_time	timestamp	The timestamp that the connection was established.
end_time	timestamp	The timestamp that the connected stopped.

Example

The following is a sample output of SYS_SESSION_HISTORY.

```
select * from sys_session_history;
 user_id | session_id |   database_name   | status | session_timeout |
 start_time          |           end_time
---------+------------+-------------------+--------+-----------------
+----------------------------+----------------------------
       1 | 1073971370 | dev               | closed |        0        | 2023-07-17
 15:50:12.030104 | 2023-07-17 15:50:12.123218
       1 | 1073979694 | dev               | closed |        0        | 2023-07-17
 15:50:24.117947 | 2023-07-17 15:50:24.131859
       1 | 1073873049 | dev               | closed |        0        | 2023-07-17
 15:49:29.067398 | 2023-07-17 15:49:29.070294
       1 | 1073873086 | database18127a4a | closed |        0        | 2023-07-17
 15:49:29.119018 | 2023-07-17 15:49:29.125925
       1 | 1073832112 | dev               | closed |        0        | 2023-07-17
 15:49:29.164688 | 2023-07-17 15:49:29.179631
       1 | 1073987697 | dev               | closed |        0        | 2023-07-17
 15:49:29.26749  | 2023-07-17 15:49:29.273034
       1 | 1073922429 | dev               | closed |        0        | 2023-07-17
 15:49:33.35315  | 2023-07-17 15:49:33.367499
       1 | 1073766783 | dev               | closed |        0        | 2023-07-17
 15:49:45.38237  | 2023-07-17 15:49:45.396902
       1 | 1073807506 | dev               | active |        0        | 2023-07-17
 15:51:48        |
```

SYS_SPATIAL_SIMPLIFY

You can query the system view SYS_SPATIAL_SIMPLIFY to get information about simplified spatial geometry objects using the COPY command. When you use COPY on a shapefile, you can specify SIMPLIFY `tolerance`, SIMPLIFY AUTO, and SIMPLIFY AUTO `max_tolerance` ingestion options. The result of the simplification is summarized in SYS_SPATIAL_SIMPLIFY system view.

When SIMPLIFY AUTO `max_tolerance` is set, this view contains a row for each geometry that exceeded the maximum size. When SIMPLIFY `tolerance` is set, then one row for the entire COPY operation is stored. This row references the COPY query ID and the specified simplification tolerance.

For more information about loading a shapefile, see Loading a shapefile into Amazon Redshift.

SYS_SPATIAL_SIMPLIFY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
query_id	bigint	The ID of the query (COPY command) that generated this row.
line_number	bigint	When COPY `SIMPLIFY AUTO` option is specified, this value is the record number of the simplified record in the shapefile.
maximum_tolerance	double precision	The distance tolerance value specified in the COPY command. This is either the maximum tolerance value using the `SIMPLIFY AUTO` option, or the fixed tolerance value using the `SIMPLIFY` option.
initial_size	bigint	The size in bytes of the `GEOMETRY` data value before simplification.
simplified	char(1)	When the COPY `SIMPLIFY AUTO` option is specified, `t` if the geometry was successfully simplified, or `f` otherwise.

Column name	Data type	Description
		The geometry might not be simplified successfully if after the simplification with the given maximum tolerance its size is still larger than the maximum geometry size.
final_size	bigint	When the COPY `SIMPLIFY AUTO` option is specified, this is the size in bytes of the geometry after simplification.
final_tol erance	double precision	Final tolerance chosen for the simplification.

Sample query

The following query returns the list of records that COPY simplified.

```
SELECT * FROM sys_spatial_simplify;


 query_id | line_number | maximum_tolerance | initial_size | simplified | final_size |
  final_tolerance
----------+-------------+-------------------+--------------+------------+------------
+----------------------
    20    |     1184704 |                -1 |      1513736 | t          |    1008808 |
  1.276386653895e-05
    20    |     1664115 |                -1 |      1233456 | t          |    1023584 |
 6.11707814796635e-06
```

SYS_STREAM_SCAN_ERRORS

Records errors for records loaded via streaming ingestion.

SYS_STREAM_SCAN_ERRORS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
external_schema_name	character (128)	The name of the Kinesis stream or Amazon MSK topic's schema. It is case sensitive.
stream_name	character (255)	The name of the stream or topic. It is case sensitive.
mv_name	character (128)	The name of the associated materialized view. Empty if none. It is case sensitive.
transaction_id	bigint	The transaction ID.
query_id	bigint	The query ID.
stream_timestamp_type	character (1)	The type of the stream timestamp. It is case sensitive.
stream_timestamp	timestamp without time zone	The time when the record arrived.
record_time	timestamp without time zone	The time when the error message was logged.
partition_id	character (128)	The partition/shard id. It is case sensitive.
position	character (128)	The position of the record. This corresponds with the sequence number in Kinesis or the offset in Amazon MSK. It is case sensitive.

Column name	Data type	Description
error_code	integer	The error code.
error_reason	character (128)	The error reason. It is case sensitive.

SYS_STREAM_SCAN_STATES

Records scan states for records loaded via streaming ingestion.

SYS_STREAM_SCAN_STATES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
external_schema_name	character (128)	The external schema name. It is case sensitive.
stream_name	character (255)	The stream name. It is case sensitive.
mv_name	character (128)	The name of the associated materialized view. Empty if none. It is case sensitive.
transaction_id	bigint	The transaction ID.
query_id	bigint	The query ID.
record_time	timestamp without	The time when the data was logged.

Column name	Data type	Description
	time zone	
partition_id	character (128)	The partition or shard id. It is case sensitive.
latest_position	character (128)	The position of the last record read in the batch. This corresponds with the sequence number in Kinesis or the offset in Amazon MSK. It is case sensitive.
scanned_rows	bigint	The number of records that were scanned in the batch.
skipped_rows	bigint	The number of records that were skipped in the batch.
scanned_bytes	bigint	The number of bytes that were scanned in the batch.
stream_record_time_min	timestamp without time zone	Kinesis or Amazon MSK arrival time for the earliest record in the batch.
stream_record_time_max	timestamp without time zone	Kinesis or Amazon MSK arrival time for the latest record in the batch.

The following query shows stream and topic data for specific queries.

```
select
 query_id,mv_name::varchar,external_schema_name::varchar,stream_name::varchar,sum(scanned_rows)
 total_records,
sum(scanned_bytes) total_bytes from sys_stream_scan_states where query in
 (5401180,8601939) group by 1,2,3,4;
```

```
  query_id  |     mv_name      | external_schema_name |   stream_name    | total_records |
  total_bytes
------------+----------------+----------------------+-----------------+---------------
+----------------
 5401180    | kinesistest    | kinesis              | kinesisstream   |    1493255696 |
 3209006490704
 8601939    | msktest        | msk                  | mskstream       |      14677023 |
   31056580668
(2 rows)
```

SYS_TRANSACTION_HISTORY

Use SYS_TRANSACTION_HISTORY to see details of a transaction when tracking a query.

SYS_TRANSACTION_HISTORY is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	ID of the user who generated the entry.
transaction_id	bigint	The ID of the transaction.
isolation_level	text	The isolation level of the transaction. Possible values are `Serializable` and `Snapshot Isolation`.
status	text	The status of the transaction. Possible statuses are `committed` and `rolledback`.
transaction_start_time	timestamp	The start time of the transaction.

Column name	Data type	Description
commit_start_time	timestamp	The start time of the commit.
commit_end_time	timestamp	The end time of the commit.
blocks_committed	bigint	The number of blocks that had to be written as part of this commit.
undo_transaction_id	bigint	The ID of the undo transaction if any transactions have been undone. Otherwise, this value is -1.

Sample queries

```
select * from sys_transaction_history order by transaction_start_time desc;

 user_id | transaction_id | isolation_level |   status   |   transaction_start_time
   |     commit_start_time      |      commit_end_time       | blocks_committed |
 undo_transaction_id
---------+----------------+-----------------+------------+----------------------------
+----------------------------+----------------------------+------------------
+---------------------
     100 |           1310 | Serializable    | committed  | 2023-08-27 21:03:11.822205 |
 2023-08-28 21:03:11.825287 | 2023-08-28 21:03:11.854883 |               17 |
        -1
     101 |           1345 | Serializable    | committed  | 2023-08-27 21:03:12.000278 |
 2023-08-28 21:03:12.003736 | 2023-08-28 21:03:12.030061 |               17 |
        -1
     102 |           1367 | Serializable    | committed  | 2023-08-27 21:03:12.1532   |
 2023-08-28 21:03:12.156124 | 2023-08-28 21:03:12.186468 |               17 |
        -1
     100 |           1370 | Serializable    | committed  | 2023-08-27 21:03:12.199316 |
 2023-08-28 21:03:12.204854 | 2023-08-28 21:03:12.238186 |               24 |
        -1
     100 |           1408 | Serializable    | committed  | 2023-08-27 21:03:53.891107 |
 2023-08-28 21:03:53.894825 | 2023-08-28 21:03:53.927465 |               17 |
        -1
```

```
     100 |            1409 | Serializable     | rolledback | 2023-08-27 21:03:53.936431 |
  2000-01-01 00:00:00        | 2023-08-28 21:04:08.712532 |                  0 |
      1409
     101 |            1415 | Serializable     | committed  | 2023-08-27 21:04:24.283188 |
  2023-08-28 21:04:24.289196 | 2023-08-28 21:04:24.374318 |                 25 |
        -1
     101 |            1416 | Serializable     | committed  | 2023-08-27 21:04:24.38818  |
  2023-08-28 21:04:24.391688 | 2023-08-28 21:04:24.415135 |                 17 |
        -1
     100 |            1417 | Serializable     | rolledback | 2023-08-27 21:04:24.424252 |
  2000-01-01 00:00:00        | 2023-08-28 21:04:28.354826 |                  0 |
      1417
     101 |            1418 | Serializable     | rolledback | 2023-08-27 21:04:24.425195 |
  2000-01-01 00:00:00        | 2023-08-28 21:04:28.680355 |                  0 |
      1418
     100 |            1420 | Serializable     | committed  | 2023-08-27 21:04:28.697607 |
  2023-08-28 21:04:28.702374 | 2023-08-28 21:04:28.735541 |                 23 |
        -1
     101 |            1421 | Serializable     | committed  | 2023-08-27 21:04:28.744854 |
  2023-08-28 21:04:28.749344 | 2023-08-28 21:04:28.779029 |                 23 |
        -1
     101 |            1423 | Serializable     | committed  | 2023-08-27 21:04:28.78942  |
  2023-08-28 21:04:28.791556 | 2023-08-28 21:04:28.817485 |                 16 |
        -1
     100 |            1430 | Serializable     | committed  | 2023-08-27 21:04:28.917788 |
  2023-08-28 21:04:28.919993 | 2023-08-28 21:04:28.944812 |                 16 |
        -1
     102 |            1494 | Serializable     | committed  | 2023-08-27 21:04:37.029058 |
  2023-08-28 21:04:37.033137 | 2023-08-28 21:04:37.062001 |                 16 |
        -1
```

SYS_UDF_LOG

Records system-defined error and warning messages generated during user-defined function (UDF) execution.

SYS_UDF_LOG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
query_id	bigint	The query identifier.
function_name	text	The name of the user-defined function.
record_time	timestamp	The time that the record was created.
sequence	integer	The sequence of a single log message.
message	text	The log message text.

Sample queries

The following example shows how UDFs handle system-defined errors. The first block shows the definition for a UDF function that returns the inverse of an argument. When you run the function and provide a 0 as your argument, the function returns an error. The last statement returns the error message logged in SYS_UDF_LOG.

```
-- Create a function to find the inverse of a number.
CREATE OR REPLACE FUNCTION f_udf_inv(a int)

RETURNS float

IMMUTABLE AS $$return 1/a

$$ LANGUAGE plpythonu;

-- Run the function with 0 to create an error.
Select f_udf_inv(0);

-- Query SYS_UDF_LOG to view the message.
Select query_id, record_time, message::varchar from sys_udf_log;


query_id    |    record_time                |                    message
```

```
----------+---------------------------
+-------------------------------------------------------
2211       | 2023-08-23 15:53:11.360538 |  ZeroDivisionError: integer division or
 modulo by zero line 2, in f_udf_inv\n return 1/a\n
```

The following example adds logging and a warning message to the UDF so that a divide by zero operation results in a warning message instead of stopping with an error message.

```
-- Create a function to find the inverse of a number and log a warning if you input 0.
CREATE OR REPLACE FUNCTION f_udf_inv_log(a int)
  RETURNS float IMMUTABLE
 AS $$
  import logging
  logger = logging.getLogger() #get root logger
  if a==0:
    logger.warning('You attempted to divide by zero.\nReturning zero instead of error.
\n')
    return 0
  else:
     return 1/a
$$ LANGUAGE plpythonu;

-- Run the function with 0 to trigger the warning.
Select f_udf_inv_log(0);

-- Query SYS_UDF_LOG to view the message.
Select query_id, record_time, message::varchar from sys_udf_log;

 query_id |        record_time         |                                    message
----------+----------------------------
+--------------------------------------------------------------------------------
     0    | 2023-08-23 16:10:48.833503 | WARNING: You attempted to divide by zero.
\nReturning zero instead of error.\n
```

SYS_UNLOAD_DETAIL

Use SYS_UNLOAD_DETAIL to view details of an UNLOAD operation. It records one row for each file created by an UNLOAD statement. For example, if an UNLOAD creates 12 files, SYS_UNLOAD_DETAIL will contain 12 corresponding rows.

SYS_UNLOAD_DETAIL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who generated the entry.
query_id	integer	The query identifier of the UNLOAD command.
session_id	integer	The ID of the process associated with the query statement.
transaction_id	bigint	The ID of the transaction associated with the query statement.
file_name	character (1280)	The complete Amazon S3 object path for the file.
start_time	timestamp	The time when the transacti on began.
end_time	timestamp	The time when the transacti on completed.
line_count	bigint	The number of lines (rows) unloaded to the file.
transfer_size	bigint	The number of bytes transferr ed.
file_format	character (10)	The file format of the unloaded files.

Sample queries

The following query shows the unloaded query details, including format, rows, and file count of unload command.

```
select query_id, substring(file_name, 0, 50), transfer_size, file_format from
 sys_unload_detail;
```

Sample output.

```

 query_id |                          substring                                | transfer_size
 | file_format
----------+-------------------------------------------------------------
+---------------+-------------
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0000_part_00.gz  |
 395886 | Text
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0001_part_00.gz  |
 406444 | Text
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0002_part_00.gz  |
 409431 | Text
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0003_part_00.gz  |
 403051 | Text
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0004_part_00.gz  |
 413592 | Text
     9272 | s3://amzn-s3-demo-bucket/my_unload_doc_venue0005_part_00.gz  |
 395689 | Text
(6 rows)
```

SYS_UNLOAD_HISTORY

Use SYS_UNLOAD_HISTORY to view details of UNLOAD commands. Each row represents a UNLOAD command with accumulated statistics for some of the fields. It contains both running and finished UNLOAD commands.

SYS_UNLOAD_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the unload.
query_id	bigint	The query identifier of the UNLOAD command.
transaction_id	bigint	The transaction identifier.
session_id	integer	The process identifier of the process running the unload.
database_name	text	The name of the database the user was connected to when the operation was issued.
status	text	The status of the UNLOAD command. Valid values include: `running`, `completed` , `aborted`, and `unknown`.
start_time	timestamp	The time when the unload began.
end_time	timestamp	The time when the unload completed.
duration	bigint	The amount of time (microsec onds) spent in the UNLOAD command.
file_format	text	The file format of the output files.
compression_type	text	The compression type.

Column name	Data type	Description
unloaded_location	text	The Amazon S3 location of unloaded files.
unloaded_rows	bigint	The number of rows.
unloaded_files_count	bigint	The file count of the output file.
unloaded_files_size	bigint	The file size of the output file.
error_message	text	The error message of the UNLOAD command.

Sample queries

The following query shows the unloaded query details, including format, rows, and file count of unload command.

```
SELECT query_id,
       file_format,
       start_time,
       duration,
       unloaded_rows,
       unloaded_files_count
FROM sys_unload_history
ORDER BY query_id,
file_format limit 100;
```

Sample output.

```
 query_id | file_format |         start_time         | duration | unloaded_rows |
 unloaded_files_count
----------+-------------+----------------------------+----------+---------------
+----------------------
   527067 | Text        | 2022-02-09 05:18:35.844452 |  5932478 |            10 |
           1
```

SYS_USERLOG

Records details for the following changes to a database user:

- Create user
- Drop user
- Alter user (rename)
- Alter user (alter properties)

You can query this view to see information about serverless workgroups and provisioned clusters.

SYS_USERLOG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The identifier of the user who submitted the unload.
user_name	character(50)	Username of the user affected by the change.
original_user_name	character(50)	The original username in a rename action. This field is empty for all other actions.
action	character(10)	The action that occurred. Valid values are alter, create, drop, and rename.
has_create_db_privs	integer	If true (a value of 1), the user has create database permissio ns.
is_superuser	integer	If true (a value of 1), the user can update system catalogs.

Column name	Data type	Description
has_update_catalog_privs	integer	If true (a value of 1), the user can update system catalogs.
password_expiration	timestamp	The password expiration date.
session_id	integer	The process ID.
transaction_id	bigint	The transaction ID.
record_time	timestamp	Time in UTC of when the query started.

Sample queries

The following example performs four user actions, then queries the SYS_USERLOG view.

```
CREATE USER userlog1 password 'Userlog1';
ALTER USER userlog1 createdb createuser;
ALTER USER userlog1 rename  to userlog2;
DROP user userlog2;

SELECT user_id, user_name, original_user_name, action, has_create_db_privs,
 is_superuser from SYS_USERLOG order by record_time desc;
```

```
user_id |  user_name | original_user_name |  action | has_create_db_privs |
 is_superuser
--------+------------+--------------------+---------+---------------------+------------
    108 |  userlog2  |                    | drop    |                   1 |   1
    108 |  userlog2  |     userlog1       | rename  |                   1 |   1
    108 |  userlog1  |                    | alter   |                   1 |   1
    108 |  userlog1  |                    | create  |                   0 |   0
 (4 rows)
```

SYS_VACUUM_HISTORY

Use SYS_VACUUM_HISTORY to view details of vacuum queries. For information on the VACUUM command, see VACUUM.

SYS_VACUUM_HISTORY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
user_id	integer	The ID of the user who initiated the query.
transaction_id	long	The transaction ID for the VACUUM statement.
query_id	long	The query identifier for the VACUUM statement. You can join this table to the SYS_QUERY_DETAIL view to see the individual SQL statements that are run for a given VACUUM transaction. If you vacuum the whole database, each table is vacuumed in a separate transaction. For automated VACUUM operations, this value is null.
database_name	text	The name of the database.
schema_name	text	The name of the schema.
table_name	text	The name of the table.
table_id	integer	The ID of the table.

Column name	Data type	Description
vacuum_type	character	The type of the VACUUM operation. Possible values are as follows: • **`Delete`** • **`Sort`** • **`Reindex`** • **`Recluster`** • **`Full`** For more information on vacuum types, see VACUUM.
is_automatic	boolean	`true` if the operation is an automatic vacuum. Otherwise , `false`.
status	character	Description of the current activity being done as part of the vacuum operation: • Initialize • Sort • Merge • Delete • Select • Failed • Complete • Skipped • Building INTERLEAVED SORTKEY order

Column name	Data type	Description
start_time	timestamp	The time the vacuum operation started.
end_time	timestamp	The time the vacuum operation ended. If the operation is ongoing, this field is blank.
record_time	timestamp	The time the vacuum operation was recorded in SYS_VACUUM_HISTORY.
duration	integer	The number of microseconds between the start and end of the vacuum operation. If the vacuum operation is ongoing, this field is blank.
rows_before_vacuum	bigint	The actual number of rows in the table plus any deleted rows that are still stored on disk (waiting to be vacuumed) .
size_before_vacuum	integer	The size of the table before the vacuum operation began, in MB.
reclaimable_rows	bigint	The number of rows the vacuum operation estimates it will reclaim before starting.
reclaimed_rows	bigint	The number of rows the vacuum operation reclaimed.
reclaimed_blocks	bigint	The number of blocks the vacuum operation reclaimed.

Column name	Data type	Description
sortedrows_before_vacuum	integer	The number of sorted rows in the table before the vacuum operation started.
sortedrows_after_vacuum	integer	The additional number of sorted rows in the table after the vacuum operation finished. This doesn't include the rows counted in `sortedrows_before_vacuum` .

System view mapping for migrating to SYS monitoring views

When you migrate your Amazon Redshift provisioned cluster to Amazon Redshift Serverless, your monitoring or diagnostic queries might reference system views that are only available on provisioned clusters. You can update your queries to use the SYS monitoring views. This page provides provisioned-only to SYS view mappings for you to reference when updating your queries.

Topics

- SYS_UNLOAD_DETAIL
- SYS_COPY_REPLACEMENTS
- SYS_DATASHARE_USAGE_CONSUMER
- SYS_DATASHARE_USAGE_PRODUCER
- SYS_DATASHARE_CROSS_REGION_USAGE
- SYS_DATASHARE_CHANGE_LOG
- SYS_EXTERNAL_QUERY_DETAIL
- SYS_EXTERNAL_QUERY_ERROR
- SYS_VACUUM_HISTORY
- SYS_ANALYZE_HISTORY
- SYS_ANALYZE_COMPRESSION_HISTORY
- SYS_MV_REFRESH_HISTORY
- SYS_MV_STATE
- SYS_PROCEDURE_CALL
- SYS_PROCEDURE_MESSAGES
- SYS_UDF_LOG
- SYS_USERLOG
- SYS_SCHEMA_QUOTA_VIOLATIONS
- SYS_SPATIAL_SIMPLIFY

SYS_QUERY_HISTORY

Some or all of the columns in the following tables are also defined in SYS_QUERY_HISTORY.

- STL_DDLTEXT
- STL_ERROR
- STL_QUERY
- STL_UTILITYTEXT
- STL_WLM_QUERY
- STV_INFLIGHT

- STV_RECENTS
- STV_WLM_QUERY_STATE
- SVL_COMPILE
- SVL_MULTI_STATEMENT_VIOLATIONS
- SVL_QLOG
- SVL_QUERY_QUEUE_INFO
- SVL_STATEMENTTEXT
- SVL_TERMINATE

SYS_QUERY_DETAIL

Some or all of the columns in the following tables are also defined in SYS_QUERY_DETAIL.

- STL_AGGR
- STL_ALERT_EVENT_LOG
- STL_BCAST
- STL_DELETE
- STL_DIST
- STL_EXPLAIN
- STL_HASH
- STL_HASHJOIN
- STL_INSERT
- STL_LIMIT
- STL_MERGE
- STL_MERGEJOIN
- STL_NESTLOOP
- STL_PARSE
- STL_PLAN_INFO
- STL_PROJECT
- STL_QUERY_METRICS

- STL_RETURN
- STL_SAVE
- STL_SCAN
- STL_SORT
- STL_STREAM_SEGS
- STL_UNIQUE
- STL_WINDOW
- STV_EXEC_STATE
- STV_QUERY_METRICS
- SVCS_QUERY_SUMMARY
- SVL_QUERY_METRICS
- SVL_QUERY_METRICS_SUMMARY
- SVL_QUERY_REPORT
- SVL_QUERY_SUMMARY
- SVV_QUERY_STATE

SYS_RESTORE_LOG

Some or all of the columns in the following table are also defined in SYS_RESTORE_LOG.

- SVL_RESTORE_ALTER_TABLE_PROGRESS

SYS_RESTORE_STATE

Some or all of the columns in the following table are also defined in SYS_RESTORE_STATE.

- STV_XRESTORE_ALTER_QUEUE_STATE

SYS_TRANSACTION_HISTORY

Some or all of the columns in the following tables are also defined in SYS_TRANSACTION_HISTORY.

- STL_COMMIT_STATS
- STL_TR_CONFLICT
- STL_UNDONE

SYS_QUERY_TEXT

Some or all of the columns in the following table are also defined in SYS_QUERY_TEXT.

- STL_QUERYTEXT

SYS_CONNECTION_LOG

Some or all of the columns in the following table are also defined in SYS_CONNECTION_LOG.

- STL_CONNECTION_LOG

SYS_SESSION_HISTORY

Some or all of the columns in the following tables are also defined in SYS_SESSION_HISTORY.

- STL_SESSIONS
- STL_RESTARTED_SESSIONS
- STV_SESSIONS

SYS_LOAD_DETAIL

Some or all of the columns in the following table are also defined in SYS_LOAD_DETAIL.

- STL_LOAD_COMMITS

SYS_LOAD_HISTORY

Some or all of the columns in the following table are also defined in SYS_LOAD_HISTORY.

- STL_LOAD_COMMITS

SYS_LOAD_ERROR_DETAIL

Some or all of the columns in the following tables are also defined in SYS_LOAD_ERROR_DETAIL.

- STL_LOADERROR_DETAIL
- STL_LOAD_ERRORS

SYS_UNLOAD_HISTORY

Some or all of the columns in the following table are also defined in SYS_UNLOAD_HISTORY.

- STL_UNLOAD_LOG

SYS_UNLOAD_DETAIL

Some or all of the columns in the following table are also defined in SYS_UNLOAD_DETAIL.

- STL_UNLOAD_LOG

SYS_COPY_REPLACEMENTS

Some or all of the columns in the following table are also defined in SYS_COPY_REPLACEMENTS.

- STL_REPLACEMENTS

SYS_DATASHARE_USAGE_CONSUMER

Some or all of the columns in the following table are also defined in SYS_DATASHARE_USAGE_CONSUMER.

- SVL_DATASHARE_USAGE_CONSUMER

SYS_DATASHARE_USAGE_PRODUCER

Some or all of the columns in the following table are also defined in SYS_DATASHARE_USAGE_PRODUCER.

- SVL_DATASHARE_USAGE_PRODUCER

SYS_DATASHARE_CROSS_REGION_USAGE

Some or all of the columns in the following table are also defined in SYS_DATASHARE_CROSS_REGION_USAGE.

- SVL_DATASHARE_CROSS_REGION_USAGE

SYS_DATASHARE_CHANGE_LOG

Some or all of the columns in the following table are also defined in SYS_DATASHARE_CHANGE_LOG.

- SVL_DATASHARE_CHANGE_LOG

SYS_EXTERNAL_QUERY_DETAIL

Some or all of the columns in the following tables are also defined in SYS_EXTERNAL_QUERY_DETAIL.

- SVL_FEDERATED_QUERY
- SVL_S3LIST
- SVL_S3QUERY
- SVL_S3QUERY_SUMMARY

SYS_EXTERNAL_QUERY_ERROR

Some or all of the columns in the following tables are also defined in SYS_EXTERNAL_QUERY_ERROR.

- SVL_SPECTRUM_SCAN_ERROR

SYS_VACUUM_HISTORY

Some or all of the columns in the following tables are also defined in SYS_VACUUM_HISTORY.

- STL_VACUUM
- SVL_VACUUM_PERCENTAGE
- SVV_VACUUM_PROGRESS
- SVV_VACUUM_SUMMARY

SYS_ANALYZE_HISTORY

Some or all of the columns in the following tables are also defined in SYS_ANALYZE_HISTORY.

- STL_ANALYZE

SYS_ANALYZE_COMPRESSION_HISTORY

Some or all of the columns in the following tables are also defined in SYS_ANALYZE_COMPRESSION_HISTORY.

- STL_ANALYZE_COMPRESSION

SYS_MV_REFRESH_HISTORY

Some or all of the columns in the following tables are also defined in SYS_MV_REFRESH_HISTORY.

- SVL_MV_REFRESH_STATUS

SYS_MV_STATE

Some or all of the columns in the following tables are also defined in SYS_MV_STATE.

- STL_MV_STATE

SYS_PROCEDURE_CALL

Some or all of the columns in the following tables are also defined in SYS_PROCEDURE_CALL.

- SVL_STORED_PROC_CALL

SYS_PROCEDURE_MESSAGES

Some or all of the columns in the following tables are also defined in SYS_PROCEDURE_MESSAGES.

- SVL_STORED_PROC_MESSAGES

SYS_UDF_LOG

Some or all of the columns in the following tables are also defined in SYS_UDF_LOG.

- SVL_UDF_LOG

SYS_USERLOG

Some or all of the columns in the following tables are also defined in SYS_USERLOG.

- STL_USERLOG

SYS_SCHEMA_QUOTA_VIOLATIONS

Some or all of the columns in the following tables are also defined in SYS_SCHEMA_QUOTA_VIOLATIONS.

- STL_SCHEMA_QUOTA_VIOLATIONS

SYS_SPATIAL_SIMPLIFY

Some or all of the columns in the following tables are also defined in SYS_SPATIAL_SIMPLIFY.

- SVL_SPATIAL_SIMPLIFY

System monitoring (provisioned only)

The following system tables and views can be queried on provisioned clusters. STL and STV tables and views contain a subset of data found in several of the system tables. These provide quicker and easier access to commonly queried data found in those tables.

SVCS views provide details about queries on both the main and concurrency scaling clusters. SVL views provide information only for queries run on the main cluster, with the exception of SVL_STATEMENTTEXT. SVL_STATEMENTTEXT can contain information for queries run on concurrency scaling clusters as well as the main cluster.

Topics

STL views for logging

STL system views are generated from Amazon Redshift log files to provide a history of the system.

These files reside on every node in the data warehouse cluster. The STL views take the information from the logs and format them into usable views for system administrators.

Log retention – STL system views retain seven days of log history. Log retention is guaranteed for all cluster sizes and node types, and it isn't affected by changes in cluster workload. Log retention also isn't affected by cluster status, such as when the cluster is paused. You have less than seven days of log history only in the case where the cluster is new. You don't need to take any action to retain logs, but you have to periodically copy log data to other tables or unload it to Amazon S3 to keep log data that's more than 7 days old.

Topics

- STL_SCHEMA_QUOTA_VIOLATIONS
- STL_SESSIONS
- STL_SORT
- STL_SSHCLIENT_ERROR
- STL_STREAM_SEGS
- STL_TR_CONFLICT
- STL_UNDONE
- STL_UNIQUE
- STL_UNLOAD_LOG
- STL_USAGE_CONTROL
- STL_USERLOG
- STL_UTILITYTEXT
- STL_VACUUM
- STL_WINDOW
- STL_WLM_ERROR
- STL_WLM_RULE_ACTION
- STL_WLM_QUERY

STL_AGGR

Analyzes aggregate execution steps for queries. These steps occur during execution of aggregate functions and GROUP BY clauses.

STL_AGGR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_AGGR only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
slots	integer	Number of hash buckets.
occupied	integer	Number of slots that contain records.
maxlength	integer	Size of the largest slot.

Column name	Data type	Description
tbl	integer	Table ID.
is_diskbased	character(1)	If true (t), the query was run as a disk-based operation. If false (f), the query was run in memory.
workmem	bigint	Number of bytes of working memory assigned to the step.
type	character(6)	The type of step. Valid values are: • HASHED. Indicates that the step used grouped, unsorted aggregation. • PLAIN. Indicates that the step used ungrouped, scalar aggregation. • SORTED. Indicates that the step used grouped, sorted aggregation.
resizes	integer	This information is for internal use only.
flushable	integer	This information is for internal use only.

Sample queries

Returns information about aggregate execution steps for SLICE 1 and TBL 239.

```
select query, segment, bytes, slots, occupied, maxlength, is_diskbased, workmem, type
from stl_aggr where slice=1 and tbl=239
order by rows
limit 10;
```

```
 query | segment | bytes |  slots   | occupied | maxlength | is_diskbased |  workmem  |
 type
-------+---------+-------+---------+----------+-----------+--------------+-----------
+--------
   562 |       1 |     0 | 4194304 |        0 |         0 | f            | 383385600 |
 HASHED
```

```
  616 |        1 |      0 | 4194304 |          0 |            0 | f              | 383385600 |
 HASHED
  546 |        1 |      0 | 4194304 |          0 |            0 | f              | 383385600 |
 HASHED
  547 |        0 |      8 |       0 |          0 |            0 | f              |         0 |
 PLAIN
  685 |        1 |     32 | 4194304 |          1 |            0 | f              | 383385600 |
 HASHED
  652 |        0 |      8 |       0 |          0 |            0 | f              |         0 |
 PLAIN
  680 |        0 |      8 |       0 |          0 |            0 | f              |         0 |
 PLAIN
  658 |        0 |      8 |       0 |          0 |            0 | f              |         0 |
 PLAIN
  686 |        0 |      8 |       0 |          0 |            0 | f              |         0 |
 PLAIN
  695 |        1 |     32 | 4194304 |          1 |            0 | f              | 383385600 |
 HASHED
(10 rows)
```

STL_ALERT_EVENT_LOG

Records an alert when the query optimizer identifies conditions that might indicate performance issues. Use the STL_ALERT_EVENT_LOG view to identify opportunities to improve query performance.

A query consists of multiple segments, and each segment consists of one or more steps. For more information, see Query processing.

STL_ALERT_EVENT_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_ALERT_EVENT_LOG only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
pid	integer	Process ID associated with the statement and slice. The same query might have multiple PIDs if it runs on multiple slices.
xid	bigint	Transaction ID associated with the statement.
event	character (1024)	Description of the alert event.
solution	character (1024)	Recommended solution.
event_time	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .

Usage notes

You can use the STL_ALERT_EVENT_LOG to identify potential issues in your queries, then follow the practices in [Query performance tuning](#) to optimize your database design and rewrite your queries. STL_ALERT_EVENT_LOG records the following alerts:

- **Missing statistics**

Statistics are missing. Run ANALYZE following data loads or significant updates and use STATUPDATE with COPY operations. For more information, see Amazon Redshift best practices for designing queries.

- **Nested loop**

  A nested loop is usually a Cartesian product. Evaluate your query to ensure that all participating tables are joined efficiently.

- **Very selective filter**

  The ratio of rows returned to rows scanned is less than 0.05. Rows scanned is the value of `rows_pre_user_filter` and rows returned is the value of rows in the STL_SCAN system view. Indicates that the query is scanning an unusually large number of rows to determine the result set. This can be caused by missing or incorrect sort keys. For more information, see Sort keys.

- **Excessive ghost rows**

  A scan skipped a relatively large number of rows that are marked as deleted but not vacuumed, or rows that have been inserted but not committed. For more information, see Vacuuming tables.

- **Large distribution**

  More than 1,000,000 rows were redistributed for hash join or aggregation. For more information, see Data distribution for query optimization.

- **Large broadcast**

  More than 1,000,000 rows were broadcast for hash join. For more information, see Data distribution for query optimization.

- **Serial execution**

  A DS_DIST_ALL_INNER redistribution style was indicated in the query plan, which forces serial execution because the entire inner table was redistributed to a single node. For more information, see Data distribution for query optimization.

Sample queries

The following query shows alert events for four queries.

```
SELECT query, substring(event,0,25) as event,
```

```
substring(solution,0,25) as solution,
trim(event_time) as event_time from stl_alert_event_log order by query;

 query |             event             |          solution            |     event_time

-------+-------------------------------+------------------------------
+---------------------
  6567 | Missing query planner statist | Run the ANALYZE command      | 2014-01-03
 18:20:58
  7450 | Scanned a large number of del | Run the VACUUM command to rec| 2014-01-03
 21:19:31
  8406 | Nested Loop Join in the query | Review the join predicates to| 2014-01-04
 00:34:22
 29512 | Very selective query filter:r | Review the choice of sort key| 2014-01-06
 22:00:00

(4 rows)
```

STL_ANALYZE

Records details for ANALYZE operations.

STL_ANALYZE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_ANALYZE_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who generated the entry.
xid	long	The transaction ID.
database	char(30)	The database name.
table_id	integer	The table ID.

Column name	Data type	Description
status	char(15)	The result of the analyze command. Possible values are `Full`, `Skipped`, and `PredicateColumn` .
rows	double	The total number of rows in the table.
modified_rows	double	The total number of rows that were modified since the last ANALYZE operation.
threshold_percent	integer	The value of the `analyze_threshold_percent` parameter.
is_auto	char(1)	The value is true (`t`) if the operation included an Amazon Redshift analyze operation by default. The value is false (`f`) if the ANALYZE command was run explicitly.
starttime	timestamp	The time in UTC that the analyze operation started running.
endtime	timestamp	The time in UTC that the analyze operation finished running.
prevtime	timestamp	The time in UTC that the table was previously analyzed.
num_predicate_cols	integer	The current number of predicate columns in the table.
num_new_predicate_cols	integer	The number of new predicate columns in the table since the previous analyze operation.
is_background	character(1)	The value is true (`t`) if the analysis was run by an automatic analyze operation. Otherwise, the value is false (`f`).
auto_analyze_phase	character(100)	Reserved for internal use.
schema_name	char(128)	The schema name for the table.

Column name	Data type	Description
table_name	char(136)	The name of the table.

Sample queries

The following example joins STV_TBL_PERM to show the table name and execution details.

```
select distinct a.xid, trim(t.name) as name, a.status, a.rows, a.modified_rows,
 a.starttime, a.endtime
from stl_analyze a
join stv_tbl_perm t  on t.id=a.table_id
where name = 'users'
order by starttime;

xid    | name  | status           | rows  | modified_rows | starttime           |
 endtime
-------+-------+-----------------+-------+---------------+---------------------
+--------------------
  1582 | users | Full            | 49990 |         49990 | 2016-09-22 22:02:23 |
 2016-09-22 22:02:28
244287 | users | Full            | 24992 |         74988 | 2016-10-04 22:50:58 |
 2016-10-04 22:51:01
244712 | users | Full            | 49984 |         24992 | 2016-10-04 22:56:07 |
 2016-10-04 22:56:07
245071 | users | Skipped         | 49984 |             0 | 2016-10-04 22:58:17 |
 2016-10-04 22:58:17
245439 | users | Skipped         | 49984 |          1982 | 2016-10-04 23:00:13 |
 2016-10-04 23:00:13
(5 rows)
```

STL_ANALYZE_COMPRESSION

Records details for compression analysis operations during COPY or ANALYZE COMPRESSION commands.

STL_ANALYZE_COMPRESSION is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_ANALYZE_COMPRESSION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who generated the entry.
start_time	timestamp	The time when the compression analysis operation started.
xid	bigint	The transaction ID of the compression analysis operation.
tbl	integer	The table ID of the table that was analyzed.
tablename	character(128)	The name of the table that was analyzed.
col	integer	The index of the column in the table that was analyzed to determine the compression encoding.
old_encoding	character(15)	The encoding type before compression analysis.
new_encoding	character(15)	The encoding type after compression analysis.
mode	character(14)	The possible values are: **PRESET** Specifies that the `new_encoding` is determined by the Amazon Redshift COPY command based on the column data type. No data is sampled.

Column name	Data type	Description
		ON Specifies that the `new_encoding` is determined by the Amazon Redshift COPY command based on an analysis of sample data. **ANALYZE ONLY** Specifies that the `new_encoding` is determined by the Amazon Redshift ANALYZE COMPRESSION command based on an analysis of sample data. However, the encoding type of the analyzed column is not changed.
best_compression_encoding	character(15)	The encoding type that gives the best compression ratio.
recommended_bytes	character(15)	The bytes used by adopting the new encoding.
best_compression_bytes	character(15)	The bytes used by adopting the best compression encoding.
ndv	bigint	The number of distinct values in the sampled rows.

Sample queries

The following example inspects the details of compression analysis on the `lineitem` table by the last COPY command run in the same session.

```
select xid, tbl, btrim(tablename) as tablename, col, old_encoding, new_encoding,
 best_compression_encoding, mode
from stl_analyze_compression
where xid = (select xid from stl_query where query = pg_last_copy_id()) order by col;
```

```
 xid  |  tbl   | tablename | col |  old_encoding   |  new_encoding   |
 best_compression_encoding |      mode
------+--------+-----------+-----+-----------------+-----------------
+---------------------------+----------------
 5308 | 158961 | $lineitem |   0 | mostly32        | az64            | delta
          | ON
 5308 | 158961 | $lineitem |   1 | mostly32        | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   2 | lzo             | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   3 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   4 | bytedict        | az64            | bytedict
          | ON
 5308 | 158961 | $lineitem |   5 | mostly32        | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   6 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   7 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |   8 | lzo             | lzo             | lzo
          | ON
 5308 | 158961 | $lineitem |   9 | runlength       | runlength       | runlength
          | ON
 5308 | 158961 | $lineitem |  10 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |  11 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |  12 | delta           | az64            | az64
          | ON
 5308 | 158961 | $lineitem |  13 | bytedict        | bytedict        | bytedict
          | ON
 5308 | 158961 | $lineitem |  14 | bytedict        | bytedict        | bytedict
          | ON
 5308 | 158961 | $lineitem |  15 | text255         | text255         | text255
          | ON
(16 rows)
```

STL_BCAST

Logs information about network activity during execution of query steps that broadcast data. Network traffic is captured by numbers of rows, bytes, and packets that are sent over the network during a given step on a given slice. The duration of the step is the difference between the logged start and end times.

To identify broadcast steps in a query, look for bcast labels in the SVL_QUERY_SUMMARY view or run the EXPLAIN command and then look for step attributes that include bcast.

STL_BCAST is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_BCAST only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .

Column name	Data type	Description
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
packets	integer	Total number of packets sent over the network.

Sample queries

The following example returns broadcast information for the queries where there are one or more packets, and the difference between the start and end of the query was one second or more.

```
select query, slice, step, rows, bytes, packets, datediff(seconds, starttime, endtime)
from stl_bcast
where packets>0 and datediff(seconds, starttime, endtime)>0;
```

```
 query | slice | step | rows | bytes | packets | date_diff
-------+-------+------+------+-------+---------+-----------
   453 |     2 |    5 |    1 |   264 |       1 |         1
   798 |     2 |    5 |    1 |   264 |       1 |         1
  1408 |     2 |    5 |    1 |   264 |       1 |         1
  2993 |     0 |    5 |    1 |   264 |       1 |         1
  5045 |     3 |    5 |    1 |   264 |       1 |         1
  8073 |     3 |    5 |    1 |   264 |       1 |         1
  8163 |     3 |    5 |    1 |   264 |       1 |         1
  9212 |     1 |    5 |    1 |   264 |       1 |         1
  9873 |     1 |    5 |    1 |   264 |       1 |         1
(9 rows)
```

STL_COMMIT_STATS

Provides metrics related to commit performance, including the timing of the various stages of commit and the number of blocks committed. Query STL_COMMIT_STATS to determine what portion of a transaction was spent on commit and how much queuing is occurring.

STL_COMMIT_STATS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_TRANSACTION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
xid	bigint	Transaction id being committed.
node	integer	Node number. -1 is the leader node.
startqueue	timestamp	Start of queueing for commit.
startwork	timestamp	Start of commit.
endflush	timestamp	End of dirty block flush phase.
endstage	timestamp	End of metadata staging phase.
endlocal	timestamp	End of local commit phase.
startglobal	timestamp	Start of global phase.
endtime	timestamp	End of the commit.
queuelen	bigint	Number of transactions that were ahead of this transaction in the commit queue.
permblocks	bigint	Number of existing permanent blocks at the time of this commit.

Column name	Data type	Description
newblocks	bigint	Number of new permanent blocks at the time of this commit.
dirtyblocks	bigint	Number of blocks that had to be written as part of this commit.
headers	bigint	Number of block headers that had to be written as part of this commit.
numxids	integer	The number of active DML transactions.
oldestxid	bigint	The XID of the oldest active DML transaction.
extwritel atency	bigint	This information is for internal use only.
metadataw ritten	int	This information is for internal use only.
tombstone dblocks	*bigint*	This information is for internal use only.
tossedblo cks	bigint	This information is for internal use only.
batched_by	bigint	This information is for internal use only.

Sample query

```
select node, datediff(ms,startqueue,startwork) as queue_time,
datediff(ms, startwork, endtime) as commit_time, queuelen
from stl_commit_stats
where xid = 2574
order by node;

node | queue_time   | commit_time | queuelen
-----+--------------+-------------+---------
```

```
  -1 |            0 |          617 |         0
   0 | 444950725641 |          616 |         0
   1 | 444950725636 |          616 |         0
```

STL_CONNECTION_LOG

Logs authentication attempts and connections and disconnections.

STL_CONNECTION_LOG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_CONNECTION_LOG. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
event	character(50)	Connection or authentication event.
recordtime	timestamp	Time the event occurred.
remotehost	character(45)	Name or IP address of remote host.
remoteport	character(32)	Port number for remote host.
pid	integer	Process ID associated with the statement.
dbname	character(50)	Database name.
username	character(50)	User name.
authmethod	character(32)	Authentication method.
duration	integer	Duration of connection in microseconds.
sslversion	character(50)	Secure Sockets Layer (SSL) version. This column is empty when SSL is disabled.

Column name	Data type	Description
sslcipher	character(128)	SSL cipher.
mtu	integer	Maximum transmission unit (MTU).
sslcompression	character(64)	SSL compression type.
sslexpansion	character(64)	SSL expansion type.
iamauthguid	character(36)	The IAM authentication ID for the CloudTrail request.
application_name	character(250)	The initial or updated name of the application for a session.
os_version	character(64)	The version of the operating system that is on the client machine that connects to your Amazon Redshift cluster.
driver_version	character(64)	The version of ODBC or JDBC driver that connects to your Amazon Redshift cluster from your third-party SQL client tools.
plugin_name	character(32)	The name of the plugin used to connect to your Amazon Redshift cluster.

Column name	Data type	Description
protocol_version	integer	The internal protocol version that the Amazon Redshift driver uses when establishing its connection with the server. The protocol versions is negotiated between the driver and server. The version describes the features available. Valid values include: • 0 (BASE_SERVER_PROTOCOL_VERSION) • 1 (EXTENDED_RESULT_METADATA_SERVER_PROTOCOL_VERSION) – To save a round trip per query, the server sends extra result set metadata information. • 2 (BINARY_PROTOCOL_VERSION) – Depending on the data type of the result set, the server sends data in binary format. • 3 (EXTENDED2_RESULT_METADATA_SERVER_PROTOCOL_VERSION) – The server sends case sensitivity (collation) information of a column.
sessionid	character(36)	The globally unique identifier for the current session. The session ID persists through node failure restarts.
compression	character(16)	The compression algorithm in use for the connection.

Sample queries

To view the details for open connections, run the following query.

```
select recordtime, username, dbname, remotehost, remoteport
from stl_connection_log
where event = 'initiating session'
and pid not in
(select pid from stl_connection_log
where event = 'disconnecting session')
order by 1 desc;
```

```
recordtime          | username    | dbname     | remotehost    | remoteport

--------------------+-------------+------------+---------------+------------
2014-11-06 20:30:06 | rdsdb       | dev        | [local]       |

2014-11-06 20:29:37 | test001     | test       | 10.49.42.138  | 11111

2014-11-05 20:30:29 | rdsdb       | dev        | 10.49.42.138  | 33333

2014-11-05 20:28:35 | rdsdb       | dev        | [local]       |
(4 rows)
```

The following example reflects a failed authentication attempt and a successful connection and disconnection.

```
select event, recordtime, remotehost, username
from stl_connection_log order by recordtime;

            event      |         recordtime        |  remotehost  | username

-----------------------+---------------------------+--------------+---------
authentication failure | 2012-10-25 14:41:56.96391 | 10.49.42.138 | john

authenticated          | 2012-10-25 14:42:10.87613 | 10.49.42.138 | john

initiating session     | 2012-10-25 14:42:10.87638 | 10.49.42.138 | john

disconnecting session  | 2012-10-25 14:42:19.95992 | 10.49.42.138 | john

(4 rows)
```

The following example shows the version of the ODBC driver, the operating system on the client machine, and the plugin used to connect to the Amazon Redshift cluster. In this example, the plugin used is for standard ODBC driver authentication using a login name and password.

```
select driver_version, os_version, plugin_name from stl_connection_log;

driver_version                          |  os_version                       |
 plugin_name
----------------------------------------+----------------------------------
+--------------------
Amazon Redshift ODBC Driver 1.4.15.0001 | Darwin 18.7.0 x86_64              | none
```

```
Amazon Redshift ODBC Driver 1.4.15.0001 | Linux 4.15.0-101-generic x86_64   | none
```

The following example shows the version of the operating system on the client machine, the driver version, and the protocol version.

```
select os_version, driver_version, protocol_version from stl_connection_log;

os_version                           |  driver_version              | protocol_version
--------------------------------+----------------------------+--------------------
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
Linux 4.15.0-101-generic x86_64 | Redshift JDBC Driver 2.0.0.0 | 2
```

STL_DDLTEXT

Captures the following DDL statements that were run on the system.

These DDL statements include the following queries and objects:

- CREATE SCHEMA, TABLE, VIEW
- DROP SCHEMA, TABLE, VIEW
- ALTER SCHEMA, TABLE

See also STL_QUERYTEXT, STL_UTILITYTEXT, and SVL_STATEMENTTEXT. These views provide a timeline of the SQL commands that are run on the system; this history is useful for troubleshooting and for creating an audit trail of all system activities.

Use the STARTTIME and ENDTIME columns to find out which statements were logged during a given time period. Long blocks of SQL text are broken into lines 200 characters long; the SEQUENCE column identifies fragments of text that belong to a single statement.

STL_DDLTEXT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
xid	bigint	Transaction ID associated with the statement.
pid	integer	Process ID associated with the statement.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field is blank.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
sequence	integer	When a single statement contains more than 200 characters, additional rows are logged for that statement. Sequence 0 is the first row, 1 is the second, and so on.
text	character(200)	SQL text, in 200-character increments. This field might contain special characters such as backslash (\\) and newline (\n).

Sample queries

The following query returns records that include previously run DDL statements.

```
select xid, starttime, sequence, substring(text,1,40) as text
```

```
from stl_ddltext order by xid desc, sequence;
```

The following is sample output that shows four CREATE TABLE statements. The DDL statements appear in the `text` column, which is truncated for readability.

```
 xid  |         starttime          | sequence |                 text
------+----------------------------+----------
+-------------------------------------------
 1806 | 2013-10-23 00:11:14.709851 |        0 | CREATE TABLE supplier ( s_suppkey int4
 N
 1806 | 2013-10-23 00:11:14.709851 |        1 |  s_comment varchar(101) NOT NULL )
 1805 | 2013-10-23 00:11:14.496153 |        0 | CREATE TABLE region ( r_regionkey int4
 N
 1804 | 2013-10-23 00:11:14.285986 |        0 | CREATE TABLE partsupp ( ps_partkey int8
 1803 | 2013-10-23 00:11:14.056901 |        0 | CREATE TABLE part ( p_partkey int8 NOT
 N
 1803 | 2013-10-23 00:11:14.056901 |        1 | ner char(10) NOT NULL , p_retailprice
 nu
(6 rows)
```

Reconstructing Stored SQL

The following SQL lists rows stored in the `text` column of STL_DDLTEXT. The rows are ordered by `xid` and `sequence`. If the original SQL was longer than 200 characters multiple rows, STL_DDLTEXT can contain multiple rows by `sequence`.

```
SELECT xid, sequence, LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text)
 END, '') WITHIN GROUP (ORDER BY sequence) as query_statement
FROM stl_ddltext GROUP BY xid, sequence ORDER BY xid, sequence;
```

```


xid     |  sequence | query_statement
--------+-----------+-----------------
7886671    0           create external schema schema_spectrum_uddh\nfrom data catalog
\ndatabase 'spectrum_db_uddh'\niam_role ''\ncreate external database if not exists;
7886752    0           CREATE EXTERNAL TABLE schema_spectrum_uddh.soccer_league\n(\n
  league_rank smallint,\n  prev_rank   smallint,\n  club_name   varchar(15),\n
 league_name varchar(20),\n  league_off  decimal(6,2),\n  le
7886752    1           ague_def  decimal(6,2),\n  league_spi  decimal(6,2),\n
 league_nspi smallint\n)\nROW FORMAT DELIMITED \n    FIELDS TERMINATED BY ',' \n
 LINES TERMINATED BY '\\n\\l'\nstored as textfile\nLOCATION 's
```

```
7886752    2          3://mybucket-spectrum-uddh/'\ntable properties
 ('skip.header.line.count'='1');
...
```

To reconstruct the SQL stored in the `text` column of STL_DDLTEXT, run the following SQL statement. It puts together DDL statements from one or more segments in the `text` column. Before running the reconstructed SQL, replace any (\n) special characters with a new line in your SQL client. The results of the following SELECT statement puts together three rows in sequence order to reconstruct the SQL, in the `query_statement` field.

```
SELECT LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END) WITHIN
 GROUP (ORDER BY sequence) as query_statement
FROM stl_ddltext GROUP BY xid, endtime order by xid, endtime;
```

```

query_statement
--------------
create external schema schema_spectrum_uddh\nfrom data catalog\ndatabase
 'spectrum_db_uddh'\niam_role ''\ncreate external database if not exists;
CREATE EXTERNAL TABLE schema_spectrum_uddh.soccer_league\n(\n  league_rank smallint,
\n  prev_rank   smallint,\n  club_name   varchar(15),\n  league_name varchar(20),\n
 league_off  decimal(6,2),\n  league_def  decimal(6,2),\n  league_spi  decimal(6,2),
\n  league_nspi smallint\n)\nROW FORMAT DELIMITED \n    FIELDS TERMINATED BY ',' \n
  LINES TERMINATED BY '\\n\\l'\nstored as textfile\nLOCATION 's3://mybucket-spectrum-
uddh/'\ntable properties ('skip.header.line.count'='1');
```

STL_DELETE

Analyzes delete execution steps for queries.

STL_DELETE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_DELETE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
tbl	integer	Table ID.

Sample queries

In order to create a row in STL_DELETE, the following example inserts a row into the EVENT table and then deletes it.

First, insert a row into the EVENT table and verify that it was inserted.

```
insert into event(eventid,venueid,catid,dateid,eventname)
values ((select max(eventid)+1 from event),95,9,1857,'Lollapalooza');
```

```
select * from event
where eventname='Lollapalooza'
order by eventid;
```

```
 eventid | venueid | catid | dateid |  eventname   |      starttime
---------+---------+-------+--------+--------------+---------------------
    4274 |     102 |     9 |   1965 | Lollapalooza | 2008-05-01 19:00:00
    4684 |     114 |     9 |   2105 | Lollapalooza | 2008-10-06 14:00:00
    5673 |     128 |     9 |   1973 | Lollapalooza | 2008-05-01 15:00:00
    5740 |      51 |     9 |   1933 | Lollapalooza | 2008-04-17 15:00:00
    5856 |     119 |     9 |   1831 | Lollapalooza | 2008-01-05 14:00:00
    6040 |     126 |     9 |   2145 | Lollapalooza | 2008-11-15 15:00:00
    7972 |      92 |     9 |   2026 | Lollapalooza | 2008-07-19 19:30:00
    8046 |      65 |     9 |   1840 | Lollapalooza | 2008-01-14 15:00:00
    8518 |      48 |     9 |   1904 | Lollapalooza | 2008-03-19 15:00:00
    8799 |      95 |     9 |   1857 | Lollapalooza |
(10 rows)
```

Now, delete the row that you added to the EVENT table and verify that it was deleted.

```
delete from event
where eventname='Lollapalooza' and eventid=(select max(eventid) from event);
```

```
select * from event
where eventname='Lollapalooza'
order by eventid;
```

```
 eventid | venueid | catid | dateid |  eventname   |      starttime
---------+---------+-------+--------+--------------+---------------------
    4274 |     102 |     9 |   1965 | Lollapalooza | 2008-05-01 19:00:00
    4684 |     114 |     9 |   2105 | Lollapalooza | 2008-10-06 14:00:00
    5673 |     128 |     9 |   1973 | Lollapalooza | 2008-05-01 15:00:00
    5740 |      51 |     9 |   1933 | Lollapalooza | 2008-04-17 15:00:00
    5856 |     119 |     9 |   1831 | Lollapalooza | 2008-01-05 14:00:00
    6040 |     126 |     9 |   2145 | Lollapalooza | 2008-11-15 15:00:00
```

```
    7972 |      92 |      9 |    2026 | Lollapalooza | 2008-07-19 19:30:00
    8046 |      65 |      9 |    1840 | Lollapalooza | 2008-01-14 15:00:00
    8518 |      48 |      9 |    1904 | Lollapalooza | 2008-03-19 15:00:00
(9 rows)
```

Then query stl_delete to see the execution steps for the deletion. In this example, the query returned over 300 rows, so the output below is shortened for display purposes.

```
select query, slice, segment, step, tasknum, rows, tbl from stl_delete order by query;
```

```
 query | slice | segment | step | tasknum | rows |  tbl
-------+-------+---------+------+---------+------+--------
     7 |     0 |       0 |    1 |       0 |    0 | 100000
     7 |     1 |       0 |    1 |       0 |    0 | 100000
     8 |     0 |       0 |    1 |       2 |    0 | 100001
     8 |     1 |       0 |    1 |       2 |    0 | 100001
     9 |     0 |       0 |    1 |       4 |    0 | 100002
     9 |     1 |       0 |    1 |       4 |    0 | 100002
    10 |     0 |       0 |    1 |       6 |    0 | 100003
    10 |     1 |       0 |    1 |       6 |    0 | 100003
    11 |     0 |       0 |    1 |       8 |    0 | 100253
    11 |     1 |       0 |    1 |       8 |    0 | 100253
    12 |     0 |       0 |    1 |       0 |    0 | 100255
    12 |     1 |       0 |    1 |       0 |    0 | 100255
    13 |     0 |       0 |    1 |       2 |    0 | 100257
    13 |     1 |       0 |    1 |       2 |    0 | 100257
    14 |     0 |       0 |    1 |       4 |    0 | 100259
    14 |     1 |       0 |    1 |       4 |    0 | 100259
    ...
```

STL_DISK_FULL_DIAG

Logs information about errors recorded when the disk is full.

STL_DISK_FULL_DIAG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description		
currenttime	bigint	The day and time the error was generated in microseconds since January 1, 2000.		
node_nur	bigint	The identifier for the node.		
query_id	bigint	The identifier for the query that caused the error.		
temp_blocks	bigint	The number of temporary blocks created by the query.		

Sample queries

The following example returns details about the data stored when there is a disk-full error.

```
select * from stl_disk_full_diag
```

The following example converts the `currenttime` to a timestamp.

```
select '2000-01-01'::timestamp + (currenttime/1000000.0)* interval '1 second' as
 currenttime,node_num,query_id,temp_blocks from pg_catalog.stl_disk_full_diag;
```

```
        currenttime         | node_num | query_id | temp_blocks
----------------------------+----------+----------+-------------
 2019-05-18 19:19:18.609338 |        0 |   569399 |       70982
 2019-05-18 19:37:44.755548 |        0 |   569580 |       70982
 2019-05-20 13:37:20.566916 |        0 |   597424 |       70869
```

STL_DIST

Logs information about network activity during execution of query steps that distribute data. Network traffic is captured by numbers of rows, bytes, and packets that are sent over the network during a given step on a given slice. The duration of the step is the difference between the logged start and end times.

To identify distribution steps in a query, look for dist labels in the QUERY_SUMMARY view or run the EXPLAIN command and then look for step attributes that include dist.

STL_DIST is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_DIST only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.

Column name	Data type	Description
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
packets	integer	Total number of packets sent over the network.

Sample queries

The following example returns distribution information for queries with one or more packets and duration greater than zero.

```
select query, slice, step, rows, bytes, packets,
datediff(seconds, starttime, endtime) as duration
from stl_dist
where packets>0 and datediff(seconds, starttime, endtime)>0
order by query
limit 10;
```

```
 query  | slice | step |  rows  |  bytes  | packets | duration
--------+-------+------+--------+---------+---------+-----------
    567 |     1 |    4 |  49990 | 6249564 |     707 |         1
    630 |     0 |    5 |   8798 |  408404 |      46 |         2
```

```
    645 |     1 |     4 |   8798 |  408404 |       46 |          1
    651 |     1 |     5 | 192497 | 9226320 |     1039 |          6
    669 |     1 |     4 | 192497 | 9226320 |     1039 |          4
    675 |     1 |     5 |   3766 |  194656 |       22 |          1
    696 |     0 |     4 |   3766 |  194656 |       22 |          1
    705 |     0 |     4 |    930 |   44400 |        5 |          1
 111525 |     0 |     3 |     68 |   17408 |        2 |          1
(9 rows)
```

STL_ERROR

Records internal processing errors generated by the Amazon Redshift database engine. STL_ERROR does not record SQL errors or messages. The information in STL_ERROR is useful for troubleshooting certain errors. An AWS support engineer might ask you to provide this information as part of the troubleshooting process.

STL_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For a list of error codes that can be generated while loading data with the Copy command, see Load error reference.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
process	character(12)	Process that threw the exception.
recordtime	timestamp	Time that the error occurred.
pid	integer	Process ID. The STL_QUERY table contains process IDs and unique query IDs for completed queries.

Column name	Data type	Description
errcode	integer	Error code corresponding to the error category.
file	character(90)	Name of the source file where the error occurred.
linenum	integer	Line number in the source file where the error occurred.
context	character(100)	Cause of the error.
error	character(512)	Error message.

Sample queries

The following example retrieves the error information from STL_ERROR.

```
select process, errcode, linenum as line,
trim(error) as err
from stl_error;

   process    | errcode | line |                               err
--------------+---------+------
+------------------------------------------------------------------
 padbmaster   |    8001 |  194 | Path prefix: s3://redshift-downloads/testnulls/
venue.txt*
 padbmaster   |    8001 |  529 | Listing bucket=redshift-downloads prefix=tests/
category-csv-quotes
 padbmaster   |       2 |  190 | database "template0" is not currently accepting
 connections
 padbmaster   |      32 | 1956 | pq_flush: could not send data to client: Broken pipe
(4 rows)
```

STL_EXPLAIN

Displays the EXPLAIN plan for a query that has been submitted for execution.

STL_EXPLAIN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_EXPLAIN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_EXPLAIN . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
nodeid	integer	Plan node identifier, where a node maps to one or more steps in the execution of the query.
parentid	integer	Plan node identifier for a parent node. A parent node has some number of child nodes. For example, a merge join is the parent of the scans on the joined tables.
plannode	character(400)	The node text from the EXPLAIN output. Plan nodes that refer to execution on compute nodes are prefixed with **XN** in the EXPLAIN output.
info	character(400)	Qualifier and filter information for the plan node. For example, join conditions and WHERE clause restrictions are included in this column.

Sample queries

Consider the following EXPLAIN output for an aggregate join query:

```
explain select avg(datediff(day, listtime, saletime)) as avgwait
from sales, listing where sales.listid = listing.listid;
                                  QUERY PLAN

------------------------------------------------------------------------------
 XN Aggregate  (cost=6350.30..6350.31 rows=1 width=16)
  ->  XN Hash Join DS_DIST_NONE  (cost=47.08..6340.89 rows=3766 width=16)
        Hash Cond: ("outer".listid = "inner".listid)
        -> XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497 width=12)
        -> XN Hash  (cost=37.66..37.66 rows=3766 width=12)
              -> XN Seq Scan on sales  (cost=0.00..37.66 rows=3766 width=12)
(6 rows)
```

If you run this query and its query ID is 10, you can use the STL_EXPLAIN table to see the same kind of information that the EXPLAIN command returns:

```
select query,nodeid,parentid,substring(plannode from 1 for 30),
substring(info from 1 for 20) from stl_explain
where query=10 order by 1,2;

query| nodeid |parentid|           substring            |    substring
-----+--------+--------+--------------------------------+-------------------
10   |      1 |      0 |XN Aggregate  (cost=6717.61..6  |
10   |      2 |      1 |  -> XN Merge Join DS_DIST_NO   | Merge Cond:("outer"
10   |      3 |      2 |       -> XN Seq Scan on lis    |
10   |      4 |      2 |       -> XN Seq Scan on sal    |
(4 rows)
```

Consider the following query:

```
select event.eventid, sum(pricepaid)
from event, sales
where event.eventid=sales.eventid
group by event.eventid order by 2 desc;

eventid |   sum
--------+----------
    289 | 51846.00
   7895 | 51049.00
   1602 | 50301.00
    851 | 49956.00
   7315 | 49823.00
```

```
...
```

If this query's ID is 15, the following system view query returns the plan nodes that were completed. In this case, the order of the nodes is reversed to show the actual order of execution:

```
select query,nodeid,parentid,substring(plannode from 1 for 56)
from stl_explain where query=15 order by 1, 2 desc;

query|nodeid|parentid|                          substring
-----+------+--------+--------------------------------------------------------
15   |    8 |      7 |                                -> XN Seq Scan on eve
15   |    7 |      5 |                          -> XN Hash(cost=87.98..87.9
15   |    6 |      5 |                          -> XN Seq Scan on sales(cos
15   |    5 |      4 |                    -> XN Hash Join DS_DIST_OUTER(cos
15   |    4 |      3 |              -> XN HashAggregate(cost=862286577.07..
15   |    3 |      2 |        -> XN Sort(cost=1000862287175.47..10008622871
15   |    2 |      1 |  -> XN Network(cost=1000862287175.47..1000862287197.
15   |    1 |      0 |XN Merge(cost=1000862287175.47..1000862287197.46 rows=87
(8 rows)
```

The following query retrieves the query IDs for any query plans that contain a window function:

```
select query, trim(plannode) from stl_explain
where plannode like '%Window%';

query|                                     btrim
-----+------------------------------------------------------------------------
26   | -> XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)
27   | -> XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)
(2 rows)
```

STL_FILE_SCAN

Returns the files that Amazon Redshift read while loading data by using the COPY command.

Querying this view can help troubleshoot data load errors. STL_FILE_SCAN can be particularly helpful with pinpointing issues in parallel data loads, because parallel data loads typically load many files with a single COPY command.

STL_FILE_SCAN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_FILE_SCAN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_LOAD_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
name	character(90)	Full path and name of the file that was loaded.
lines	bigint	Number of lines read from the file.
bytes	bigint	Number of bytes read from the file.
loadtime	bigint	Amount of time spent loading the file (in microseconds).
curtime	Timestamp	Timestamp representing the time that Amazon Redshift started processing the file.
is_partial	integer	Value that if true (1) indicates the input file is split into ranges during a COPY operation. If this value is false (0), the input file isn't split.

Column name	Data type	Description
start_offset	bigint	Value that, if the input file is split during a COPY operation , indicates the offset value of the split (in bytes). If the file isn't split, this value is 0.

Sample queries

The following query retrieves the names and load times of any files that took over 1,000,000 microseconds for Amazon Redshift to read.

```
select trim(name)as name, loadtime from stl_file_scan
where loadtime > 1000000;
```

This query returns the following example output.

```
           name            | loadtime
---------------------------+----------
 listings_pipe.txt         |  9458354
 allusers_pipe.txt         |  2963761
 allevents_pipe.txt        |  1409135
 tickit/listings_pipe.txt  |  7071087
 tickit/allevents_pipe.txt |  1237364
 tickit/allusers_pipe.txt  |  2535138
 listings_pipe.txt         |  6706370
 allusers_pipe.txt         |  3579461
 allevents_pipe.txt        |  1313195
 tickit/allusers_pipe.txt  |  3236060
 tickit/listings_pipe.txt  |  4980108
(11 rows)
```

STL_HASH

Analyzes hash execution steps for queries.

STL_HASH is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_HASH only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.

Column name	Data type	Description
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
slots	integer	Total number of hash buckets.
occupied	integer	Total number of slots that contain records.
maxlength	integer	Size of the largest slot.
tbl	integer	Table ID.
is_diskbased	character(1)	If true (t), the query was performed as a disk-based operation. If false (f), the query was performed in memory.
workmem	bigint	Total number of bytes of working memory assigned to the step.
num_parts	integer	Total number of partitions that a hash table was divided into during a hash step.
est_rows	bigint	Estimated number of rows to be hashed.
num_blocks_permitted	integer	This information is for internal use only.
resizes	integer	This information is for internal use only.
checksum	bigint	This information is for internal use only.
runtime_filter_size	integer	Size of the runtime filter in bytes.

Column name	Data type	Description
max_runtime_filter_size	integer	Maximum size of the runtime filter in bytes.

Sample queries

The following example returns information about the number of partitions that were used in a hash for query 720, and indicates that none of the steps ran on disk.

```
select slice, rows, bytes, occupied, workmem, num_parts, est_rows,
 num_blocks_permitted, is_diskbased
from stl_hash
where query=720 and segment=5
order by slice;
```

```
 slice | rows | bytes  | occupied | workmem  | num_parts | est_rows |
 num_blocks_permitted | is_diskbased
-------+------+--------+----------+----------+-----------+----------
+----------------------+--------------
     0 |  145 | 585800 |        1 | 88866816 |        16 |        1 |
 52              f
     1 |    0 |      0 |        0 |        0 |        16 |        1 |
 52              f
(2 rows)
```

STL_HASHJOIN

Analyzes hash join execution steps for queries.

STL_HASHJOIN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_HASHJOIN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain

plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
tbl	integer	Table ID.

Column name	Data type	Description
num_parts	integer	Total number of partitions that a hash table was divided into during a hash step.
join_type	integer	The type of join for the step: • 0. The query used an inner join. • 1. The query used a left outer join. • 2. The query used a full outer join. • 3. The query used a right outer join. • 4. The query used a UNION operator. • 5. The query used an IN condition. • 6. This information is for internal use only. • 7. This information is for internal use only. • 8. This information is for internal use only. • 9. This information is for internal use only. • 10. This information is for internal use only. • 11. This information is for internal use only. • 12. This information is for internal use only.
hash_looped	character(1)	This information is for internal use only.
switched_parts	character(1)	Indicates whether the build (or outer) and probe (or inner) sides have switched.
used_prefetching	character(1)	This information is for internal use only.
hash_segment	integer	The segment of the corresponding hash step.
hash_step	integer	The step number of the corresponding hash step.

Column name	Data type	Description
checksum	bigint	This information is for internal use only.
distribution	integer	This information is for internal use only.

Sample queries

The following example returns the number of partitions used in a hash join for query 720.

```
select query, slice, tbl, num_parts
from stl_hashjoin
where query=720 limit 10;
```

```
 query | slice | tbl | num_parts
-------+-------+-----+-----------
   720 |     0 | 243 |         1
   720 |     1 | 243 |         1
(2 rows)
```

STL_INSERT

Analyzes insert execution steps for queries.

STL_INSERT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_INSERT only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
tbl	integer	Table ID.
inserted_mega_value	character(1)	This information is for internal use only. This information shows whether the given insert step has inserted a large value. A large value will be stored in multiple blocks. Block size is 1 MB by default, a large value is greater than 1 MB in a default setting.

Sample queries

The following example returns insert execution steps for the most recent query.

```
select slice, segment, step, tasknum, rows, tbl
from stl_insert
where query=pg_last_query_id();
```

```
 slice | segment | step | tasknum | rows  |  tbl
-------+---------+------+---------+-------+--------
     0 |       2 |    2 |      15 | 24958 | 100548
     1 |       2 |    2 |      15 | 25032 | 100548
(2 rows)
```

STL_LIMIT

Analyzes the execution steps that occur when a LIMIT clause is used in a SELECT query.

STL_LIMIT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_LIMIT only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.

Column name	Data type	Description
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
checksum	bigint	This information is for internal use only.

Sample queries

In order to generate a row in STL_LIMIT, this example first runs the following query against the VENUE table using the LIMIT clause.

```
select * from venue
order by 1
limit 10;
```

```
 venueid |         venuename            |    venuecity     | venuestate | venueseats
---------+----------------------------+-----------------+------------+------------
       1 | Toyota Park                  | Bridgeview       | IL         |          0
```

```
       2 | Columbus Crew Stadium      | Columbus        | OH          |         0
       3 | RFK Stadium                | Washington      | DC          |         0
       4 | CommunityAmerica Ballpark  | Kansas City     | KS          |         0
       5 | Gillette Stadium           | Foxborough      | MA          |     68756
       6 | New York Giants Stadium    | East Rutherford | NJ          |     80242
       7 | BMO Field                  | Toronto         | ON          |         0
       8 | The Home Depot Center      | Carson          | CA          |         0
       9 | Dick's Sporting Goods Park | Commerce City   | CO          |         0
      10 | Pizza Hut Park             | Frisco          | TX          |         0
(10 rows)
```

Next, run the following query to find the query ID of the last query you ran against the VENUE table.

```
select max(query)
from stl_query;
```

```
  max
--------
 127128
(1 row)
```

Optionally, you can run the following query to verify that the query ID corresponds to the LIMIT query you previously ran.

```
select query, trim(querytxt)
from stl_query
where query=127128;
```

```
 query  |                  btrim
--------+------------------------------------------
 127128 | select * from venue order by 1 limit 10;
(1 row)
```

Finally, run the following query to return information about the LIMIT query from the STL_LIMIT table.

```
select slice, segment, step, starttime, endtime, tasknum
from stl_limit
where query=127128
```

```
order by starttime, endtime;
```

```
 slice | segment | step |         starttime          |          endtime           |
 tasknum
-------+---------+------+----------------------------+----------------------------
+---------
     1 |       1 |    3 | 2013-09-06 22:56:43.608114 | 2013-09-06 22:56:43.609383 |
   15
     0 |       1 |    3 | 2013-09-06 22:56:43.608708 | 2013-09-06 22:56:43.609521 |
   15
 10000 |       2 |    2 | 2013-09-06 22:56:43.612506 | 2013-09-06 22:56:43.612668 |
    0
(3 rows)
```

STL_LOAD_COMMITS

Returns information to track or troubleshoot a data load.

This view records the progress of each data file as it is loaded into a database table.

STL_LOAD_COMMITS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_LOAD_COMMITS only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_LOAD_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.

Column name	Data type	Description
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Slice loaded for this entry.
name	character(256)	System-defined value.
filename	character(256)	Name of file being tracked.
byte_offset	integer	This information is for internal use only.
lines_scanned	integer	Number of lines scanned from the load file. This number may not match the number of rows that are actually loaded. For example, the load may scan but tolerate a number of bad records, based on the MAXERROR option in the COPY command.
errors	integer	This information is for internal use only.
curtime	timestamp	Time that this entry was last updated.
status	integer	This information is for internal use only.
file_format	character(16)	Format of the load file. Possible values are as follows: • Avro • JSON • ORC • Parquet • Text
is_partial	integer	Value that if true (1) indicates the input file is split into ranges during a COPY operation. If this value is false (0), the input file isn't split.

Column name	Data type	Description
start_offset	bigint	Value that, if the input file is split during a COPY operation , indicates the offset value of the split (in bytes). Each file split is logged as a separate record with the corresponding start_offset value. If the file isn't split, this value is 0.
copy_job_id	bigint	The copy job identifier. A `0` indicates no job identifier.

Sample queries

The following example returns details for the last COPY operation.

```
select query, trim(filename) as file, curtime as updated
from stl_load_commits
where query = pg_last_copy_id();

 query |               file               |          updated
-------+----------------------------------+----------------------------
 28554 | s3://dw-tickit/category_pipe.txt | 2013-11-01 17:14:52.648486
(1 row)
```

The following query contains entries for a fresh load of the tables in the TICKIT database:

```
select query, trim(filename), curtime
from stl_load_commits
where filename like '%tickit%' order by query;
```

```
 query |           btrim           |          curtime
-------+---------------------------+----------------------------
 22475 | tickit/allusers_pipe.txt  | 2013-02-08 20:58:23.274186
 22478 | tickit/venue_pipe.txt     | 2013-02-08 20:58:25.070604
 22480 | tickit/category_pipe.txt  | 2013-02-08 20:58:27.333472
 22482 | tickit/date2008_pipe.txt  | 2013-02-08 20:58:28.608305
 22485 | tickit/allevents_pipe.txt | 2013-02-08 20:58:29.99489
 22487 | tickit/listings_pipe.txt  | 2013-02-08 20:58:37.632939
 22593 | tickit/allusers_pipe.txt  | 2013-02-08 21:04:08.400491
 22596 | tickit/venue_pipe.txt     | 2013-02-08 21:04:10.056055
 22598 | tickit/category_pipe.txt  | 2013-02-08 21:04:11.465049
```

```
 22600 | tickit/date2008_pipe.txt  | 2013-02-08 21:04:12.461502
 22603 | tickit/allevents_pipe.txt | 2013-02-08 21:04:14.785124
 22605 | tickit/listings_pipe.txt  | 2013-02-08 21:04:20.170594

(12 rows)
```

The fact that a record is written to the log file for this system view does not mean that the load committed successfully as part of its containing transaction. To verify load commits, query the STL_UTILITYTEXT view and look for the COMMIT record that corresponds with a COPY transaction. For example, this query joins STL_LOAD_COMMITS and STL_QUERY based on a subquery against STL_UTILITYTEXT:

```
select l.query,rtrim(l.filename),q.xid
from stl_load_commits l, stl_query q
where l.query=q.query
and exists
(select xid from stl_utilitytext where xid=q.xid and rtrim("text")='COMMIT');

 query |           rtrim           |  xid
-------+---------------------------+-------
 22600 | tickit/date2008_pipe.txt  | 68311
 22480 | tickit/category_pipe.txt  | 68066
  7508 | allusers_pipe.txt         | 23365
  7552 | category_pipe.txt         | 23415
  7576 | allevents_pipe.txt        | 23429
  7516 | venue_pipe.txt            | 23390
  7604 | listings_pipe.txt         | 23445
 22596 | tickit/venue_pipe.txt     | 68309
 22605 | tickit/listings_pipe.txt  | 68316
 22593 | tickit/allusers_pipe.txt  | 68305
 22485 | tickit/allevents_pipe.txt | 68071
  7561 | allevents_pipe.txt        | 23429
  7541 | category_pipe.txt         | 23415
  7558 | date2008_pipe.txt         | 23428
 22478 | tickit/venue_pipe.txt     | 68065
   526 | date2008_pipe.txt         |  2572
  7466 | allusers_pipe.txt         | 23365
 22482 | tickit/date2008_pipe.txt  | 68067
 22598 | tickit/category_pipe.txt  | 68310
 22603 | tickit/allevents_pipe.txt | 68315
 22475 | tickit/allusers_pipe.txt  | 68061
   547 | date2008_pipe.txt         |  2572
 22487 | tickit/listings_pipe.txt  | 68072
```

```
  7531 | venue_pipe.txt            | 23390
  7583 | listings_pipe.txt         | 23445
(25 rows)
```

The following examples highlight is_partial and start_offset column values.

```
-- Single large file copy without scan range
SELECT count(*) FROM stl_load_commits WHERE query = pg_last_copy_id();
1

-- Single large uncompressed, delimited file copy with scan range
SELECT count(*) FROM stl_load_commits WHERE query = pg_last_copy_id();
16

-- Scan range offset logging in the file at 64MB boundary.
SELECT start_offset FROM stl_load_commits
WHERE query = pg_last_copy_id() ORDER BY start_offset;
0
67108864
134217728
201326592
268435456
335544320
402653184
469762048
536870912
603979776
671088640
738197504
805306368
872415232
939524096
1006632960
```

STL_LOAD_ERRORS

Displays the records of all Amazon Redshift load errors.

STL_LOAD_ERRORS contains a history of all Amazon Redshift load errors. See Load error reference for a comprehensive list of possible load errors and explanations.

Query STL_LOADERROR_DETAIL for additional details, such as the exact data row and column where a parse error occurred, after you query STL_LOAD_ERRORS to find out general information about the error.

STL_LOAD_ERRORS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_LOAD_ERRORS only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_LOAD_ERROR_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
slice	integer	Slice where the error occurred.
tbl	integer	Table ID.
starttime	timestamp	Start time in UTC for the load.
session	integer	Session ID for the session performing the load.
query	integer	Query ID. The query column can be used to join other system tables and views.
filename	character(256)	Complete path to the input file for the load.

Column name	Data type	Description
line_number	bigint	Line number in the load file with the error. For COPY from JSON, the line number of the last line of the JSON object with the error.
colname	character(127)	Field with the error.
type	character(10)	Data type of the field.
col_length	character(10)	Column length, if applicable. This field is populated when the data type has a limit length. For example, for a column with a data type of "character(3)", this column will contain the value "3".
position	integer	Position of the error in the field.
raw_line	character(1024)	Raw load data that contains the error. Multibyte characters in the load data are replaced with a period.
raw_field_value	char(1024)	The pre-parsing value for the field "colname" that lead to the parsing error.
err_code	integer	Error code.
err_reason	character(100)	Explanation for the error.
is_partial	integer	Value that if true (1) indicates the input file is split into ranges during a COPY operation. If this value is false (0), the input file isn't split.
start_offset	bigint	Value that, if the input file is split during a COPY operation , indicates the offset value of the split (in bytes). If the line number in the file is unknown, the line number is -1. If the file isn't split, this value is 0.
copy_job_id	bigint	The copy job identifier. A `0` indicates no job identifier.

Sample queries

The following query joins STL_LOAD_ERRORS to STL_LOADERROR_DETAIL to view the details errors that occurred during the most recent load.

```
select d.query, substring(d.filename,14,20),
d.line_number as line,
substring(d.value,1,16) as value,
substring(le.err_reason,1,48) as err_reason
from stl_loaderror_detail d, stl_load_errors le
where d.query = le.query
and d.query = pg_last_copy_id();

 query |    substring      | line |  value   |              err_reason
-------+-------------------+------+----------+----------------------------
    558| allusers_pipe.txt |  251 | 251      | String contains invalid or
                                              unsupported UTF8 code
    558| allusers_pipe.txt |  251 | ZRU29FGR | String contains invalid or
                                              unsupported UTF8 code
    558| allusers_pipe.txt |  251 | Kaitlin  | String contains invalid or
                                              unsupported UTF8 code
    558| allusers_pipe.txt |  251 | Walter   | String contains invalid or
                                              unsupported UTF8 code
```

The following example uses STL_LOAD_ERRORS with STV_TBL_PERM to create a new view, and then uses that view to determine what errors occurred while loading data into the EVENT table:

```
create view loadview as
(select distinct tbl, trim(name) as table_name, query, starttime,
trim(filename) as input, line_number, colname, err_code,
trim(err_reason) as reason
from stl_load_errors sl, stv_tbl_perm sp
where sl.tbl = sp.id);
```

Next, the following query actually returns the last error that occurred while loading the EVENT table:

```
select table_name, query, line_number, colname, starttime,
trim(reason) as error
from loadview
where table_name ='event'
```

```
order by line_number limit 1;
```

The query returns the last load error that occurred for the EVENT table. If no load errors occurred, the query returns zero rows. In this example, the query returns a single error:

```
 table_name | query | line_number | colname | error | starttime
------+-----+----+----+--------------------------------------------------------
+----------------------
event | 309 |  0 |  5 | Error in Timestamp value or format [%Y-%m-%d %H:%M:%S] |
 2014-04-22 15:12:44

(1 row)
```

In cases where the COPY command automatically splits large, uncompressed, text-delimited file data to facilitate parallelism, the *line_number*, *is_partial*, and *start_offset* columns show information pertaining to splits. (The line number can be unknown in cases where the line number from the original file is unavailable.)

```
--scan ranges information
SELECT line_number, POSITION, btrim(raw_line), btrim(raw_field_value),
btrim(err_reason), is_partial, start_offset FROM stl_load_errors
WHERE query = pg_last_copy_id();

--result
-1,51,"1008771|13463413|463414|2|28.00|38520.72|0.06|0.07|NO|1998-08-30|1998-09-25|
1998-09-04|TAKE BACK RETURN|RAIL|ans cajole sly","NO","Char length exceeds DDL
 length",1,67108864
```

STL_LOADERROR_DETAIL

Displays a log of data parse errors that occurred while using a COPY command to load tables. To conserve disk space, a maximum of 20 errors per node slice are logged for each load operation.

A parse error occurs when Amazon Redshift cannot parse a field in a data row while loading it into a table. For example, if a table column is expecting an integer data type and the data file contains a string of letters in that field, it causes a parse error.

Query STL_LOADERROR_DETAIL for additional details, such as the exact data row and column where a parse error occurred, after you query STL_LOAD_ERRORS to find out general information about the error.

The STL_LOADERROR_DETAIL view contains all data columns including and prior to the column where the parse error occurred. Use the VALUE field to see the data value that was actually parsed in this column, including the columns that parsed correctly up to the error.

This view is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_LOADERROR_DETAIL only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_LOAD_ERROR_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
slice	integer	Slice where the error occurred.
session	integer	Session ID for the session performing the load.
query	integer	Query ID. The query column can be used to join other system tables and views.
filename	character(256)	Complete path to the input file for the load.
line_number	bigint	Line number in the load file with the error.
field	integer	Field with the error.
colname	character(1024)	Column name.

Column name	Data type	Description
value	character(1024)	Parsed data value of the field. (May be truncated.) Multibyte characters in the load data are replaced with a period.
is_null	integer	Whether or not the parsed value is null.
type	character(10)	Data type of the field.
col_length	character(10)	Column length, if applicable. This field is populated when the data type has a limit length. For example, for a column with a data type of "character(3)", this column will contain the value "3".

Sample query

The following query joins STL_LOAD_ERRORS to STL_LOADERROR_DETAIL to view the details of a parse error that occurred while loading the EVENT table, which has a table ID of 100133:

```
select d.query, d.line_number, d.value,
le.raw_line, le.err_reason
from stl_loaderror_detail d, stl_load_errors le
where
d.query = le.query
and tbl = 100133;
```

The following sample output shows the columns that loaded successfully, including the column with the error. In this example, two columns successfully loaded before the parse error occurred in the third column, where a character string was incorrectly parsed for a field expecting an integer. Because the field expected an integer, it parsed the string "aaa", which is uninitialized data, as a null and generated a parse error. The output shows the raw value, parsed value, and error reason:

```
query  | line_number | value | raw_line | err_reason
-------+-------------+-------+----------+----------------
4      |      3      |  1201 |  1201    | Invalid digit
4      |      3      |   126 |   126    | Invalid digit
4      |      3      |       |   aaa    | Invalid digit
```

```
(3 rows)
```

When a query joins STL_LOAD_ERRORS and STL_LOADERROR_DETAIL, it displays an error reason for each column in the data row, which simply means that an error occurred in that row. The last row in the results is the actual column where the parse error occurred.

STL_MERGE

Analyzes merge execution steps for queries. These steps occur when the results of parallel operations (such as sorts and joins) are merged for subsequent processing.

STL_MERGE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_MERGE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.

Column name	Data type	Description
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.

Sample queries

The following example returns 10 merge execution results.

```
select query, step, starttime, endtime, tasknum, rows
from stl_merge
limit 10;
```

```
 query | step |       starttime     |        endtime      | tasknum | rows
-------+------+---------------------+---------------------+---------+------
     9 |    0 | 2013-08-12 20:08:14 | 2013-08-12 20:08:14 |       0 |    0
    12 |    0 | 2013-08-12 20:09:10 | 2013-08-12 20:09:10 |       0 |    0
    15 |    0 | 2013-08-12 20:10:24 | 2013-08-12 20:10:24 |       0 |    0
    20 |    0 | 2013-08-12 20:11:27 | 2013-08-12 20:11:27 |       0 |    0
    26 |    0 | 2013-08-12 20:12:28 | 2013-08-12 20:12:28 |       0 |    0
    32 |    0 | 2013-08-12 20:14:33 | 2013-08-12 20:14:33 |       0 |    0
    38 |    0 | 2013-08-12 20:16:43 | 2013-08-12 20:16:43 |       0 |    0
    44 |    0 | 2013-08-12 20:17:05 | 2013-08-12 20:17:05 |       0 |    0
    50 |    0 | 2013-08-12 20:18:48 | 2013-08-12 20:18:48 |       0 |    0
    56 |    0 | 2013-08-12 20:20:48 | 2013-08-12 20:20:48 |       0 |    0
(10 rows)
```

STL_MERGEJOIN

Analyzes merge join execution steps for queries.

STL_MERGEJOIN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_MERGEJOIN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision

Column name	Data type	Description
		for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
tbl	integer	Table ID. This is the ID for the inner table that was used in the merge join.
checksum	bigint	This information is for internal use only.

Sample queries

The following example returns merge join results for the most recent query.

```
select sum(s.qtysold), e.eventname
from event e, listing l, sales s
where e.eventid=l.eventid
and l.listid= s.listid
group by e.eventname;

select * from stl_mergejoin where query=pg_last_query_id();
```

```
 userid | query | slice | segment | step |         starttime     |          endtime     |
 tasknum | rows | tbl
--------+-------+-------+---------+------+---------------------+---------------------
+---------+------+-----
    100 | 27399 |     3 |       4 |    4 | 2013-10-02 16:30:41 | 2013-10-02 16:30:41 |
     19 |43428 | 240
    100 | 27399 |     0 |       4 |    4 | 2013-10-02 16:30:41 | 2013-10-02 16:30:41 |
     19 |43159 | 240
    100 | 27399 |     2 |       4 |    4 | 2013-10-02 16:30:41 | 2013-10-02 16:30:41 |
     19 |42778 | 240
    100 | 27399 |     1 |       4 |    4 | 2013-10-02 16:30:41 | 2013-10-02 16:30:41 |
     19 |43091 | 240
```

STL_MV_STATE

The STL_MV_STATE view contains a row for every state transition of a materialized view.

For more information about materialized views, see Materialized views in Amazon Redshift.

STL_MV_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_MV_STATE. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	bigint	The ID of the user who created the event.
starttime	timestamp	The start time of the event.
xid	bigint	The transaction id of the event.
event_desc	char(500)	The event that prompted the state change. Some example values include the following: • Column type was changed • Column was dropped • Column was renamed • Schema name was changed • Small table conversion • TRUNCATE • Vacuum Note that there are other possible values for this column.

Column name	Data type	Description
db_name	char(128)	The database that contains the materialized view.
base_table_schema	char(128)	The schema of the base table.
base_table_name	char(128)	The name of the base table.
mv_schema	char(128)	The schema of the materialized view.
mv_name	char(128)	The name of the materialized view.
state	character(32)	The changed state of the materialized view as follows: • Recompute • Unrefreshable

The following table shows example combinations of `event_desc` and `state`.

```
          event_desc     |     state
-------------------------+---------------
 TRUNCATE                | Recompute
 TRUNCATE                | Recompute
 Small table conversion  | Recompute
 Vacuum                  | Recompute
 Column was renamed      | Unrefreshable
 Column was dropped      | Unrefreshable
 Table was renamed       | Unrefreshable
 Column type was changed | Unrefreshable
 Schema name was changed | Unrefreshable
```

Sample query

To view the log of state transitions of materialized views, run the following query.

```
select * from stl_mv_state;
```

This query returns the following sample output:

```
 userid |         starttime          | xid  |             event_desc         | db_name |
 base_table_schema   |   base_table_name     |      mv_schema        | mv_name        |
  state
--------+----------------------------+------+-----------------------------+---------
+----------------------+----------------------+----------------------+---------------
+---------------
    138 | 2020-02-14 02:21:25.578885 | 5180 | TRUNCATE                    | dev     |
 public               | mv_base_table        | public               | mv_test        |
 Recompute
    138 | 2020-02-14 02:21:56.846774 | 5275 | Column was dropped          | dev     |
                      | mv_base_table        | public               | mv_test        |
 Unrefreshable
    100 | 2020-02-13 22:09:53.041228 | 1794 | Column was renamed          | dev     |
                      | mv_base_table        | public               | mv_test        |
 Unrefreshable
      1 | 2020-02-13 22:10:23.630914 | 1893 | ALTER TABLE ALTER SORTKEY   | dev     |
 public               | mv_base_table_sorted | public               | mv_test        |
 Recompute
      1 | 2020-02-17 22:57:22.497989 | 8455 | ALTER TABLE ALTER DISTSTYLE | dev     |
 public               | mv_base_table        | public               | mv_test        |
 Recompute
    173 | 2020-02-17 22:57:23.591434 | 8504 | Table was renamed           | dev     |
                      | mv_base_table        | public               | mv_test        |
 Unrefreshable
    173 | 2020-02-17 22:57:27.229423 | 8592 | Column type was changed     | dev     |
                      | mv_base_table        | public               | mv_test        |
 Unrefreshable
    197 | 2020-02-17 22:59:06.212569 | 9668 | TRUNCATE                    | dev     |
 schemaf796e415850f4f | mv_base_table        | schemaf796e415850f4f | mv_test        |
 Recompute
    138 | 2020-02-14 02:21:55.705655 | 5226 | Column was renamed          | dev     |
                      | mv_base_table        | public               | mv_test        |
 Unrefreshable
      1 | 2020-02-14 02:22:26.292434 | 5325 | ALTER TABLE ALTER SORTKEY   | dev     |
 public               | mv_base_table_sorted | public               | mv_test        |
 Recompute
```

STL_NESTLOOP

Analyzes nested-loop join execution steps for queries.

STL_NESTLOOP is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_NESTLOOP only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision

Column name	Data type	Description
		for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
tbl	integer	Table ID.
checksum	bigint	This information is for internal use only.

Sample queries

Because the following query neglects to join the CATEGORY table, it produces a partial Cartesian product, which is not recommended. It is shown here to illustrate a nested loop.

```
select count(event.eventname), event.eventname, category.catname, date.caldate
from event, category, date
where event.dateid = date.dateid
group by event.eventname, category.catname, date.caldate;
```

The following query shows the results from the previous query in the STL_NESTLOOP view.

```
select query, slice, segment as seg, step,
datediff(msec, starttime, endtime) as duration, tasknum, rows, tbl
from stl_nestloop
where query = pg_last_query_id();
```

```
 query | slice | seg | step | duration | tasknum | rows  | tbl
-------+-------+-----+------+----------+---------+-------+-----
  6028 |     0 |   4 |    5 |       41 |      22 | 24277 | 240
  6028 |     1 |   4 |    5 |       26 |      23 | 24189 | 240
  6028 |     3 |   4 |    5 |       25 |      23 | 24376 | 240
  6028 |     2 |   4 |    5 |       54 |      22 | 23936 | 240
```

STL_PARSE

Analyzes query steps that parse strings into binary values for loading.

STL_PARSE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_PARSE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision

Column name	Data type	Description
		for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.

Sample queries

The following example returns all query step results for slice 1 and segment 0 where strings were parsed into binary values.

```
select query, step, starttime, endtime, tasknum, rows
from stl_parse
where slice=1 and segment=0;
```

```
 query | step |      starttime      |        endtime      | tasknum |  rows
-------+------+---------------------+---------------------+---------+--------
   669 |    1 | 2013-08-12 22:35:13 | 2013-08-12 22:35:17 |      32 | 192497
   696 |    1 | 2013-08-12 22:35:49 | 2013-08-12 22:35:49 |      32 |      0
   525 |    1 | 2013-08-12 22:32:03 | 2013-08-12 22:32:03 |      13 |  49990
   585 |    1 | 2013-08-12 22:33:18 | 2013-08-12 22:33:19 |      13 |    202
   621 |    1 | 2013-08-12 22:34:03 | 2013-08-12 22:34:03 |      27 |    365
   651 |    1 | 2013-08-12 22:34:47 | 2013-08-12 22:34:53 |      35 | 192497
   590 |    1 | 2013-08-12 22:33:28 | 2013-08-12 22:33:28 |      19 |      0
   599 |    1 | 2013-08-12 22:33:39 | 2013-08-12 22:33:39 |      31 |     11
   675 |    1 | 2013-08-12 22:35:26 | 2013-08-12 22:35:27 |      38 |   3766
   567 |    1 | 2013-08-12 22:32:47 | 2013-08-12 22:32:48 |      23 |  49990
   630 |    1 | 2013-08-12 22:34:17 | 2013-08-12 22:34:17 |      36 |      0
   572 |    1 | 2013-08-12 22:33:04 | 2013-08-12 22:33:04 |      29 |      0
   645 |    1 | 2013-08-12 22:34:37 | 2013-08-12 22:34:38 |      29 |   8798
   604 |    1 | 2013-08-12 22:33:47 | 2013-08-12 22:33:47 |      37 |      0
(14 rows)
```

STL_PLAN_INFO

Use the STL_PLAN_INFO view to look at the EXPLAIN output for a query in terms of a set of rows. This is an alternative way to look at query plans.

STL_PLAN_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_PLAN_INFO only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
nodeid	integer	Plan node identifier, where a node maps to one or more steps in the execution of the query.
segment	integer	Number that identifies the query segment.
step	integer	Number that identifies the query step.
locus	integer	Location where the step runs. 0 if on a compute node and 1 if on the leader node.

Column name	Data type	Description
plannode	integer	Enumerated value of the plan node. See the following table for enums for plannode. (The PLANNODE column in STL_EXPLAIN contains the plan node text.)
startupcost	double precision	The estimated relative cost of returning the first row for this step.
totalcost	double precision	The estimated relative cost of executing the step.
rows	bigint	The estimated number of rows that will be produced by the step.
bytes	bigint	The estimated number of bytes that will be produced by the step.

Sample queries

The following examples compare the query plans for a simple SELECT query returned by using the EXPLAIN command and by querying the STL_PLAN_INFO view.

```
explain select * from category;
QUERY PLAN
-------------------------------------------------------------
XN Seq Scan on category (cost=0.00..0.11 rows=11 width=49)
(1 row)

select * from category;
catid | catgroup | catname | catdesc
-------+----------+-----------+--------------------------------------------
1 | Sports | MLB | Major League Baseball
3 | Sports | NFL | National Football League
5 | Sports | MLS | Major League Soccer
...

select * from stl_plan_info where query=256;

query | nodeid | segment | step | locus | plannode | startupcost | totalcost
| rows | bytes
```

```
-------+--------+---------+------+-------+----------+-------------+----------+------
+-------
256 | 1 | 0 | 1 | 0 | 104 | 0 | 0.11 | 11 | 539
256 | 1 | 0 | 0 | 0 | 104 | 0 | 0.11 | 11 | 539
(2 rows)
```

In this example, PLANNODE 104 refers to the sequential scan of the CATEGORY table.

```
select distinct eventname from event order by 1;

eventname
------------------------------------------------------------------------
.38 Special
3 Doors Down
70s Soul Jam
A Bronx Tale
...

explain select distinct eventname from event order by 1;

QUERY PLAN
-------------------------------------------------------------------------------------
XN Merge (cost=1000000000136.38..1000000000137.82 rows=576 width=17)
Merge Key: eventname
-> XN Network (cost=1000000000136.38..1000000000137.82 rows=576
width=17)
Send to leader
-> XN Sort (cost=1000000000136.38..1000000000137.82 rows=576
width=17)
Sort Key: eventname
-> XN Unique (cost=0.00..109.98 rows=576 width=17)
-> XN Seq Scan on event (cost=0.00..87.98 rows=8798
width=17)
(8 rows)

select * from stl_plan_info where query=240 order by nodeid desc;

query | nodeid | segment | step | locus | plannode | startupcost |
totalcost | rows | bytes
-------+--------+---------+------+-------+----------+-----------------
+-----------------+------+--------
240 | 5 | 0 | 0 | 0 | 104 | 0                | 87.98   | 8798 | 149566
240 | 5 | 0 | 1 | 0 | 104 | 0                | 87.98   | 8798 | 149566
```

```
240 | 4 | 0 | 2 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 0 | 3 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 1 | 0 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 1 | 1 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 3 | 1 | 2 | 0 | 114 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 3 | 2 | 0 | 0 | 114 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 2 | 2 | 1 | 0 | 123 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 1 | 3 | 0 | 0 | 122 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
(10 rows)
```

STL_PROJECT

Contains rows for query steps that are used to evaluate expressions.

STL_PROJECT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_PROJECT only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.

Column name	Data type	Description
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
checksum	bigint	This information is for internal use only.

Sample queries

The following example returns all rows for query steps that were used to evaluate expressions for slice 0 and segment 1.

```
select query, step, starttime, endtime, tasknum, rows
from stl_project
where slice=0 and segment=1;
```

```
 query  | step |      starttime      |       endtime       | tasknum | rows
--------+------+---------------------+---------------------+---------+------
  86399 |    2 | 2013-08-29 22:01:21 | 2013-08-29 22:01:21 |      25 |   -1
  86399 |    3 | 2013-08-29 22:01:21 | 2013-08-29 22:01:21 |      25 |   -1
    719 |    1 | 2013-08-12 22:38:33 | 2013-08-12 22:38:33 |       7 |   -1
  86383 |    1 | 2013-08-29 21:58:35 | 2013-08-29 21:58:35 |       7 |   -1
    714 |    1 | 2013-08-12 22:38:17 | 2013-08-12 22:38:17 |       2 |   -1
  86375 |    1 | 2013-08-29 21:57:59 | 2013-08-29 21:57:59 |       2 |   -1
```

```
   86397 |     2 | 2013-08-29 22:01:20 | 2013-08-29 22:01:20 |        19 |    -1
     627 |     1 | 2013-08-12 22:34:13 | 2013-08-12 22:34:13 |        34 |    -1
   86326 |     2 | 2013-08-29 21:45:28 | 2013-08-29 21:45:28 |        34 |    -1
   86326 |     3 | 2013-08-29 21:45:28 | 2013-08-29 21:45:28 |        34 |    -1
   86325 |     2 | 2013-08-29 21:45:27 | 2013-08-29 21:45:27 |        28 |    -1
   86371 |     1 | 2013-08-29 21:57:42 | 2013-08-29 21:57:42 |         4 |    -1
  111100 |     2 | 2013-09-03 19:04:45 | 2013-09-03 19:04:45 |        12 |    -1
     704 |     2 | 2013-08-12 22:36:34 | 2013-08-12 22:36:34 |        37 |    -1
     649 |     2 | 2013-08-12 22:34:47 | 2013-08-12 22:34:47 |        38 |    -1
     649 |     3 | 2013-08-12 22:34:47 | 2013-08-12 22:34:47 |        38 |    -1
     632 |     2 | 2013-08-12 22:34:22 | 2013-08-12 22:34:22 |        13 |    -1
     705 |     2 | 2013-08-12 22:36:48 | 2013-08-12 22:36:49 |        13 |    -1
     705 |     3 | 2013-08-12 22:36:48 | 2013-08-12 22:36:49 |        13 |    -1
       3 |     1 | 2013-08-12 20:07:40 | 2013-08-12 20:07:40 |         3 |    -1
   86373 |     1 | 2013-08-29 21:57:58 | 2013-08-29 21:57:58 |         3 |    -1
  107976 |     1 | 2013-09-03 04:05:12 | 2013-09-03 04:05:12 |         3 |    -1
   86381 |     1 | 2013-08-29 21:58:35 | 2013-08-29 21:58:35 |         8 |    -1
   86396 |     1 | 2013-08-29 22:01:20 | 2013-08-29 22:01:20 |        15 |    -1
     711 |     1 | 2013-08-12 22:37:10 | 2013-08-12 22:37:10 |        20 |    -1
   86324 |     1 | 2013-08-29 21:45:27 | 2013-08-29 21:45:27 |        24 |    -1
(26 rows)
```

STL_QUERY

Returns execution information about a database query.

> **Note**
>
> The STL_QUERY and STL_QUERYTEXT views only contain information about queries, not other utility and DDL commands. For a listing and information on all statements run by Amazon Redshift, you can also query the STL_DDLTEXT and STL_UTILITYTEXT views. For a complete listing of all statements run by Amazon Redshift, you can query the SVL_STATEMENTTEXT view.

STL_QUERY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Note that when your query text length is over 4000 characters, STL_QUERY only displays truncated data. To get the full query text, you can use UNION on the query text across rows.

Note

To verify whether a transaction containing the executed query was successfully committed, you need to perform a join operation between system tables and the `sys_transaction_history` table. For example:

```
SELECT
    stlq.xid AS transaction_id,
    stlq.query AS query_id,
    TRIM(stlq.querytxt) AS query_text,
    th.status AS transaction_status
FROM
    stl_query stlq
LEFT JOIN
    sys_transaction_history th ON stlq.xid = th.transaction_id;
```

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field value is `default`.
xid	bigint	Transaction ID.
pid	integer	Process ID. Normally, all of the queries in a session are run in the same process, so this value usually remains

Column name	Data type	Description
		constant if you run a series of queries in the same session. Following certain internal events, Amazon Redshift might restart an active session and assign a new PID. For more information, see STL_RESTARTED_SESSIONS.
database	character(32)	The name of the database the user was connected to when the query was issued.
querytxt	character(4000)	Actual query text for the query.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
aborted	integer	If a query was stopped by the system or canceled by the user, this column contains **1**. If the query ran to completion (including returning results to the client), this column contains **0**. If a client disconnects before receiving the results, the query will be marked as canceled (**1**), even if it completed successfully in the backend.
insert_pristine	integer	Whether write queries are/were able to run while the current query is/was running. 1 = no write queries allowed. 0 = write queries allowed. This column is intended for use in debugging.

Column name	Data type	Description
concurrency_scaling_status	integer	Indicates whether the query ran on the main cluster or on a concurrency scaling cluster. Possible values are as follows: 0 - Ran on the main cluster 1 - Ran on a concurrency scaling cluster Greater than 1 - Ran on the main cluster

Sample queries

The following query lists the five most recent queries.

```
select query, trim(querytxt) as sqlquery
from stl_query
order by query desc limit 5;

query |                                    sqlquery
------+--------------------------------------------------
129 | select query, trim(querytxt) from stl_query order by query;
128 | select node from stv_disk_read_speeds;
127 | select system_status from stv_gui_status
126 | select * from systable_topology order by slice
125 | load global dict registry
(5 rows)
```

The following query returns the time elapsed in descending order for queries that ran on February 15, 2013.

```
select query, datediff(seconds, starttime, endtime),
trim(querytxt) as sqlquery
from stl_query
where starttime >= '2013-02-15 00:00' and endtime < '2013-02-16 00:00'
order by date_diff desc;

 query | date_diff |  sqlquery
-------+-----------+-------------------------------------------
```

```
 55    |       119 | padb_fetch_sample: select count(*) from category
121    |         9 | select * from svl_query_summary;
181    |         6 | select * from svl_query_summary where query in(179,178);
172    |         5 | select * from svl_query_summary where query=148;
...
(189 rows)
```

The following query shows the queue time and execution time for queries. Queries with `concurrency_scaling_status = 1` ran on a concurrency scaling cluster. All other queries ran on the main cluster.

```
SELECT w.service_class AS queue
     , q.concurrency_scaling_status
     , COUNT( * ) AS queries
     , SUM( q.aborted )  AS aborted
     , SUM( ROUND( total_queue_time::NUMERIC / 1000000,2 ) ) AS queue_secs
     , SUM( ROUND( total_exec_time::NUMERIC / 1000000,2 ) )  AS exec_secs
FROM stl_query q
     JOIN stl_wlm_query w
          USING (userid,query)
WHERE q.userid > 1
  AND service_class > 5
  AND q.starttime > '2019-03-01 16:38:00'
  AND q.endtime   < '2019-03-01 17:40:00'
GROUP BY 1,2
ORDER BY 1,2;
```

STL_QUERY_METRICS

Contains metrics information, such as the number of rows processed, CPU usage, input/output, and disk use, for queries that have completed running in user-defined query queues (service classes). To view metrics for active queries that are currently running, see the STV_QUERY_METRICS system view.

Query metrics are sampled at one second intervals. As a result, different runs of the same query might return slightly different times. Also, query segments that run in less than one second might not be recorded.

STL_QUERY_METRICS tracks and aggregates metrics at the query, segment, and step level. For information about query segments and steps, see Query planning and execution workflow. Many metrics (such as `max_rows`, `cpu_time`, and so on) are summed across node slices. For more information about node slices, see Data warehouse system architecture.

To determine the level at which the row reports metrics, examine the `segment` and `step_type` columns.

- If both `segment` and `step_type` are `-1`, then the row reports metrics at the query level.
- If `segment` is not `-1` and `step_type` is `-1`, then the row reports metrics at the segment level.
- If both `segment` and `step_type` are not `-1`, then the row reports metrics at the step level.

The SVL_QUERY_METRICS view and the SVL_QUERY_METRICS_SUMMARY view aggregate the data in this view and present the information in a more accessible form.

STL_QUERY_METRICS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user that ran the query that generated the entry.
service_class	integer	ID for the service class. Query queues are defined in the WLM configuration. Metrics are reported only for user-defi ned queues.
query	integer	Query ID. The query column can be used to join other system tables and views.
segment	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process. If the segment value is -1, metrics segment values are rolled up to the query level.

Column name	Data type	Description
step_type	integer	Type of step that ran. For a description of step types, see Step types.
starttime	timestamp	Time in UTC that the query started executing, with 6 digits of precision for fractional seconds. For example: `2009-06-12 11:29:19.131358`.
slices	integer	Number of slices for the cluster.
max_rows	bigint	Maximum number of rows output for a step, aggregated across all slices.
rows	bigint	Number of rows processed by a step.
max_cpu_time	bigint	Maximum CPU time used, in microseconds. At the segment level, the maximum CPU time used by the segment across all slices. At the query level, the maximum CPU time used by any query segment.
cpu_time	bigint	CPU time used, in microseconds. At the segment level, the total CPU time for the segment across all slices. At the query level, the sum of CPU time for the query across all slices and segments.
max_blocks_read	bigint	Maximum number of 1 MB blocks read by the segment, aggregated across all slices. At the segment level, the maximum number of 1 MB blocks read for the segment across all slices. At the query level, the maximum number of 1 MB blocks read by any query segment.
blocks_read	bigint	Number of 1 MB blocks read by the query or segment.
max_run_time	bigint	The maximum elapsed time for a segment, in microseconds. At the segment level, the maximum run time for the segment across all slices. At the query level, the maximum run time for any query segment.

Column name	Data type	Description
run_time	bigint	Total run time, summed across slices. Run time doesn't include wait time. At the segment level, the run time for the segment, summed across all slices. At the query level, the run time for the query summed across all slices and segments. Because this value is a sum, run time is not related to query execution time.
max_blocks_to_disk	bigint	The maximum amount of disk space used to write intermediate results, in MB blocks. At the segment level, the maximum amount of disk space used by the segment across all slices. At the query level, the maximum amount of disk space used by any query segment.
blocks_to_disk	bigint	The amount of disk space used by a query or segment to write intermediate results, in MB blocks.
step	integer	Query step that ran.
max_query_scan_size	bigint	The maximum size of data scanned by a query, in MB. At the segment level, the maximum size of data scanned by the segment across all slices. At the query level, the maximum size of data scanned by any query segment.
query_scan_size	bigint	The size of data scanned by a query, in MB.
query_priority	integer	The priority of the query. Possible values are `-1`, `0`, `1`, `2`, `3`, and `4`, where `-1` means that query priority isn't supported.
query_queue_time	bigint	The amount of time in microseconds that the query was queued.
service_class_name	character(64)	The name of the service class.

Sample query

To find queries with high CPU time (more the 1,000 seconds), run the following query.

```
Select query, cpu_time / 1000000 as cpu_seconds
from stl_query_metrics where segment = -1 and cpu_time > 1000000000
order by cpu_time;

query | cpu_seconds
------+------------
25775 |        9540
```

To find active queries with a nested loop join that returned more than one million rows, run the following query.

```
select query, rows
from stl_query_metrics
where step_type = 15 and rows > 1000000
order by rows;

query | rows
------+-----------
25775 | 2621562702
```

To find active queries that have run for more than 60 seconds and have used less than 10 seconds of CPU time, run the following query.

```
select query, run_time/1000000 as run_time_seconds
from stl_query_metrics
where segment = -1 and run_time > 60000000 and cpu_time < 10000000;

query | run_time_seconds
------+-----------------
25775 |              114
```

STL_QUERYTEXT

Captures the query text for SQL commands.

Query the STL_QUERYTEXT view to capture the SQL that was logged for the following statements:

- SELECT, SELECT INTO

- INSERT, UPDATE, DELETE
- COPY
- UNLOAD
- The queries generated by running VACUUM and ANALYZE
- CREATE TABLE AS (CTAS)

To query activity for these statements over a given time period, join the STL_QUERYTEXT and STL_QUERY views.

> **Note**
>
> The STL_QUERY and STL_QUERYTEXT views only contain information about queries, not other utility and DDL commands. For a listing and information on all statements run by Amazon Redshift, you can also query the STL_DDLTEXT and STL_UTILITYTEXT views. For a complete listing of all statements run by Amazon Redshift, you can query the SVL_STATEMENTTEXT view.

See also STL_DDLTEXT, STL_UTILITYTEXT, and SVL_STATEMENTTEXT.

STL_QUERYTEXT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_TEXT. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Note that when your query text length is over 4000 characters, STL_QUERYTEXT only displays truncated data. To get the full query text, you can use UNION on the query text across rows.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.

Column name	Data type	Description
xid	bigint	Transaction ID.
pid	integer	Process ID. Normally, all of the queries in a session are run in the same process, so this value usually remains constant if you run a series of queries in the same session. Following certain internal events, Amazon Redshift might restart an active session and assign a new PID. For more information, see STL_RESTARTED_SESSIONS. You can use this column to join to the STL_ERROR view.
query	integer	Query ID. The query column can be used to join other system tables and views.
sequence	integer	When a single statement contains more than 200 characters, additional rows are logged for that statement. Sequence 0 is the first row, 1 is the second, and so on.
text	character(200)	SQL text, in 200-character increments. This field might contain special characters such as backslash (\\) and newline (\n).

Sample queries

You can use the PG_BACKEND_PID() function to retrieve information for the current session. For example, the following query returns the query ID and a portion of the query text for queries completed in the current session.

```
select query, substring(text,1,60)
from stl_querytext
where pid = pg_backend_pid()
order by query desc;

 query |                          substring
-------+--------------------------------------------------------------
 28262 | select query, substring(text,1,80) from stl_querytext where
 28252 | select query, substring(path,0,80) as path from stl_unload_l
```

```
 28248 | copy category from 's3://dw-tickit/manifest/category/1030_ma
 28247 | Count rows in target table
 28245 | unload ('select * from category') to 's3://dw-tickit/manifes
 28240 | select query, substring(text,1,40) from stl_querytext where
(6 rows)
```

Reconstructing stored SQL

To reconstruct the SQL stored in the `text` column of STL_QUERYTEXT, run a SELECT statement to create SQL from 1 or more parts in the `text` column. Before running the reconstructed SQL, replace any (\n) special characters with a new line. The result of the following SELECT statement is rows of reconstructed SQL in the `query_statement` field.

```
SELECT query, LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END)
 WITHIN GROUP (ORDER BY sequence) as query_statement, COUNT(*) as row_count
FROM stl_querytext GROUP BY query ORDER BY query desc;
```

For example, the following query selects 3 columns. The query itself is longer than 200 characters and is stored in parts in STL_QUERYTEXT.

```
select
1 AS a0123456789012345678901234567890123456789012345678901234567890,
2 AS b0123456789012345678901234567890123456789012345678901234567890,
3 AS b012345678901234567890123456789012345678901234
FROM stl_querytext;
```

In this example, the query is stored in 2 parts (rows) in the `text` column of STL_QUERYTEXT.

```
select query, sequence, text
from stl_querytext where query=pg_last_query_id() order by query desc, sequence limit
 10;
```

```


query  | sequence |
                          text

-------+----------
+-----------------------------------------------------------------------------------------
    45 |        0 | select\n1 AS
 a0123456789012345678901234567890123456789012345678901234567890,\n2 AS
```

```
b01234567890123456789012345678901234567890123456789012345678901234567890,\n3 AS
b0123456789012345678901234567890123456789012341234
   45 |        1 | \nFROM stl_querytext;
```

To reconstruct the SQL stored in STL_QUERYTEXT, run the following SQL.

```
select LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END, '')
 within group (order by sequence) AS text
from stl_querytext where query=pg_last_query_id();
```

To use the resulting reconstructed SQL in your client, replace any (\n) special characters with a new line.

```
                      text
-------------------------------------------------------------------------------------------------
 select\n1 AS a01234567890123456789012345678901234567890123456789012345678901234567890,
\n2 AS b01234567890123456789012345678901234567890123456789012345678901234567890,\n3 AS
 b012345678901234567890123456789012345678901234\nFROM stl_querytext;
```

STL_REPLACEMENTS

Displays a log that records when invalid UTF-8 characters were replaced by the COPY command with the ACCEPTINVCHARS option. A log entry is added to STL_REPLACEMENTS for each of the first 100 rows on each node slice that required at least one replacement.

STL_REPLACEMENTS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_NESTLOOP only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_COPY_REPLACEMENTS . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Node slice number where the replacement occurred.
tbl	integer	Table ID.
starttime	timestamp	Start time in UTC for the COPY command.
session	integer	Session ID for the session performing the COPY command.
filename	character (256)	Complete path to the input file for the COPY command.
line_number	bigint	Line number in the input data file that contained an invalid UTF-8 character. A -1 indicates that the line number is not available, such as, when copying from a columnar data file.
colname	character (127)	First field that contained an invalid UTF-8 character.
raw_line	character (1024)	Raw load data that contained an invalid UTF-8 character.

Sample queries

The following example returns replacements for the most recent COPY operation.

```
select query, session, filename, line_number, colname
from stl_replacements
where query = pg_last_copy_id();

 query | session |   filename                                        | line_number | colname
 ------+---------+---------------------------------------------------+-------------+--------
```

```
    96 |     6314 | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt   |          251 | city
    96 |     6314 | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt   |          317 | city
    96 |     6314 | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt   |          569 | city
    96 |     6314 | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt   |          623 | city
    96 |     6314 | s3://DOC-EXAMPLE-BUCKET/allusers_pipe.txt   |          694 | city
...
```

STL_RESTARTED_SESSIONS

To maintain continuous availability following certain internal events, Amazon Redshift might restart an active session with a new process ID (PID). When Amazon Redshift restarts a session, STL_RESTARTED_SESSIONS records the new PID and the old PID.

For more information, see the examples following in this section.

STL_RESTARTED_SESSIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_SESSION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
currenttime	timestamp	Time of the event.
dbname	character (50)	Name of the database associated with the session.
newpid	integer	Process ID for the restarted session.
oldpid	integer	Process ID for the original session.
username	character (50)	Name of the user associated with the session.
remotehost	character (45)	Name or IP address of the remote host.

Column name	Data type	Description
remoteport	character (32)	Port number of the remote host.
parkedtime	timestamp	This information is for internal use only.
session_vars	character (2000)	This information is for internal use only.

Sample queries

The following example joins STL_RESTARTED_SESSIONS with STL_SESSIONS to show user names for sessions that have been restarted.

```
select process, stl_restarted_sessions.newpid, user_name
from stl_sessions
inner join stl_restarted_sessions on stl_sessions.process =
 stl_restarted_sessions.oldpid
order by process;

...
```

STL_RETURN

Contains details for *return* steps in queries. A return step returns the results of queries completed on the compute nodes to the leader node. The leader node then merges the data and returns the results to the requesting client. For queries completed on the leader node, a return step returns results to the client.

A query consists of multiple segments, and each segment consists of one or more steps. For more information, see Query processing.

STL_RETURN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_RETURN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
packets	integer	Total number of packets sent over the network.
checksum	bigint	This information is for internal use only.

Sample queries

The following query shows which steps in the most recent query were performed on each slice.

```
SELECT query, slice, segment, step, endtime, rows, packets
from stl_return where query = pg_last_query_id();

 query |  slice | segment | step |          endtime           | rows | packets
-------+--------+---------+------+----------------------------+------+---------
     4 |      2 |       3 |    2 | 2013-12-27 01:43:21.469043 |    3 |       0
     4 |      3 |       3 |    2 | 2013-12-27 01:43:21.473321 |    0 |       0
     4 |      0 |       3 |    2 | 2013-12-27 01:43:21.469118 |    2 |       0
     4 |      1 |       3 |    2 | 2013-12-27 01:43:21.474196 |    0 |       0
     4 |      4 |       3 |    2 | 2013-12-27 01:43:21.47704  |    2 |       0
     4 |      5 |       3 |    2 | 2013-12-27 01:43:21.478593 |    0 |       0
     4 |   12811|       4 |    1 | 2013-12-27 01:43:21.480755 |    0 |       0
(7 rows)
```

STL_S3CLIENT

Records transfer time and other performance metrics.

Use the STL_S3CLIENT table to find the time spent transferring data from Amazon S3.

STL_S3CLIENT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
recordtime	timestamp	Time the record is logged.

Column name	Data type	Description
pid	integer	Process ID. All of the queries in a session are run in the same process, so this value remains constant if you run a series of queries in the same session.
http_method	character (64)	HTTP method name corresponding to the Amazon S3 request.
bucket	character (64)	S3 bucket name.
key	character (256)	Key corresponding to the Amazon S3 object.
transfer_size	bigint	Number of bytes transferred.
data_size	bigint	Number of bytes of data. This value is the same as transfer_size for uncompressed data. If compression was used, this is the size of the uncompressed data.
start_time	bigint	Time when the transfer began (in microseconds since January 1, 2000).
end_time	bigint	Time when the transfer ended (in microseconds since January 1, 2000).
transfer_time	bigint	Time taken by the transfer (in microseconds).
compression_time	bigint	Portion of the transfer time that was spent uncompressing data (in microseconds).
connect_time	bigint	Time from the start until the connect to the remote server was completed (in microseconds).
app_connect_time	bigint	Time from the start until the SSL connect/handshake with the remote host was completed (in microseconds).
retries	bigint	Number of times the transfer was retried.

Column name	Data type	Description
request_id	char(32)	Request ID from Amazon S3 HTTP response header
extended_ request_id	char(128)	Extended request ID from Amazon S3 HTTP header response (x-amz-id-2).
ip_address	char(64)	IP address of the server (ip V4 or V6).
is_partial	integer	Value that if true (1) indicates the input file is split into ranges during a COPY operation. If this value is false (0), the input file isn't split.
start_offset	bigint	Value that, if the input file is split during a COPY operation , indicates the offset value of the split (in bytes). If the file isn't split, this value is 0.

Sample query

The following query returns the time taken to load files using a COPY command.

```
select slice, key, transfer_time
from stl_s3client
where query = pg_last_copy_id();
```

Result

```
 slice |   key                         | transfer_time
-------+-------------------------------+---------------
     0 | listing10M0003_part_00        |    16626716
     1 | listing10M0001_part_00        |    12894494
     2 | listing10M0002_part_00        |    14320978
     3 | listing10M0000_part_00        |    11293439
  3371 | prefix=listing10M;marker=     |       99395
```

The following query converts the `start_time` and `end_time` to a timestamp.

```
select userid,query,slice,pid,recordtime,start_time,end_time,
'2000-01-01'::timestamp + (start_time/1000000.0)* interval '1 second' as start_ts,
'2000-01-01'::timestamp + (end_time/1000000.0)* interval '1 second' as end_ts
```

```
from stl_s3client where query> -1 limit 5;
```

```
 userid | query | slice |  pid  |         recordtime         |   start_time    |
 end_time     |          start_ts          |           end_ts
--------+-------+-------+-------+----------------------------+-----------------
+-----------------+----------------------------+----------------------------
      0 |     0 |     0 | 23449 | 2019-07-14 16:27:17.207839 | 616436837154256 |
 616436837207838 | 2019-07-14 16:27:17.154256 | 2019-07-14 16:27:17.207838
      0 |     0 |     0 | 23449 | 2019-07-14 16:27:17.252521 | 616436837208208 |
 616436837252520 | 2019-07-14 16:27:17.208208 | 2019-07-14 16:27:17.25252
      0 |     0 |     0 | 23449 | 2019-07-14 16:27:17.284376 | 616436837208460 |
 616436837284374 | 2019-07-14 16:27:17.20846  | 2019-07-14 16:27:17.284374
      0 |     0 |     0 | 23449 | 2019-07-14 16:27:17.285307 | 616436837208980 |
 616436837285306 | 2019-07-14 16:27:17.20898  | 2019-07-14 16:27:17.285306
      0 |     0 |     0 | 23449 | 2019-07-14 16:27:17.353853 | 616436837302216 |
 616436837353851 | 2019-07-14 16:27:17.302216 | 2019-07-14 16:27:17.353851
```

STL_S3CLIENT_ERROR

Records errors encountered by a slice while loading a file from Amazon S3.

Use the STL_S3CLIENT_ERROR to find details for errors encountered while transferring data from Amazon S3 as part of a COPY command.

STL_S3CLIENT_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views. The query ID -1 is for internal use.
sliceid	integer	Number that identifies the slice where the query was running.

Column name	Data type	Description
recordtime	timestamp	Time the record is logged.
pid	integer	Process ID. All of the queries in a session are run in the same process, so this value remains constant if you run a series of queries in the same session.
http_method	character (64)	HTTP method name corresponding to the Amazon S3 request.
bucket	character (64)	Amazon S3 bucket name.
key	character (256)	Key corresponding to the Amazon S3 object.
error	character (1024)	Error message.
is_partial	integer	Value that, if true (1), indicates the input file is split into ranges during a COPY operation. If this value is false (0), the input file isn't split.
start_offset	bigint	Value that, if the input file is split during a COPY operation , indicates the offset value of the split (in bytes). If the file isn't split, this value is 0.

Usage notes

If you see multiple errors with "Connection timed out", you might have a networking issue. If you're using Enhanced VPC Routing, verify that you have a valid network path between your cluster's VPC and your data resources. For more information, see Amazon Redshift Enhanced VPC Routing.

Sample query

The following query returns the errors from COPY commands completed during the current session.

```
select query, sliceid, substring(key from 1 for 20) as file,
```

```
substring(error from 1 for 35) as error
from stl_s3client_error
where pid = pg_backend_pid()
order by query desc;
```

Result

```
 query  | sliceid |     file           |              error

--------+---------+--------------------+------------------------------------
 362228 |      12 | part.tbl.25.159.gz | transfer closed with 1947655 bytes
 362228 |      24 | part.tbl.15.577.gz | transfer closed with 1881910 bytes
 362228 |       7 | part.tbl.22.600.gz | transfer closed with 700143 bytes r
 362228 |      22 | part.tbl.3.34.gz   | transfer closed with 2334528 bytes
 362228 |      11 | part.tbl.30.274.gz | transfer closed with 699031 bytes r
 362228 |      30 | part.tbl.5.509.gz  | Unknown SSL protocol error in conne
 361999 |      10 | part.tbl.23.305.gz | transfer closed with 698959 bytes r
 361999 |      19 | part.tbl.26.582.gz | transfer closed with 1881458 bytes
 361999 |       4 | part.tbl.15.629.gz | transfer closed with 2275907 bytes
 361999 |      20 | part.tbl.6.456.gz  | transfer closed with 692162 bytes r
(10 rows)
```

STL_SAVE

Contains details for *save* steps in queries. A save step saves the input stream to a transient table. A transient table is a temporary table that stores intermediate results during query execution.

A query consists of multiple segments, and each segment consists of one or more steps. For more information, see Query processing.

STL_SAVE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_SAVE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
tbl	integer	ID of the materialized transient table.
is_diskbased	character(1)	Whether this step of the query was performed as a disk-based operation: true (`t`) or false (`f`).
workmem	bigint	Number of bytes of working memory assigned to the step.

Sample queries

The following query shows which save steps in the most recent query were performed on each slice.

```
select query, slice, segment, step, tasknum, rows,  tbl
from stl_save where query = pg_last_query_id();

 query | slice | segment | step | tasknum | rows | tbl
-------+-------+---------+------+---------+------+-----
 52236 |     3 |       0 |    2 |      21 |    0 | 239
 52236 |     2 |       0 |    2 |      20 |    0 | 239
 52236 |     2 |       2 |    2 |      20 |    0 | 239
 52236 |     3 |       2 |    2 |      21 |    0 | 239
 52236 |     1 |       0 |    2 |      21 |    0 | 239
 52236 |     0 |       0 |    2 |      20 |    0 | 239
 52236 |     0 |       2 |    2 |      20 |    0 | 239
 52236 |     1 |       2 |    2 |      21 |    0 | 239
(8 rows)
```

STL_SCAN

Analyzes table scan steps for queries. The step number for rows in this table is always 0 because a scan is the first step in a segment.

STL_SCAN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_SCAN only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
fetches	bigint	This information is for internal use only.
type	integer	ID of the scan type. For a list of valid values, see the following table.
tbl	integer	Table ID.

Column name	Data type	Description
is_rrscan	character(1)	If true (t), indicates that range-restricted scan was used on the step.
is_delayed_scan	character(1)	This information is for internal use only.
rows_pre_filter	bigint	For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters.
rows_pre_user_filter	bigint	For scans of permanent tables, the number of rows processed after filtering rows marked for deletion (ghost rows) but before applying user-defined query filters.
perm_table_name	character(136)	For scans of permanent tables, the name of the table scanned.
is_rlf_scan	character(1)	If true (t), indicates that row-level filtering was used on the step.
is_rlf_scan_reason	integer	This information is for internal use only.
num_em_blocks	integer	This information is for internal use only.
checksum	bigint	This information is for internal use only.
runtime_filtering	character(1)	If true (t), indicates that runtime filters are applied.
scan_region	integer	This information is for internal use only.

Column name	Data type	Description
num_sortkey_as_predicate	integer	This information is for internal use only.
row_fetcher_state	integer	This information is for internal use only.
consumed_scan_ranges	bigint	This information is for internal use only.
work_stealing_reason	bigint	This information is for internal use only.
is_vectorized_scan	character(1)	This information is for internal use only.
is_vectorized_scan_reason	integer	This information is for internal use only.
row_fetcher_reason	bigint	This information is for internal use only.
topology_signature	bigint	This information is for internal use only.
use_tpm_partition	character(1)	This information is for internal use only.
is_rrscan_expr	character(1)	This information is for internal use only.

Column name	Data type	Description
scanned_mega_value	character(1)	This information is for internal use only. This information shows whether the given scan step has scanned a large value. A large value will be stored in multiple blocks. Block size is 1 MB by default, a large value is greater than 1 MB in a default setting.

Scan types

Type ID	Description
1	Data from the network.
2	Permanent user tables in compressed shared memory.
3	Transient row-wise tables.
21	Load files from Amazon S3.
22	Load tables from Amazon DynamoDB.
23	Load data from a remote SSH connection.
24	Load data from remote cluster (sorted region). This is used for resizing.
25	Load data from remote cluster(unsorted region). This is used for resizing.
28	Read data from a time series view with UNION ALL on multiple tables.
29	Read data from Amazon S3 external tables.
30	Read partition information of an Amazon S3 external table.
33	Read data from a remote Postgres table.
36	Read data from a remote MySQL table.
37	Read data from a remote Kinesis stream.

Usage notes

Ideally rows should be relatively close to rows_pre_filter. A large difference between rows and rows_pre_filter is an indication that the execution engine is scanning rows that are later discarded, which is inefficient. The difference between rows_pre_filter and rows_pre_user_filter is the number of ghost rows in the scan. Run a VACUUM to remove rows marked for deletion. The difference between rows and rows_pre_user_filter is the number of rows filtered by the query. If a lot of rows are discarded by the user filter, review your choice of sort column or, if this is due to a large unsorted region, run a vacuum.

Sample queries

The following example shows that rows_pre_filter is larger than rows_pre_user_filter because the table has deleted rows that have not been vacuumed (ghost rows).

```
SELECT query, slice, segment,step,rows, rows_pre_filter, rows_pre_user_filter
from stl_scan where query = pg_last_query_id();

 query |  slice | segment | step | rows   | rows_pre_filter | rows_pre_user_filter
-------+--------+---------+------+-------+-----------------+----------------------
 42915 |      0 |       0 |    0 | 43159 |           86318 |                43159
 42915 |      0 |       1 |    0 |     1 |               0 |                    0
 42915 |      1 |       0 |    0 | 43091 |           86182 |                43091
 42915 |      1 |       1 |    0 |     1 |               0 |                    0
 42915 |      2 |       0 |    0 | 42778 |           85556 |                42778
 42915 |      2 |       1 |    0 |     1 |               0 |                    0
 42915 |      3 |       0 |    0 | 43428 |           86856 |                43428
 42915 |      3 |       1 |    0 |     1 |               0 |                    0
 42915 |  10000 |       2 |    0 |     4 |               0 |                    0
(9 rows)
```

STL_SCHEMA_QUOTA_VIOLATIONS

Records the occurrence, timestamp, XID, and other useful information when a schema quota is exceeded.

STL_SCHEMA_QUOTA_VIOLATIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_SCHEMA_QUOTA_VIOLATIONS. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
ownerid	integer	The ID of the schema owner.
xid	bigint	The transaction ID associated with the statement.
pid	integer	The process ID associated with the statement.
userid	integer	The ID of the user who generated the entry.
schema_id	integer	The namespace or schema ID.
schema_name	character (128)	The namespace or schema name.
quota	integer	The amount of disk space (in MB) that the schema can use.
disk_usage	integer	The disk space (in MB) that is currently used by the schema.
disk_usage_pct	double precision	The disk space percentage that is currently used by the schema out of the configured quota.
timestamp	timestamp without time zone	The time when the violation occurred.

Sample queries

The following query shows the result of quota violation:

```
SELECT userid, TRIM(SCHEMA_NAME) "schema_name", quota, disk_usage, disk_usage_pct,
 timestamp FROM
stl_schema_quota_violations WHERE SCHEMA_NAME = 'sales_schema' ORDER BY timestamp DESC;
```

This query returns the following sample output for the specified schema:

```
userid | schema_name   | quota | disk_usage | disk_usage_pct |timestamp
-------+--------------+-------+------------+----------------
+----------------------------
104    | sales_schema | 2048  | 2798       |  136.62        | 2020-04-20
 20:09:25.494723
(1 row)
```

STL_SESSIONS

Returns information about user session history.

STL_SESSIONS differs from STV_SESSIONS in that STL_SESSIONS contains session history, where STV_SESSIONS contains the current active sessions.

STL_SESSIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_SESSION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
starttime	timestamp	Time in UTC that the session started.
endtime	timestamp	Time in UTC that the session ended.
process	integer	Process ID for the session.
user_name	character(50)	User name associated with the session.
db_name	character(50)	Name of the database associated with the session.

Column name	Data type	Description
timeout_sec	int	The maximum time in seconds that a session remains inactive or idle before timing out. 0 indicates that no timeout is set.
timed_out	int	A value that indicates why the connection was terminated. It can have the following values: • `0`: The connection was terminated due to an unknown error. • 1: The connection timed out. • 2: The client side terminated the connection. • 3: An Amazon Redshift backend internal error terminated the connection.

Sample queries

To view session history for the TICKIT database, type the following query:

```
select starttime, process, user_name, timeout_sec, timed_out
from stl_sessions
where db_name='tickit' order by starttime;
```

This query returns the following sample output:

```

    starttime              | process |  user_name             | timeout_sec | timed_out
---------------------------+---------+------------------------+-------------
+-------------
2008-09-15 09:54:06.746705 |   32358 | dwuser                 | 120         | 1
2008-09-15 09:56:34.30275  |   32744 | dwuser                 | 60          | 1
2008-09-15 11:20:34.694837 |   14906 | dwuser                 | 0           | 0
2008-09-15 11:22:16.749818 |   15148 | dwuser                 | 0           | 0
2008-09-15 14:32:44.66112  |   14031 | dwuser                 | 0           | 0
2008-09-15 14:56:30.22161  |   18380 | dwuser                 | 0           | 0
2008-09-15 15:28:32.509354 |   24344 | dwuser                 | 0           | 0
2008-09-15 16:01:00.557326 |   30153 | dwuser                 | 120         | 1
```

```
2008-09-15 17:28:21.419858 |   12805 | dwuser                   | 0             | 0
2008-09-15 20:58:37.601937 |   14951 | dwuser                   | 60            | 1
2008-09-16 11:12:30.960564 |   27437 | dwuser                   | 60            | 1
2008-09-16 14:11:37.639092 |   23790 | dwuser                   | 3600          | 1
2008-09-16 15:13:46.02195  |    1355 | dwuser                   | 120           | 1
2008-09-16 15:22:36.515106 |    2878 | dwuser                   | 120           | 1
2008-09-16 15:44:39.194579 |    6470 | dwuser                   | 120           | 1
2008-09-16 16:50:27.02138  |   17254 | dwuser                   | 120           | 1
2008-09-17 12:05:02.157208 |    8439 | dwuser                   | 3600          | 0
(17 rows)
```

STL_SORT

Displays sort execution steps for queries, such as steps that use ORDER BY processing.

STL_SORT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_SORT only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.

Column name	Data type	Description
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
bytes	bigint	Size, in bytes, of all the output rows for the step.
tbl	integer	Table ID.
is_diskbased	character(1)	If true (t), the query was performed as a disk-based operation. If false (f), the query was performed in memory.
workmem	bigint	Total number of bytes in working memory that were assigned to the step.
checksum	bigint	This information is for internal use only.

Sample queries

The following example returns sort results for slice 0 and segment 1.

```
select query, bytes, tbl, is_diskbased, workmem
from stl_sort
where slice=0 and segment=1;
```

```
 query |  bytes   | tbl | is_diskbased |  workmem
-------+---------+-----+--------------+-----------
   567 | 3126968 | 241 | f            | 383385600
   604 |    5292 | 242 | f            | 383385600
   675 |  104776 | 251 | f            | 383385600
   525 | 3126968 | 251 | f            | 383385600
   585 |    5068 | 241 | f            | 383385600
   630 |  204808 | 266 | f            | 383385600
   704 |       0 | 242 | f            |         0
   669 | 4606416 | 241 | f            | 383385600
   696 |  104776 | 241 | f            | 383385600
   651 | 4606416 | 254 | f            | 383385600
   632 |       0 | 256 | f            |         0
   599 |     396 | 241 | f            | 383385600
 86397 |       0 | 242 | f            |         0
   621 |    5292 | 241 | f            | 383385600
 86325 |       0 | 242 | f            |         0
   572 |    5068 | 242 | f            | 383385600
   645 |  204808 | 241 | f            | 383385600
   590 |     396 | 242 | f            | 383385600
(18 rows)
```

STL_SSHCLIENT_ERROR

Records all errors seen by the SSH client.

STL_SSHCLIENT_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.

Column name	Data type	Description
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
recordtime	timestamp	Time that the error was logged.
pid	integer	Process that logged the error.
ssh_username	character (1024)	The SSH user name.
endpoint	character (1024)	The SSH endpoint.
command	character (4096)	The complete SSH command.
error	character (1024)	The error message.

STL_STREAM_SEGS

Lists the relationship between streams and concurrent segments.

Streams in this context are Amazon Redshift streams. This system view doesn't pertain to Streaming ingestion to a materialized view.

STL_STREAM_SEGS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
> STL_STREAM_SEGS only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view

SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
stream	integer	The set of concurrent segments of a query.
segment	integer	Number that identifies the query segment.

Sample queries

To view the relationship between streams and concurrent segments for the most recent query, type the following query:

```
select *
from stl_stream_segs
where query = pg_last_query_id();

 query | stream | segment
-------+--------+---------
    10 |      1 |       2
    10 |      0 |       0
    10 |      2 |       4
    10 |      1 |       3
    10 |      0 |       1
(5 rows)
```

STL_TR_CONFLICT

Displays information to identify and resolve transaction conflicts with database tables.

A transaction conflict occurs when two or more users are querying and modifying data rows from tables such that their transactions cannot be serialized. The transaction that runs a statement that would break serializability is stopped and rolled back. Every time a transaction conflict occurs, Amazon Redshift writes a data row to the STL_TR_CONFLICT system table containing details about the canceled transaction. For more information, see Serializable isolation.

STL_TR_CONFLICT is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_TRANSACTION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
xact_id	bigint	Transaction ID for the rolled back transaction.
process_id	bigint	Process associated with the transaction that was rolled back.
xact_start_ts	timestamp	Timestamp (UTC) when the transaction started.
abort_time	timestamp	Timestamp (UTC) when the transaction was stopped.
table_id	bigint	Table ID for the table where the conflict occurred.

Sample query

To return information about conflicts that involved a particular table, run a query that specifies the table ID:

```
select * from stl_tr_conflict where table_id=100234
order by xact_start_ts;

xact_id|process_|      xact_start_ts       |        abort_time        |table_
```

```
       |id      |                          |                          |id
-------+--------+--------------------------+--------------------------+------
  1876 |  8551  |2010-03-30 09:19:15.852326|2010-03-30 09:20:17.582499|100234
  1928 | 15034  |2010-03-30 13:20:00.636045|2010-03-30 13:20:47.766817|100234
  1991 | 23753  |2010-04-01 13:05:01.220059|2010-04-01 13:06:06.94098 |100234
  2002 | 23679  |2010-04-01 13:17:05.173473|2010-04-01 13:18:27.898655|100234
(4 rows)
```

You can get the table ID from the DETAIL section of the error message for serializability violations (error 1023).

STL_UNDONE

Displays information about transactions that have been undone.

STL_UNDONE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_TRANSACTION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
xact_id	bigint	ID for the undo transaction.
xact_id_undone	bigint	ID for the transaction that was undone.
undo_start_ts	timestamp	Start time for the undo transaction.
undo_end_ts	timestamp	End time for the undo transaction.
table_id	bigint	ID for the table that was affected by the undo transaction.

Sample query

To view a concise log of all undone transactions, type the following command:

```
select xact_id, xact_id_undone, table_id from stl_undone;
```

This command returns the following sample output:

```
 xact_id | xact_id_undone | table_id
---------+----------------+----------
1344 |           1344 |   100192
1326 |           1326 |   100192
1551 |           1551 |   100192
(3 rows)
```

STL_UNIQUE

Analyzes execution steps that occur when a DISTINCT function is used in the SELECT list or when duplicates are removed in a UNION or INTERSECT query.

STL_UNIQUE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_UNIQUE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.

Column name	Data type	Description
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
`type`	character(6)	The type of step. Valid values are: • HASHED. Indicates that the step used grouped, unsorted aggregation. • PLAIN. Indicates that the step used ungrouped, scalar aggregation. • SORTED. Indicates that the step used grouped, sorted aggregation.

Column name	Data type	Description
is_diskbased	character(1)	If true (t), the query was performed as a disk-based operation. If false (f), the query was performed in memory.
slots	integer	Total number of hash buckets.
workmem	bigint	Total number of bytes in working memory that were assigned to the step.
max_buffers_used	bigint	Maximum number of buffers used in the hash table before going to disk.
resizes	integer	This information is for internal use only.
occupied	integer	This information is for internal use only.
flushable	integer	This information is for internal use only.
used_unique_prefetching	character(1)	This information is for internal use only.
bytes	biginit	The number of bytes of all the output rows for the step.

Sample queries

Suppose you run the following query:

```
select distinct eventname
from event order by 1;
```

Assuming the ID for the previous query is 6313, the following example shows the number of rows produced by the unique step for each slice in segments 0 and 1.

```
select query, slice, segment, step, datediff(msec, starttime, endtime) as msec,
 tasknum, rows
from stl_unique where query = 6313
```

```
order by query desc, slice, segment, step;
```

```
 query | slice | segment | step | msec | tasknum | rows
-------+-------+---------+------+------+---------+------
  6313 |     0 |       0 |    2 |    0 |      22 |  550
  6313 |     0 |       1 |    1 |  256 |      20 |  145
  6313 |     1 |       0 |    2 |    1 |      23 |  540
  6313 |     1 |       1 |    1 |   42 |      21 |  127
  6313 |     2 |       0 |    2 |    1 |      22 |  540
  6313 |     2 |       1 |    1 |  255 |      20 |  158
  6313 |     3 |       0 |    2 |    1 |      23 |  542
  6313 |     3 |       1 |    1 |   38 |      21 |  146
(8 rows)
```

STL_UNLOAD_LOG

Records the details for an unload operation.

STL_UNLOAD_LOG records one row for each file created by an UNLOAD statement. For example, if an UNLOAD creates 12 files, STL_UNLOAD_LOG will contain 12 corresponding rows.

STL_UNLOAD_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STL_UNLOAD_LOG only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_UNLOAD_HISTORY and SYS_UNLOAD_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.

Column name	Data type	Description
query	integer	The query ID.
slice	integer	Number that identifies the slice where the query was running.
pid	integer	Process ID associated with the query statement.
path	character(1280)	The complete Amazon S3 object path for the file.
start_time	timestamp	Start time for the transaction.
end_time	timestamp	End time for the transaction.
line_count	bigint	Number of lines (rows) unloaded to the file.
transfer_size	bigint	Number of bytes transferred.
file_format	character(10)	Format of unloaded file.

Sample query

To get a list of the files that were written to Amazon S3 by an UNLOAD command, you can call an Amazon S3 list operation after the UNLOAD completes. You can also query STL_UNLOAD_LOG.

The following query returns the pathname for files that were created by an UNLOAD for the last query completed:

```
select query, substring(path,0,40) as path
from stl_unload_log
where query = pg_last_query_id()
order by path;
```

This command returns the following sample output:

```
 query |             path
```

```
-------+-------------------------------------
  2320 | s3://amzn-s3-demo-bucket/venue0000_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0001_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0002_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0003_part_00
(4 rows)
```

STL_USAGE_CONTROL

The STL_USAGE_CONTROL view contains information that is logged when a usage limit is reached. For more information about usage limits, see Managing Usage Limits in the *Amazon Redshift Management Guide*.

STL_USAGE_CONTROL is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
eventtime	timestamp	The time (UTC) when the query exceeded a usage limit.
query	integer	The query identifier. You can use this ID to join various other system tables and views.
xid	bigint	The transaction identifier.
pid	integer	The process identifier associated with the query.
usage_limit_id	character(40)	A universally unique identifier (UUID) generated by Amazon Redshift, for example `25d9297e-3e7b-41c8-9f4d-c4b6eb731c09`.
feature_type	character(30)	The feature whose usage limit was exceeded. Possible values include `CONCURRENCY_SCALING` and `SPECTRUM`.

Sample query

The following SQL example returns some of the information logged when a usage limit is reached.

```
select query, pid, eventtime, feature_type
from stl_usage_control
order by eventtime desc
limit 5;
```

STL_USERLOG

Records details for the following changes to a database user:

- Create user
- Drop user
- Alter user (rename)
- Alter user (alter properties)

STL_USERLOG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_USERLOG. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user affected by the change.
username	character(50)	User name of the user affected by the change.
oldusername	character(50)	For a rename action, the original user name. For any other action, this field is empty.
action	character(10)	Action that occurred. Valid values: • Alter

Column name	Data type	Description
		• Create • Drop • Rename
usecreatedb	integer	If true (1), indicates that the user has create database privileges.
usesuper	integer	If true (1), indicates that the user is a superuser.
usecatupd	integer	If true (1), indicates that the user can update system catalogs.
valuntil	timestamp	Password expiration date.
pid	integer	Process ID.
xid	bigint	Transaction ID.
recordtime	timestamp	Time in UTC that the query started.

Sample queries

The following example performs four user actions, then queries the STL_USERLOG view.

```
create user userlog1 password 'Userlog1';
alter user userlog1 createdb createuser;
alter user userlog1 rename  to userlog2;
drop user userlog2;

select userid, username, oldusername, action, usecreatedb, usesuper from stl_userlog
 order by recordtime desc;
```

```
 userid |  username | oldusername |  action | usecreatedb | usesuper
--------+-----------+-------------+---------+-------------+----------
```

```
    108 | userlog2  |              | drop     |          1 |   1
    108 | userlog2  | userlog1     | rename   |          1 |   1
    108 | userlog1  |              | alter    |          1 |   1
    108 | userlog1  |              | create   |          0 |   0
 (4 rows)
```

STL_UTILITYTEXT

Captures the text of non-SELECT SQL commands run on the database.

Query the STL_UTILITYTEXT view to capture the following subset of SQL statements that were run on the system:

- ABORT, BEGIN, COMMIT, END, ROLLBACK
- ANALYZE
- CALL
- CANCEL
- COMMENT
- CREATE, ALTER, DROP DATABASE
- CREATE, ALTER, DROP USER
- EXPLAIN
- GRANT, REVOKE
- LOCK
- RESET
- SET
- SHOW
- TRUNCATE

See also STL_DDLTEXT, STL_QUERYTEXT, and SVL_STATEMENTTEXT.

Use the STARTTIME and ENDTIME columns to find out which statements were logged during a given time period. Long blocks of SQL text are broken into lines 200 characters long; the SEQUENCE column identifies fragments of text that belong to a single statement.

STL_UTILITYTEXT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
xid	bigint	Transaction ID.
pid	integer	Process ID associated with the query statement.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field is blank.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
sequence	integer	When a single statement contains more than 200 characters, additional rows are logged for that statement. Sequence 0 is the first row, 1 is the second, and so on.
text	character(200)	SQL text, in 200-character increments. This field might contain special characters such as backslash (\\) and newline (\n).

Sample queries

The following query returns the text for "utility" commands that were run on January 26th, 2012. In this case, some SET commands and a SHOW ALL command were run:

```
select starttime, sequence, rtrim(text)
from stl_utilitytext
where starttime like '2012-01-26%'
order by starttime, sequence;

starttime          | sequence |              rtrim
---------------------------+-----+----------------------------------
2012-01-26 13:05:52.529235 |   0 | show all;
2012-01-26 13:20:31.660255 |   0 | SET query_group to ''
2012-01-26 13:20:54.956131 |   0 | SET query_group to 'soldunsold.sql'
...
```

Reconstructing Stored SQL

To reconstruct the SQL stored in the `text` column of STL_UTILITYTEXT, run a SELECT statement to create SQL from 1 or more parts in the `text` column. Before running the reconstructed SQL, replace any (\n) special characters with a new line. The result of the following SELECT statement is rows of reconstructed SQL in the `query_statement` field.

```
SELECT LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END) WITHIN
 GROUP (ORDER BY sequence) as query_statement
FROM stl_utilitytext GROUP BY xid order by xid;
```

For example, the following query sets the query_group to a string of zeros. The query itself is longer than 200 characters and is stored in parts in STL_UTILITYTEXT.

```
set query_group to
 '00000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000
             000000';
```

In this example, the query is stored in 2 parts (rows) in the `text` column of STL_UTILITYTEXT.

```
select query, sequence, text
from stl_utilitytext where query=pg_last_query_id() order by query desc, sequence limit
 10;
```

```
        starttime          | sequence |
                                          text

----------------------------+----------
+-----------------------------------------------------------------------------------------------
 2019-07-23 22:55:34.926198 |        0 | set query_group to
 '00000000000000000000000000000000000000000000000000000000000000000000000000000000\n00000000000
 2019-07-23 22:55:34.926198 |        1 |                   000000';
```

To reconstruct the SQL stored in STL_UTILITYTEXT, run the following SQL.

```
select LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END, '')
 within group (order by sequence) AS query_statement
from stl_utilitytext where query=pg_last_query_id();
```

To use the resulting reconstructed SQL in your client, replace any (\n) special characters with a new line.

```
                                               query_statement


-----------------------------------------------------------------------------------------------
 set query_group to
 '00000000000000000000000000000000000000000000000000000000000000000000000000000000\n00000000000
                  000000';
```

STL_VACUUM

Displays row and block statistics for tables that have been vacuumed.

The view shows information specific to when each vacuum operation started and finished, and demonstrates the benefits of running the operation. For information about the requirements for running this command, see the VACUUM command description.

STL_VACUUM is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_VACUUM_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who generated the entry.
xid	bigint	The transaction ID for the VACUUM statement. You can join this table to the STL_QUERY view to see the individual SQL statements that are run for a given VACUUM transaction. If you vacuum the whole database, each table is vacuumed in a separate transacti on.
table_id	integer	The Table ID.
status	character(30)	The status of the VACUUM operation for each table. Possible values are the following: • **`Started`** • **`Started Delete Only`** • **`Started Delete Only (Sorted >= nn%)`** Only the delete phase was started for a VACUUM FULL. The sort phase was skipped because the table was already sorted at or above the sort threshold. • **`Started Sort Only`** • **`Started Ranged Partition`** • **`Started Reindex`** • **`Finished`** Time the operation completed for the table. To find out how long a vacuum operation took on a specific table, subtract the Started time from the Finished time for a particular transaction ID and table ID.

Column name	Data type	Description
		• **`Skipped`** The table was skipped because the table was fully sorted and no rows were marked for deletion. • **`Skipped (delete only)`** The table was skipped because DELETE ONLY was specified and no rows were marked for deletion. • **`Skipped (sort only)`** The table was skipped because SORT ONLY was specified and the table was already sorted fully sorted. • **`Skipped (sort only, sorted>=xx%)`** The table was skipped because SORT ONLY was specified and the table was already sorted at or above the sort threshold. • **`Skipped (0 rows)`** The table was skipped because it was empty. • **`VacuumBG`** An automatic vacuum operation was performed in the background. This status is prepended to other statuses when they're performed automatic ally. For example, a delete only vacuum performed automatically would have a starting row with the status `[VacuumBG] Started Delete Only` . For more information about the VACUUM sort threshold setting, see VACUUM.

Column name	Data type	Description
rows	bigint	The actual number of rows in the table plus any deleted rows that are still stored on disk (waiting to be vacuumed). This column shows the count before the vacuum started for rows with a **Started** status, and the count after the vacuum for rows with a **Finished** status.
sortedrows	integer	The number of rows in the table that are sorted. This column shows the count before the vacuum started for rows with **Started** in the Status column, and the count after the vacuum for rows with **Finished** in the Status column.
blocks	integer	The total number of data blocks used to store the table data before the vacuum operation (rows with a **Started** status) and after the vacuum operation (**Finished** column). Each data block uses 1 MB.
max_merge_partitions	integer	This column is used for performance analysis and represents the maximum number of partitions that vacuum can process for the table per merge phase iteration. (Vacuum sorts the unsorted region into one or more sorted partitions. Depending on the number of columns in the table and the current Amazon Redshift configuration, the merge phase can process a maximum number of partitions in a single merge iteration. The merge phase will still work if the number of sorted partitions exceeds the maximum number of merge partitions, but more merge iterations will be required.)
eventtime	timestamp	When the vacuum operation started or finished.

Column name	Data type	Description
reclaimable_rows	bigint	The number of reclaimable rows for the current cutoff_xid. This column shows Redshift's estimated number of reclaimable rows before the vacuum started for rows with a **Started** status, and the actual number of reclaimable rows remaining after the vacuum for rows with a **Finished** status.
reclaimable_space_mb	bigint	Reclaimable space in MB for the current cutoff_xid. This column shows Redshift's estimated amount of reclaimable space before the vacuum started for rows with a **Started** status, and the actual amount of reclaimable space remaining after the vacuum for rows with a **Finished** status.
cutoff_xid	bigint	The cutoff transaction ID for the VACUUM operation. Any transactions after the cutoff are not included in the VACUUM operation.
is_recluster	integer	If 1 (true), the VACUUM operation executed the recluster algorithm, If 0 (false), it was not.

Sample queries

The following query reports vacuum statistics for table 108313. The table was vacuumed following a series of inserts and deletes.

```
select xid, table_id, status, rows, sortedrows, blocks, eventtime,
                reclaimable_rows, reclaimable_space_mb
from stl_vacuum where table_id=108313 order by eventtime;

 xid   | table_id | status                  | rows | sortedrows | blocks |  eventtime
         | reclaimable_rows | reclaimable_space_mb
-------+----------+-------------------------+------+------------+--------
+---------------------+------------------+----------------------
 14294 |   108313 | Started                 | 1950 |        408 |     28 |  2016-05-19
 17:36:01 |              984 |                       17
```

```
 14294 |    108313 | Finished                    |  966 |        966 |      11 |  2016-05-19
 18:26:13 |                0 |                     0
 15126 |    108313 | Skipped(sorted>=95%)        |  966 |        966 |      11 |  2016-05-19
 18:26:38 |                0 |                     0
```

At the start of the VACUUM, the table contained 1,950 rows stored in 28 1 MB blocks. Amazon Redshift estimated it could reclaim 984, or 17 blocks of disk space, with a vacuum operation.

In the row for the Finished status, the ROWS column shows a value of 966, and the BLOCKS column value is 11, down from 28. The vacuum reclaimed the estimated amount of disk space, with no reclaimable rows or space remaining after the vacuum operation completed.

In the sort phase (transaction 15126), the vacuum was able to skip the table because the rows were inserted in sort key order.

The following example shows the statistics for a SORT ONLY vacuum on the SALES table (table 110116 in this example) after a large INSERT operation:

```
vacuum sort only sales;

select xid, table_id, status, rows, sortedrows, blocks, eventtime
from stl_vacuum order by xid, table_id, eventtime;

xid |table_id|     status       | rows  |sortedrows|blocks|     eventtime
----+--------+-----------------+-------+----------+------+--------------------
...
2925| 110116 |Started Sort Only|1379648|   172456 |  132 | 2011-02-24 16:25:21...
2925| 110116 |Finished         |1379648|  1379648 |  132 | 2011-02-24 16:26:28...
```

STL_WINDOW

Analyzes query steps that perform window functions.

STL_WINDOW is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

STL_WINDOW only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
slice	integer	Number that identifies the slice where the query was running.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
starttime	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
endtime	timestamp	Time in UTC that the query finished. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .
tasknum	integer	Number of the query task process that was assigned to run the step.
rows	bigint	Total number of rows that were processed.
is_diskbased	character(1)	If true (t), the query was performed as a disk-based operation. If false (f), the query was performed in memory.

Column name	Data type	Description
workmem	bigint	Total number of bytes in working memory that were assigned to the step.

Sample queries

The following example returns window function results for slice 0 and segment 3.

```
select query, tasknum, rows, is_diskbased, workmem
from stl_window
where slice=0 and segment=3;
```

```
 query | tasknum | rows | is_diskbased | workmem
-------+---------+------+--------------+----------
 86326 |      36 | 1857 | f            | 95256616
   705 |      15 | 1857 | f            | 95256616
 86399 |      27 | 1857 | f            | 95256616
   649 |      10 |    0 | f            | 95256616
(4 rows)
```

STL_WLM_ERROR

Records all WLM-related errors as they occur.

STL_WLM_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
recordtime	timestamp	Time that the error occurred.
pid	integer	ID for the process that generated the error.

Column name	Data type	Description
error_string	character(256)	Error description.

STL_WLM_RULE_ACTION

Records details about actions resulting from WLM query monitoring rules associated with user-defined queues. For more information, see WLM query monitoring rules.

STL_WLM_RULE_ACTION is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	User that ran the query.
query	integer	Query ID.
service_class	integer	ID for the service class. Query queues are defined in the WLM configuration. Service classes greater than 5 are user-defined queues.
rule	character(256)	Name of a query monitoring rule.
action	character(256)	Resulting action. Possible values are as follows: • log • hop(reassign) • hop(restart) • abort • change_query_priority • none

Column name	Data type	Description
		A value of none indicates that the rule's predicates were met but the action was superseded by another rule with a higher severity action.
recordtime	timestamp	Time the action was logged in UTC.
action_value	character(256)	If `action` is `change_query_priority` , then possible values are `highest`, `high`, `normal`, `low`, and `lowest`. If `action` is `log`, `hop`, or `abort` then the value is empty.
service_class_name	character(64)	The name of the service class.

Sample queries

The following example finds queries that were stopped by a query monitoring rule.

```
Select query, rule
from stl_wlm_rule_action
where action = 'abort'
order by query;
```

STL_WLM_QUERY

Contains a record of each attempted execution of a query in a service class handled by WLM.

STL_WLM_QUERY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
xid	integer	Transaction ID of the query or subquery.
task	integer	ID used to track a query through the workload manager. Can be associated with multiple query IDs. If a query is restarted, the query is assigned a new query ID but not a new task ID.
query	integer	Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
slot_count	integer	Number of WLM query slots that a query uses according to the concurrency level set for the queue. Default is 1. For more information, see wlm_query_slot_count.
service_class_start_time	timestamp	Time that the query was assigned to the service class. This time is in the UTC time zone.
queue_start_time	timestamp	Time that the query entered the queue for the service class. This time is in the UTC time zone.
queue_end_time	timestamp	Time when the query left the queue for the service class. This time is in the UTC time zone.
total_queue_time	bigint	Total number of microseconds that the query spent in the queue
exec_start_time	timestamp	Time that the query began executing in the service class. This time is in the UTC time zone.

Column name	Data type	Description
exec_end_time	timestamp	Time that the query completed execution in the service class. This time is in the UTC time zone.
total_exec_time	bigint	Number of microseconds that the query spent executing.
service_class_end_time	timestamp	Time that the query left the service class. This time is in the UTC time zone.
final_state	character(16)	Reserved for system use.
est_peak_mem	bigint	Reserved for system use.
query_priority	char(20)	The priority of the query. Possible values are `n/a`, `lowest`, `low`, `normal`, `high`, and `highest`, where `n/a` means that query priority isn't supported.
service_class_name	character(64)	The service class name. For more information about service classes, see WLM system tables and views.

Sample queries

View average query Time in queues and executing

The following queries display the current configuration for service classes greater than 4. For a list of service class IDs, see WLM service class IDs.

The following query returns the average time (in microseconds) that each query spent in query queues and executing for each service class.

```
select service_class as svc_class, count(*),
avg(datediff(microseconds, queue_start_time, queue_end_time)) as avg_queue_time,
avg(datediff(microseconds, exec_start_time, exec_end_time )) as avg_exec_time
from stl_wlm_query
where service_class > 4
group by service_class
order by service_class;
```

This query returns the following sample output:

```
 svc_class | count | avg_queue_time | avg_exec_time
-----------+-------+----------------+---------------
         5 | 20103 |              0 |         80415
         5 |  3421 |          34015 |        234015
         6 |    42 |              0 |        944266
         7 |   196 |           6439 |       1364399
(4 rows)
```

View maximum query time in queues and executing

The following query returns the maximum amount of time (in microseconds) that a query spent in any query queue and executing for each service class.

```
select service_class as svc_class, count(*),
max(datediff(microseconds, queue_start_time, queue_end_time)) as max_queue_time,
max(datediff(microseconds, exec_start_time, exec_end_time )) as max_exec_time
from stl_wlm_query
where svc_class > 5
group by service_class
order by service_class;
```

```
 svc_class | count | max_queue_time | max_exec_time
-----------+-------+----------------+---------------
         6 |    42 |              0 |       3775896
         7 |   197 |          37947 |      16379473
(4 rows)
```

STV tables for snapshot data

STV tables are virtual system tables that contain snapshots of the current system data.

Topics

- STV_INFLIGHT
- STV_LOAD_STATE
- STV_LOCKS
- STV_ML_MODEL_INFO
- STV_MV_DEPS
- STV_MV_INFO
- STV_NODE_STORAGE_CAPACITY
- STV_PARTITIONS
- STV_QUERY_METRICS
- STV_RECENTS
- STV_SESSIONS
- STV_SLICES
- STV_STARTUP_RECOVERY_STATE
- STV_TBL_PERM
- STV_TBL_TRANS
- STV_WLM_CLASSIFICATION_CONFIG
- STV_WLM_QMR_CONFIG
- STV_WLM_QUERY_QUEUE_STATE
- STV_WLM_QUERY_STATE
- STV_WLM_QUERY_TASK_STATE
- STV_WLM_SERVICE_CLASS_CONFIG
- STV_WLM_SERVICE_CLASS_STATE
- STV_XRESTORE_ALTER_QUEUE_STATE

STV_ACTIVE_CURSORS

STV_ACTIVE_CURSORS displays details for currently open cursors. For more information, see DECLARE.

STV_ACTIVE_CURSORS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views. A user can only view cursors opened by that user. A superuser can view all cursors.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
name	character (256)	Cursor name.
xid	bigint	Transaction context.
pid	integer	Leader process running the query.
starttime	timestamp	Time when the cursor was declared.
row_count	bigint	Number of rows in the cursor result set.
byte_count	bigint	Number of bytes in the cursor result set.
fetched_rows	bigint	Number of rows currently fetched from the cursor result set.

STV_BLOCKLIST

STV_BLOCKLIST contains the number of 1 MB disk blocks that are used by each slice, table, or column in a database.

Use aggregate queries with STV_BLOCKLIST, as the following examples show, to determine the number of 1 MB disk blocks allocated per database, table, slice, or column. You can also use STV_PARTITIONS to view summary information about disk utilization.

STV_BLOCKLIST is visible only to superusers. For more information, see Visibility of data in system tables and views.

> **Note**
>
> STV_BLOCKLIST only records blocks owned by the provisioned cluster or serverless namespace. If the database includes blocks shared from a datashare producer, those blocks

aren't included in STV_BLOCKLIST. For more information about datashares, go to [Data sharing in Amazon Redshift](#).

Table columns

Column name	Data type	Description
slice	integer	Node slice.
col	integer	Zero-based index for the column. Every table you create has three hidden columns appended to it: INSERT_XID, DELETE_XID, and ROW_ID (OID). A table with 3 user-defined columns contains 6 actual columns, and the user-defined columns are internally numbered as 0, 1, and 2. The INSERT_XID, DELETE_XID, and ROW_ID columns are numbered 3, 4, and 5, respectively, in this example.
tbl	integer	Table ID for the database table.
blocknum	integer	ID for the data block.
num_values	integer	Number of values contained on the block.
extended_ limits	integer	For internal use.
minvalue	bigint	Minimum data value of the block. Stores first eight characters as 64-bit integer for non-numeric data. Used for disk scanning.
maxvalue	bigint	Maximum data value of the block. Stores first eight characters as 64-bit integer for non-numeric data. Used for disk scanning.
sb_pos	integer	Internal Amazon Redshift identifier for super block position on the disk.
pinned	integer	Whether or not the block is pinned into memory as part of pre-load. 0 = false; 1 = true. Default is false.

Column name	Data type	Description
on_disk	integer	Whether or not the block is automatically stored on disk. 0 = false; 1 = true. Default is false.
modified	integer	Whether or not the block has been modified. 0 = false; 1 = true. Default is false.
hdr_modified	integer	Whether or not the block header has been modified. 0 = false; 1 = true. Default is false.
unsorted	integer	Whether or not a block is unsorted. 0 = false; 1 = true. Default is true.
tombstone	integer	For internal use.
preferred_diskno	integer	Disk number that the block should be on, unless the disk has failed. Once the disk has been fixed, the block will move back to this disk.
temporary	integer	Whether or not the block contains temporary data, such as from a temporary table or intermediate query results. 0 = false; 1 = true. Default is false.
newblock	integer	Indicates whether or not a block is new (true) or was never committed to disk (false). 0 = false; 1 = true.
num_readers	integer	Number of references on each block.
flags	integer	Internal Amazon Redshift flags for the block header.

Sample queries

STV_BLOCKLIST contains one row per allocated disk block, so a query that selects all the rows potentially returns a very large number of rows. We recommend using only aggregate queries with STV_BLOCKLIST.

The SVV_DISKUSAGE view provides similar information in a more user-friendly format; however, the following example demonstrates one use of the STV_BLOCKLIST table.

To determine the number of 1 MB blocks used by each column in the VENUE table, type the following query:

```
select col, count(*)
from stv_blocklist, stv_tbl_perm
where stv_blocklist.tbl = stv_tbl_perm.id
and stv_blocklist.slice = stv_tbl_perm.slice
and stv_tbl_perm.name = 'venue'
group by col
order by col;
```

This query returns the number of 1 MB blocks allocated to each column in the VENUE table, shown by the following sample data:

```
 col | count
-----+-------
   0 |  4
   1 |  4
   2 |  4
   3 |  4
   4 |  4
   5 |  4
   7 |  4
   8 |  4
(8 rows)
```

The following query shows whether or not table data is actually distributed over all slices:

```
select trim(name) as table, stv_blocklist.slice, stv_tbl_perm.rows
from stv_blocklist,stv_tbl_perm
where stv_blocklist.tbl=stv_tbl_perm.id
and stv_tbl_perm.slice=stv_blocklist.slice
and stv_blocklist.id > 10000 and name not like '%#m%'
and name not like 'systable%'
group by name, stv_blocklist.slice, stv_tbl_perm.rows
order by 3 desc;
```

This query produces the following sample output, showing the even data distribution for the table with the most rows:

```
table   | slice | rows
----------+-------+-------
listing  |    13 | 10527
listing  |    14 | 10526
listing  |     8 | 10526
listing  |     9 | 10526
listing  |     7 | 10525
listing  |     4 | 10525
listing  |    17 | 10525
listing  |    11 | 10525
listing  |     5 | 10525
listing  |    18 | 10525
listing  |    12 | 10525
listing  |     3 | 10525
listing  |    10 | 10525
listing  |     2 | 10524
listing  |    15 | 10524
listing  |    16 | 10524
listing  |     6 | 10524
listing  |    19 | 10524
listing  |     1 | 10523
listing  |     0 | 10521
...
(180 rows)
```

The following query determines whether any tombstoned blocks were committed to disk:

```
select slice, col, tbl, blocknum, newblock
from stv_blocklist
where  tombstone > 0;

slice | col |   tbl  | blocknum | newblock
-------+-----+--------+----------+----------
4     |  0  | 101285 |    0     |   1
4     |  2  | 101285 |    0     |   1
4     |  4  | 101285 |    1     |   1
5     |  2  | 101285 |    0     |   1
5     |  0  | 101285 |    0     |   1
5     |  1  | 101285 |    0     |   1
5     |  4  | 101285 |    1     |   1
...
(24 rows)
```

STV_CURSOR_CONFIGURATION

STV_CURSOR_CONFIGURATION displays cursor configuration constraints. For more information, see Cursor constraints.

STV_CURSOR_CONFIGURATION is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
current_cursor_count	integer	Number of cursors currently open.
max_diskspace_usable	integer	Amount of disk space available for cursors, in megabytes. This constraint is based on the maximum cursor result set size for the cluster.
current_diskspace_used	integer	Amount of disk space currently used by cursors, in megabytes.

STV_DB_ISOLATION_LEVEL

STV_DB_ISOLATION_LEVEL displays the current isolation level for databases. For more information about isolation levels, see CREATE DATABASE.

STV_DB_ISOLATION_LEVEL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
db_name	character(128)	The database name.

Column name	Data type	Description
isolation_level	character (20)	The isolation level of the database. Possible values include `Serializable` and `Snapshot Isolation`.

STV_EXEC_STATE

Use the STV_EXEC_STATE table to find out information about queries and query steps that are actively running on compute nodes.

This information is usually used only to troubleshoot engineering issues. The views SVV_QUERY_STATE and SVL_QUERY_SUMMARY extract their information from STV_EXEC_STATE.

STV_EXEC_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
query	integer	Query ID. Can be used to join various other system tables and views.
slice	integer	Node slice where the step completed.
segment	integer	Segment of the query that ran. A query segment is a series of steps.
step	integer	Step of the query segment that completed. A step is the smallest unit that a query performs.

Column name	Data type	Description
starttime	timestamp	Time that the step ran.
currenttime	timestamp	Current time.
tasknum	integer	Query task process that is assigned to complete the step.
rows	bigint	Number of rows processed.
bytes	bigint	Number of bytes processed.
label	char(256)	Step label, which consists of a query step name and, when applicable, table ID and table name (for example, `scan tbl=100448 name =user`). Three-digit table IDs usually refer to scans of transient tables. When you see `tbl=0`, it usually refers to a scan of a constant value.
is_diskbased	char(1)	Whether this step of the query was completed as a disk-based operation: true (**t**) or false (**f**). Only certain steps, such as hash, sort, and aggregate steps, can go to disk. Many types of steps are always completed in memory.
workmem	bigint	Number of bytes of working memory assigned to the step.
num_parts	integer	Number of partitions a hash table is divided into during a hash step. A positive number in this column does not imply that the hash step ran as a disk-based operation . Check the value in the IS_DISKBASED column to see if the hash step was disk-based.
is_rrscan	char(1)	If true (**t**), indicates that range-restricted scan was used on the step. Default is false (**f**).
is_delayed_scan	char(1)	If true (**t**), indicates that delayed scan was used on the step. Default is false (**f**).

Sample queries

Rather than querying STV_EXEC_STATE directly, Amazon Redshift recommends querying SVL_QUERY_SUMMARY or SVV_QUERY_STATE to obtain the information in STV_EXEC_STATE in a more user-friendly format. See the SVL_QUERY_SUMMARY or SVV_QUERY_STATE table documentation for more details.

STV_INFLIGHT

Use the STV_INFLIGHT table to determine what queries are currently running on the cluster. If you're troubleshooting, it's helpful for checking the status of long-running queries.

STV_INFLIGHT does not show leader-node only queries. For more information, see Leader node–only functions. STV_INFLIGHT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Troubleshooting with STV_INFLIGHT

If you use STV_INFLIGHT to troubleshoot performance for a query, or a collection of queries, note the following:

- Long-running open transactions generally increase load. These open transactions can result in longer running times for other queries.
- Long-running COPY and ETL jobs can affect other queries running on the cluster, if they're taking a lot of compute resources. In most cases, moving these long-running jobs to times of low use increases performance for reporting or analytics workloads.
- There are views that provide related information to STV_INFLIGHT. These include STL_QUERYTEXT, which captures the query text for SQL commands, and SVV_QUERY_INFLIGHT, which joins STV_INFLIGHT to STL_QUERYTEXT. You can also use STV_RECENTS with STV_INFLIGHT for troubleshooting. For example, STV_RECENTS can indicate if specific queries are in a *Running* or *Done* state. Combining this information with results from STV_INFLIGHT can give you more information about a query's properties and compute-resource impact.

You can also monitor running queries using the Amazon Redshift console.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
slice	integer	Slice where the query is running.
query	integer	Query ID. Can be used to join various other system tables and views.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field is blank.
xid	bigint	Transaction ID.
pid	integer	Process ID. All of the queries in a session are run in the same process, so this value remains constant if you run a series of queries in the same session. You can use this column to join to the STL_ERROR table.
starttime	timestamp	Time that the query started.
text	character(100)	Query text, truncated to 100 characters if the statement exceeds that limit.
suspended	integer	Whether the query is suspended or not. 0 = false; 1 = true.
insert_pristine	integer	Whether write queries are/were able to run while the current query is/was running. 1 = no write queries allowed. 0 = write queries allowed. This column is intended for use in debugging.
concurrency_scaling_status	integer	Indicates whether the query ran on the main cluster or on a concurrency scaling cluster, Possible values are as follows:

Column name	Data type	Description
		0 - Ran on the main cluster 1 - Ran on a concurrency scaling cluster

Sample queries

To view all active queries currently running on the database, type the following query:

```
select * from stv_inflight;
```

The sample output below shows two queries currently running, including the STV_INFLIGHT query itself and a query that was run from a script called `avgwait.sql`:

```
select slice, query, trim(label) querylabel, pid,
starttime, substring(text,1,20) querytext
from stv_inflight;

slice|query|querylabel | pid |        starttime          |      querytext
-----+-----+-----------+-----+--------------------------+--------------------
1011 |  21 |           | 646 |2012-01-26 13:23:15.645503|select slice, query,
1011 |  20 |avgwait.sql| 499 |2012-01-26 13:23:14.159912|select avg(datediff(
(2 rows)
```

The following query selects several columns, including concurrency_scaling_status. This column indicates whether queries are being sent to the concurrency-scaling cluster. If the value is 1 for some results, it's an indication that concurrency-scaling compute resources are being used. For more information, see [Concurrency scaling](#).

```
select userid,
query,
pid,
starttime,
text,
suspended,
concurrency_scaling_status
 from STV_INFLIGHT;
```

The sample output shows one query being sent to the concurrency scaling cluster.

```
 query  | pid     |        starttime           |   text                  | suspended
 |  concurrency_scaling_status
--------+---------
+----------------------------|-----------------------|---------------|------------------------
1234567 | 123456  | 2012-01-26 13:23:15.645503 | select userid, query...  0
    1
2345678 | 234567  | 2012-01-26 13:23:14.159912 | select avg(datediff(...  0
    0
(2 rows)
```

For more tips on troubleshooting query performance, see Query troubleshooting.

STV_LOAD_STATE

Use the STV_LOAD_STATE table to find information about current state of ongoing COPY statements.

The COPY command updates this table after every million records are loaded.

STV_LOAD_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
session	integer	Session PID of process doing the load.
query	integer	Query ID. Can be used to join various other system tables and views.
slice	integer	Node slice number.
pid	integer	Process ID. All of the queries in a session are run in the same process, so this value remains constant if you run a series of queries in the same session.

Column name	Data type	Description
recordtime	timestamp	Time the record is logged.
bytes_to_load	bigint	Total number of bytes to be loaded by this slice. This is 0 if the data being loaded is compressed
bytes_loaded	bigint	Number of bytes loaded by this slice. If the data being loaded is compressed, this is the number of bytes loaded after the data is uncompressed.
bytes_to_load_compressed	bigint	Total number of bytes of compressed data to be loaded by this slice. This is 0 if the data being loaded is not compressed.
bytes_loaded_compressed	bigint	Number of bytes of compressed data loaded by this slice. This is 0 if the data being loaded is not compressed.
lines	integer	Number of lines loaded by this slice.
num_files	integer	Number of files to be loaded by this slice.
num_files_complete	integer	Number of files loaded by this slice.
current_file	character (256)	Name of the file being loaded by this slice.
pct_complete	integer	Percentage of data load completed by this slice.

Sample query

To view the progress of each slice for a COPY command, type the following query. This example uses the PG_LAST_COPY_ID() function to retrieve information for the last COPY command.

```
select slice , bytes_loaded, bytes_to_load , pct_complete from stv_load_state where
 query = pg_last_copy_id();

 slice | bytes_loaded | bytes_to_load | pct_complete
-------+--------------+---------------+--------------
     2 |            0 |             0 |            0
```

```
     3 |      12840898 |       39104640 |           32
(2 rows)
```

STV_LOCKS

Use the STV_LOCKS table to view any current updates on tables in the database.

Amazon Redshift locks tables to prevent two users from updating the same table at the same time. While the STV_LOCKS table shows all current table updates, query the STL_TR_CONFLICT table to see a log of lock conflicts. Use the SVV_TRANSACTIONS view to identify open transactions and lock contention issues.

STV_LOCKS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
table_id	bigint	Table ID for the table acquiring the lock.
last_commit	timestamp	Timestamp for the last commit in the table.
last_update	timestamp	Timestamp for the last update for the table.
lock_owner	bigint	Transaction ID associated with the lock.
lock_owner_pid	bigint	Process ID associated with the lock.
lock_owner_start_ts	timestamp	Timestamp for the transaction start time.
lock_owner_end_ts	timestamp	Timestamp for the transaction end time.
lock_status	character (22)	Status of the process either waiting for or holding a lock.

Sample query

To view all locks taking place in current transactions, type the following command:

```
select table_id, last_update, lock_owner, lock_owner_pid from stv_locks;
```

This query returns the following sample output, which displays three locks currently in effect:

```
 table_id |        last_update         | lock_owner | lock_owner_pid
----------+----------------------------+------------+----------------
100004   | 2008-12-23 10:08:48.882319 |       1043 |           5656
100003   | 2008-12-23 10:08:48.779543 |       1043 |           5656
100140   | 2008-12-23 10:08:48.021576 |       1043 |           5656
(3 rows)
```

STV_ML_MODEL_INFO

State information about the current state of the machine learning model.

STV_ML_MODEL_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
schema_name	char(128)	The namespace of the model.
user_name	char(128)	The owner of the model.
model_name	char(128)	The name of the model.
life_cycle	char(20)	The lifecycle status of the model.
is_refreshable	integer	The state of the model whether it is refreshab le if original tables and columns in the training query still exist and the user still has the permissions to them. Possible values are: 1 (refreshable) and 0 (not refreshable).
model_state	char(128)	The current state of the model.

Sample query

The following query displays the current state of machine learning models.

```
SELECT schema_name, model_name, model_state
FROM stv_ml_model_info;

 schema_name |        model_name            |             model_state
-------------+------------------------------+--------------------------------------
 public      | customer_churn_auto_model    | Train Model On SageMaker In Progress
 public      | customer_churn_xgboost_model | Model is Ready
(2 row)
```

STV_MV_DEPS

The STV_MV_DEPS table shows the dependencies of materialized views on other materialized views within Amazon Redshift.

For more information about materialized views, see Materialized views in Amazon Redshift.

STV_MV_DEPS is visible to all users. Superusers can see all rows; regular users can only list materialized views residing in schemas they have access to. For more information, see Visibility of data insystem tables and views.

Table columns

Column name	Data type	Description
db_name	char(128)	The database that contains the specified materialized view.
schema	char(128)	The schema of the materialized view.
name	char(128)	The name of the materialized view.
ref_schema	char(128)	The materialized view schema on which this materialized view depends.
ref_name	char(128)	The name of the materialized view on which this materialized view depends.

Column name	Data type	Description
ref_datab ase_name	char(128)	The name of the database on which this materialized view depends.

Sample query

The following query returns an output row that indicates that the materialized view mv_over_foo uses the materialized view mv_foo in its definition as a dependency.

```
CREATE SCHEMA test_ivm_setup;
CREATE TABLE test_ivm_setup.foo(a INT);
CREATE MATERIALIZED VIEW test_ivm_setup.mv_foo AS SELECT * FROM test_ivm_setup.foo;
CREATE MATERIALIZED VIEW test_ivm_setup.mv_over_foo AS SELECT * FROM
 test_ivm_setup.mv_foo;

SELECT * FROM stv_mv_deps;

 db_name | schema          | name        |   ref_schema   | ref_name |
 ref_database_name
---------+----------------+------------+---------------+----------
+------------------
 dev     | test_ivm_setup  | mv_over_foo | test_ivm_setup | mv_foo   | dev
```

STV_MV_INFO

The STV_MV_INFO table contains a row for every materialized view, whether the data is stale, and state information.

For more information about materialized views, see Materialized views in Amazon Redshift.

STV_MV_INFO is visible to all users. Superusers can see all rows; regular users can only list materialized views residing in schemas they have access to. For more information, see Visibility of data insystem tables and views.

Table columns

Column name	Data type	Description
db_name	char(128)	The database that contains the materialized view.
schema	char(128)	The schema of the database.
name	char(128)	The materialized view name.
updated_upto_xid	bigint	Reserved for internal use.
is_stale	char(1)	A `t` indicates that the materialized view is stale. A *stale* materialized view is one where the base tables have been updated but the materialized view hasn't been refreshed. The information might not be accurate if a refresh hasn't been run since the last restart. The `is_stale` column is always set to `t` if the materialized view depends on a mutable function. A mutable function returns a different result when given the same argument or arguments. For instance, most functions that return a date or timestamp are mutable functions.
owner_user_name	char(128)	The user who owns the materialized view.
state	integer	The state of the materialized view as follows: • 0 – The materialized view is fully recomputed when refreshed. • 1 – The materialized view is incremental. • 101 – The materialized view can't be refreshed due to a dropped column. This constraint

Column name	Data type	Description
		applies even if the column isn't used in the materialized view. • 102 – The materialized view can't be refreshed due to a changed column type. This constrain t applies even if the column isn't used in the materialized view. • 103 – The materialized view can't be refreshed due to a renamed table. • 104 – The materialized view can't be refreshed due to a renamed column. This constraint applies even if the column isn't used in the materialized view. • 105 – The materialized view can't be refreshed due to a renamed schema.
autorewrite	char(1)	A `t` indicates that the materialized view is eligible for automatic rewriting of queries.
autorefresh	char(1)	A `t` indicates that the materialized view can be automatically refreshed.

Sample query

To view the state of all materialized views, run the following query.

```
select * from stv_mv_info;
```

This query returns the following sample output.

```
 db_name |       schema        |   name  | updated_upto_xid | is_stale | owner_user_name
 | state | autorefresh | autorewrite
---------+--------------------+---------+------------------+----------
+-----------------+-------+------------+------------
 dev     | test_ivm_setup     | mv      |             1031 | f        | catch-22
 |     1 |             1 |           0
```

```
 dev      | test_ivm_setup     | old_mv  |              988 | t         | lotr
 |     1 |           0 |           1
```

STV_NODE_STORAGE_CAPACITY

The STV_NODE_STORAGE_CAPACITY table shows details of total storage capacity and total used capacity for each node in a cluster. It contains a row for each node.

STV_NODE_STORAGE_CAPACITY is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
node	integer	The node number.
used	integer	The number of 1 MB disk blocks currently in use on the node. For RA3 node types, used blocks include both locally cached blocks and blocks persisted in Amazon S3.
capacity	integer	The total storage capacity provisioned for the node in 1 MB blocks. The capacity includes space that is reserved by Amazon Redshift on DC2 node types for internal use. The capacity is larger than the nominal node capacity, which is the amount of node space available for user data. For RA3 node types, this capacity is the same as the total managed storage quota for the cluster. For more information about capacity by node type, see Node type details in the *Amazon Redshift Management Guide*.

Sample queries

> **Note**
>
> The results of the following examples vary based on the node specifications of your cluster. Add column `capacity` to your SQL SELECT to retrieve the capacity of your cluster.

The following query returns used space and total capacity in 1 MB disk blocks. This example ran on a two-node dc2.8xlarge cluster.

```
select node, used from stv_node_storage_capacity order by node;
```

This query returns the following sample output.

```
 node | used
------+-------
    0 | 30597
    1 | 27089
```

The following query returns used space and total capacity in 1 MB disk blocks. This example ran on a two-node ra3.16xlarge cluster.

```
select node, used from stv_node_storage_capacity order by node;
```

This query returns the following sample output.

```
 node | used
------+-------
    0 | 30591
    1 | 27103
```

STV_PARTITIONS

Use the STV_PARTITIONS table to find out the disk speed performance and disk utilization for Amazon Redshift.

STV_PARTITIONS contains one row per node per logical disk volume.

STV_PARTITIONS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
owner	integer	Disk node that owns the partition.
host	integer	Node that is physically attached to the partition.
diskno	integer	Disk containing the partition.
part_begin	bigint	Offset of the partition. Raw devices are logically partitioned to open space for mirror blocks.
part_end	bigint	End of the partition.
used	integer	Number of 1 MB disk blocks currently in use on the partition .
tossed	integer	Number of blocks that are ready to be deleted but are not yet removed because it is not safe to free their disk addresses. If the addresses were freed immediately, a pending transaction could write to the same location on disk. Therefore, these tossed blocks are released as of the next commit. Disk blocks might be marked as tossed, for example, when a table column is dropped, during INSERT operations, or during disk-based query operations.
capacity	integer	Total capacity of the partition in 1 MB disk blocks.
reads	bigint	Number of reads that have occurred since the last cluster restart.
writes	bigint	Number of writes that have occurred since the last cluster restart.

Column name	Data type	Description
seek_forward	integer	Number of times that a request is not for the subsequent address given the previous request address.
seek_back	integer	Number of times that a request is not for the previous address given the subsequent address.
is_san	integer	Whether the partition belongs to a SAN. Valid values are **0** (false) or **1** (true).
failed	integer	This column is deprecated.
mbps	integer	Disk speed in megabytes per second.
mount	character (256)	Directory path to the device.

Sample query

The following query returns the disk space used and capacity, in 1 MB disk blocks, and calculates disk utilization as a percentage of raw disk space. The raw disk space includes space that is reserved by Amazon Redshift for internal use, so it is larger than the nominal disk capacity, which is the amount of disk space available to the user. The **Percentage of Disk Space Used** metric on the **Performance** tab of the Amazon Redshift Management Console reports the percentage of nominal disk capacity used by your cluster. We recommend that you monitor the **Percentage of Disk Space Used** metric to maintain your usage within your cluster's nominal disk capacity.

> **Important**
>
> We strongly recommend that you do not exceed your cluster's nominal disk capacity. While it might be technically possible under certain circumstances, exceeding your nominal disk capacity decreases your cluster's fault tolerance and increases your risk of losing data.

This example was run on a two-node cluster with six logical disk partitions per node. Space is being used very evenly across the disks, with approximately 25% of each disk in use.

```
select owner, host, diskno, used, capacity,
```

```
(used-tossed)/capacity::numeric *100 as pctused
from stv_partitions order by owner;

 owner | host | diskno |  used  | capacity | pctused
-------+------+--------+--------+----------+---------
   0   |  0   |    0   | 236480 |  949954  | 24.9
   0   |  0   |    1   | 236420 |  949954  | 24.9
   0   |  0   |    2   | 236440 |  949954  | 24.9
   0   |  1   |    2   | 235150 |  949954  | 24.8
   0   |  1   |    1   | 237100 |  949954  | 25.0
   0   |  1   |    0   | 237090 |  949954  | 25.0
   1   |  1   |    0   | 236310 |  949954  | 24.9
   1   |  1   |    1   | 236300 |  949954  | 24.9
   1   |  1   |    2   | 236320 |  949954  | 24.9
   1   |  0   |    2   | 237910 |  949954  | 25.0
   1   |  0   |    1   | 235640 |  949954  | 24.8
   1   |  0   |    0   | 235380 |  949954  | 24.8

(12 rows)
```

STV_QUERY_METRICS

Contains metrics information, such as the number of rows processed, CPU usage, input/output, and disk use, for active queries running in user-defined query queues (service classes). To view metrics for queries that have completed, see the STL_QUERY_METRICS system table.

Query metrics are sampled at one second intervals. As a result, different runs of the same query might return slightly different times. Also, query segments that run in less than 1 second might not be recorded.

STV_QUERY_METRICS tracks and aggregates metrics at the query, segment, and step level. For information about query segments and steps, see Query planning and execution workflow. Many metrics (such as `max_rows`, `cpu_time`, and so on) are summed across node slices. For more information about node slices, see Data warehouse system architecture.

To determine the level at which the row reports metrics, examine the `segment` and `step_type` columns:

- If both `segment` and `step_type` are `-1`, then the row reports metrics at the query level.
- If `segment` is not `-1` and `step_type` is `-1`, then the row reports metrics at the segment level.
- If both `segment` and `step_type` are not `-1`, then the row reports metrics at the step level.

STV_QUERY_METRICS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user that ran the query that generated the entry.
service_class	integer	ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Metrics are reported only for user-defined queues.
query	integer	Query ID. The query column can be used to join other system tables and views.
starttime	timestamp	Time in UTC that the query started executing, with 6 digits of precision for fractional seconds. For example: `2009-06-12 11:29:19.131358`.
slices	integer	Number of slices for the cluster.
segment	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process. If the segment value is -1, metrics segment values are rolled up to the query level.
step_type	integer	Type of step that ran. For a description of step types, see Step types.
rows	bigint	Number of rows processed by a step.
max_rows	bigint	Maximum number of rows output for a step, aggregated across all slices.

Column name	Data type	Description
cpu_time	bigint	CPU time used, in microseconds. At the segment level, the total CPU time for the segment across all slices. At the query level, the sum of CPU time for the query across all slices and segments.
max_cpu_time	bigint	Maximum CPU time used, in microseconds. At the segment level, the maximum CPU time used by the segment across all slices. At the query level, the maximum CPU time used by any query segment.
blocks_read	bigint	Number of 1 MB blocks read by the query or segment.
max_blocks_read	bigint	Maximum number of 1 MB blocks read by the segment, aggregated across all slices. At the segment level, the maximum number of 1 MB blocks read for the segment across all slices. At the query level, the maximum number of 1 MB blocks read by any query segment.
run_time	bigint	Total run time, summed across slices. Run time doesn't include wait time. At the segment level, the run time for the segment, summed across all slices. At the query level, the run time for the query summed across all slices and segments. Because this value is a sum, run time is not related to query execution time.
max_run_time	bigint	The maximum elapsed time for a segment, in microseconds. At the segment level, the maximum run time for the segment across all slices. At the query level, the maximum run time for any query segment.

Column name	Data type	Description
max_blocks_to_disk	bigint	The maximum amount of disk space used to write intermediate results, in 1 MB blocks. At the segment level, the maximum amount of disk space used by the segment across all slices. At the query level, the maximum amount of disk space used by any query segment.
blocks_to_disk	bigint	The amount of disk space used by a query or segment to write intermediate results, in 1 MB blocks.
step	integer	Query step that ran.
max_query_scan_size	bigint	The maximum size of data scanned by a query, in MB. At the segment level, the maximum size of data scanned by the segment across all slices. At the query level, the maximum size of data scanned by any query segment.
query_scan_size	bigint	The size of data scanned by a query, in MB.
query_priority	integer	The priority of the query. Possible values are `-1`, `0`, `1`, `2`, `3`, and `4`, where `-1` means that query priority isn't supported.
query_queue_time	bigint	The amount of time in microseconds that the query was queued.

Step types

The following table lists step types relevant to database users. The table doesn't list step types that are for internal use only. If step type is -1, the metric is not reported at the step level.

Step type	Description
1	Scan table
2	Insert rows
3	Aggregate rows

Step type	Description
6	Sort step
7	Merge step
8	Distribution step
9	Broadcast distribution step
10	Hash join
11	Merge join
12	Save step
14	Hash
15	Nested loop join
16	Project fields and expressions
17	Limit the number of rows returned
18	Unique
20	Delete rows
26	Limit the number of sorted rows returned
29	Compute a window function
32	UDF
33	Unique
37	Return rows from the leader node to the client
38	Return rows from the compute nodes to the leader node
40	Spectrum scan.

Sample query

To find active queries with high CPU time (more the 1,000 seconds), run the following query.

```
select query, cpu_time / 1000000 as cpu_seconds
from stv_query_metrics where segment = -1 and cpu_time > 1000000000
order by cpu_time;

query | cpu_seconds
------+------------
25775 |        9540
```

To find active queries with a nested loop join that returned more than one million rows, run the following query.

```
select query, rows
from stv_query_metrics
where step_type = 15 and rows > 1000000
order by rows;

query | rows
------+-----------
25775 | 1580225854
```

To find active queries that have run for more than 60 seconds and have used less than 10 seconds of CPU time, run the following query.

```
select query, run_time/1000000 as run_time_seconds
from stv_query_metrics
where segment = -1 and run_time > 60000000 and cpu_time < 10000000;

query | run_time_seconds
------+-----------------
25775 |             114
```

STV_RECENTS

Use the STV_RECENTS table to find out information about the currently active and recently run queries against a database.

STV_RECENTS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Troubleshooting with STV_RECENTS

STV_RECENTS is particularly helpful for determining if a query or collection of queries is currently running or done. It also shows the duration a query has been running. This is helpful for getting a sense for which queries are long running.

You can join STV_RECENTS to other system views, such as STV_INFLIGHT, to gather additional metadata about running queries. (There's an example that shows how to do this in the sample queries section.) You can also use returned records from this view along with the monitoring features in the Amazon Redshift console for troubleshooting in real time.

System views that compliment STV_RECENTS include STL_QUERYTEXT, which retrieves the query text for SQL commands, and SVV_QUERY_INFLIGHT, which joins STV_INFLIGHT to STL_QUERYTEXT.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
status	character(20)	Query status. Valid values are **Running**, **Done**.
starttime	timestamp	Time that the query started.
duration	integer	Number of microseconds since the session started.
user_name	character(50)	User name who ran the process.
db_name	character(50)	Name of the database.
query	character(600)	Query text, up to 600 characters. Any additional character s are truncated.
pid	integer	Process ID for the session associated with the query, which is always -1 for queries that have completed.

Sample queries

To determine which queries are currently running against the database, run the following query:

```
select user_name, db_name, pid, query
from stv_recents
where status = 'Running';
```

The sample output below shows a single query running on the TICKIT database:

```

user_name | db_name |   pid   | query
----------+---------+---------+-------------
dwuser    | tickit  |  19996  |select venuename, venueseats from
venue where venueseats > 50000 order by venueseats desc;
```

The following example returns a list of queries (if any) that are running or waiting in a queue to run:

```
select * from stv_recents where status<>'Done';

status |    starttime        | duration |user_name|db_name| query     | pid
-------+---------------------+----------+---------+-------+-----------+------
Running| 2010-04-21 16:11... | 281566454| dwuser  |tickit | select ...| 23347
```

This query does not return results unless you are running a number of concurrent queries and some of those queries are in a queue.

The following example extends the previous example. In this case, queries that are truly "in flight" (running, not waiting) are excluded from the result:

```
select * from stv_recents where status<>'Done'
and pid not in (select pid from stv_inflight);
...
```

For more tips on troubleshooting query performance, see Query troubleshooting.

STV_SESSIONS

Use the STV_SESSIONS table to view information about the active user sessions for Amazon Redshift.

To view the session history, use the STL_SESSIONS table, rather than STV_SESSIONS.

STV_SESSIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_SESSION_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
starttime	timestamp	Time that the session started.
process	integer	Process ID for the session.
user_name	character(50)	User associated with the session.
db_name	character(50)	Name of the database associated with the session.
timeout_sec	int	The maximum time in seconds that a session remains inactive or idle before timing out. 0 indicates that no timeout is set.

Sample queries

To perform a quick check to see if any other users are currently logged into Amazon Redshift, type the following query:

```
select count(*)
from stv_sessions;
```

If the result is greater than one, then at least one other user is currently logged in to the database.

To view all active sessions for Amazon Redshift, type the following query:

```
select *
```

```
from stv_sessions;
```

The following result shows four active sessions running on Amazon Redshift:

```
       starttime         | process |user_name                   | db_name
      | timeout_sec
-------------------------+---------+----------------------------
+----------------------------+-------------
  2018-08-06 08:44:07.50 |   13779 | IAMA:aws_admin:admin_grp   | dev
      | 0
  2008-08-06 08:54:20.50 |   19829 | dwuser                     | dev
      | 120
  2008-08-06 08:56:34.50 |   20279 | dwuser                     | dev
      | 120
  2008-08-06 08:55:00.50 |   19996 | dwuser                     | tickit
      | 0
(3 rows)
```

The user name prefixed with IAMA indicates that the user signed on using federated single sign-on. For more information, see Using IAM authentication to generate database user credentials.

STV_SLICES

Use the STV_SLICES table to view the current mapping of a slice to a node.

The information in STV_SLICES is used mainly for investigation purposes.

STV_SLICES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
node	integer	Cluster node where the slice is located.
slice	integer	Node slice.
localslice	integer	This information is for internal use only.

Column name	Data type	Description
type	character (1)	This information is for internal use only.

Sample query

To view which cluster nodes are managing which slices, type the following query:

```
select node, slice from stv_slices;
```

This query returns the following sample output:

```
 node | slice
------+-------
    0 |     2
    0 |     3
    0 |     1
    0 |     0
(4 rows)
```

STV_STARTUP_RECOVERY_STATE

Records the state of tables that are temporarily locked during cluster restart operations. Amazon Redshift places a temporary lock on tables while they are being processed to resolve stale transactions following a cluster restart.

STV_STARTUP_RECOVERY_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
db_id	integer	Database ID.
table_id	integer	Table ID.

Column name	Data type	Description
table_name	character(137)	Table name.

Sample queries

To monitor which tables are temporarily locked, run the following query after a cluster restart.

```
select * from STV_STARTUP_RECOVERY_STATE;

  db_id | tbl_id | table_name
--------+--------+------------
 100044 | 100058 | lineorder
 100044 | 100068 | part
 100044 | 100072 | customer
 100044 | 100192 | supplier
(4 rows)
```

STV_TBL_PERM

The STV_TBL_PERM table contains information about the permanent tables in Amazon Redshift, including temporary tables created by a user for the current session. STV_TBL_PERM contains information for all tables in all databases.

This table differs from STV_TBL_TRANS, which contains information about transient database tables that the system creates during query processing.

STV_TBL_PERM is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
slice	integer	Node slice allocated to the table.
id	integer	Table ID.

Column name	Data type	Description
name	character (72)	Table name.
rows	bigint	Number of data rows in the slice.
sorted_rows	bigint	Number of rows in the slice that are already sorted on disk. If this number does not match the ROWS number, vacuum the table to resort the rows.
temp	integer	Whether or not the table is a temporary table. 0 = false; 1 = true.
db_id	integer	ID of the database where the table was created.
insert_pristine	integer	For internal use.
delete_pristine	integer	For internal use.
backup	integer	Value that indicates whether the table is included in cluster snapshots. 0 = no; 1 = yes. For more information, see the BACKUP parameter for the CREATE TABLE command.
dist_style	integer	Distribution style of the table that the slice belongs to. For information on the values, see Viewing distribution styles. For information on distribution styles, see Distribution styles.
block_count	integer	Number of blocks used by the slice. The value is -1 when the block count can't be calculated.

Sample queries

The following query returns a list of distinct table IDs and names:

```
select distinct id, name
from stv_tbl_perm order by name;
```

```
   id   |          name
--------+-------------------------
 100571 | category
 100575 | date
 100580 | event
 100596 | listing
 100003 | padb_config_harvest
 100612 | sales
...
```

Other system tables use table IDs, so knowing which table ID corresponds to a certain table can be very useful. In this example, SELECT DISTINCT is used to remove the duplicates (tables are distributed across multiple slices).

To determine the number of blocks used by each column in the VENUE table, type the following query:

```
select col, count(*)
from stv_blocklist, stv_tbl_perm
where stv_blocklist.tbl = stv_tbl_perm.id
and stv_blocklist.slice = stv_tbl_perm.slice
and stv_tbl_perm.name = 'venue'
group by col
order by col;

 col | count
-----+-------
   0 |     8
   1 |     8
   2 |     8
   3 |     8
   4 |     8
   5 |     8
   6 |     8
   7 |     8
(8 rows)
```

Usage notes

The ROWS column includes counts of deleted rows that have not been vacuumed (or have been vacuumed but with the SORT ONLY option). Therefore, the SUM of the ROWS column in the STV_TBL_PERM table might not match the COUNT(*) result when you query a given table directly.

For example, if 2 rows are deleted from VENUE, the COUNT(*) result is 200 but the SUM(ROWS) result is still 202:

```
delete from venue
where venueid in (1,2);

select count(*) from venue;
count
-------
200
(1 row)

select trim(name) tablename, sum(rows)
from stv_tbl_perm where name='venue' group by name;

tablename | sum
-----------+-----
venue     | 202
(1 row)
```

To synchronize the data in STV_TBL_PERM, run a full vacuum the VENUE table.

```
vacuum venue;

select trim(name) tablename, sum(rows)
from stv_tbl_perm
where name='venue'
group by name;

tablename | sum
-----------+-----
venue     | 200
(1 row)
```

STV_TBL_TRANS

Use the STV_TBL_TRANS table to find out information about the transient database tables that are currently in memory.

Transient tables are typically temporary row sets that are used as intermediate results while a query runs. STV_TBL_TRANS differs from STV_TBL_PERM in that STV_TBL_PERM contains information about permanent database tables.

STV_TBL_TRANS is visible only to superusers. For more information, see [Visibility of data in system tables and views](#).

Table columns

Column name	Data type	Description
slice	integer	Node slice allocated to the table.
id	integer	Table ID.
rows	bigint	Number of data rows in the table.
size	bigint	Number of bytes allocated to the table.
query_id	bigint	Query ID.
ref_cnt	integer	Number of references.
from_suspended	integer	Whether or not this table was created during a query that is now suspended.
prep_swap	integer	Whether or not this transient table is prepared to swap to disk if needed. (The swap will only occur in situations where memory is low.)

Sample queries

To view transient table information for a query with a query ID of 90, type the following command:

```
select slice, id, rows, size, query_id, ref_cnt
from stv_tbl_trans
where query_id = 90;
```

This query returns the transient table information for query 90, as shown in the following sample output:

```

slice | id | rows | size | query_ | ref_ | from_     | prep_
      |    |      |      | id     | cnt  | suspended | swap
```

```
------+----+------+------+--------+------+-----------+-------
 1013 | 95 |    0 |    0 |     90 |    4 |         0 |    0
    7 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   10 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   17 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   14 | 96 |    0 |    0 |     90 |    4 |         0 |    0
    3 | 96 |    0 |    0 |     90 |    4 |         0 |    0
 1013 | 99 |    0 |    0 |     90 |    4 |         0 |    0
    9 | 96 |    0 |    0 |     90 |    4 |         0 |    0
    5 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   19 | 96 |    0 |    0 |     90 |    4 |         0 |    0
    2 | 96 |    0 |    0 |     90 |    4 |         0 |    0
 1013 | 98 |    0 |    0 |     90 |    4 |         0 |    0
   13 | 96 |    0 |    0 |     90 |    4 |         0 |    0
    1 | 96 |    0 |    0 |     90 |    4 |         0 |    0
 1013 | 96 |    0 |    0 |     90 |    4 |         0 |    0
    6 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   11 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   15 | 96 |    0 |    0 |     90 |    4 |         0 |    0
   18 | 96 |    0 |    0 |     90 |    4 |         0 |    0
```

In this example, you can see that the query data involves tables 95, 96, and 98. Because zero bytes are allocated to this table, this query can run in memory.

STV_WLM_CLASSIFICATION_CONFIG

Contains the current classification rules for WLM.

STV_WLM_CLASSIFICATION_CONFIG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
id	integer	Service class ID. For a list of service class IDs, see WLM service class IDs.
condition	character(128)	Query conditions.
action_seq	integer	Reserved for system use.

Column name	Data type	Description
action	character(64)	Reserved for system use.
action_se rvice_class	integer	The service class where the action takes place.

Sample query

```
select * from STV_WLM_CLASSIFICATION_CONFIG;

id | condition                                    | action_seq | action |
 action_service_class
---+---------------------------------------------+------------+--------
+---------------------
 1 | (system user) and (query group: health)     |          0 | assign |
    1
 2 | (system user) and (query group: metrics)    |          0 | assign |
    2
 3 | (system user) and (query group: cmstats)    |          0 | assign |
    3
 4 | (system user)                               |          0 | assign |
    4
 5 | (super user) and (query group: superuser)   |          0 | assign |
    5
 6 | (query group: querygroup1)                  |          0 | assign |
    6
 7 | (user group: usergroup1)                    |          0 | assign |
    6
 8 | (user group: usergroup2)                    |          0 | assign |
    7
 9 | (query group: querygroup3)                  |          0 | assign |
    8
10 | (query group: querygroup4)                  |          0 | assign |
    9
11 | (user group: usergroup4)                    |          0 | assign |
    9
12 | (query group: querygroup*)                  |          0 | assign |
   10
13 | (user group: usergroup*)                    |          0 | assign |
   10
```

```
14 | (querytype: any)                                |          0 | assign |
    11
(4 rows)
```

STV_WLM_QMR_CONFIG

Records the configuration for WLM query monitoring rules (QMR). For more information, see WLM query monitoring rules.

STV_WLM_QMR_CONFIG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
service_class	integer	ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Rules can be defined only for user-defined queues. For a list of service class IDs, see WLM service class IDs.
rule_name	character(256)	Name of the query monitoring rule.
action	character(256)	Rule action. Possible values are `log`, `hop`, `abort`, and `change_query_priority` .
metric_name	character(256)	Name of the metric.
metric_op erator	character(256)	The metric operator. Possible values are >, =, <.
metric_value	double	The threshold value for the specified metric that triggers an action.
action_value	character(256)	If `action` is `change_query_priority` , then possible values are `highest`, `high`, `normal`, `low`, and `lowest`. If `action` is `log`, `hop`, or `abort` then the value is empty.

Sample query

To view the QMR rule definitions for all service classes greater than 5 (which includes user-defined queues), run the following query. For a list of service class IDs, see WLM service class IDs.

```
Select *
from stv_wlm_qmr_config
where service_class > 5
order by service_class;
```

STV_WLM_QUERY_QUEUE_STATE

Records the current state of the query queues for the service classes.

STV_WLM_QUERY_QUEUE_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
position	integer	Position of the query in the queue. The query with the smallest **position** value runs next.
task	integer	ID used to track a query through the workload manager. Can be associated with multiple query IDs. If a query is restarted, the query is assigned a new query ID but not a new task ID.
query	integer	Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.

Column name	Data type	Description
slot_count	integer	Number of WLM query slots.
start_time	timestamp	Time that the query entered the queue.
queue_time	bigint	Number of microseconds that the query has been in the queue.

Sample query

The following query shows the queries in the queue for service classes greater than 4.

```
select * from stv_wlm_query_queue_state
where service_class > 4
order by service_class;
```

This query returns the following sample output.

```
 service_class | position | task | query | slot_count |        start_time          |
 queue_time
---------------+----------+------+-------+------------+----------------------------
+------------
             5 |        0 |  455 |   476 |          5 | 2010-10-06 13:18:24.065838 |
 20937257
             6 |        1 |  456 |   478 |          5 | 2010-10-06 13:18:26.652906 |
 18350191
(2 rows)
```

STV_WLM_QUERY_STATE

Records the current state of queries being tracked by WLM.

STV_WLM_QUERY_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
xid	integer	Transaction ID of the query or subquery.
task	integer	ID used to track a query through the workload manager. Can be associated with multiple query IDs. If a query is restarted, the query is assigned a new query ID but not a new task ID.
query	integer	Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
slot_count	integer	Number of WLM query slots.
wlm_start_time	timestamp	Time that the query entered the system table queue or short query queue.
state	character(16)	Current state of the query or subquery. Possible values are the following: • `Classified` – Query has been assigned to a service class. • `Completed` – Query is finished running. The query either ran successfully or was canceled. For the final state, check the results of STL_QUERY. • `Dequeued` – Internal use only. • `Evicted` – Query has been evicted from the service class for restart.

Column name	Data type	Description
		• `Evicting` – Query is being evicted from the service class for restart. • `Initialized` – Internal use only. • `Invalid` – Internal use only. • `Queued` – Query was sent to the query queue because no slots were available to run it. • `QueuedWaiting` – Query is waiting in the query queue. • `Rejected` – Internal use only. • `Returning` – Query is returning results to the client. • `Running` – Query is running. • `TaskAssigned` – Internal use only.
queue_time	bigint	Number of microseconds that the query has spent in the queue.
exec_time	bigint	Number of microseconds that the query has been running.
query_priority	char(20)	The priority of the query. Possible values are `n/a`, `lowest`, `low`, `normal`, `high`, and `highest`, where `n/a` means that query priority isn't supported.

Sample query

The following query displays all currently executing queries in service classes greater than 4. For a list of service class IDs, see WLM service class IDs.

```
select xid, query, trim(state) as state, queue_time, exec_time
from stv_wlm_query_state
where service_class > 4;
```

This query returns the following sample output:

```
xid    | query | state   | queue_time | exec_time
-------+-------+---------+------------+-----------
100813 | 25942 | Running |          0 |    1369029
100074 | 25775 | Running |          0 | 2221589242
```

STV_WLM_QUERY_TASK_STATE

Contains the current state of service class query tasks.

STV_WLM_QUERY_TASK_STATE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
task	integer	ID used to track a query through the workload manager. Can be associated with multiple query IDs. If a query is restarted, the query is assigned a new query ID but not a new task ID.
query	integer	Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.
slot_count	integer	Number of WLM query slots.
start_time	timestamp	Time that the query began executing.
exec_time	bigint	Number of microseconds that the query has been executing.

Sample query

The following query displays the current state of queries in service classes greater than 4. For a list of service class IDs, see WLM service class IDs.

```
select * from stv_wlm_query_task_state
where service_class > 4;
```

This query returns the following sample output:

```
service_class | task | query |         start_time         | exec_time
--------------+------+-------+----------------------------+-----------
    5         |  466 |   491 | 2010-10-06 13:29:23.063787 | 357618748
(1 row)
```

STV_WLM_SERVICE_CLASS_CONFIG

Records the service class configurations for WLM.

STV_WLM_SERVICE_CLASS_CONFIG is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
queueing_ strategy	character(32)	Reserved for system use.
num_query_tasks	integer	Current actual concurrency level of the service class. If `num_query_tasks` and `target_num_query_tasks` are different, a dynamic WLM transition is in process. A value of `-1` indicates that **Auto WLM** is configured.
target_nu m_query_tasks	integer	Concurrency level set by the most recent WLM configura tion change.
evictable	character(8)	Reserved for system use.
eviction_ threshold	bigint	Reserved for system use.

Column name	Data type	Description
query_wor king_mem	integer	Current actual amount of working memory, in MB per slot, per node, assigned to the service class. If `query_wor king_mem` and `target_query_working_mem` are different, a dynamic WLM transition is in process. A value of `-1` indicates than **Auto WLM** is configured.
target_qu ery_worki ng_mem	integer	The amount of working memory, in MB per slot, per node, set by the most recent WLM configuration change.
min_step_mem	integer	Reserved for system use.
name	character(64)	The name of the service class.
max_execu tion_time	bigint	Number of milliseconds that the query can run before being terminated.
user_grou p_wild_card	Boolean	If TRUE, the WLM queue treats an asterisk (*) as a wildcard character in user group strings in the WLM configuration.
query_gro up_wild_card	Boolean	If TRUE, the WLM queue treats an asterisk (*) as a wildcard character in query group strings in the WLM configura tion.
concurren cy_scaling	character(20)	Describes if the concurrency scaling is on or `off`.
query_priority	character(20)	The value of the query priority.
user_role _wild_card	Boolean	If TRUE, the WLM queue treats an asterisk (*) as a wildcard character in user user strings in the WLM configuration.

Sample query

The first user-defined service class is service class 6, which is named Service class #1. The following query displays the current configuration for service classes greater than 4. For a list of service class IDs, see [WLM service class IDs](#).

```
select rtrim(name) as name,
num_query_tasks as slots,
query_working_mem as mem,
max_execution_time as max_time,
user_group_wild_card as user_wildcard,
query_group_wild_card as query_wildcard
from stv_wlm_service_class_config
where service_class > 4;

name                           | slots | mem | max_time | user_wildcard | query_wildcard
-------------------------------+-------+-----+----------+---------------+---------------
Service class for super user |     1 | 535 |        0 | false         | false
Queue 1                        |     5 | 125 |        0 | false         | false
Queue 2                        |     5 | 125 |        0 | false         | false
Queue 3                        |     5 | 125 |        0 | false         | false
Queue 4                        |     5 | 627 |        0 | false         | false
Queue 5                        |     5 | 125 |        0 | true          | true
Default queue                  |     5 | 125 |        0 | false         | false
```

The following query shows the status of a dynamic WLM transition. While the transition is in process, `num_query_tasks` and `target_query_working_mem` are updated until they equal the target values. For more information, see WLM dynamic and static configuration properties.

```
select rtrim(name) as name,
num_query_tasks as slots,
target_num_query_tasks as target_slots,
query_working_mem as memory,
target_query_working_mem as target_memory
from stv_wlm_service_class_config
where num_query_tasks > target_num_query_tasks
or query_working_mem > target_query_working_mem
and service_class > 5;

 name             | slots | target_slots | memory | target_mem
------------------+-------+--------------+--------+------------
 Queue 3          |     5 |           15 |    125 |        375
 Queue 5          |    10 |            5 |    250 |        125
 (2 rows)
```

STV_WLM_SERVICE_CLASS_STATE

Contains the current state of the service classes.

STV_WLM_SERVICE_CLASS_STATE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
service_class	integer	ID for the service class. For a list of service class IDs, see WLM service class IDs.
num_queued_queries	integer	Number of queries currently in the queue.
num_executing_queries	integer	Number of queries currently executing.
num_serviced_queries	integer	Number of queries that have ever been in the service class.
num_executed_queries	integer	Number of queries that have run since Amazon Redshift was restarted.
num_evicted_queries	integer	Number of queries that have been evicted since Amazon Redshift was restarted. Some of the reasons for an evicted query include a WLM timeout, a QMR hop action, and a query failing on a concurrency scaling cluster.
num_concurrency_scaling_queries	integer	Number of queries run on a concurrency scaling cluster since Amazon Redshift was restarted.

Sample query

The following query displays the state for service classes greater than 5. For a list of service class IDs, see WLM service class IDs.

```
select service_class, num_executing_queries,
num_executed_queries
from stv_wlm_service_class_state
where service_class > 5
order by service_class;
```

```
 service_class | num_executing_queries | num_executed_queries
---------------+-----------------------+----------------------
             6 |                     1 |                  222
             7 |                     0 |                  135
             8 |                     1 |                   39
(3 rows)
```

STV_XRESTORE_ALTER_QUEUE_STATE

Use STV_XRESTORE_ALTER_QUEUE_STATE to monitor the migration progress of each table during a classic resize. This is specifically applicable when the target node type is RA3. For more information about classic resize to RA3 nodes, go to Classic resize.

STV_XRESTORE_ALTER_QUEUE_STATE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_RESTORE_STATE. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who initiated the resize.
db_id	integer	The ID of the database.
schema	char(128)	The name of the schema.
table_name	char(128)	The name of the table.
tbl	integer	The ID of the table.
status	char(64)	The status of the migration progress of the table. Possible values are as follows. • `Waiting`: Waiting for redistribution to start • `Applying`: Currently redistributing

Column name	Data type	Description
		• `Finished`: Finished redistributing
task_type	integer	The redistribution type for the table. Possible values are as follows. • 1: KEY • 2: EVEN For more information about distribution styles, see [Distribution styles]().

Sample query

The following query shows the number of tables in a database that are waiting to be resized, are currently being resized, and are finished resizing.

```
select db_id, status, count(*)
from stv_xrestore_alter_queue_state
group by 1,2 order by 3 desc

db_id  |   status   | count
-------+------------+------
694325 | Waiting    |   323
694325 | Finished   |    60
694325 | Applying   |     1
```

SVCS views for main and concurrency scaling clusters

SVCS system views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

Topics

- SVCS_ALERT_EVENT_LOG
- SVCS_COMPILE

- SVCS_CONCURRENCY_SCALING_USAGE
- SVCS_EXPLAIN
- SVCS_PLAN_INFO
- SVCS_QUERY_SUMMARY
- SVCS_S3LIST
- SVCS_S3LOG
- SVCS_S3PARTITION_SUMMARY
- SVCS_S3QUERY_SUMMARY
- SVCS_STREAM_SEGS
- SVCS_UNLOAD_LOG

SVCS_ALERT_EVENT_LOG

Records an alert when the query optimizer identifies conditions that might indicate performance issues. This view is derived from the STL_ALERT_EVENT_LOG system table but doesn't show slice-level for queries run on a concurrency scaling cluster. Use the SVCS_ALERT_EVENT_LOG table to identify opportunities to improve query performance.

A query consists of multiple segments, and each segment consists of one or more steps. For more information, see Query processing.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

SVCS_ALERT_EVENT_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
segment	integer	Number that identifies the query segment.
step	integer	Query step that ran.
pid	integer	Process ID associated with the statement and slice. The same query might have multiple PIDs if it runs on multiple slices.
xid	bigint	Transaction ID associated with the statement.
event	character (1024)	Description of the alert event.
solution	character (1024)	Recommended solution.
event_time	timestamp	Time in UTC that the query started. Total time includes queuing and execution. with 6 digits of precision for fractional seconds. For example: **`2009-06-12 11:29:19.131358`** .

Usage notes

You can use the SVCS_ALERT_EVENT_LOG to identify potential issues in your queries, then follow the practices in Query performance tuning to optimize your database design and rewrite your queries. SVCS_ALERT_EVENT_LOG records the following alerts:

- **Missing statistics**

  Statistics are missing. Run ANALYZE following data loads or significant updates and use STATUPDATE with COPY operations. For more information, see Amazon Redshift best practices for designing queries.

- **Nested loop**

  A nested loop is usually a Cartesian product. Evaluate your query to ensure that all participating tables are joined efficiently.
- **Very selective filter**

  The ratio of rows returned to rows scanned is less than 0.05. Rows scanned is the value of `rows_pre_user_filter` and rows returned is the value of rows in the STL_SCAN system table. Indicates that the query is scanning an unusually large number of rows to determine the result set. This can be caused by missing or incorrect sort keys. For more information, see Sort keys.
- **Excessive ghost rows**

  A scan skipped a relatively large number of rows that are marked as deleted but not vacuumed, or rows that have been inserted but not committed. For more information, see Vacuuming tables.
- **Large distribution**

  More than 1,000,000 rows were redistributed for hash join or aggregation. For more information, see Data distribution for query optimization.
- **Large broadcast**

  More than 1,000,000 rows were broadcast for hash join. For more information, see Data distribution for query optimization.
- **Serial execution**

  A DS_DIST_ALL_INNER redistribution style was indicated in the query plan, which forces serial execution because the entire inner table was redistributed to a single node. For more information, see Data distribution for query optimization.

Sample queries

The following query shows alert events for four queries.

```
SELECT query, substring(event,0,25) as event,
substring(solution,0,25) as solution,
trim(event_time) as event_time from svcs_alert_event_log order by query;

 query |             event             |          solution            |     event_time
```

```
-------+------------------------------+-----------------------------
+---------------------
  6567 | Missing query planner statist | Run the ANALYZE command      | 2014-01-03
 18:20:58
  7450 | Scanned a large number of del | Run the VACUUM command to rec| 2014-01-03
 21:19:31
  8406 | Nested Loop Join in the query | Review the join predicates to| 2014-01-04
 00:34:22
 29512 | Very selective query filter:r | Review the choice of sort key| 2014-01-06
 22:00:00

(4 rows)
```

SVCS_COMPILE

Records compile time and location for each query segment of queries, including queries run on a scaling cluster as well as queries run on the main cluster.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_COMPILE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SCL_COMPILE, see SVL_COMPILE.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who generated the entry.
xid	bigint	The transaction ID associated with the statement.
pid	integer	The process ID associated with the statement.

Column name	Data type	Description
query	integer	The query ID. You can use this ID to join various other system tables and views.
segment	integer	The query segment to be compiled.
locus	integer	The location where the segment runs, **1** if on a compute node and **2** if on the leader node.
starttime	timestamp	The time in Universal Coordinated Time (UTC) that the compile started.
endtime	timestamp	The time in UTC that the compile ended.
compile	integer	A value that is **0** if the compile was reused and **1** if the segment was compiled.

Sample queries

In this example, queries 35878 and 35879 ran the same SQL statement. The compile column for query 35878 shows 1 for four query segments, which indicates that the segments were compiled. Query 35879 shows `0` in the compile column for every segment, indicating that the segments did not need to be compiled again.

```
select userid, xid,  pid, query, segment, locus,
datediff(ms, starttime, endtime) as duration, compile
from svcs_compile
where query = 35878 or query = 35879
order by query, segment;

 userid |  xid   |  pid  | query | segment | locus | duration | compile
--------+--------+-------+-------+---------+-------+----------+---------
    100 | 112780 | 23028 | 35878 |       0 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       1 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       2 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       3 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       4 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       5 |     1 |        0 |       0
```

```
    100 | 112780 | 23028 | 35878 |        6 |       1 |       1380 |          1
    100 | 112780 | 23028 | 35878 |        7 |       1 |       1085 |          1
    100 | 112780 | 23028 | 35878 |        8 |       1 |       1197 |          1
    100 | 112780 | 23028 | 35878 |        9 |       2 |        905 |          1
    100 | 112782 | 23028 | 35879 |        0 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        1 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        2 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        3 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        4 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        5 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        6 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        7 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        8 |       1 |          0 |          0
    100 | 112782 | 23028 | 35879 |        9 |       2 |          0 |          0
(20 rows)
```

SVCS_CONCURRENCY_SCALING_USAGE

Records the usage periods for concurrency scaling. Each usage period is a consecutive duration where an individual concurrency scaling cluster is actively processing queries.

SVCS_CONCURRENCY_SCALING_USAGE This table is visible to superusers. The database's superuser can choose to open it up to all users.

Table columns

Column name	Data type	Description
start_time	timestamp without time zone	When the usage period starts.
end_time	timestamp without time zone	When the usage period ends.
queries	bigint	Number of queries run during this usage period.
usage_in_seconds	numeric(27,0)	Total seconds in this usage period.

Sample queries

To view the usage duration in seconds for a specific period, enter the following query:

```
select * from svcs_concurrency_scaling_usage order by start_time;

start_time | end_time | queries | usage_in_seconds
----------------------------+----------------------------+---------+------------------
2019-02-14 18:43:53.01063 | 2019-02-14 19:16:49.781649 | 48 | 1977
```

SVCS_EXPLAIN

Displays the EXPLAIN plan for a query that has been submitted for execution.

Note

System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

SVCS_EXPLAIN is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
nodeid	integer	Plan node identifier, where a node maps to one or more steps in the execution of the query.

Column name	Data type	Description
parentid	integer	Plan node identifier for a parent node. A parent node has some number of child nodes. For example, a merge join is the parent of the scans on the joined tables.
plannode	character(400)	The node text from the EXPLAIN output. Plan nodes that refer to execution on compute nodes are prefixed with **XN** in the EXPLAIN output.
info	character(400)	Qualifier and filter information for the plan node. For example, join conditions and WHERE clause restrictions are included in this column.

Sample queries

Consider the following EXPLAIN output for an aggregate join query:

```
explain select avg(datediff(day, listtime, saletime)) as avgwait
from sales, listing where sales.listid = listing.listid;
                                  QUERY PLAN

------------------------------------------------------------------------------
 XN Aggregate  (cost=6350.30..6350.31 rows=1 width=16)
  ->  XN Hash Join DS_DIST_NONE  (cost=47.08..6340.89 rows=3766 width=16)
        Hash Cond: ("outer".listid = "inner".listid)
        -> XN Seq Scan on listing  (cost=0.00..1924.97 rows=192497 width=12)
        -> XN Hash  (cost=37.66..37.66 rows=3766 width=12)
              -> XN Seq Scan on sales  (cost=0.00..37.66 rows=3766 width=12)
(6 rows)
```

If you run this query and its query ID is 10, you can use the SVCS_EXPLAIN table to see the same kind of information that the EXPLAIN command returns:

```
select query,nodeid,parentid,substring(plannode from 1 for 30),
substring(info from 1 for 20) from svcs_explain
where query=10 order by 1,2;

query| nodeid |parentid|           substring            |    substring
```

```
-----+--------+--------+---------------------------------+-------------------
10   |      1 |      0 |XN Aggregate  (cost=6717.61..6  |
10   |      2 |      1 |  -> XN Merge Join DS_DIST_NO| Merge Cond:("outer"
10   |      3 |      2 |       -> XN Seq Scan on lis |
10   |      4 |      2 |       -> XN Seq Scan on sal |
(4 rows)
```

Consider the following query:

```
select event.eventid, sum(pricepaid)
from event, sales
where event.eventid=sales.eventid
group by event.eventid order by 2 desc;

eventid |   sum
--------+----------
    289 | 51846.00
   7895 | 51049.00
   1602 | 50301.00
    851 | 49956.00
   7315 | 49823.00
...
```

If this query's ID is 15, the following system table query returns the plan nodes that were performed. In this case, the order of the nodes is reversed to show the actual order of execution:

```
select query,nodeid,parentid,substring(plannode from 1 for 56)
from svcs_explain where query=15 order by 1, 2 desc;

query|nodeid|parentid|                          substring
-----+------+--------+--------------------------------------------------------
15   |    8 |      7 |                                -> XN Seq Scan on eve
15   |    7 |      5 |                          -> XN Hash(cost=87.98..87.9
15   |    6 |      5 |                          -> XN Seq Scan on sales(cos
15   |    5 |      4 |                    -> XN Hash Join DS_DIST_OUTER(cos
15   |    4 |      3 |              -> XN HashAggregate(cost=862286577.07..
15   |    3 |      2 |        -> XN Sort(cost=1000862287175.47..10008622871
15   |    2 |      1 |  -> XN Network(cost=1000862287175.47..1000862287197.
15   |    1 |      0 |XN Merge(cost=1000862287175.47..1000862287197.46 rows=87
(8 rows)
```

The following query retrieves the query IDs for any query plans that contain a window function:

```
select query, trim(plannode) from svcs_explain
where plannode like '%Window%';

query|                                     btrim
-----+------------------------------------------------------------------------
26   | -> XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)
27   | -> XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)
(2 rows)
```

SVCS_PLAN_INFO

Use the SVCS_PLAN_INFO table to look at the EXPLAIN output for a query in terms of a set of rows. This is an alternative way to look at query plans.

Note

System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

SVCS_PLAN_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
nodeid	integer	Plan node identifier, where a node maps to one or more steps in the execution of the query.
segment	integer	Number that identifies the query segment.
step	integer	Number that identifies the query step.

Column name	Data type	Description
locus	integer	Location where the step runs. 0 if on a compute node and 1 if on the leader node.
plannode	integer	Enumerated value of the plan node. See the following table for enums for plannode. (The PLANNODE column in SVCS_EXPLAIN contains the plan node text.)
startupcost	double precision	The estimated relative cost of returning the first row for this step.
totalcost	double precision	The estimated relative cost of executing the step.
rows	bigint	The estimated number of rows that will be produced by the step.
bytes	bigint	The estimated number of bytes that will be produced by the step.

Sample queries

The following examples compare the query plans for a simple SELECT query returned by using the EXPLAIN command and by querying the SVCS_PLAN_INFO table.

```
explain select * from category;
QUERY PLAN
-------------------------------------------------------------
XN Seq Scan on category (cost=0.00..0.11 rows=11 width=49)
(1 row)

select * from category;
catid | catgroup | catname | catdesc
-------+----------+-----------+--------------------------------------------
1 | Sports | MLB | Major League Baseball
3 | Sports | NFL | National Football League
5 | Sports | MLS | Major League Soccer
...
```

```
select * from svcs_plan_info where query=256;

query | nodeid | segment | step | locus | plannode | startupcost | totalcost
| rows | bytes
-------+--------+---------+------+-------+----------+-------------+----------+------
+-------
256 | 1 | 0 | 1 | 0 | 104 | 0 | 0.11 | 11 | 539
256 | 1 | 0 | 0 | 0 | 104 | 0 | 0.11 | 11 | 539
(2 rows)
```

In this example, PLANNODE 104 refers to the sequential scan of the CATEGORY table.

```
select distinct eventname from event order by 1;

eventname
------------------------------------------------------------------------
.38 Special
3 Doors Down
70s Soul Jam
A Bronx Tale
...

explain select distinct eventname from event order by 1;

QUERY PLAN
-------------------------------------------------------------------------------------
XN Merge (cost=1000000000136.38..1000000000137.82 rows=576 width=17)
Merge Key: eventname
-> XN Network (cost=1000000000136.38..1000000000137.82 rows=576
width=17)
Send to leader
-> XN Sort (cost=1000000000136.38..1000000000137.82 rows=576
width=17)
Sort Key: eventname
-> XN Unique (cost=0.00..109.98 rows=576 width=17)
-> XN Seq Scan on event (cost=0.00..87.98 rows=8798
width=17)
(8 rows)

select * from svcs_plan_info where query=240 order by nodeid desc;

query | nodeid | segment | step | locus | plannode | startupcost |
totalcost | rows | bytes
```

```
-------+--------+---------+------+-------+----------+-----------------
+-----------------+------+--------
240 | 5 | 0 | 0 | 0 | 104 | 0                 | 87.98   | 8798 | 149566
240 | 5 | 0 | 1 | 0 | 104 | 0                 | 87.98   | 8798 | 149566
240 | 4 | 0 | 2 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 0 | 3 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 1 | 0 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 4 | 1 | 1 | 0 | 117 | 0                 | 109.975 | 576  | 9792
240 | 3 | 1 | 2 | 0 | 114 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 3 | 2 | 0 | 0 | 114 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 2 | 2 | 1 | 0 | 123 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
240 | 1 | 3 | 0 | 0 | 122 | 1000000000136.38 | 1000000000137.82 | 576 | 9792
(10 rows)
```

SVCS_QUERY_SUMMARY

Use the SVCS_QUERY_SUMMARY view to find general information about the execution of a query.

Note that the information in SVCS_QUERY_SUMMARY is aggregated from all nodes.

> **Note**
>
> The SVCS_QUERY_SUMMARY view only contains information about queries completed by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements completed by Amazon Redshift, including DDL and utility commands, you can query the SVL_STATEMENTTEXT view.
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_QUERY_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For information about SVL_QUERY_SUMMARY, see SVL_QUERY_SUMMARY.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
query	integer	Query ID. Can be used to join various other system tables and views.
stm	integer	Stream: A set of concurrent segments in a query. A query has one or more streams.
seg	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process.
step	integer	Query step that ran.
maxtime	bigint	Maximum amount of time for the step to run (in microseconds).
avgtime	bigint	Average time for the step to run (in microseconds).
rows	bigint	Number of data rows involved in the query step.
bytes	bigint	Number of data bytes involved in the query step.
rate_row	double precision	Query execution rate per row.
rate_byte	double precision	Query execution rate per byte.
label	text	Step label, which consists of a query step name and, when applicable, table ID and table name (for example, scan tbl=100448 name =user). Three-digit table IDs usually refer to scans of transient tables. When you see `tbl=0`, it usually refers to a scan of a constant value.

Column name	Data type	Description
is_diskbased	character(1)	Whether this step of the query was performed as a disk-based operation on any node in the cluster: true (**t**) or false (**f**). Only certain steps, such as hash, sort, and aggregate steps, can go to disk. Many types of steps are always run in memory.
workmem	bigint	Amount of working memory (in bytes) assigned to the query step.
is_rrscan	character(1)	If true (**t**), indicates that range-restricted scan was used on the step. Default is false (**f**).
is_delayed_scan	character(1)	If true (**t**), indicates that delayed scan was used on the step. Default is false (**f**).
rows_pre_filter	bigint	For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows).

Sample queries

Viewing processing information for a query step

The following query shows basic processing information for each step of query 87:

```
select query, stm, seg, step, rows, bytes
from svcs_query_summary
where query = 87
order by query, seg, step;
```

This query retrieves the processing information about query 87, as shown in the following sample output:

```
 query | stm | seg | step |  rows  |  bytes
-------+-----+-----+------+--------+---------
87     |   0 |   0 |    0 |     90 |    1890
87     |   0 |   0 |    2 |     90 |     360
87     |   0 |   1 |    0 |     90 |     360
87     |   0 |   1 |    2 |     90 |    1440
87     |   1 |   2 |    0 | 210494 | 4209880
```

```
87      |   1 |   2 |    3 |  89500 |       0
87      |   1 |   2 |    6 |      4 |      96
87      |   2 |   3 |    0 |      4 |      96
87      |   2 |   3 |    1 |      4 |      96
87      |   2 |   4 |    0 |      4 |      96
87      |   2 |   4 |    1 |      1 |      24
87      |   3 |   5 |    0 |      1 |      24
87      |   3 |   5 |    4 |      0 |       0
(13 rows)
```

Determining whether query steps spilled to disk

The following query shows whether or not any of the steps for the query with query ID 1025 (see the SVL_QLOG view to learn how to obtain the query ID for a query) spilled to disk or if the query ran entirely in-memory:

```
select query, step, rows, workmem, label, is_diskbased
from svcs_query_summary
where query = 1025
order by workmem desc;
```

This query returns the following sample output:

```
query| step|  rows  |  workmem   |  label        | is_diskbased
-----+-----+--------+-----------+---------------+--------------
1025 |  0  |16000000|  141557760 |scan tbl=9     | f
1025 |  2  |16000000|  135266304 |hash tbl=142   | t
1025 |  0  |16000000|  128974848 |scan tbl=116536| f
1025 |  2  |16000000|  122683392 |dist           | f
(4 rows)
```

By scanning the values for IS_DISKBASED, you can see which query steps went to disk. For query 1025, the hash step ran on disk. Steps might run on disk include hash, aggr, and sort steps. To view only disk-based query steps, add **`and is_diskbased = 't'`** clause to the SQL statement in the above example.

SVCS_S3LIST

Use the SVCS_S3LIST view to get details about Amazon Redshift Spectrum queries at the segment level. One segment can perform one external table scan. This view is derived from the SVL_S3LIST system view but doesn't show slice-level for queries run on a concurrency scaling cluster.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_S3LIST is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SVL_S3LIST, see SVL_S3LIST.

Table columns

Column name	Data type	Description
query	integer	The query ID.
segment	integer	The segment number. A query consists of multiple segments.
node	integer	The node number.
eventtime	timestamp	The time in UTC that the event is recorded.
bucket	char(256)	The Amazon S3 bucket name.
prefix	char(256)	The prefix of the Amazon S3 bucket location.
recursive	char(1)	Whether there is recursive scan for subfolders.
retrieved_files	integer	The number of listed files.
max_file_size	bigint	The maximum file size among listed files.
avg_file_size	double precision	The average file size among listed files.

Column name	Data type	Description
generated_splits	integer	The number of file splits.
avg_split_length	double precision	The average length of file splits in bytes.
duration	bigint	The duration of file listing, in microseconds.

Sample query

The following example queries SVCS_S3LIST for the last query performed.

```
select *
from svcs_s3list
where query = pg_last_query_id()
order by query,segment;
```

SVCS_S3LOG

Use the SVCS_S3LOG view to get troubleshooting details about Redshift Spectrum queries at the segment level. One segment can perform one external table scan. This view is derived from the SVL_S3LOG system view but doesn't show slice-level for queries run on a concurrency scaling cluster.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_S3LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SVL_S3LOG, see SVL_S3LOG.

Table columns

Column name	Data type	Description
pid	integer	The process ID.
query	integer	The query ID.
segment	integer	The segment number. A query consists of multiple segments, and each segment consists of one or more steps.
step	integer	The query step that ran.
node	integer	The node number.
eventtime	timestamp	The time in UTC that the event is recorded.
message	char(512)	The message for the log entry.

Sample query

The following example queries SVCS_S3LOG for the last query that ran.

```
select *
from svcs_s3log
where query = pg_last_query_id()
order by query,segment;
```

SVCS_S3PARTITION_SUMMARY

Use the SVCS_S3PARTITION_SUMMARY view to get a summary of Redshift Spectrum queries partition processing at the segment level. One segment can perform one external table scan.

Note

System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_S3PARTITION_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SVL_S3PARTITION, see SVL_S3PARTITION.

Table columns

Column name	Data type	Description
query	integer	The query ID. You can use this value to join various other system tables and views.
segment	integer	The segment number. A query consists of multiple segments.
assignment	char(1)	The type of partition assignment across nodes.
min_starttime	timestamp	The time in UTC that the partition processing started.
max_endtime	timestamp	The time in UTC that the partition processing completed.
min_duration	bigint	The minimum partition processing time used by a node for this query (in microseconds).
max_duration	bigint	The maximum partition processing time used by a node for this query (in microseconds).

Column name	Data type	Description
avg_duration	bigint	The average partition processing time used by a node for this query (in microseconds).
total_partitions	integer	The total number of partitions in an external table.
qualified_partitions	integer	The total number of qualified partitions.
min_assigned_partitions	integer	The minimum number of partitions assigned on one node.
max_assigned_partitions	integer	The maximum number of partitions assigned on one node.
avg_assigned_partitions	bigint	The average number of partitions assigned on one node.

Sample query

The following example gets the partition scan details for the last query performed.

```
select query, segment, assignment, min_starttime, max_endtime, min_duration,
 avg_duration
from svcs_s3partition_summary
where query = pg_last_query_id()
order by query,segment;
```

SVCS_S3QUERY_SUMMARY

Use the SVCS_S3QUERY_SUMMARY view to get a summary of all Redshift Spectrum queries (S3 queries) that have been run on the system. One segment can perform one external table scan.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the views with the prefix SVL except that the SVL views provide information only for queries run on the main cluster.

SVCS_S3QUERY_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SVL_S3QUERY, see SVL_S3QUERY.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user that generated the given entry.
query	integer	The query ID. You can use this value to join various other system tables and views.
xid	bigint	The transaction ID.
pid	integer	The process ID.
segment	integer	The segment number. A query consists of multiple segments, and each segment consists of one or more steps.
step	integer	The query step that ran.
starttime	timestamp	The time in UTC that the Redshift Spectrum query in this segment started running. One segment can have one external table scan.
endtime	timestamp	The time in UTC that the Redshift Spectrum query in this segment completed. One segment can have one external table scan.

Column name	Data type	Description
elapsed	integer	The length of time that it took the Redshift Spectrum query in this segment to run (in microseconds).
aborted	integer	If a query was stopped by the system or canceled by the user, this column contains **1**. If the query ran to completio n, this column contains **0**.
external_table_name	char(136)	The internal format of name of the external name of the table for the external table scan.
file_format	character(16)	The file format of the external table data.
is_partitioned	char(1)	If true (**t**), this column value indicates that the external table is partitioned.
is_rrscan	char(1)	If true (**t**), this column value indicates that a range-res tricted scan was applied.
is_nested	varchar(1)	If true (**t**), this column value indicates that the nested column data type is accessed.
s3_scanned_rows	bigint	The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.
s3_scanned_bytes	bigint	The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer, based on compressed data.
s3query_returned_rows	bigint	The number of rows returned from the Redshift Spectrum layer to the cluster.

Column name	Data type	Description
s3query_returned_bytes	bigint	The number of bytes returned from the Redshift Spectrum layer to the cluster. A large amount of data returned to Amazon Redshift might affect system performance.
files	integer	The number of files that were processed for this Redshift Spectrum query. A small number of files limits the benefits of parallel processing.
files_max	integer	The maximum number of file processed on one slice.
files_avg	integer	The average number of file processed on one slice.
splits	bigint	The number of splits processed for this segment. The number of splits processed on this slice. With large splitable data files, for example, data files larger than about 512 MB, Redshift Spectrum tries to split the files into multiple S3 requests for parallel processing.
splits_max	integer	The maximum number of splits processed on this slice.
splits_avg	bigint	The average number of splits processed on this slice.
total_split_size	bigint	The total size of all splits processed.
max_split_size	bigint	The maximum split size processed, in bytes.
avg_split_size	bigint	The average split size processed, in bytes.
total_retries	bigint	The total number of retries for the Redshift Spectrum query in this segment.

Column name	Data type	Description
max_retries	integer	The maximum number of retries for one individual processed file.
max_request_duration	bigint	The maximum duration of an individual file request (in microseconds). Long running queries might indicate a bottleneck.
avg_request_duration	bigint	The average duration of the file requests (in microseconds).
max_request_parallelism	integer	The maximum number of parallel requests at one slice for this Redshift Spectrum query.
avg_request_parallelism	double precision	The average number of parallel requests at one slice for this Redshift Spectrum query.
total_slowdown_count	bigint	The total number of Amazon S3 requests with a slow down error that occurred during the external table scan.
max_slowdown_count	integer	The maximum number of Amazon S3 requests with a slow down error that occurred during the external table scan on one slice.

Sample query

The following example gets the scan step details for the last query run.

```
select query, segment, elapsed, s3_scanned_rows, s3_scanned_bytes,
 s3query_returned_rows, s3query_returned_bytes, files
from svcs_s3query_summary
where query = pg_last_query_id()
order by query,segment;
```

```
query | segment | elapsed | s3_scanned_rows | s3_scanned_bytes | s3query_returned_rows
 | s3query_returned_bytes | files
------+---------+---------+-----------------+------------------+----------------------
+------------------------+------
 4587 |       2 |   67811 |               0 |                0 |                     0
 |                      0 |     0
 4587 |       2 |  591568 |          172462 |         11260097 |                  8513
 |                 170260 |     1
 4587 |       2 |  216849 |               0 |                0 |                     0
 |                      0 |     0
 4587 |       2 |  216671 |               0 |                0 |                     0
 |                      0 |     0
```

SVCS_STREAM_SEGS

Lists the relationship between streams and concurrent segments.

Note

System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

SVCS_STREAM_SEGS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
stream	integer	The set of concurrent segments of a query.
segment	integer	Number that identifies the query segment.

Sample queries

To view the relationship between streams and concurrent segments for the most recent query, type the following query:

```
select *
from svcs_stream_segs
where query = pg_last_query_id();

 query | stream | segment
-------+--------+---------
    10 |      1 |       2
    10 |      0 |       0
    10 |      2 |       4
    10 |      1 |       3
    10 |      0 |       1
(5 rows)
```

SVCS_UNLOAD_LOG

Use the SVCS_UNLOAD_LOG to get details of UNLOAD operations.

SVCS_UNLOAD_LOG records one row for each file created by an UNLOAD statement. For example, if an UNLOAD creates 12 files, SVCS_UNLOAD_LOG contains 12 corresponding rows. This view is derived from the STL_UNLOAD_LOG system table but doesn't show slice-level for queries run on a concurrency scaling cluster.

> **Note**
>
> System views with the prefix SVCS provide details about queries on both the main and concurrency scaling clusters. The views are similar to the tables with the prefix STL except that the STL tables provide information only for queries run on the main cluster.

SVCS_UNLOAD_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who generated the entry.
query	integer	The query ID.
pid	integer	The process ID associated with the query statement.
path	character(1280)	The complete Amazon S3 object path for the file.
start_time	timestamp	The start time for the UNLOAD operation.
end_time	timestamp	The end time for the UNLOAD operation.
line_count	bigint	The number of lines (rows) unloaded to the file.
transfer_size	bigint	The number of bytes transferred.
file_format	character(10)	The format of unloaded file.

Sample query

To get a list of the files that were written to Amazon S3 by an UNLOAD command, you can call an Amazon S3 list operation after the UNLOAD completes; however, depending on how quickly you issue the call, the list might be incomplete because an Amazon S3 list operation is eventually consistent. To get a complete, authoritative list immediately, query SVCS_UNLOAD_LOG.

The following query returns the path name for files that were created by an UNLOAD for the last query completed:

```
select query, substring(path,0,40) as path
from svcs_unload_log
where query = pg_last_query_id()
order by path;
```

This command returns the following sample output:

```
 query |              path
 ------+---------------------------------------------
  2320 | s3://amzn-s3-demo-bucket/venue0000_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0001_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0002_part_00
  2320 | s3://amzn-s3-demo-bucket/venue0003_part_00
(4 rows)
```

SVL views for main cluster

SVL views are system views in Amazon Redshift that contain references to STL tables and logs for more detailed information.

These views provide quicker and easier access to commonly queried data found in those tables.

Note

The SVL_QUERY_SUMMARY view only contains information about queries run by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements run by Amazon Redshift, including DDL and utility commands, you can query the SVL_STATEMENTTEXT view.

Topics

- SVL_QLOG
- SVL_QUERY_METRICS
- SVL_QUERY_METRICS_SUMMARY
- SVL_QUERY_QUEUE_INFO
- SVL_QUERY_REPORT
- SVL_QUERY_SUMMARY
- SVL_RESTORE_ALTER_TABLE_PROGRESS
- SVL_S3LIST
- SVL_S3LOG
- SVL_S3PARTITION
- SVL_S3PARTITION_SUMMARY
- SVL_S3QUERY
- SVL_S3QUERY_SUMMARY
- SVL_S3RETRIES
- SVL_SPATIAL_SIMPLIFY
- SVL_SPECTRUM_SCAN_ERROR
- SVL_STATEMENTTEXT
- SVL_STORED_PROC_CALL
- SVL_STORED_PROC_MESSAGES
- SVL_TERMINATE
- SVL_UDF_LOG
- SVL_USER_INFO
- SVL_VACUUM_PERCENTAGE

SVL_AUTO_WORKER_ACTION

Records automated actions taken by Amazon Redshift on tables defined for automatic optimization.

SVL_AUTO_WORKER_ACTION is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
table_id	integer	The table identifier.
type	character (32)	The type of recommendation. Possible values are distkey and sortkey.
status	character (128)	The completion status of the recommendation. Possible values are Start, Complete, Skipped, Abort, Checkpoint, and Failed.
eventtime	timestamp	The timestamp of the `status` column.
sequence	integer	The sequence number of a truncated `previous_state` value. When a single `previous_state` contains more than 200 characters, additional rows are logged for that value. Sequence is 0 is the first row, 1 is the second, and so on.
previous_state	character (200)	The previous distribution style and sort keys of the table before applying the recommendation. The value is truncated into 200-character increments.

Some examples of values of the `status` column are as follows:

- Skipped:Table not found.
- Skipped:Recommendation is empty.
- Skipped:Apply sortkey recommendation is disabled.
- Skipped:Retry exceeds the maximum limit for a table.
- Skipped:Table column has changed.
- Abort:This table is not AUTO.
- Abort:This table has been recently converted.
- Abort:This table exceeds table size threshold.
- Abort:This table is already the recommended style.
- Checkpoint: progress *21.9963*%.

Sample queries

In the following example, the rows in the result show actions taken by Amazon Redshift.

```
select table_id, type, status, eventtime, sequence, previous_state
from SVL_AUTO_WORKER_ACTION;
```

```
 table_id |  type   |                        status                        |
 eventtime          | sequence | previous_state
----------+---------+------------------------------------------------------
+----------------------------+----------+----------------
   118082 | sortkey | Start                                                | 2020-08-22
 19:42:20.727049 | 0        |
   118078 | sortkey | Start                                                | 2020-08-22
 19:43:54.728819 | 0        |
   118082 | sortkey | Start                                                | 2020-08-22
 19:42:52.690264 | 0        |
   118072 | sortkey | Start                                                | 2020-08-22
 19:44:14.793572 | 0        |
   118082 | sortkey | Failed                                               | 2020-08-22
 19:42:20.728917 | 0        |
   118078 | sortkey | Complete                                             | 2020-08-22
 19:43:54.792705 | 0        | SORTKEY: None;
   118086 | sortkey | Complete                                             | 2020-08-22
 19:42:00.72635  | 0        | SORTKEY: None;
   118082 | sortkey | Complete                                             | 2020-08-22
 19:43:34.728144 | 0        | SORTKEY: None;
   118072 | sortkey | Skipped:Retry exceeds the maximum limit for a table. | 2020-08-22
 19:44:46.706155 | 0        |
   118086 | sortkey | Start                                                | 2020-08-22
 19:42:00.685255 | 0        |
   118082 | sortkey | Start                                                | 2020-08-22
 19:43:34.69531  | 0        |
   118072 | sortkey | Start                                                | 2020-08-22
 19:44:46.703331 | 0        |
   118082 | sortkey | Checkpoint: progress 14.755079%                      | 2020-08-22
 19:42:52.692828 | 0        |
   118072 | sortkey | Failed                                               | 2020-08-22
 19:44:14.796071 | 0        |
   116723 | sortkey | Abort:This table is not AUTO.                        | 2020-10-28
 05:12:58.479233 | 0        |
```

```
  110203 | distkey | Abort:This table is not AUTO.                        | 2020-10-28
05:45:54.67259  | 0        |
```

SVL_COMPILE

Records compile time and location for each query segment of queries.

SVL_COMPILE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

SVL_COMPILE only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_QUERY_HISTORY . The data in the SYS monitoring view is formatted to be easier to use and understand.

For information about SVCS_COMPILE, see SVCS_COMPILE.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
xid	bigint	Transaction ID associated with the statement.
pid	integer	Process ID associated with the statement.
query	integer	Query ID. Can be used to join various other system tables and views.
segment	integer	The query segment to be compiled.
locus	integer	Location where the segment runs. **1** if on a compute node and **2** if on the leader node.
starttime	timestamp	Time in UTC that the compile started.

Column name	Data type	Description
endtime	timestamp	Time in UTC that the compile ended.
compile	integer	**0** if the compile was reused, **1** if the segment was compiled.

Sample queries

In this example, queries 35878 and 35879 ran the same SQL statement. The compile column for query 35878 shows 1 for four query segments, which indicates that the segments were compiled. Query 35879 shows 0 in the compile column for every segment, indicating that the segments did not need to be compiled again.

```
select userid, xid,  pid, query, segment, locus,
datediff(ms, starttime, endtime) as duration, compile
from svl_compile
where query = 35878 or query = 35879
order by query, segment;

 userid |  xid   |  pid  | query | segment | locus | duration | compile
--------+--------+-------+-------+---------+-------+----------+---------
    100 | 112780 | 23028 | 35878 |       0 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       1 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       2 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       3 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       4 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       5 |     1 |        0 |       0
    100 | 112780 | 23028 | 35878 |       6 |     1 |     1380 |       1
    100 | 112780 | 23028 | 35878 |       7 |     1 |     1085 |       1
    100 | 112780 | 23028 | 35878 |       8 |     1 |     1197 |       1
    100 | 112780 | 23028 | 35878 |       9 |     2 |      905 |       1
    100 | 112782 | 23028 | 35879 |       0 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       1 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       2 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       3 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       4 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       5 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       6 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       7 |     1 |        0 |       0
    100 | 112782 | 23028 | 35879 |       8 |     1 |        0 |       0
```

```
    100 | 112782 | 23028 | 35879 |        9 |      2 |         0 |        0
(20 rows)
```

SVL_DATASHARE_CHANGE_LOG

Records the consolidated view for tracking changes to datashares on both producer and consumer clusters.

SVL_DATASHARE_CHANGE_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_DATASHARE_CHANGE_LOG. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user taking the action.
username	varchar(128)	The name of the user taking the action.
pid	integer	The ID of the process.
xid	bigint	The ID of the transaction.
share_id	integer	The ID of the datashare affected.
share_name	varchar(128)	The name of the datashare.
source_database_id	integer	The ID of the database to which the datashare belongs.
source_database_name	varchar(128)	The name of the database to which the datashare belongs.

Column name	Data type	Description
consumer_database_id	integer	The ID of the database imported from the datashare.
consumer_database_name	varchar(128)	The name of the database imported from the datashare.
arn	varchar(192)	The ARN of the resource backing the imported database.
recordtime	timestamp	The timestamp of the action.
action	varchar(128)	The action being run. Possible values are CREATE DATASHARE, DROP DATASHARE, GRANT ALTER, REVOKE ALTER, GRANT SHARE, REVOKE SHARE, ALTER ADD, ALTER REMOVE, ALTER SET, GRANT USAGE, REVOKE USAGE, CREATE DATABASE, GRANT or REVOKE USAGE on a shared database, DROP SHARED DATABASE, ALTER SHARED DATABASE.
status	integer	The status of the action. Possible values are SUCCESS and ERROR-ERROR CODE.
share_object_type	varchar(64)	The type of database object that was added to or removed from the datashare. Possible values are schemas, tables, columns, functions, and views. This is a field for the producer cluster.
share_object_id	integer	The ID of database object that was added to or removed from the datashare. This is a field for the producer cluster.
share_object_name	varchar(128)	The name of database object that was added to or removed from the datashare. This is a field for the producer cluster.
target_user_type	varchar(16)	The type of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.

Column name	Data type	Description
target_userid	integer	The ID of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.
target_username	varchar(128)	The name of users or groups that a privilege was granted to. This is a field for both the producer and consumer cluster.
consumer_account	varchar(16)	The account ID of the data consumer. This is a field for the producer cluster.
consumer_namespace	varchar(64)	The namespace of the data consumer account. This is a field for the producer cluster.
producer_account	varchar(16)	The account ID of the producer account that the datashare belongs to. This is a field for the consumer cluster.
producer_namespace	varchar(64)	The namespace of the product account that the datashare belongs to. This is a field for the consumer cluster.
attribute_name	varchar(64)	The name of an attribute of the datashare or shared database.
attribute_value	varchar(128)	The value of an attribute of the datashare or shared database.
message	varchar(512)	The error message when an action fails.

Sample queries

The following example shows a SVL_DATASHARE_CHANGE_LOG view.

```
SELECT DISTINCT action
FROM svl_datashare_change_log
WHERE share_object_name LIKE 'tickit%';

         action
 -----------------------
```

```
"ALTER DATASHARE ADD"
```

SVL_DATASHARE_CROSS_REGION_USAGE

Use the SVL_DATASHARE_CROSS_REGION_USAGE view to get a summary of cross-Region data transferred usage caused by cross-Region datasharing query. SVL_DATASHARE_CROSS_REGION_USAGE aggregates details at the segment level.

SVL_DATASHARE_CROSS_REGION_USAGE is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_DATASHARE_CROSS_REGION_USAGE. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
query	integer	The ID of the query. Use this value to join other system tables and views.
segment	bigint	The number of the segment. A query consists of multiple segments, and each segment consists of one or more steps.
start_time	time	The time in UTC that the data transfer began.
end_time	time	The time in UTC that the data transfer ended.
transferred_data	bigint	The number of bytes of data transferred from a producer Region to a consumer Region.
source_region	char(25)	The producer Region that the query transferred data from.
recordtime	timestamp	The time when the action is recorded.

Sample queries

The following example shows a SVL_DATASHARE_CROSS_REGION_USAGE view.

```
SELECT query, segment, transferred_data, source_region
from svl_datashare_cross_region_usage
where query = pg_last_query_id()
order by query,segment;

  query | segment | transferred_data | source_region
--------+---------+------------------+---------------
 200048 |       2 |          4194304 |    us-west-1
 200048 |       2 |          4194304 |    us-east-2
```

SVL_DATASHARE_USAGE_CONSUMER

Records the activity and usage of datashares. This view is only relevant on the consumer cluster.

SVL_DATASHARE_USAGE_CONSUMER is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_DATASHARE_USAGE_CONSUMER. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user issuing the request.
pid	integer	The ID of the leader process running the query.
xid	bigint	The context of the current transaction.
request_id	varchar(50)	The unique ID of the requested API call.

Column name	Data type	Description
request_type	varchar(25)	The type of the request made to the producer cluster.
transaction_uid	varchar(50)	The unique ID of the transaction.
recordtime	timestamp	The time when the action is recorded.
status	integer	The status of the requested API call.
error	varchar(512)	The message for an error.

Sample queries

The following example shows a SVL_DATASHARE_USAGE_CONSUMER view.

```
SELECT request_type, status, trim(error) AS error
FROM svl_datashare_usage_consumer

  request_type  | status | error
----------------+--------+--------
 "GET RELATION" |   0    |
```

SVL_DATASHARE_USAGE_PRODUCER

Records the activity and usage of datashares. This view is only relevant on the producer cluster.

SVL_DATASHARE_USAGE_PRODUCER is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_DATASHARE_USAGE_PRODUCER. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
share_id	integer	The object ID (OID) of the datashare.
share_name	varchar(128)	The name of the datashare.
request_id	varchar(50)	The unique ID of the requested API call.
request_type	varchar(25)	The type of the request made to the producer cluster.
object_type	varchar(64)	The type of the object being shared from the datashare. Possible values are schemas, tables, columns, functions, and views.
object_oid	integer	The ID of the object being shared from the datashare.
object_name	varchar(128)	The name of the object being shared from the datashare.
consumer_account	varchar(16)	The account of the consumer account that the datashare is shared to.
consumer_namespace	varchar(64)	The namespace of the consumer account that the datashare is shared to.
consumer_transaction_uid	varchar(50)	The unique transaction ID of the statement on the consumer cluster.
recordtime	timestamp	The time when the action is recorded.
status	integer	The status of the datashare.
error	varchar(512)	The message for an error.

Column name	Data type	Description
consumer_region	char(64)	The Region that the consumer cluster is in.

Sample queries

The following example shows a SVL_DATASHARE_USAGE_PRODUCER view.

```
SELECT DISTINCT request_type
FROM svl_datashare_usage_producer
WHERE object_name LIKE 'tickit%';

   request_type
 ------------------
   "GET RELATION"
```

SVL_FEDERATED_QUERY

Use the SVL_FEDERATED_QUERY view to view information about a federated query call.

SVL_FEDERATED_QUERY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user running the query.
xid	bigint	The transaction ID.
pid	integer	The ID of the leader process running the query.

Column name	Data type	Description
query	integer	The query ID of a federated call.
sourcetype	character (32)	The federated call source type, for example "PG".
recordtime	timestamp	The time when a query is sent for federation. UTC is used.
querytext	character (4000)	The query string sent to the remote PostgreSQL engine for execution.
num_rows	bigint	The number of rows returned by the federated query.
num_bytes	bigint	The number of bytes returned by the federated query.
duration	bigint	The time (microseconds) spent fetching rows from cursor calls. It is the time spent running the federated query, as well as, getting results back.

Sample queries

To show information about federated query calls, run the following query.

```
select query, trim(sourcetype) as type, recordtime, trim(querytext) as "PG Subquery"
 from svl_federated_query where query = 4292;

 query | type |         recordtime         |                          pg subquery
-------+------+----------------------------
+---------------------------------------------------------------
```

```
  4292 | PG   | 2020-03-27 04:29:58.485126 | SELECT "level" FROM functional.employees
 WHERE ("level" >= 6)
(1 row)
```

SVL_MULTI_STATEMENT_VIOLATIONS

Use the SVL_MULTI_STATEMENT_VIOLATIONS view to get a complete record of all of the SQL commands run on the system that violates transaction block restrictions.

Violations occur when you run any of the following SQL commands that Amazon Redshift restricts inside a transaction block or multi-statement requests:

- CREATE DATABASE
- DROP DATABASE
- ALTER TABLE APPEND
- CREATE EXTERNAL TABLE
- DROP EXTERNAL TABLE
- RENAME EXTERNAL TABLE
- ALTER EXTERNAL TABLE
- CREATE TABLESPACE
- DROP TABLESPACE
- CREATE LIBRARY
- DROP LIBRARY
- REBUILDCAT
- INDEXCAT
- REINDEX DATABASE
- VACUUM
- GRANT
- COPY

Note

If there are any entries in this view, then change your corresponding applications and SQL scripts. We recommend changing your application code to move the use of these restricted

SQL commands outside of the transaction block. If you need further assistance, contact AWS Support.

SVL_MULTI_STATEMENT_VIOLATIONS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user who caused the violation.
database	character(32)	The name of the database that the user was connected to.
cmdname	character(20)	The name of the command that cannot run inside a transaction block or multi-statement request. For example, CREATE DATABASE, DROP DATABASE, ALTER TABLE APPEND, CREATE EXTERNAL TABLE, DROP EXTERNAL TABLE, RENAME EXTERNAL TABLE, ALTER EXTERNAL TABLE, CREATE LIBRARY, DROP LIBRARY, REBUILDCAT, INDEXCAT, REINDEX DATABASE, VACUUM, GRANT on external resources, CLUSTER, COPY, CREATE TABLESPACE, and DROP TABLESPACE.
xid	bigint	The transaction ID associated with the statement.
pid	integer	The process ID for the statement.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the

Column name	Data type	Description
		query is not file-based or the QUERY_GROUP parameter is not set, this field is blank.
starttime	timestamp	The exact time when the statement started executing , with 6 digits of precision for fractional seconds, for example: **2009-06-12 11:29:19.131358**
endtime	timestamp	The exact time when the statement finished executing , with 6 digits of precision for fractional seconds, for example: **2009-06-12 11:29:19.193640**
sequence	integer	When a single statement contains more than 200 characters, additional rows are logged for that statement. Sequence 0 is the first row, 1 is the second, and so on.
type	varchar(10)	The type of SQL statement: **QUERY**, **DDL**, or **UTILITY**.
text	character(200)	The SQL text, in 200-character increments. This field might contain special characters such as backslash (\\) and newline (\n).

Sample query

The following query returns multiple statements that have violations.

```
select * from svl_multi_statement_violations order by starttime asc;

userid | database | cmdname | xid | pid | label | starttime | endtime | sequence | type
 | text
==============================================================================================
1 | dev | CREATE DATABASE | 1034 | 5729 |label1 | ********* | ******* | 0 | DDL |
 create table c(b int);
1 | dev | CREATE DATABASE | 1034 | 5729 |label1 | ********* | ******* | 0 | UTILITY |
 create database b;
1 | dev | CREATE DATABASE | 1034 | 5729 |label1 | ********* | ******* | 0 | UTILITY |
 COMMIT
...
```

SVL_MV_REFRESH_STATUS

The SVL_MV_REFRESH_STATUS view contains a row for the refresh activity of materialized views.

For more information about materialized views, see Materialized views in Amazon Redshift.

SVL_MV_REFRESH_STATUS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_MV_REFRESH_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
db_name	char(128)	The database that contains the materialized view.
userid	bigint	The ID of the user who performed the refresh.
schema_name	char(128)	The schema of the materialized view.
mv_name	char(128)	The materialized view name.
xid	bigint	The transaction ID of the refresh.
starttime	timestamp	The start time of the refresh.
endtime	timestamp	The end time of the refresh.
status	text	The status of the refresh. Example values include the following: • *Refresh successfully updated MV incrementally* If it's a materialized view for streaming, the message might have additional qualifier s regarding the number of records. These include the following:

Column name	Data type	Description
		Stream returned no new data – There were no records retrieved. *All records received from the stream were skipped* – Records were retrieved, but due to errors all were skipped. *Some stream records were skipped* – Records were retrieved, but due to errors some were skipped. If there are no qualifiers, then at least one record was retrieved and all records are available in the materialized view. There is one remaining possible qualifier: *The stream may contain more data* – The refresh ended before Amazon Redshift determined that there were no further records to consume. The stream can be up to date, but it hasn't been confirmed by Amazon Redshift. *Refresh successfully recomputed MV from scratch* *Refresh partially updated MV incrementally up to an active transaction* *MV was already updated* *Cascade automatic refresh skipped because materialized view <schema>.<name> was not refreshed.* *Cascade refresh skipped because materialized view <schema>.<name> was not refreshed.* *Cascade automatic refresh failed because materialized view <schema>.<name> was not refreshed.*

Column name	Data type	Description
		Cascade refresh failed because materialized view <schema>.<name> was not refreshed. • *Refresh failed. A base table column was renamed* • *Refresh failed. A base table column type was changed* • *Refresh failed. A base table was renamed* • *Refresh failed due to an internal error* • *Refresh failed. A base table column was dropped* • *Refresh failed. Schema of MV was renamed* • *Refresh failed. MV was not found* • *Auto refresh aborted due to excessive user workload* • *Refresh failed. Serializable isolation violation*
refresh_type	char(32)	The definition of the refresh type. Example values include *Manual* and *Auto*.

Sample query

To view the refresh status of materialized views, run the following query.

```
select * from svl_mv_refresh_status;
```

This query returns the following sample output:

```
 db_name | userid |  schema    |  name    |  xid  |          starttime           |
 endtime            |                              status
                  |  refresh_type
---------+--------+-----------+---------+-------+----------------------------
+---------------------------
```

```
+-------------------------------------------------------------------------------------
+-----------------
 dev      |    169 | mv_schema | mv_test |  6640 | 2020-02-14 02:26:53.497935 |
 2020-02-14 02:26:53.556156 | Refresh successfully recomputed MV from scratch
                            |  Manual
 dev      |    166 | mv_schema | mv_test |  6517 | 2020-02-14 02:26:39.287438 |
 2020-02-14 02:26:39.349539 | Refresh successfully updated MV incrementally
                            |  Auto
 dev      |    162 | mv_schema | mv_test |  6388 | 2020-02-14 02:26:27.863426 |
 2020-02-14 02:26:27.918307 | Refresh successfully recomputed MV from scratch
                            |  Manual
 dev      |    161 | mv_schema | mv_test |  6323 | 2020-02-14 02:26:20.020717 |
 2020-02-14 02:26:20.080002 | Refresh successfully updated MV incrementally
                            |  Auto
 dev      |    161 | mv_schema | mv_test |  6301 | 2020-02-14 02:26:05.796146 |
 2020-02-14 02:26:07.853986 | Refresh successfully recomputed MV from scratch
                            |  Manual
 dev      |    153 | mv_schema | mv_test |  6024 | 2020-02-14 02:25:18.762335 |
 2020-02-14 02:25:20.043462 | MV was already updated
                            |  Manual
 dev      |    143 | mv_schema | mv_test |  5557 | 2020-02-14 02:24:23.100601 |
 2020-02-14 02:24:23.100633 | MV was already updated
                            |  Manual
 dev      |    141 | mv_schema | mv_test |  5447 | 2020-02-14 02:23:54.102837 |
 2020-02-14 02:24:00.310166 | Refresh successfully updated MV incrementally
                            |  Auto
 dev      |      1 | mv_schema | mv_test |  5329 | 2020-02-14 02:22:26.328481 |
 2020-02-14 02:22:28.369217 | Refresh successfully recomputed MV from scratch
                            |  Auto
 dev      |    138 | mv_schema | mv_test |  5290 | 2020-02-14 02:21:56.885093 |
 2020-02-14 02:21:56.885098 | Refresh failed. MV was not found
                            |  Manual
 dev      |    138 | mv_schema | mv_test |  5100 | 2020-02-14 02:20:33.123445 |
 2020-02-14 02:20:33.123445 | Cascade refresh failed because materialized view
 mv_schema.child was not refreshed. |  Manual
 dev      |    138 | mv_schema | child   |  5100 | 2020-02-14 02:20:33.123445 |
 2020-02-14 02:20:33.123445 | Refresh failed due to an internal error.
                            |  Manual
 dev      |    138 | mv_schema | mv_test |  5099 | 2020-02-14 02:10:23.492344 |
 2020-02-14 02:10:23.492344 | Cascade refresh skipped because materialized view
 mv_schema.child was not refreshed.|  Manual
```

```
dev      |     138 | mv_schema | child    |  5099 | 2020-02-14 02:10:23.492344 |
2020-02-14 02:10:23.492344 | Refresh failed due to an internal error.
                           |  Manual
```

SVL_QERROR

The SVL_QERROR view is deprecated.

SVL_QLOG

The SVL_QLOG view contains a log of all queries run against the database.

Amazon Redshift creates the SVL_QLOG view as a readable subset of information from the STL_QUERY table. Use this table to find the query ID for a recently run query or to see how long it took a query to complete.

SVL_QLOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user who generated the entry.
query	integer	Query ID. You can use this ID to join various other system tables and views.
xid	bigint	Transaction ID.
pid	integer	Process ID associated with the query.
starttime	timestamp	Exact time when the statement started executing, with six digits of precision for fractional seconds—for example: **2009-06-12 11:29:19.131358**

Column name	Data type	Description
endtime	timestamp	Exact time when the statement finished executing, with six digits of precision for fractional seconds—for example: **2009-06-12 11:29:19.193640**
elapsed	bigint	Length of time that it took the query to run (in microseconds).
aborted	integer	If a query was stopped by the system or canceled by the user, this column contains **1**. If the query ran to completion, this column contains **0**. Queries that are canceled for workload management purposes and subsequently restarted also have a value of **1** in this column.
label	character(320)	Either the name of the file used to run the query, or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field value is `default`.
substring	character(60)	Truncated query text.
source_query	integer	If the query used result caching, the query ID of the query that was the source of the cached results. If result caching was not used, this field value is `NULL`.
concurrency_scaling_status_txt	text	A description of whether the query ran on the main cluster or concurrency scaling cluster.
from_sp_call	integer	If the query was called from a stored procedure, the query ID of the procedure call. If the query wasn't run as part of a stored procedure, this field is `NULL`.

Sample queries

The following example returns the query ID, execution time, and truncated query text for the five most recent database queries run by the user with `userid = 100`.

```
select query, pid, elapsed, substring from svl_qlog
where userid = 100
order by starttime desc
limit 5;

 query  |  pid  | elapsed  |           substring
--------+-------+----------+-----------------------------------------------
 187752 | 18921 | 18465685 | select query, elapsed, substring from svl_...
 204168 |  5117 |    59603 | insert into testtable values (100);
 187561 | 17046 |  1003052 | select * from pg_table_def where tablename...
 187549 | 17046 |  1108584 | select * from STV_WLM_SERVICE_CLASS_CONFIG
 187468 | 17046 |  5670661 | select * from pg_table_def where schemaname...
(5 rows)
```

The following example returns the SQL script name (LABEL column) and elapsed time for a query that was cancelled (**`aborted=1`**):

```
select query, elapsed, trim(label) querylabel
from svl_qlog where aborted=1;

 query | elapsed  |       querylabel
-------+----------+-------------------------
    16 |  6935292 | alltickittablesjoin.sql
(1 row)
```

SVL_QUERY_METRICS

The SVL_QUERY_METRICS view shows the metrics for completed queries. This view is derived from the STL_QUERY_METRICS system table. Use the values in this view as an aid to determine threshold values for defining query monitoring rules. For more information, see WLM query monitoring rules.

SVL_QUERY_METRICS is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user that ran the query that generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
service_class	integer	ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Metrics are reported only for user-defined queues. For a list of service class IDs, see WLM service class IDs.
dimension	varchar(24)	Dimension on which the metric is reported. Possible values are query, segment, and step.
segment	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process. If the segment value is 0, metrics segment values are rolled up to the query level.
step	integer	ID for the type of step performed. The description for the step type is shown in the `step_label` column. .
step_label	varchar(30)	Type of step performed.
query_cpu_time	bigint	CPU time used by the query, in seconds. CPU time is distinct from query run time.
query_blocks_read	bigint	Number of 1 MB blocks read by the query.

Column name	Data type	Description
query_exe cution_time	bigint	Elapsed execution time for a query, in seconds. Execution time doesn't include time spent waiting in a queue. See `query_queue_time` for the time queued.
query_cpu _usage_percent	bigint	Percent of CPU capacity used by the query.
query_tem p_blocks_ to_disk	bigint	The amount of disk space used by a query to write intermedi ate results, in MB.
segment_e xecution_time	bigint	Elapsed execution time for a single segment, in seconds.
cpu_skew	numeric(3 8,2)	The ratio of maximum CPU usage for any slice to average CPU usage for all slices. This metric is defined at the segment level.
io_skew	numeric(3 8,2)	The ratio of maximum blocks read (I/O) for any slice to average blocks read for all slices.
scan_row_count	bigint	The number of rows in a scan step. The row count is the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters.
join_row_count	bigint	The number of rows processed in a join step.
nested_lo op_join_r ow_count	bigint	The number of rows in a nested loop join.
return_ro w_count	bigint	The number of rows returned by the query.
spectrum_ scan_row_count	bigint	The number of rows scanned by Amazon Redshift Spectrum in Amazon S3.

Column name	Data type	Description
spectrum_scan_size_mb	bigint	The amount of data, in MB, scanned by Amazon Redshift Spectrum in Amazon S3.
query_queue_time	bigint	The amount of time in seconds that the query was queued.

SVL_QUERY_METRICS_SUMMARY

The SVL_QUERY_METRICS_SUMMARY view shows the maximum values of metrics for completed queries. This view is derived from the STL_QUERY_METRICS system table. Use the values in this view as an aid to determine threshold values for defining query monitoring rules. For more information about rules and metrics for query monitoring for Amazon Redshift, see WLM query monitoring rules.

SVL_QUERY_METRICS_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of the user that ran the query that generated the entry.
query	integer	Query ID. The query column can be used to join other system tables and views.
service_class	integer	ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Metrics are reported only for user-defined queues. For a list of service class IDs, see WLM service class IDs.

Column name	Data type	Description
query_cpu_time	bigint	CPU time used by the query, in seconds. CPU time is distinct from query run time.
query_blocks_read	bigint	Number of 1 MB blocks read by the query.
query_execution_time	bigint	Elapsed execution time for a query, in seconds. Execution time doesn't include time spent waiting in a queue.
query_cpu_usage_percent	numeric(38,2)	Percent of CPU capacity used by the query.
query_temp_blocks_to_disk	bigint	The amount of disk space used by a query to write intermediate results, in MB.
segment_execution_time	bigint	Elapsed execution time for a single segment, in seconds.
cpu_skew	numeric(38,2)	The ratio of maximum CPU usage for any slice to average CPU usage for all slices. This metric is defined at the segment level.
io_skew	numeric(38,2)	The ratio of maximum blocks read (I/O) for any slice to average blocks read for all slices.
scan_row_count	bigint	The number of rows in a scan step. The row count is the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters.
join_row_count	bigint	The number of rows processed in a join step.
nested_loop_join_row_count	bigint	The number of rows in a nested loop join.

Column name	Data type	Description
return_row_count	bigint	The number of rows returned by the query.
spectrum_scan_row_count	bigint	The number of rows scanned by Amazon Redshift Spectrum in Amazon S3.
spectrum_scan_size_mb	bigint	The amount of data, in MB, scanned by Amazon Redshift Spectrum in Amazon S3.
query_queue_time	bigint	The amount of time in seconds that the query was queued.

SVL_QUERY_QUEUE_INFO

Summarizes details for queries that spent time in a workload management (WLM) query queue or a commit queue.

The SVL_QUERY_QUEUE_INFO view filters queries performed by the system and shows only queries performed by a user.

The SVL_QUERY_QUEUE_INFO view summarizes information from the STL_QUERY, STL_WLM_QUERY, and STL_COMMIT_STATS system tables.

SVL_QUERY_QUEUE_INFO is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
database	text	The name of the database the user was connected to when the query was issued.
query	integer	Query ID.
xid	bigint	Transaction ID.

Column name	Data type	Description
userid	integer	ID of the user that generated the query.
querytxt	text	First 100 characters of the query text.
queue_start_time	timestamp	Time in UTC when the query entered the WLM queue.
exec_start_time	timestamp	Time in UTC when query execution started.
service_class	integer	ID for the service class. Service classes are defined in the WLM configuration file.
slots	integer	Number of WLM query slots.
queue_elapsed	bigint	Time that the query spent waiting in a WLM queue (in seconds).
exec_elapsed	bigint	Time spent executing the query (in seconds).
wlm_total_elapsed	bigint	Time that the query spent in a WLM queue (queue_elapsed), plus time spent executing the query (exec_elapsed).
commit_queue_elapsed	bigint	Time that the query spent waiting in the commit queue (in seconds).
commit_exec_time	bigint	Time that the query spent in the commit operation (in seconds).
service_class_name	character(64)	The name of the service class.

Sample queries

The following example shows the time that queries spent in WLM queues.

```
select query, service_class, queue_elapsed, exec_elapsed, wlm_total_elapsed
from svl_query_queue_info
where wlm_total_elapsed > 0;

  query   | service_class | queue_elapsed | exec_elapsed | wlm_total_elapsed
---------+---------------+---------------+--------------+-------------------
 2742669 |             6 |             2 |          916 |                918
 2742668 |             6 |             4 |          197 |                201
(2 rows)
```

SVL_QUERY_REPORT

Amazon Redshift creates the SVL_QUERY_REPORT view from a UNION of a number of Amazon Redshift STL system tables to provide information about completed query steps.

This view breaks down the information about completed queries by slice and by step, which can help with troubleshooting node and slice issues in the Amazon Redshift cluster.

SVL_QUERY_REPORT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
query	integer	Query ID. Can be used to join various other system tables and views.
slice	integer	Data slice where the step ran.
segment	integer	Segment number.

Column name	Data type	Description
		A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process.
step	integer	Query step that completed.
start_time	timestamp	Exact time in UTC when the segment started executing, with 6 digits of precision for fractional seconds. For example: **2012-12-12 11:29:19.131358**
end_time	timestamp	Exact time in UTC when the segment finished executing, with 6 digits of precision for fractional seconds. For example: **2012-12-12 11:29:19.131467**
elapsed_time	bigint	Time (in microseconds) that it took the segment to run.
rows	bigint	Number of rows produced by the step (per slice). This number represents the number of rows for the slice that result from the execution of the step, not the number of rows received or processed by the step. In other words, this is the number of rows that survive the step and are passed on to the next step.
bytes	bigint	Number of bytes produced by the step (per slice).
label	char(256)	Step label, which consists of a query step name and, when applicable, table ID and table name (for example, `scan tbl=100448 name =user`). Three-digit table IDs usually refer to scans of transient tables. When you see `tbl=0`, it usually refers to a scan of a constant value.
is_diskbased	character (1)	Whether this step of the query was performed as a disk-based operation: true (**t**) or false (**f**). Only certain steps, such as hash, sort, and aggregate steps, can go to disk. Many types of steps are always performed in memory.

Column name	Data type	Description
workmem	bigint	Amount of working memory (in bytes) assigned to the query step. This value is the query_working_mem threshold allocated for use during execution, not the amount of memory that was actually used
is_rrscan	character (1)	If true (**t**), indicates that range-restricted scan was used on the step.
is_delayed_scan	character (1)	If true (**t**), indicates that delayed scan was used on the step.
rows_pre_filter	bigint	For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters.

Sample queries

The following query demonstrates the data skew of the returned rows for the query with query ID 279. Use this query to determine if database data is evenly distributed over the slices in the data warehouse cluster:

```
select query, segment, step, max(rows), min(rows),
case when sum(rows) > 0
then ((cast(max(rows) -min(rows) as float)*count(rows))/sum(rows))
else 0 end
from svl_query_report
where query = 279
group by query, segment, step
order by segment, step;
```

This query should return data similar to the following sample output:

```
query | segment | step |   max    |   min    |         case
------+---------+------+----------+----------+----------------------
279 |       0 |    0 | 19721687 | 19721687 |                     0
279 |       0 |    1 | 19721687 | 19721687 |                     0
279 |       1 |    0 |   986085 |   986084 | 1.01411202804304e-06
279 |       1 |    1 |   986085 |   986084 | 1.01411202804304e-06
```

```
279 |        1 |     4 |   986085 |    986084 | 1.01411202804304e-06
279 |        2 |     0 |  1775517 |    788460 |     1.00098637606408
279 |        2 |     2 |  1775517 |    788460 |     1.00098637606408
279 |        3 |     0 |  1775517 |    788460 |     1.00098637606408
279 |        3 |     2 |  1775517 |    788460 |     1.00098637606408
279 |        3 |     3 |  1775517 |    788460 |     1.00098637606408
279 |        4 |     0 |  1775517 |    788460 |     1.00098637606408
279 |        4 |     1 |  1775517 |    788460 |     1.00098637606408
279 |        4 |     2 |        1 |         1 |                    0
279 |        5 |     0 |        1 |         1 |                    0
279 |        5 |     1 |        1 |         1 |                    0
279 |        6 |     0 |       20 |        20 |                    0
279 |        6 |     1 |        1 |         1 |                    0
279 |        7 |     0 |        1 |         1 |                    0
279 |        7 |     1 |        0 |         0 |                    0
(19 rows)
```

SVL_QUERY_SUMMARY

Use the SVL_QUERY_SUMMARY view to find general information about the execution of a query.

The SVL_QUERY_SUMMARY view contains a subset of data from the SVL_QUERY_REPORT view. Note that the information in SVL_QUERY_SUMMARY is aggregated from all nodes.

Note

The SVL_QUERY_SUMMARY view only contains information about queries performed by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements performed by Amazon Redshift, including DDL and utility commands, you can query the SVL_STATEMENTTEXT view.

SVL_QUERY_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For information about SVCS_QUERY_SUMMARY, see SVCS_QUERY_SUMMARY.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
query	integer	Query ID. Can be used to join various other system tables and views.
stm	integer	Stream: A set of concurrent segments in a query. A query has one or more streams.
seg	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can run in parallel. Each segment runs in a single process.
step	integer	Query step that ran.
maxtime	bigint	Maximum amount of time for the step to run (in microseconds).
avgtime	bigint	Average time for the step to run (in microseconds).
rows	bigint	Number of data rows involved in the query step.
bytes	bigint	Number of data bytes involved in the query step.
rate_row	double precision	Query execution rate per row.
rate_byte	double precision	Query execution rate per byte.
label	text	Step label, which consists of a query step name and, when applicable, table ID and table name (for example, scan tbl=100448 name =user). Three-digit table IDs usually refer to scans of transient tables. When you see `tbl=0`, it usually refers to a scan of a constant value.

Column name	Data type	Description
is_diskbased	character(1)	Whether this step of the query was performed as a disk-based operation on any node in the cluster: true (**t**) or false (**f**). Only certain steps, such as hash, sort, and aggregate steps, can go to disk. Many types of steps are always performed in memory.
workmem	bigint	Amount of working memory (in bytes) assigned to the query step.
is_rrscan	character(1)	If true (**t**), indicates that range-restricted scan was used on the step. Default is false (**f**).
is_delayed_scan	character(1)	If true (**t**), indicates that delayed scan was used on the step. Default is false (**f**).
rows_pre_filter	bigint	For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows).

Sample queries

Viewing processing information for a query step

The following query shows basic processing information for each step of query 87:

```
select query, stm, seg, step, rows, bytes
from svl_query_summary
where query = 87
order by query, seg, step;
```

This query retrieves the processing information about query 87, as shown in the following sample output:

```
 query | stm | seg | step |  rows  |  bytes
-------+-----+-----+------+--------+---------
87     |   0 |   0 |    0 |     90 |    1890
87     |   0 |   0 |    2 |     90 |     360
87     |   0 |   1 |    0 |     90 |     360
87     |   0 |   1 |    2 |     90 |    1440
87     |   1 |   2 |    0 | 210494 | 4209880
```

```
87      |   1 |   2 |    3 |  89500 |       0
87      |   1 |   2 |    6 |      4 |      96
87      |   2 |   3 |    0 |      4 |      96
87      |   2 |   3 |    1 |      4 |      96
87      |   2 |   4 |    0 |      4 |      96
87      |   2 |   4 |    1 |      1 |      24
87      |   3 |   5 |    0 |      1 |      24
87      |   3 |   5 |    4 |      0 |       0
(13 rows)
```

Determining whether query steps spilled to disk

The following query shows whether or not any of the steps for the query with query ID 1025 (see the SVL_QLOG view to learn how to obtain the query ID for a query) spilled to disk or if the query ran entirely in-memory:

```
select query, step, rows, workmem, label, is_diskbased
from svl_query_summary
where query = 1025
order by workmem desc;
```

This query returns the following sample output:

```
query| step|  rows  |  workmem   |  label         | is_diskbased
-----+-----+--------+-----------+---------------+--------------
1025 |  0  |16000000|  141557760 |scan tbl=9     | f
1025 |  2  |16000000|  135266304 |hash tbl=142   | t
1025 |  0  |16000000|  128974848 |scan tbl=116536| f
1025 |  2  |16000000|  122683392 |dist           | f
(4 rows)
```

By scanning the values for IS_DISKBASED, you can see which query steps went to disk. For query 1025, the hash step ran on disk. Steps might run on disk include hash, aggr, and sort steps. To view only disk-based query steps, add **`and is_diskbased = 't'`** clause to the SQL statement in the above example.

SVL_RESTORE_ALTER_TABLE_PROGRESS

Use SVL_RESTORE_ALTER_TABLE_PROGRESS to monitor the migration progress of each table in the cluster during a classic resize to RA3 nodes. It captures the historic throughput of data migration during the resize operation. For more information about classic resize to RA3 nodes, go to Classic resize.

SVL_RESTORE_ALTER_TABLE_PROGRESS is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_RESTORE_LOG. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Note

Rows with a progress of `100.00%` or `ABORTED` are deleted after 7 days. Rows for tables dropped during or after a classic resize can still appear in SVL_RESTORE_ALTER_TABLE_PROGRESS.

Table columns

Column name	Data type	Description
tbl	integer	The ID of the table.
progress	char(32)	The status of redistribution progress of the table. Possible values are percentages from `0.00%` to `100.00%` and the message `ABORTED`. `ABORTED` means that the redistribution was stopped without finishing, with the reason explained in the `message` column.
message	char(256)	The message associated with the redistribution progress of the table.

Sample query

The following query returns running and queued queries.

```
select * from svl_restore_alter_table_progress;
```

```
tbl     | progress |                          message
--------+----------+-----------------------------------------------------------
105614  | ABORTED  | Abort:Table no longer contains the prior dist key column.
105610  | ABORTED  | Abort:Table no longer contains the prior dist key column.
105594  | 0.00%    | Table waiting for alter diststyle conversion.
105602  | ABORTED  | Abort:Table no longer contains the prior dist key column.
105606  | ABORTED  | Abort:Table no longer contains the prior dist key column.
105598  | 100.00%  | Restored to distkey successfully.
```

SVL_S3LIST

Use the SVL_S3LIST view to get details about Amazon Redshift Spectrum queries at the segment level.

SVL_S3LIST is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> SVL_S3LIST only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
query	integer	The query ID.
segment	integer	The segment number. A query consists of multiple segments.
node	integer	The node number.

Column name	Data type	Description
slice	integer	The data slice that a particular segment ran against.
eventtime	timestamp	The time in UTC that the event is recorded.
bucket	text	The Amazon S3 bucket name.
prefix	text	The prefix of the Amazon S3 bucket location.
recursive	char(1)	Whether there is recursive scan for subfolders.
retrieved_files	integer	The number of listed files.
max_file_size	bigint	The maximum file size among listed files.
avg_file_size	double precision	The average file size among listed files.
generated_splits	integer	The number of file splits.
avg_split_length	double precision	The average length of file splits in bytes.
duration	bigint	The duration of file listing, in microseconds.

Sample query

The following example queries SVL_S3LIST for the last query to run.

```
select *
from svl_s3list
where query = pg_last_query_id()
order by query,segment;
```

SVL_S3LOG

Use the SVL_S3LOG view to get details about Amazon Redshift Spectrum queries at the segment and node slice level.

SVL_S3LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> SVL_S3LOG only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
pid	integer	The process ID.
query	integer	The query ID.
segment	integer	The segment number. A query consists of multiple segments, and each segment consists of one or more steps.
step	integer	The query step that ran.
node	integer	The node number.
slice	integer	The data slice that a particular segment ran against.
eventtime	timestamp	Time in UTC that the step started executing.
message	text	Message for the log entry.

Sample query

The following example queries SVL_S3LOG for the last query that ran.

```
select *
from svl_s3log
where query = pg_last_query_id()
order by query,segment,slice;
```

SVL_S3PARTITION

Use the SVL_S3PARTITION view to get details about Amazon Redshift Spectrum partitions at the segment and node slice level.

SVL_S3PARTITION is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Note

SVL_S3PARTITION only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
query	integer	The query ID.
segment	integer	A segment number. A query consists of multiple segments, and each segment consists of one or more steps.
node	integer	The node number.

Column name	Data type	Description
slice	integer	The data slice that a particular segment ran against.
starttime	timestamp without time zone	Time in UTC that the partition pruning started executing.
endtime	timestamp without time zone	Time in UTC that the partition pruning completed.
duration	bigint	Elapsed time (in microseconds).
total_partitions	integer	Number of total partitions.
qualified_partitions	integer	Number of qualified partitions.
assigned_partitions	integer	Number of assigned partitions on the slice.
assignment	character	Type of assignment.

Sample query

The following example gets the partition details for the last query completed.

```
SELECT query, segment,
       MIN(starttime) AS starttime,
       MAX(endtime) AS endtime,
       datediff(ms,MIN(starttime),MAX(endtime)) AS dur_ms,
       MAX(total_partitions) AS total_partitions,
       MAX(qualified_partitions) AS qualified_partitions,
       MAX(assignment) as assignment_type
FROM svl_s3partition
WHERE query=pg_last_query_id()
GROUP BY query, segment
```

```
query | segment |           starttime           |           endtime           | dur_ms|
 total_partitions | qualified_partitions | assignment_type
------+---------+-------------------------------+-----------------------------+-------
+------------------+----------------------+----------------
99232 |       0 | 2018-04-17 22:43:50.201515    | 2018-04-17 22:43:54.674595  |   4473 |
       2526       |         334          | p
```

SVL_S3PARTITION_SUMMARY

Use the SVL_S3PARTITION_SUMMARY view to get a summary of Redshift Spectrum queries partition processing at the segment level.

SVL_S3PARTITION_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

For information about SVCS_S3PARTITION, see SVCS_S3PARTITION_SUMMARY.

Table columns

Column name	Data type	Description
query	integer	The query ID. You can use this value to join various other system tables and views.
segment	integer	The segment number. A query consists of multiple segments.
assignment	char(1)	The type of partition assignment across nodes.
min_starttime	timestamp	The time in UTC that the partition processing started.
max_endtime	timestamp	The time in UTC that the partition processing completed.
min_duration	bigint	The minimum partition processing time used by a node for this query (in microseconds).

Column name	Data type	Description
max_duration	bigint	The maximum partition processing time used by a node for this query (in microseconds).
avg_duration	bigint	The average partition processing time used by a node for this query (in microseconds).
total_partitions	integer	The total number of partitions in an external table.
qualified_partitions	integer	The total number of qualified partitions.
min_assigned_partitions	integer	The minimum number of partitions assigned on one node.
max_assigned_partitions	integer	The maximum number of partitions assigned on one node.
avg_assigned_partitions	bigint	The average number of partitions assigned on one node.

Sample query

The following example gets the partition scan details for the last query completed.

```
select query, segment, assignment, min_starttime, max_endtime, min_duration,
 avg_duration
from svl_s3partition_summary
where query = pg_last_query_id()
order by query,segment;
```

SVL_S3QUERY

Use the SVL_S3QUERY view to get details about Amazon Redshift Spectrum queries at the segment and node slice level.

SVL_S3QUERY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

> **Note**
>
> SVL_S3QUERY only contains queries run on main provisioned clusters. It doesn't contain queries run on concurrency scaling clusters or on serverless namespaces. To access explain plans for queries run on both main clusters, concurrency scaling clusters, and serverless namespaces, we recommend that you use the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL . The data in the SYS monitoring view is formatted to be easier to use and understand.

Table columns

Column name	Data type	Description
userid	integer	The ID of user who generated a given entry.
query	integer	The query ID.
segment	integer	A segment number. A query consists of multiple segments, and each segment consists of one or more steps.
step	integer	The query step that ran.
node	integer	The node number.
slice	integer	The data slice that a particular segment ran against.
starttime	timestamp	Time in UTC that the query started executing.
endtime	timestamp	Time in UTC that the query execution completed

Column name	Data type	Description
elapsed	integer	Elapsed time (in microseconds).
external_table_name	char(136)	Internal format of external table name for the s3 scan step.
is_partitioned	char(1)	If true (**t**), this column value indicates that the external table is partitioned.
is_rrscan	char(1)	If true (**t**), this column value indicates that a range-restricted scan was applied.
s3_scanned_rows	bigint	The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.
s3_scanned_bytes	bigint	The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer.
s3query_returned_rows	bigint	The number of rows returned from the Redshift Spectrum layer to the cluster.
s3query_returned_bytes	bigint	The number of bytes returned from the Redshift Spectrum layer to the cluster.
files	integer	The number of files that were processed for this S3 scan step on this slice.
splits	int	The number of splits processed on this slice. With large splitable data files, for example, data files larger than about 512 MB, Redshift Spectrum tries to split the files into multiple S3 requests for parallel processing.
total_split_size	bigint	The total size of all splits processed on this slice, in bytes.

Column name	Data type	Description
max_split_size	bigint	The maximum split size processed for this slice, in bytes.
total_retries	integer	The total number of retries for the processed files.
max_retries	integer	The maximum number of retries for an individual processed file.
max_request_duration	integer	The maximum duration of an individual Redshift Spectrum request (in microseconds).
avg_request_duration	double precision	The average duration of the Redshift Spectrum requests (in microseconds).
max_request_parallelism	integer	The maximum number of outstanding Redshift Spectrum on this slice for this S3 scan step.
avg_request_parallelism	double precision	The average number of parallel Redshift Spectrum requests on this slice for this S3 scan step.

Sample query

The following example gets the scan step details for the last query completed.

```
select query, segment, slice, elapsed, s3_scanned_rows, s3_scanned_bytes,
 s3query_returned_rows, s3query_returned_bytes, files
from svl_s3query
where query = pg_last_query_id()
order by query,segment,slice;
```

```
query | segment | slice | elapsed | s3_scanned_rows | s3_scanned_bytes |
 s3query_returned_rows | s3query_returned_bytes | files
------+---------+-------+---------+-----------------+------------------
+-----------------------+-----------------------+------
 4587 |       2 |     0 |   67811 |               0 |                0 |
      0 |                         0 |     0
 4587 |       2 |     1 |  591568 |          172462 |         11260097 |
   8513 |                    170260 |     1
 4587 |       2 |     2 |  216849 |               0 |                0 |
      0 |                         0 |     0
 4587 |       2 |     3 |  216671 |               0 |                0 |
      0 |                         0 |     0
```

SVL_S3QUERY_SUMMARY

Use the SVL_S3QUERY_SUMMARY view to get a summary of all Amazon Redshift Spectrum queries (S3 queries) that have been run on the system. SVL_S3QUERY_SUMMARY aggregates detail from SVL_S3QUERY at the segment level.

SVL_S3QUERY_SUMMARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_EXTERNAL_QUERY_DETAIL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

For SVCS_S3QUERY_SUMMARY, see SVCS_S3QUERY_SUMMARY.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user that generated the given entry.
query	integer	The query ID. You can use this value to join various other system tables and views.
xid	bigint	The transaction ID.
pid	integer	The process ID.

Column name	Data type	Description
segment	integer	The segment number. A query consists of multiple segments, and each segment consists of one or more steps.
step	integer	The query step that ran.
starttime	timestamp	Time in UTC that the query started executing.
endtime	timestamp	Time in UTC that the query completed.
elapsed	integer	The length of time that it took the query to run (in microseconds).
aborted	integer	If a query was stopped by the system or canceled by the user, this column contains **1**. If the query ran to completion, this column contains **0**.
external_table_name	char(136)	The internal format of name of the external name of the table for the external table scan.
file_format	character(16)	The file format of the external table data.
is_partitioned	char(1)	If true (**t**), this column value indicates that the external table is partitioned.
is_rrscan	char(1)	If true (**t**), this column value indicates that a range-restricted scan was applied.
is_nested	char(1)	If true (**t**), this column value indicates that the nested column data type is accessed.
s3_scanned_rows	bigint	The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.

Column name	Data type	Description
s3_scanned_bytes	bigint	The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer, based on compressed data.
s3query_returned_rows	bigint	The number of rows returned from the Redshift Spectrum layer to the cluster.
s3query_returned_bytes	bigint	The number of bytes returned from the Redshift Spectrum layer to the cluster. A large amount of data returned to Amazon Redshift might affect system performance.
files	integer	The number of files that were processed for this Redshift Spectrum query. A small number of files limits the benefits of parallel processing.
files_max	integer	The maximum number of files processed on one slice.
files_avg	integer	The average number of files processed on one slice.
splits	int	The number of splits processed for this segment. The number of splits processed on this slice. With large splitable data files, for example, data files larger than about 512 MB, Redshift Spectrum tries to split the files into multiple S3 requests for parallel processing.
splits_max	int	The maximum number of splits processed on this slice.
splits_avg	int	The average number of splits processed on this slice.
total_split_size	bigint	The total size of all splits processed.
max_split_size	bigint	The maximum split size processed, in bytes.

Column name	Data type	Description
avg_split_size	bigint	The average split size processed, in bytes.
total_retries	integer	The total number of retries for one individual processed file.
max_retries	integer	The maximum number of retries for any of processed files.
max_request_duration	integer	The maximum duration of an individual file request (in microseconds). Long running queries might indicate a bottleneck.
avg_request_duration	double precision	The average duration of the file requests (in microseconds).
max_request_parallelism	integer	The maximum number of parallel requests at one slice for this Redshift Spectrum query.
avg_request_parallelism	double precision	The average number of parallel requests at one slice for this Redshift Spectrum query.
total_slowdown_count	bigint	The total number of Amazon S3 requests with a slow down error that occurred during the external table scan.
max_slowdown_count	integer	The maximum number of Amazon S3 requests with a slow down error that occurred during the external table scan on one slice.

Sample query

The following example gets the scan step details for the last query completed.

```
select query, segment, elapsed, s3_scanned_rows, s3_scanned_bytes,
 s3query_returned_rows, s3query_returned_bytes, files
from svl_s3query_summary
where query = pg_last_query_id()
order by query,segment;
```

```
query | segment | elapsed | s3_scanned_rows | s3_scanned_bytes | s3query_returned_rows
 | s3query_returned_bytes | files
------+---------+---------+-----------------+------------------+----------------------
+------------------------+------
 4587 |       2 |   67811 |               0 |                0 |                     0
 |                      0 |     0
 4587 |       2 |  591568 |          172462 |         11260097 |                  8513
 |                 170260 |     1
 4587 |       2 |  216849 |               0 |                0 |                     0
 |                      0 |     0
 4587 |       2 |  216671 |               0 |                0 |                     0
 |                      0 |     0
```

SVL_S3RETRIES

Use the SVL_S3RETRIES view to get information about why an Amazon Redshift Spectrum query based on Amazon S3 has failed.

SVL_S3RETRIES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description		
query	integer	The query ID.		
segment	integer	Segment number. A query consists of multiple segments, and each segment consists of one or more steps. Query segments can		

Column name	Data type	Description
		run in parallel. Each segment runs in a single process.
node	integer	The node number.
slice	integer	The data slice that a particular segment ran against.
eventtime	timestamp without time zone	Time in UTC that the step started executing.
retries	integer	The number of retries for the query.
successful_fetches	integer	The number of times data was returned.
file_size	bigint	This size of the file in bytes.
location	text	The location of the table.
message	text	The error message.

Sample query

The following example retrieves data about failed S3 queries.

```
SELECT svl_s3retries.query, svl_s3retries.segment, svl_s3retries.node,
 svl_s3retries.slice, svl_s3retries.eventtime, svl_s3retries.retries,
svl_s3retries.successful_fetches, svl_s3retries.file_size,
 btrim((svl_s3retries."location")::text) AS "location",
 btrim((svl_s3retries.message)::text)
```

```
AS message FROM svl_s3retries;
```

SVL_SPATIAL_SIMPLIFY

You can query the system view SVL_SPATIAL_SIMPLIFY to get information about simplified spatial geometry objects using the COPY command. When you use COPY on a shapefile, you can specify SIMPLIFY `tolerance`, SIMPLIFY AUTO, and SIMPLIFY AUTO `max_tolerance` ingestion options. The result of the simplification is summarized in SVL_SPATIAL_SIMPLIFY system view.

When SIMPLIFY AUTO `max_tolerance` is set, this view contains a row for each geometry that exceeded the maximum size. When SIMPLIFY `tolerance` is set, then one row for the entire COPY operation is stored. This row references the COPY query ID and the specified simplification tolerance.

SVL_SPATIAL_SIMPLIFY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_SPATIAL_SIMPLIFY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
query	integer	The ID of the query (COPY command) that generated this row.
line_number	integer	When COPY `SIMPLIFY AUTO` option is specified, this value is the record number of the simplified record in the shapefile.
maximum_tolerance	double	The distance tolerance value specified in the COPY command. This is either the maximum tolerance value using the `SIMPLIFY AUTO` option, or the fixed tolerance value using the `SIMPLIFY` option.

Column name	Data type	Description
initial_size	integer	The size in bytes of the GEOMETRY data value before simplification.
simplified	char(1)	When the COPY SIMPLIFY AUTO option is specified, t if the geometry was successfully simplified, or f otherwise. The geometry might not be simplified successfully if after the simplification with the given maximum tolerance its size is still larger than the maximum geometry size.
final_size	integer	When the COPY SIMPLIFY AUTO option is specified, this is the size in bytes of the geometry after simplification.
final_tolerance	double	

Sample query

The following query returns the list of records that COPY simplified.

```
SELECT * FROM svl_spatial_simplify WHERE query = pg_last_copy_id();
 query | line_number | maximum_tolerance | initial_size | simplified | final_size | 
 final_tolerance
-------+-------------+-------------------+--------------+------------+------------
+----------------------
    20 |     1184704 |                -1 |      1513736 | t          |    1008808 | 
 1.276386653895e-05
    20 |     1664115 |                -1 |      1233456 | t          |    1023584 | 
 6.11707814796635e-06
```

SVL_SPECTRUM_SCAN_ERROR

You can query the system view SVL_SPECTRUM_SCAN_ERROR to get information about Redshift Spectrum scan errors.

SVL_SPECTRUM_SCAN_ERROR is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_EXTERNAL_QUERY_ERROR. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Displays a sample of logged errors. The default is 10 entries per query.

Column name	Data type	Description
userid	integer	The ID of the user that generated this row.
query	integer	The ID of the query that generated this row.
location	character(128)	The location of the data being queried.
rowid	character(128)	The location of the error within the file. The `rowid` parts are separated with a `:` (colon) and additional parts might be added in the future. `row_offset :row_group :row_id` A row_offset is the offset (in bytes) of the row within the file and is set to `-1` for unsupported file formats. A table is divided into row_groups, and each group has rows with distinct row_ids.
colname	character(128)	The name of the column returned by the query.
original_value	character(128)	Original value queried.
modified_value	character(128)	Modified value returned based on the data handling configuration option specified in the query.
trigger	character(128)	Data handling option specified in the query.
action	character(128)	Action associated with the data handling option specified in the query.

Column name	Data type	Description
action_value	character(128)	Value of action parameter associated with the data handling option specified in the query.
error_code	integer	Result code of the data handling option specified in the query.

Sample query

The following query returns the list of rows for which data handling operations were performed.

```
SELECT * FROM svl_spectrum_scan_error;
```

The query returns results similar to the following.

```
  userid  query     location                                            rowid   colname
       original_value             modified_value       trigger          action
               action_valueerror_code
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:0     league_name
       Barclays Premier League    Barclays Premier Lea UNSPECIFIED      TRUNCATE
                                   156
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:0     league_nspi
        34595                      32767                 UNSPECIFIED
 OVERFLOW_VALUE                                 199
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:1     league_nspi
        34151                      32767                 UNSPECIFIED
 OVERFLOW_VALUE                                 199
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:2     league_name
       Barclays Premier League    Barclays Premier Lea UNSPECIFIED      TRUNCATE
                                   156
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:2     league_nspi
        33223                      32767                 UNSPECIFIED
 OVERFLOW_VALUE                                 199
    100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:3     league_name
       Barclays Premier League    Barclays Premier Lea UNSPECIFIED      TRUNCATE
                                   156
```

```
     100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:3     league_nspi
           32808                          32767                     UNSPECIFIED
 OVERFLOW_VALUE                                          199
     100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:4     league_nspi
           32790                          32767                     UNSPECIFIED
 OVERFLOW_VALUE                                          199
     100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:5     league_name
          Spanish Primera Division    Spanish Primera Divi UNSPECIFIED       TRUNCATE
                                          156
     100   1574007   s3://spectrum-uddh/league/spi_global_rankings.0:6     league_name
          Spanish Primera Division    Spanish Primera Divi UNSPECIFIED       TRUNCATE
                                          156
```

SVL_STATEMENTTEXT

Use the SVL_STATEMENTTEXT view to get a complete record of all of the SQL commands that have been run on the system.

The SVL_STATEMENTTEXT view contains the union of all of the rows in the STL_DDLTEXT, STL_QUERYTEXT, and STL_UTILITYTEXT tables. This view also includes a join to the STL_QUERY table.

SVL_STATEMENTTEXT is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	ID of user who generated entry.
xid	bigint	Transaction ID associated with the statement.
pid	integer	Process ID for the statement.

Column name	Data type	Description
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter is not set, this field is blank.
starttime	timestamp	Exact time when the statement started executing, with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.131358**
endtime	timestamp	Exact time when the statement finished executing, with 6 digits of precision for fractional seconds. For example: **2009-06-12 11:29:19.193640**
sequence	integer	When a single statement contains more than 200 characters, additional rows are logged for that statement. Sequence 0 is the first row, 1 is the second, and so on.
type	varchar(10)	Type of SQL statement: **QUERY**, **DDL**, or **UTILITY**.
text	character(200)	SQL text, in 200-character increments. This field might contain special characters such as backslash (\\) and newline (\n).

Sample query

The following query returns DDL statements that were run on June 16th, 2009:

```
select starttime, type, rtrim(text) from svl_statementtext
where starttime like '2009-06-16%' and type='DDL' order by starttime asc;

starttime                   | type |              rtrim
---------------------------|------|--------------------------------
2009-06-16 10:36:50.625097 | DDL  | create table ddltest(c1 int);
2009-06-16 15:02:16.006341 | DDL  | drop view alltickitjoin;
2009-06-16 15:02:23.65285  | DDL  | drop table sales;
2009-06-16 15:02:24.548928 | DDL  | drop table listing;
```

```
2009-06-16 15:02:25.536655 | DDL  | drop table event;
...
```

Reconstructing stored SQL

To reconstruct the SQL stored in the `text` column of SVL_STATEMENTTEXT, run a SELECT statement to create SQL from 1 or more parts in the `text` column. Before running the reconstructed SQL, replace any (\n) special characters with a new line. The result of the following SELECT statement is rows of reconstructed SQL in the `query_statement` field.

```
select LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END, '')
 within group (order by sequence) AS query_statement
from SVL_STATEMENTTEXT where pid=pg_backend_pid();
```

For example, the following query selects 3 columns. The query itself is longer than 200 characters and is stored in parts in SVL_STATEMENTTEXT.

```
select
1 AS a0123456789012345678901234567890123456789012345678901234567890,
2 AS b0123456789012345678901234567890123456789012345678901234567890,
3 AS b012345678901234567890123456789012345678901234
FROM stl_querytext;
```

In this example, the query is stored in 2 parts (rows) in the `text` column of SVL_STATEMENTTEXT.

```
select sequence, text from SVL_STATEMENTTEXT where pid = pg_backend_pid() order by
 starttime, sequence;
```

```

 sequence |
                text

----------
+-------------------------------------------------------------------------------------
       0 | select\n1 AS
 a0123456789012345678901234567890123456789012345678901234567890,\n2 AS
 b0123456789012345678901234567890123456789012345678901234567890,\n3 AS
 b012345678901234567890123456789012345678901234
       1 | \nFROM stl_querytext;
```

To reconstruct the SQL stored in STL_STATEMENTTEXT, run the following SQL.

```
select LISTAGG(CASE WHEN LEN(RTRIM(text)) = 0 THEN text ELSE RTRIM(text) END, '')
 within group (order by sequence) AS text
from SVL_STATEMENTTEXT where pid=pg_backend_pid();
```

To use the resulting reconstructed SQL in your client, replace any (\n) special characters with a new line.

```
                      text

-------------------------------------------------------------------------------------------------
 select\n1 AS a0123456789012345678901234567890123456789012345678901234567890,
\n2 AS b0123456789012345678901234567890123456789012345678901234567890,\n3 AS
 b012345678901234567890123456789012345678901234\nFROM stl_querytext;
```

SVL_STORED_PROC_CALL

You can query the system view SVL_STORED_PROC_CALL to get information about stored procedure calls, including start time, end time, and whether a call is canceled. Each stored procedure call receives a query ID.

SVL_STORED_PROC_CALL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_PROCEDURE_CALL. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user whose privileges were used to run the statement. If this call was nested within a SECURITY DEFINER stored procedure, then this is the userid of the owner of that stored procedure.

Column name	Data type	Description
session_userid	integer	The ID of the user that created the session and is the invoker of the top-level stored procedure call.
query	integer	The query ID of the procedure call.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter isn't set, this field value is default.
xid	bigint	The transaction ID.
pid	integer	The process ID. Usually, all of the queries in a session are run in the same process, so this value usually remains constant if you run a series of queries in the same session. Following certain internal events, Amazon Redshift might restart an active session and assign a new pid value. For more information, see STL_RESTARTED_SESSIONS.
database	character(32)	The name of the database that the user was connected to when the query was issued.
querytxt	character(4000)	The actual text of the procedure call query.
starttime	timestamp	The time in UTC that the query started running, with six digits of precision for fractional seconds, for example: **`2009-06-12 11:29:19.131358.`**
endtime	timestamp	The time in UTC that the query finished running, with six digits of precision for fractional seconds, for example: **`2009-06-12 11:29:19.131358.`**
aborted	integer	If a stored procedure was stopped by the system or canceled by the user, this column contains 1. If the call runs to completion, this column contains 0.

Column name	Data type	Description
from_sp_call	integer	If the procedure call was invoked by another procedure call, this column contains the query ID of the outer call. Otherwise, the field is NULL.

Sample query

The following query returns the elapsed time in descending order and the completion status for stored procedure calls in the past day.

```
select query, datediff(seconds, starttime, endtime) as elapsed_time, aborted,
 trim(querytxt) as call from svl_stored_proc_call where starttime >= getdate() -
 interval '1 day' order by 2 desc;

  query | elapsed_time | aborted |                                       call
--------+--------------+---------
+-------------------------------------------------------------------------------------
   4166 |            7 |       0 | call search_batch_status(35,'succeeded');
   2433 |            3 |       0 | call test_batch (123456)
   1810 |            1 |       0 | call prod_benchmark (123456)
   1836 |            1 |       0 | call prod_testing (123456)
   1808 |            1 |       0 | call prod_portfolio ('N', 123456)
   1816 |            1 |       1 | call prod_portfolio ('Y', 123456)
```

SVL_STORED_PROC_MESSAGES

You can query the system view SVL_STORED_PROC_MESSAGES to get information about stored procedure messages. Raised messages are logged even if the stored procedure call is canceled. Each stored procedure call receives a query ID. For more information about how to set the minimum level for logged messages, see stored_proc_log_min_messages.

SVL_STORED_PROC_MESSAGES is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_PROCEDURE_MESSAGES. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
userid	integer	The ID of the user whose privileges were used to run the statement. If this call was nested within a SECURITY DEFINER stored procedure, then this is the userid of the owner of that stored procedure.
session_userid	integer	The ID of the user that created the session and is the invoker of the top-level stored procedure call.
pid	integer	The process ID.
xid	bigint	The transaction ID of the procedure call query.
query	integer	The query ID of the procedure call.
recordtime	timestamp	The time in UTC that the message was raised.
loglevel	integer	The numeric value of the log level of the raised message. Possible values: 20 – for LOG 30 – for INFO 40 – for NOTICE 50 – for WARNING 60 – for EXCEPTION
loglevel_text	character(10)	The log level that corresponds to the numeric value in loglevel. Possible values: LOG, INFO, NOTICE, WARNING, and EXCEPTION.
message	character(1024)	The text of the raised message.
linenum	integer	The line number of the raised statement.
querytext	character(500)	The actual text of the procedure call query.
label	character(320)	Either the name of the file used to run the query or a label defined with a SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP parameter isn't set, this field value is default.

Column name	Data type	Description
aborted	integer	If a stored procedure was stopped by the system or canceled by the user, this column contains 1. If the call runs to completion, this column contains 0.
message_xid	bigint	The transaction ID of the raised message.

Sample query

The following SQL statements show how to use SVL_STORED_PROC_MESSAGES to review raised messages.

```
-- Create and run a stored procedure
CREATE OR REPLACE PROCEDURE test_proc1(f1 int) AS
$$
BEGIN
    RAISE INFO 'Log Level: Input f1 is %',f1;
    RAISE NOTICE 'Notice Level: Input f1 is %',f1;
    EXECUTE 'select invalid';
    RAISE NOTICE 'Should not print this';

EXCEPTION WHEN OTHERS THEN
     raise exception 'EXCEPTION level: Exception Handling';
END;
$$ LANGUAGE plpgsql;

-- Call this stored procedure
CALL test_proc1(2);

-- Show raised messages with level higher than INFO
SELECT query, recordtime, loglevel, loglevel_text, trim(message) as message, aborted
 FROM svl_stored_proc_messages
  WHERE loglevel > 30 AND query = 193 ORDER BY recordtime;

 query |         recordtime         | loglevel | loglevel_text |                message
              | aborted
-------+----------------------------+----------+---------------
+-------------------------------------+---------
```

```
   193 | 2020-03-17 23:57:18.277196 |       40 | NOTICE        | Notice Level: Input f1
 is 2          |       1
   193 | 2020-03-17 23:57:18.277987 |       60 | EXCEPTION     | EXCEPTION level:
 Exception Handling |       1
(2 rows)

-- Show raised messages at EXCEPTION level
SELECT query, recordtime, loglevel, loglevel_text, trim(message) as message, aborted
 FROM svl_stored_proc_messages
  WHERE loglevel_text = 'EXCEPTION' AND query = 193 ORDER BY recordtime;

 query |         recordtime         | loglevel | loglevel_text |               message
              | aborted
-------+----------------------------+----------+---------------
+-------------------------------------+---------
   193 | 2020-03-17 23:57:18.277987 |       60 | EXCEPTION     | EXCEPTION level:
 Exception Handling |       1
```

The following SQL statements show how to use SVL_STORED_PROC_MESSAGES to review raised messages with the SET option when creating a stored procedure. Because test_proc() has a minimum log level of NOTICE, only NOTICE, WARNING, and EXCEPTION level messages are logged in SVL_STORED_PROC_MESSAGES.

```
-- Create a stored procedure with minimum log level of NOTICE
CREATE OR REPLACE PROCEDURE test_proc() AS
$$
BEGIN
    RAISE LOG 'Raise LOG messages';
    RAISE INFO 'Raise INFO messages';
    RAISE NOTICE 'Raise NOTICE messages';
    RAISE WARNING 'Raise WARNING messages';
    RAISE EXCEPTION 'Raise EXCEPTION messages';
    RAISE WARNING 'Raise WARNING messages again'; -- not reachable
END;
$$ LANGUAGE plpgsql SET stored_proc_log_min_messages = NOTICE;

-- Call this stored procedure
CALL test_proc();

-- Show the raised messages
SELECT query, recordtime, loglevel_text, trim(message) as message, aborted FROM
 svl_stored_proc_messages
  WHERE query = 149 ORDER BY recordtime;
```

```
 query |        recordtime         | loglevel_text |          message          |
 aborted
-------+----------------------------+---------------+---------------------------
+---------
   149 | 2020-03-16 21:51:54.847627 | NOTICE        | Raise NOTICE messages     |
 1
   149 | 2020-03-16 21:51:54.84766  | WARNING       | Raise WARNING messages    |
 1
   149 | 2020-03-16 21:51:54.847668 | EXCEPTION     | Raise EXCEPTION messages |
 1
(3 rows)
```

SVL_TERMINATE

Records the time when a user cancels or terminates a process.

SELECT PG_TERMINATE_BACKEND(*pid*), SELECT PG_CANCEL_BACKEND(*pid*), and CANCEL *pid* creates a log entry in SVL_TERMINATE.

SVL_TERMINATE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_QUERY_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
pid	integer	The process ID of the canceled or terminated process.
eventtime	timestamp	The time when the process is canceled or terminated.
userid	integer	The user ID of the user running the command.
type	string	The type of termination. It can be CANCEL or TERMINATE.

The following command shows the latest cancelled query.

```
select * from svl_terminate order by eventtime desc limit 1;
 pid  |         eventtime          | userid |  type
------+----------------------------+--------+--------
 8324 | 2020-03-24 09:42:07.298937 |      1 | CANCEL
(1 row)
```

SVL_UDF_LOG

Records system-defined error and warning messages generating during user-defined function (UDF) execution.

SVL_UDF_LOG is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_UDF_LOG. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
query	bigint	The query ID. You can use this ID to join various other system tables and views.
message	char(4096)	The message generated by the function.
created	timestamp	The time that the log was created.
traceback	char(4096)	If available, this value provides a stack traceback for the UDF. For more informati on, see traceback in the Python Standard Library.
funcname	character(256)	The name of the UDF that is executing.

Column name	Data type	Description
node	integer	The node where the message was generated.
slice	integer	The slice where the message was generated.
seq	integer	The sequence of the message on the slice.

Sample queries

The following example shows how UDFs handle system-defined errors. The first block shows the definition for a UDF function that returns the inverse of an argument. When you run the function and provide a 0 argument, as the second block shows, the function returns an error. The third statement reads the error message that is logged in SVL_UDF_LOG

```
-- Create a function to find the inverse of a number

CREATE OR REPLACE FUNCTION  f_udf_inv(a int)
  RETURNS float IMMUTABLE
AS $$
   return 1/a
$$ LANGUAGE plpythonu;

-- Run the function with a 0 argument to create an error
Select f_udf_inv(0) from sales;

-- Query SVL_UDF_LOG to view the message

Select query, created, message::varchar
from svl_udf_log;

 query |          created           | message
-------+----------------------------
+---------------------------------------------------------
  2211 | 2015-08-22 00:11:12.04819  | ZeroDivisionError: long division or modulo by
 zero\nNone
```

The following example adds logging and a warning message to the UDF so that a divide by zero operation results in a warning message instead of stopping with an error message.

```
-- Create a function to find the inverse of a number and log a warning

CREATE OR REPLACE FUNCTION f_udf_inv_log(a int)
  RETURNS float IMMUTABLE
 AS $$
  import logging
  logger = logging.getLogger() #get root logger
  if a==0:
    logger.warning('You attempted to divide by zero.\nReturning zero instead of error.
\n')
    return 0
  else:
     return 1/a
$$ LANGUAGE plpythonu;
```

The following example runs the function, then queries SVL_UDF_LOG to view the message.

```

-- Run the function with a 0 argument to trigger the warning
Select f_udf_inv_log(0) from sales;

-- Query SVL_UDF_LOG to view the message

Select query, created, message::varchar
from svl_udf_log;

query |          created           | message
------+----------------------------+---------------------------------
    0 | 2015-08-22 00:11:12.04819  | You attempted to divide by zero.
                                     Returning zero instead of error.
```

SVL_USER_INFO

You can retrieve data about Amazon Redshift database users with the SVL_USER_INFO view.

SVL_USER_INFO is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
usename	text	The user name for the role.
usesysid	integer	The user ID for the user.
usecreatedb	boolean	A value that indicates whether the user has permissions to create databases.
usesuper	boolean	A value that indicates whether the user is a superuser.
usecatupd	boolean	A value that indicates whether the user can update system catalogs.
useconnlimit	text	The number of connections that the user can open.
syslogaccess	text	A value that indicates whether the user has access to the system logs. The two possible values are `RESTRICTED` and `UNRESTRICTED`. `RESTRICTED` means that users that are not superusers can see their own records. `UNRESTRICTED` means that user that are not superusers can see all records in the system views and tables to which they have `SELECT` privileges.
last_ddl_ts	timestamp	The timestamp for the last data definition language (DDL) create statement run by the user.
sessiontimeout	integer	The maximum time in seconds that a session remains inactive or idle before timing out. 0 indicates that no timeout is set. For information about the cluster's idle or inactive timeout setting, see [Quotas and limits in Amazon Redshift] in the *Amazon Redshift Management Guide*.
external_id	text	Unique identifier of the user in the third-party identity provider.

Sample queries

The following command retrieves user information from SVL_USER_INFO.

```
SELECT * FROM SVL_USER_INFO;
```

SVL_VACUUM_PERCENTAGE

The SVL_VACUUM_PERCENTAGE view reports the percentage of data blocks allocated to a table after performing a vacuum. This percentage number shows how much disk space was reclaimed. See the VACUUM command for more information about the vacuum utility.

SVL_VACUUM_PERCENTAGE is visible only to superusers. For more information, see Visibility of data in system tables and views.

Some or all of the data in this table can also be found in the SYS monitoring view SYS_VACUUM_HISTORY. The data in the SYS monitoring view is formatted to be easier to use and understand. We recommend that you use the SYS monitoring view for your queries.

Table columns

Column name	Data type	Description
xid	bigint	Transaction ID for the vacuum statement.
table_id	integer	Table ID for the vacuumed table.
percentage	bigint	Percentage of data blocks after a vacuum (relative to the number of blocks in the table before the vacuum was run).

Sample query

The following query displays the percentage for a specific operation on table 100238:

```
select * from svl_vacuum_percentage
where table_id=100238 and xid=2200;

xid  | table_id | percentage
```

```
-----+----------+------------
1337 |   100238 |          60
(1 row)
```

After this vacuum operation, the table contained 60 percent of the original blocks.

System catalog tables

Topics

The system catalogs store schema metadata, such as information about tables and columns. System catalog tables have a PG prefix.

The standard PostgreSQL catalog tables are accessible to Amazon Redshift users. For more information about PostgreSQL system catalogs, see PostgreSQL system tables

PG_ATTRIBUTE_INFO

PG_ATTRIBUTE_INFO is an Amazon Redshift system view built on the PostgreSQL catalog table PG_ATTRIBUTE and the internal catalog table PG_ATTRIBUTE_ACL. PG_ATTRIBUTE_INFO includes details about columns of a table or view, including column access control lists, if any.

Table columns

PG_ATTRIBUTE_INFO shows the following column in addition to the columns in PG_ATTRIBUTE.

Column name	Data type	Description
attacl	aclitem[]	The column-level access privileges, if any, that have been granted specifically on this column.

PG_CLASS_INFO

PG_CLASS_INFO is an Amazon Redshift system view built on the PostgreSQL catalog tables PG_CLASS and PG_CLASS_EXTENDED. PG_CLASS_INFO includes details about table creation time and the current distribution style. For more information, see Data distribution for query optimization.

PG_CLASS_INFO is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

PG_CLASS_INFO shows the following columns in addition to the columns in PG_CLASS. The `oid` column in PG_CLASS is called `reloid` in the PG_CLASS_INFO table.

Column name	Data type	Description
relcreationtime	timestamp	Time in UTC that the table was created.
releffectivediststyle	integer	The distribution style of a table or, if the table uses automatic distribution, the current distribution style assigned by Amazon Redshift.

The RELEFFECTIVEDISTSTYLE column in PG_CLASS_INFO indicates the current distribution style for the table. If the table uses automatic distribution, RELEFFECTIVEDISTSTYLE is 10, 11, or 12, which indicates whether the effective distribution style is AUTO (ALL), AUTO (EVEN), or AUTO (KEY). If the table uses automatic distribution, the distribution style might initially show AUTO (ALL), then change to AUTO (EVEN) when the table grows or AUTO (KEY) if a column is found to be useful as a distribution key.

The following table gives the distribution style for each value in RELEFFECTIVEDISTSTYLE column:

RELEFFECTIVEDISTSTYLE	Current distribution style
0	EVEN
1	KEY
8	ALL
10	AUTO (ALL)
11	AUTO (EVEN)
12	AUTO (KEY)

Example

The following query returns the current distribution style of tables in the catalog.

```
select reloid as tableid,trim(nspname) as schemaname,trim(relname) as
 tablename,reldiststyle,releffectivediststyle,
CASE WHEN "reldiststyle" = 0 THEN 'EVEN'::text
     WHEN "reldiststyle" = 1 THEN 'KEY'::text
     WHEN "reldiststyle" = 8 THEN 'ALL'::text
     WHEN "releffectivediststyle" = 10 THEN 'AUTO(ALL)'::text
     WHEN "releffectivediststyle" = 11 THEN 'AUTO(EVEN)'::text
     WHEN "releffectivediststyle" = 12 THEN 'AUTO(KEY)'::text ELSE '<<UNKNOWN>>'::text
 END as diststyle,relcreationtime
from pg_class_info a left join pg_namespace b on a.relnamespace=b.oid;
```

```

 tableid | schemaname | tablename | reldiststyle | releffectivediststyle | diststyle  |
      relcreationtime
---------+------------+-----------+--------------+-----------------------+------------
+----------------------------
 3638033 | public     | customer  |            0 |                     0 | EVEN       |
 2019-06-13 15:02:50.666718
 3638037 | public     | sales     |            1 |                     1 | KEY        |
 2019-06-13 15:03:29.595007
```

```
 3638035 | public      | lineitem  |            8 |                     8 | ALL         |
 2019-06-13 15:03:01.378538
 3638039 | public      | product   |            9 |                    10 | AUTO(ALL)   |
 2019-06-13 15:03:42.691611
 3638041 | public      | shipping  |            9 |                    11 | AUTO(EVEN) |
 2019-06-13 15:03:53.69192
 3638043 | public      | support   |            9 |                    12 | AUTO(KEY)   |
 2019-06-13 15:03:59.120695
(6 rows)
```

PG_DATABASE_INFO

PG_DATABASE_INFO is an Amazon Redshift system view that extends the PostgreSQL catalog table PG_DATABASE.

PG_DATABASE_INFO is visible to all users.

Table columns

PG_DATABASE_INFO contains the following columns in addition to columns in PG_DATABASE. The `oid` column in PG_DATABASE is called `datid` in the PG_DATABASE_INFO table. For more information, see the PostgreSQL documentation.

Column name	Data type	Description
datid	oid	The object identifier (OID) used internally by system tables.
datconnlimit	text	The maximum number of concurrent connections that can be made to this database. A value of -1 means no limit.

PG_DEFAULT_ACL

Stores information about default access privileges. For more information on default access privileges, see ALTER DEFAULT PRIVILEGES.

PG_DEFAULT_ACL is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
defacluser	integer	ID of the user to which the listed privileges are applied.
defaclnamespace	oid	The object ID of the schema where default privileges are applied. The default value is 0 if no schema is specified.
defaclobjtype	character	The type of object to which default privileges are applied. Valid values are as follows: • r – relation (table or view) • f – function • p – stored procedure
defaclacl	aclitem[]	A string that defines the default privileges for the specified user or user group and object type. If the privileges are granted to a user, the string is in the following form: `{ username=privilegestring/grantor }` *username* The name of the user to which privileges are granted. If *username* is omitted, the privileges are granted to PUBLIC. If the privileges are granted to a user group, the string is in the following form: `{ "group groupname=privilegestring/grantor" }` *privilegestring* A string that specifies which privileges are granted.

Column name	Data type	Description
		Valid values are: • a – INSERT (append) • r – SELECT (read) • w – UPDATE (write) • d – DELETE • R – RULE • x – Grants the privilege to create a foreign key constrain t (REFERENCES). • t – TRIGGER • X – EXECUTE • U – USAGE • C – CREATE • T – CREATE TEMP • D – DROP • P – TRUNCATE • A – ALTER • * – Indicates that the user receiving the preceding privilege can in turn grant the same privilege to others (WITH GRANT OPTION). A string holding all privilege code chars, in order by bitmask position, looks like "arwdRxtXUCTDPA". *grantor* The name of the user that granted the privileges. The following example indicates that the user `admin` granted all privileges, including WITH GRANT OPTION, to the user `dbuser`.

Column name	Data type	Description
		`dbuser=r*a*w*d*x*X*/admin`

Example

The following query returns all default privileges defined for the database.

```
select pg_get_userbyid(d.defacluser) as user,
n.nspname as schema,
case d.defaclobjtype when 'r' then 'tables' when 'f' then 'functions' end
as object_type,
array_to_string(d.defaclacl, ' + ')  as default_privileges
from pg_catalog.pg_default_acl d
left join pg_catalog.pg_namespace n on n.oid = d.defaclnamespace;

 user  | schema | object_type |              default_privileges
-------+--------+-------------+-------------------------------------------------------
 admin | tickit | tables      | user1=r/admin + "group group1=a/admin" + user2=w/admin
```

The result in the preceding example shows that for all new tables created by user `admin` in the `tickit` schema, `admin` grants SELECT privileges to `user1`, INSERT privileges to `group1`, and UPDATE privileges to `user2`.

PG_EXTERNAL_SCHEMA

Stores information about external schemas.

PG_EXTERNAL_SCHEMA is visible to all users. Superusers can see all rows; regular users can see only metadata to which they have access. For more information, see CREATE EXTERNAL SCHEMA.

Table columns

Column name	Data type	Description
esoid	oid	External schema ID.

Column name	Data type	Description
eskind	integer	Kind of external schema.
esdbname	text	External database name.
esoptions	text	External schema options.

Example

The following example shows details for external schemas.

```
select esoid, nspname as schemaname, nspowner, esdbname as external_db, esoptions
from pg_namespace a,pg_external_schema b where a.oid=b.esoid;

esoid  | schemaname      | nspowner | external_db | esoptions

-------+-----------------+----------+-------------
+-------------------------------------------------------------
100134 | spectrum_schema |      100 | spectrum_db |
 {"IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
100135 | spectrum        |      100 | spectrumdb  |
 {"IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
100149 | external        |      100 | external_db |
 {"IAM_ROLE":"arn:aws:iam::123456789012:role/mySpectrumRole"}
```

PG_LIBRARY

Stores information about user-defined libraries.

PG_LIBRARY is visible to all users. Superusers can see all rows; regular users can see only their own data. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
name	name	Library name.

Column name	Data type	Description
language_oid	oid	Reserved for system use.
file_store_id	integer	Reserved for system use.
owner	integer	User ID of the library owner.

Example

The following example returns information for user-installed libraries.

```
select * from pg_library;

name       | language_oid | file_store_id | owner
-----------+--------------+---------------+------
f_urlparse |       108254 |          2000 |   100
```

PG_PROC_INFO

PG_PROC_INFO is an Amazon Redshift system view built on the PostgreSQL catalog table PG_PROC and the internal catalog table PG_PROC_EXTENDED. PG_PROC_INFO includes details about stored procedures and functions, including information related to output arguments, if any.

Table columns

PG_PROC_INFO shows the following columns in addition to the columns in PG_PROC. The `oid` column in PG_PROC is called `prooid` in the PG_PROC_INFO table.

Column name	Data type	Description
prooid	oid	The object ID of the function or stored procedure.

Column name	Data type	Description
prokind	"char"	A value that indicates the type of functions or stored procedures. This value is 'f' for regular functions, 'p' for stored procedures, and 'a' for aggregate functions.
proargmodes	"char"[ ]	An array with the modes of the procedure arguments, encoded as 'i' for IN arguments, 'o' for OUT arguments, and 'b' for INOUT arguments. If all the arguments are IN arguments, this field is NULL. Subscripts correspond to positions in the proallargtypes array.
proallargtypes	oid[ ]	An array with the data types of the procedure arguments. This array includes all types of arguments (including OUT and INOUT arguments). However, if all the arguments are IN arguments, this field is NULL. Subscripting is one-based. In contrast, proargtypes is subscripted from zero.

The field proargnames in PG_PROC_INFO contains the names of all types of arguments (including OUT and INOUT), if any.

PG_STATISTIC_INDICATOR

Stores information about the number of rows inserted or deleted since the last ANALYZE. The PG_STATISTIC_INDICATOR table is updated frequently following DML operations, so statistics are approximate.

PG_STATISTIC_INDICATOR is visible only to superusers. For more information, see Visibility of data in system tables and views.

Table columns

Column name	Data type	Description
stairelid	oid	Table ID

Column name	Data type	Description
stairows	float	Total number of rows in the table.
staiins	float	Number of rows inserted since the last ANALYZE.
staidels	float	Number of rows deleted or updated since the last ANALYZE.

Example

The following example returns information for table changes since the last ANALYZE.

```
select * from pg_statistic_indicator;

stairelid | stairows | staiins | staidels
----------+----------+---------+---------
   108271 |       11 |       0 |        0
   108275 |      365 |       0 |        0
   108278 |     8798 |       0 |        0
   108280 |    91865 |       0 |   100632
   108267 |    89981 |   49990 |     9999
   108269 |      808 |     606 |      374
   108282 |   152220 |   76110 |   248566
```

PG_TABLE_DEF

Stores information about table columns.

PG_TABLE_DEF only returns information about tables that are visible to the user. If PG_TABLE_DEF does not return the expected results, verify that the search_path parameter is set correctly to include the relevant schemas.

You can use SVV_TABLE_INFO to view more comprehensive information about a table, including data distribution skew, key distribution skew, table size, and statistics.

Table columns

Column name	Data type	Description
schemaname	name	Schema name.
tablename	name	Table name.
column	name	Column name.
type	text	Datatype of column.
encoding	character(32)	Encoding of column.
distkey	boolean	True if this column is the distribution key for the table.
sortkey	integer	Order of the column in the sort key. If the table uses a compound sort key, then all columns that are part of the sort key have a positive value that indicates the position of the column in the sort key. If the table uses an interleaved sort key, then each column that is part of the sort key has a value that is alternately positive or negative, where the absolute value indicates the position of the column in the sort key. If 0, the column is not part of a sort key.
notnull	boolean	True if the column has a NOT NULL constraint.

Example

The following example shows the compound sort key columns for the LINEORDER_COMPOUND table.

```
select "column", type, encoding, distkey, sortkey, "notnull"
from pg_table_def
where tablename = 'lineorder_compound'
and sortkey <> 0;
```

```
column       | type    | encoding | distkey | sortkey | notnull
-------------+---------+----------+---------+---------+--------
lo_orderkey  | integer | delta32k | false   |       1 | true
lo_custkey   | integer | none     | false   |       2 | true
lo_partkey   | integer | none     | true    |       3 | true
lo_suppkey   | integer | delta32k | false   |       4 | true
lo_orderdate | integer | delta    | false   |       5 | true
(5 rows)
```

The following example shows the interleaved sort key columns for the LINEORDER_INTERLEAVED table.

```
select "column", type, encoding, distkey, sortkey, "notnull"
from pg_table_def
where tablename = 'lineorder_interleaved'
and sortkey <> 0;

column       | type    | encoding | distkey | sortkey | notnull
-------------+---------+----------+---------+---------+--------
lo_orderkey  | integer | delta32k | false   |      -1 | true
lo_custkey   | integer | none     | false   |       2 | true
lo_partkey   | integer | none     | true    |      -3 | true
lo_suppkey   | integer | delta32k | false   |       4 | true
lo_orderdate | integer | delta    | false   |      -5 | true
(5 rows)
```

PG_TABLE_DEF will only return information for tables in schemas that are included in the search path. For more information, see search_path.

For example, suppose you create a new schema and a new table, then query PG_TABLE_DEF.

```
create schema demo;
create table demo.demotable (one int);
select * from pg_table_def where tablename = 'demotable';

schemaname|tablename|column| type | encoding | distkey | sortkey | notnull
----------+---------+------+------+----------+---------+---------+--------
```

The query returns no rows for the new table. Examine the setting for `search_path`.

```
show search_path;
```

```
  search_path
---------------
 $user, public
(1 row)
```

Add the demo schema to the search path and run the query again.

```
set search_path to '$user', 'public', 'demo';

select * from pg_table_def where tablename = 'demotable';

schemaname| tablename |column|  type   | encoding |distkey|sortkey| notnull
----------+-----------+------+---------+----------+-------+-------+--------
demo      | demotable | one  | integer | none     | f     |     0 | f
(1 row)
```

PG_USER_INFO

PG_USER_INFO is an Amazon Redshift system view that shows user information, such as user ID and password expiration time.

Only superusers can see PG_USER_INFO.

Table columns

PG_USER_INFO contains the following columns. For more information, see the PostgreSQL documentation.

Column name	Data type	Description
usename	name	The username.
usesysid	integer	The user ID.
usecreatedb	boolean	True if the user can create databases.
usesuper	boolean	True if the user is a superuser.

Column name	Data type	Description
usecatupd	boolean	True if the user can update system catalogs.
passwd	text	The password.
valuntil	abstime	The password's expiration date and time.
useconfig	text[]	The session defaults for run-time variables.
useconnlimit	text	The number of connections that the user can open.

Querying the catalog tables

Topics

- Examples of catalog queries

In general, you can join catalog tables and views (relations whose names begin with **PG_**) to Amazon Redshift tables and views.

The catalog tables use a number of data types that Amazon Redshift does not support. The following data types are supported when queries join catalog tables to Amazon Redshift tables:

- bool
- "char"
- float4
- int2
- int4
- int8
- name
- oid
- text
- varchar

If you write a join query that explicitly or implicitly references a column that has an unsupported data type, the query returns an error. The SQL functions that are used in some of the catalog tables are also unsupported, except for those used by the PG_SETTINGS and PG_LOCKS tables.

For example, the PG_STATS table cannot be queried in a join with an Amazon Redshift table because of unsupported functions.

The following catalog tables and views provide useful information that can be joined to information in Amazon Redshift tables. Some of these tables allow only partial access because of data type and function restrictions. When you query the partially accessible tables, select or reference their columns carefully.

The following tables are completely accessible and contain no unsupported types or functions:

- pg_attribute
- pg_cast
- pg_depend
- pg_description
- pg_locks
- pg_opclass

The following tables are partially accessible and contain some unsupported types, functions, and truncated text columns. Values in text columns are truncated to varchar(256) values.

- pg_class
- pg_constraint
- pg_database
- pg_group
- pg_language
- pg_namespace
- pg_operator
- pg_proc
- pg_settings
- pg_statistic
- pg_tables

- pg_type
- pg_user
- pg_views

The catalog tables that are not listed here are either inaccessible or unlikely to be useful to Amazon Redshift administrators. However, you can query any catalog table or view openly if your query does not involve a join to an Amazon Redshift table.

You can use the OID columns in the Postgres catalog tables as joining columns. For example, the join condition `pg_database.oid = stv_tbl_perm.db_id` matches the internal database object ID for each PG_DATABASE row with the visible DB_ID column in the STV_TBL_PERM table. The OID columns are internal primary keys that are not visible when you select from the table. The catalog views do not have OID columns.

Some Amazon Redshift functions must run only on the compute nodes. If a query references a user-created table, the SQL runs on the compute nodes.

A query that references only catalog tables (tables with a PG prefix, such as PG_TABLE_DEF) or that does not reference any tables, runs exclusively on the leader node.

If a query that uses a compute-node function doesn't reference a user-defined table or Amazon Redshift system table returns the following error.

```
[Amazon](500310) Invalid operation: One or more of the used functions must be applied
 on at least one user created table.
```

Examples of catalog queries

The following queries show a few of the ways in which you can query the catalog tables to get useful information about an Amazon Redshift database.

View table ID, database, schema, and table name

The following view definition joins the STV_TBL_PERM system table with the PG_CLASS, PG_NAMESPACE, and PG_DATABASE system catalog tables to return the table ID, database name, schema name, and table name.

```
create view tables_vw as
select distinct(stv_tbl_perm.id) table_id
```

```
,trim(pg_database.datname)   db_name
,trim(pg_namespace.nspname)   schema_name
,trim(pg_class.relname)   table_name
from stv_tbl_perm
join pg_class on pg_class.oid = stv_tbl_perm.id
join pg_namespace on pg_namespace.oid = pg_class.relnamespace
join pg_database on pg_database.oid = stv_tbl_perm.db_id;
```

The following example returns the information for table ID 117855.

```
select * from tables_vw where table_id = 117855;
```

```
table_id | db_name   | schema_name | table_name
---------+-----------+-------------+-----------
  117855 |       dev | public      | customer
```

List the number of columns per Amazon Redshift table

The following query joins some catalog tables to find out how many columns each Amazon Redshift table contains. Amazon Redshift table names are stored in both PG_TABLES and STV_TBL_PERM; where possible, use PG_TABLES to return Amazon Redshift table names.

This query does not involve any Amazon Redshift tables.

```
select nspname, relname, max(attnum) as num_cols
from pg_attribute a, pg_namespace n, pg_class c
where n.oid = c.relnamespace and  a.attrelid = c.oid
and c.relname not like '%pkey'
and n.nspname not like 'pg%'
and n.nspname not like 'information%'
group by 1, 2
order by 1, 2;

nspname | relname  | num_cols
--------+----------+----------
public  | category |        4
public  | date     |        8
public  | event    |        6
public  | listing  |        8
public  | sales    |       10
public  | users    |       18
public  | venue    |        5
```

```
(7 rows)
```

List the schemas and tables in a database

The following query joins STV_TBL_PERM to some PG tables to return a list of tables in the TICKIT database and their schema names (NSPNAME column). The query also returns the total number of rows in each table. (This query is helpful when multiple schemas in your system have the same table names.)

```
select datname, nspname, relname, sum(rows) as rows
from pg_class, pg_namespace, pg_database, stv_tbl_perm
where pg_namespace.oid = relnamespace
and pg_class.oid = stv_tbl_perm.id
and pg_database.oid = stv_tbl_perm.db_id
and datname ='tickit'
group by datname, nspname, relname
order by datname, nspname, relname;

datname | nspname | relname  |  rows
--------+---------+----------+--------
tickit  | public  | category |     11
tickit  | public  | date     |    365
tickit  | public  | event    |   8798
tickit  | public  | listing  | 192497
tickit  | public  | sales    | 172456
tickit  | public  | users    |  49990
tickit  | public  | venue    |    202
(7 rows)
```

List table IDs, data types, column names, and table names

The following query lists some information about each user table and its columns: the table ID, the table name, its column names, and the data type of each column:

```
select distinct attrelid, rtrim(name), attname, typname
from pg_attribute a, pg_type t, stv_tbl_perm p
where t.oid=a.atttypid and a.attrelid=p.id
and a.attrelid between 100100 and 110000
and typname not in('oid','xid','tid','cid')
order by a.attrelid asc, typname, attname;
```

```
attrelid |  rtrim   |    attname     |  typname
---------+----------+----------------+-----------
  100133 | users    | likebroadway   | bool
  100133 | users    | likeclassical  | bool
  100133 | users    | likeconcerts   | bool
...
  100137 | venue    | venuestate     | bpchar
  100137 | venue    | venueid        | int2
  100137 | venue    | venueseats     | int4
  100137 | venue    | venuecity      | varchar
...
```

Count the number of data blocks for each column in a table

The following query joins the STV_BLOCKLIST table to PG_CLASS to return storage information for the columns in the SALES table.

```
select col, count(*)
from stv_blocklist s, pg_class p
where s.tbl=p.oid and relname='sales'
group by col
order by col;

col | count
----+-------
  0 |     4
  1 |     4
  2 |     4
  3 |     4
  4 |     4
  5 |     4
  6 |     4
  7 |     4
  8 |     4
  9 |     8
 10 |     4
 12 |     4
 13 |     8
(13 rows)
```

Configuration reference

You can use configurations to help customize your environment. With Amazon Redshift, you can customize and optimize your data warehousing environment by configuring various parameters and settings. The configuration reference outlines the available cluster properties, database parameters, and workload management (WLM) configuration options. You can consult this reference to fine-tune performance, security, and resource allocation based on their specific requirements. The following reference provides detailed guidance on modifying these configurations to achieve your desired data warehousing setup.

Topics

- navigate_super_null_on_error
- parse_super_null_on_error
- pg_federation_repeatable_read
- query_group
- search_path
- spectrum_enable_pseudo_columns
- enable_spectrum_oid
- spectrum_query_maxerror
- statement_timeout
- stored_proc_log_min_messages
- timezone
- use_fips_ssl
- wlm_query_slot_count

Modifying the server configuration

You can change the server configuration in the following ways:

- By using a SET command to override a setting for the duration of the current session only.

  For example:

  ```
  set extra_float_digits to 2;
  ```

- By modifying the parameter group settings for the cluster. The parameter group settings include additional parameters that you can configure. For more information, see Amazon Redshift Parameter Groups in the *Amazon Redshift Management Guide*.
- By using the ALTER USER command to set a configuration parameter to a new value for all sessions run by the specified user.

  ```
  ALTER USER username SET parameter { TO | = } { value | DEFAULT }
  ```

Use the SHOW command to view the current parameter settings. Use SHOW ALL to view all the settings that you can configure by using the SET command.

```
SHOW ALL;

name                       | setting
---------------------------+--------------
analyze_threshold_percent  | 10
datestyle                  | ISO, MDY
extra_float_digits         | 2
query_group                | default
search_path                | $user, public
statement_timeout          | 0
timezone                   | UTC
wlm_query_slot_count       | 1
```

Note

Note that configuration parameters are applied to the database you are connected to in your data warehouse.

analyze_threshold_percent

Values (default in bold)

10, 0 to 100.0

Description

Sets the threshold for percentage of rows changed for analyzing a table. To reduce processing time and improve overall system performance, Amazon Redshift skips ANALYZE for any table that has a lower percentage of changed rows than specified by `analyze_threshold_percent`. For example, if a table contains 100,000,000 rows and 9,000,000 rows have changed since the last ANALYZE, then by default the table is skipped because fewer than 10 percent of the rows have changed. To analyze tables when only a small number of rows have changed, set `analyze_threshold_percent` to an arbitrarily small number. For example, if you set `analyze_threshold_percent` to 0.01, then a table with 100,000,000 rows will not be skipped if at least 10,000 rows have changed. To analyze all tables even if no rows have changed, set `analyze_threshold_percent` to 0.

You can modify the `analyze_threshold_percent` parameter for the current session only by using a SET command. The parameter can't be modified in a parameter group.

Example

```
set analyze_threshold_percent to 15;
set analyze_threshold_percent to 0.01;
set analyze_threshold_percent to 0;
```

cast_super_null_on_error

Values (default in bold)

on, off

Description

Specifies that when you try to access a nonexistent member of an object or element of an array, Amazon Redshift returns a NULL value if your query is run in the default lax mode.

datashare_break_glass_session_var

Values (default in bold)

There is no default. The value can be any character string generated by Amazon Redshift when an operation occurs that isn't recommended, as described following.

Description

Applies a permission that allows certain operations that generally aren't recommended for an AWS Data Exchange datashare.

In general, we recommend that you don't drop or alter an AWS Data Exchange datashare using the DROP DATASHARE or ALTER DATASHARE SET PUBLICACCESSIBLE statement. To allow dropping or altering an AWS Data Exchange datashare to turn off the publicly accessible setting, set the `datashare_break_glass_session_var` variable to a one-time value. This one-time value is generated by Amazon Redshift and provided in an error message after the initial attempt at the operation in question.

After setting the variable to the one-time generated value, run the DROP DATASHARE or ALTER DATASHARE statement again.

For more information, see ALTER DATASHARE usage notes or DROP DATASHARE usage notes.

Example

```
set datashare_break_glass_session_var to '620c871f890c49';
```

datestyle

Values (default in bold)

Format specification (**ISO**, Postgres, SQL, or German), and year/month/day ordering (DMY, **MDY**, YMD).

- ISO – uses the datestyle of YYYY-MM-DD HH:MM:SS.
- Postgres – uses the datestyle of MM-DD HH:MM:SS YYYY.
- SQL – uses the datestyle of MM-DD-YYYY HH:MM:SS.
- German – uses the datestyle of DD-MM-YYYY HH:MM:SS.

Description

Sets the display format for date and time values and also the rules for interpreting ambiguous date input values. The string contains two parameters that you can change separately or together.

Example

```
show datestyle;
DateStyle
-----------
ISO, MDY
(1 row)
```

```
set datestyle to 'SQL,DMY';
```

default_geometry_encoding

Values (default in bold)

1, **2**

Description

A session configuration that specifies if spatial geometries created during this session are encoded with a bounding box. If `default_geometry_encoding` is 1, then geometries are not encoded with a bounding box. If `default_geometry_encoding` is 2, then geometries are encoded with a bounding box. For more information about support for bounding boxes, see Bounding box.

describe_field_name_in_uppercase

Values (default in bold)

off (false), on (true)

Description

Specifies whether column names returned by SELECT statements are uppercase or lowercase. If this parameter is on, column names are returned in uppercase. If this parameter is off, column names are returned in lowercase. Amazon Redshift stores column names in lowercase regardless of the setting for `describe_field_name_in_uppercase`.

Example

```
set describe_field_name_in_uppercase to on;

show describe_field_name_in_uppercase;

DESCRIBE_FIELD_NAME_IN_UPPERCASE
--------------------------------
on
```

downcase_delimited_identifier

Values (default in bold)

on, off

Description

This configuration is being retired. Instead use `enable_case_sensitive_identifier`.

Enables the super parser to read JSON fields that are in uppercase or mixed-case. Also enables federated query support to supported PostgreSQL databases with mixed-case names of database, schema, table, and column. To use case-sensitive identifiers, set this parameter to off.

Usage Notes

- If you're using row-level security or dynamic data masking features, we recommend setting the `downcase_delimited_identifier` value in your cluster or workgroup's parameter group. This ensures that `downcase_delimited_identifier` stays constant throughout creating and attaching a policy, and then querying a relation that has a policy applied. For information on row-level security, see Row-level security. For information on dynamic data masking, see Dynamic data masking.
- When you set `downcase_delimited_identifier` to off and create a table, you can set case sensitive column names. When you set `downcase_delimited_identifier` to on and query the table, the column names are downcased. This can produce query results different from when `downcase_delimited_identifier` is set to off. Consider the following example:

```
SET downcase_delimited_identifier TO off;
--Amazon Redshift preserves case for column names and other identifiers.

--Create a table with two columns that are identical except for the case.
CREATE TABLE t ("c" int, "C" int);

INSERT INTO t VALUES (1, 2);

SELECT * FROM t;

 c | C
---+---
```

```
 1 | 2
(1 row)

SET enable_downcase_delimited_identifier TO on;
--Amazon Redshift no longer preserves case for column names and other identifiers.

SELECT * FROM t;

 c | c
---+---
 1 | 1
(1 row)
```

- We recommend that regular users querying tables with dynamic data masking or row-level security policies attached have the default downcase_delimited_identifier setting. For more information, see For information on row-level security, see Row-level security. For information on dynamic data masking, see Dynamic data masking.

enable_case_sensitive_identifier

Values (default in bold)

true, **false**

Description

A configuration value that determines whether name identifiers of databases, schemas, tables, and columns are case sensitive. The case of name identifiers is preserved when you enclose identifiers within double quotation marks and set `enable_case_sensitive_identifier` to `true`. The case of name identifiers is not preserved, and instead converted to lowercase, when you do not enclose identifiers within double quotation marks or when you set `enable_case_sensitive_identifier` to `false`.

The case of a *username* enclosed in double quotation marks is always preserved regardless of the setting of the `enable_case_sensitive_identifier` configuration option.

Examples

The following example shows how to create and use case sensitive identifiers for a table and column name.

```
-- To create and use case sensitive identifiers
SET enable_case_sensitive_identifier TO true;

-- Create tables and columns with case sensitive identifiers
CREATE TABLE public."MixedCasedTable" ("MixedCasedColumn" int);

INSERT INTO public."MixedCasedTable" VALUES (1);
INSERT INTO public."MixedCasedTable" VALUES (2);
INSERT INTO public."MixedCasedTable" VALUES (3);
INSERT INTO public."MixedCasedTable" VALUES (4);
INSERT INTO public."MixedCasedTable" VALUES (5);

-- Now query with case sensitive identifiers
SELECT "MixedCasedColumn" FROM public."MixedCasedTable";

MixedCasedColumn
------------------
1
2
3
4
5

(5 rows)


SELECT * FROM public."MixedCasedTable" WHERE "MixedCasedColumn" = 1;

mixedcasedcolumn
------------------
1

(1 row)
```

The following example shows when the case of identifiers is not preserved.

```
-- To not use case sensitive identifiers
RESET enable_case_sensitive_identifier;

-- Mixed case identifiers are lowercased despite double quotation marks

CREATE TABLE "MixedCasedTable2" ("MixedCasedColumn" int);
```

```
CREATE TABLE MixedCasedTable2 (MixedCasedColumn int);

ERROR:  Relation "mixedcasedtable2" already exists


SELECT "MixedCasedColumn" FROM "MixedCasedTable2";

 mixedcasedcolumn
------------------
(0 rows)


SELECT MixedCasedColumn FROM MixedCasedTable2;

 mixedcasedcolumn
------------------
(0 rows)
```

Usage Notes

- If you're using autorefresh for materialized views, we recommend setting the `enable_case_sensitive_identifier` value in your cluster or workgroup's parameter group. This ensures that `enable_case_sensitive_identifier` stays constant when your materialized views are refreshed. For information on autorefresh for materialized views, see Refreshing a materialized view. For information on setting configuration values in parameter groups, see Amazon Redshift parameter groups in the *Amazon Redshift Management Guide*.
- If you're using row-level security or dynamic data masking features, we recommend setting the `enable_case_sensitive_identifier` value in your cluster or workgroup's parameter group. This ensures that `enable_case_sensitive_identifier` stays constant throughout creating and attaching a policy, and then querying a relation that has a policy applied. For information on row-level security, see Row-level security. For information on dynamic data masking, see Dynamic data masking.
- When you set `enable_case_sensitive_identifier` to on and create a table, you can set case sensitive column names. When you set `enable_case_sensitive_identifier` to off and query the table, the column names are downcased. This can produce query results different from when `enable_case_sensitive_identifier` is set to on. Consider the following example:

```
SET enable_case_sensitive_identifier TO on;
--Amazon Redshift preserves case for column names and other identifiers.
```

```
--Create a table with two columns that are identical except for the case.
CREATE TABLE t ("c" int, "C" int);

INSERT INTO t VALUES (1, 2);

SELECT * FROM t;

 c | C
---+---
 1 | 2
(1 row)

SET enable_case_sensitive_identifier TO off;
--Amazon Redshift no longer preserves case for column names and other identifiers.

SELECT * FROM t;

 c | c
---+---
 1 | 1
(1 row)
```

- We recommend that regular users querying tables with dynamic data masking or row-level security policies attached have the default enable_case_sensitive_identifier setting. For information on row-level security, see Row-level security. For information on dynamic data masking, see Dynamic data masking.
- To reference identifiers with mixed case using dot notation, wrap each case-sensitive identifier in double quotation marks. For example, `public."MixedCasedTable"."MixedCasedColumn"`.

enable_case_sensitive_super_attribute

Values (default in bold)

true, **false**

Description

A configuration value that determines whether navigating SUPER data type structures with non-delimited attribute names is case sensitive. When you set enable_case_sensitive_super_attribute to true, navigating SUPER type structures with non-delimited attribute names is case sensitive. When you set the value to false, navigating SUPER type structures with non-delimited attribute names is not case sensitive.

When you enclose an attribute name in double quotation marks and set enable_case_sensitive_identifier to true, case is always preserved, regardless of the setting of the enable_case_sensitive_super_attribute configuration option.

enable_case_sensitive_super_attribute only applies to columns with the SUPER data type. For all other columns, consider using enable_case_sensitive_identifier instead.

For more information on navigating uppercase and mixed-case JSON fields, see Accessing JSON fields with uppercase and mixed-case field names or attributes.

Examples

The following example shows the results of selecting SUPER values with enable_case_sensitive_super_attribute enabled and with it disabled.

```
--Create a table with a SUPER column.
CREATE TABLE tbl (col SUPER);

--Insert values.
INSERT INTO tbl VALUES (json_parse('{
 "A": "HELLO", "a": "123"
}'));

SET enable_case_sensitive_super_attribute TO ON;

SELECT col.A FROM tbl;
  a
-----
 "HELLO"
(1 row)

SELECT col.a FROM tbl;
  a
-----
 "123"
(1 row)

SET enable_case_sensitive_super_attribute TO OFF;
```

```
SELECT col.A FROM tbl;
  a
-----
 "123"
(1 row)

SELECT col.a FROM tbl;
  a
-----
 "123"
(1 row)
```

Usage Notes

- Views and materialized views follow the value of `enable_case_sensitive_super_attribute` at the time of their creation. Late-binding views, stored procedures, and user-defined functions follow the value of `enable_case_sensitive_super_attribute` at the time of querying.
- If you're using autorefresh for materialized views, we recommend setting the `enable_case_sensitive_identifier value` in your cluster or workgroup's parameter group. This ensures that `enable_case_sensitive_identifier` stays constant when your materialized views are refreshed. For information on autorefresh for materialized views, see [Refreshing a materialized view](). For information on setting configuration values in parameter groups, see [Amazon Redshift parameter groups]() in the *Amazon Redshift Management Guide*.
- The column name in statement results is always downcased, regardless of the value of `enable_case_sensitive_super_attribute`. To make the column name case sensitive as well, enable `enable_case_sensitive_identifier`.
- We recommend that regular users querying tables with row-level security policies attached have the default `enable_case_sensitive_identifier` setting. For more information, see For information on row-level security, see [Row-level security]().

enable_numeric_rounding

Values (default in bold)

on (true), **off (false)**

Description

Specifies whether to use numeric rounding. If `enable_numeric_rounding` is on, Amazon Redshift rounds NUMERIC values when casting them to other numeric types, such as INTEGER or DECIMAL. If `enable_numeric_rounding` is `off`, Amazon Redshift truncates NUMERIC values when casting them to other numeric types. For more information on numeric types, see Numeric types.

Example

```
--Create a table and insert the numeric value 1.5 into it.
CREATE TABLE t (a numeric(10, 2));

INSERT INTO t VALUES (1.5);

SET enable_numeric_rounding to ON;
--Amazon Redshift now rounds NUMERIC values when casting to other numeric types.

SELECT a::int FROM t;

 a
---
 2
(1 row)


SELECT a::decimal(10, 0) FROM t;

 a
---
 2
(1 row)


 SELECT a::decimal(10, 5) FROM t;

    a
---------
 1.50000
(1 row)
```

```
SET enable_numeric_rounding to OFF;
--Amazon Redshift now truncates NUMERIC values when casting to other numeric types.

SELECT a::int FROM t;

 a
---
 1
(1 row)


SELECT a::decimal(10, 0) FROM t;

 a
---
 1
(1 row)


SELECT a::decimal(10, 5) FROM t;

    a
---------
 1.50000
(1 row)
```

enable_result_cache_for_session

Values (default in bold)

on (true), off (false)

Description

Specifies whether to use query results caching. If `enable_result_cache_for_session` is on, Amazon Redshift checks for a valid, cached copy of the query results when a query is submitted. If a match is found in the result cache, Amazon Redshift uses the cached results and doesn't run the query. If `enable_result_cache_for_session` is `off`, Amazon Redshift ignores the results cache and runs all queries when they are submitted.

Example

```
SET enable_result_cache_for_session TO off;
--Amazon Redshift now ignores the results cache
```

enable_vacuum_boost

Values (default in bold)

false, true

Description

Specifies whether to enable the vacuum boost option for all VACUUM commands run in a session. If `enable_vacuum_boost` is `true`, Amazon Redshift runs all VACUUM commands in the session with the BOOST option. If `enable_vacuum_boost` is `false`, Amazon Redshift doesn't run with the BOOST option by default. For more information about the BOOST option, see VACUUM.

error_on_nondeterministic_update

Values (default in bold)

false, true

Description

Specifies whether UPDATE queries with multiple matches per row return an error.

Example

```
SET error_on_nondeterministic_update TO true;

CREATE TABLE t1(x1 int, y1 int);

CREATE TABLE t2(x2 int, y2 int);
```

```
INSERT INTO t1 VALUES (1,10), (2,20), (3,30);

INSERT INTO t2 VALUES (2,40), (2,50);

UPDATE t1 SET y1=y2 FROM t2 WHERE x1=x2;

ERROR: Found multiple matches to update the same tuple.
```

extra_float_digits

Values (default in bold)

0, -15 to 2

Description

Sets the number of digits displayed for floating-point values, including float4 and float8. The value is added to the standard number of digits (FLT_DIG or DBL_DIG as appropriate). The value can be set as high as 2, to include partially significant digits. This is especially useful for outputting float data that must be restored exactly. Or it can be set negative to suppress unwanted digits.

Example

The following example sets `extra_float_digits` to `-2`. First, show the current parameter setting.

```
show all;
      name                      | setting
--------------------------+----------------
analyze_threshold_percent | 10
datestyle                 | ISO, MDY
extra_float_digits        | 2
query_group               | default
search_path               | $user, public
statement_timeout         | 0
timezone                  | UTC
wlm_query_slot_count      | 1
```

Then, set the new value to `-2`.

```
set extra_float_digits to -2;
```

Finally show the updated parameter setting.

```
show all;
      name                      | setting
--------------------------+----------------
analyze_threshold_percent | 10
datestyle                 | ISO, MDY
extra_float_digits        | -2
query_group               | default
search_path               | $user, public
statement_timeout         | 0
timezone                  | UTC
wlm_query_slot_count      | 1
```

interval_forbid_composite_literals

Values (default in bold)

false, **true**

Description

A session configuration that modifies the value of an interval that contain both YEAR TO MONTH and DAY TO SECOND parts.

If `interval_forbid_composite_literals` is `true`, an error is returned if an interval with both YEAR TO MONTH and DAY TO SECOND parts is encountered. For example, the following SQL contains an INTERVAL DAY TO SECOND with both YEAR TO MONTH and DAY TO SECOND parts.

```
SELECT INTERVAL '1 year 1 day' DAY TO SECOND;
ERROR:  Interval Day To Second literal cannot contain year-month parts. Disable the GUC
 interval_forbid_composite_literals to suppress this error and silently discard the
 year-month part.
```

If `interval_forbid_composite_literals` is `false`, Amazon Redshift suppresses an error and truncates the YEAR TO MONTH part from an INTERVAL DAY TO SECOND value. For example, the following SQL contains an INTERVAL DAY TO SECOND with both YEAR TO MONTH and DAY TO SECOND parts.

```
SET interval_forbid_composite_literals to "false";
SELECT INTERVAL '1 year 1 day' DAY TO SECOND;


 intervald2s
------------------------------
1 days 0 hours 0 mins 0.0 secs
```

json_serialization_enable

Values (default in bold)

false, true

Description

A session configuration that modifies the JSON serialization behavior of ORC, JSON, Ion, and Parquet formatted data. If `json_serialization_enable` is `true`, all top-level collections are automatically serialized to JSON and returned as VARCHAR(65535). Noncomplex columns are not affected or serialized. Because collection columns are serialized as VARCHAR(65535), their nested subfields can no longer be accessed directly as part of the query syntax (that is, in the filter clause). If `json_serialization_enable` is `false`, top-level collections are not serialized to JSON. For more information about nested JSON serialization, see Serializing complex nested JSON.

json_serialization_parse_nested_strings

Values (default in bold)

false, true

Description

A session configuration that modifies the JSON serialization behavior of ORC, JSON, Ion, and Parquet formatted data. When both `json_serialization_parse_nested_strings` and json_serialization_enable are true, string values that are stored in complex types (such as, maps, structures, or arrays) are parsed and written inline directly into the result if they are valid JSON. If json_serialization_parse_nested_strings is false, strings within nested complex types are serialized as escaped JSON strings. For more information, see [Serializing complex types containing JSON strings].

max_concurrency_scaling_clusters

Values (default in bold)

1, 0 to 10

Description

Sets the maximum number of concurrency scaling clusters allowed when concurrency scaling is enabled. Increase this value if more concurrency scaling is required. Decrease this value to reduce the usage of concurrency scaling clusters and the resulting billing charges.

The maximum number of concurrency scaling clusters is an adjustable quota. For more information, see [Amazon Redshift quotas] in the *Amazon Redshift Management Guide*.

max_cursor_result_set_size

Values (default in bold)

0 (defaults to maximum) - 14400000 MB

Description

The max_cursor_result_set_size parameter is no longer used. For more information about cursor result set size, see [Cursor constraints].

mv_enable_aqmv_for_session

Values (default in bold)

true, false

Description

Specifies whether Amazon Redshift can perform automatic query rewriting of materialized views at the session level.

navigate_super_null_on_error

Values (default in bold)

on, off

Description

Specifies that when you try to navigate a nonexistent member of an object or element of an array, Amazon Redshift returns a NULL value if your query is run in the default lax mode.

parse_super_null_on_error

Values (default in bold)

off, on

Description

Specifies that when Amazon Redshift tries to parse a nonexistent member of an object or element of an array, Amazon Redshift returns a NULL value if your query is run in the strict mode.

pg_federation_repeatable_read

Values (default in bold)

true, *false*

Description

Specifies the federated query transaction isolation level for the results from the PostgreSQL database.

- When `pg_federation_repeatable_read` is true, federated transactions are processed with REPEATABLE READ isolation level semantics. This is the default.

- When `pg_federation_repeatable_read` is false, federated transactions are processed with READ COMMITTED isolation level semantics.

For more information, see the following:

- Considerations when accessing federated data with Amazon Redshift.
- Managing concurrent write operations.

Examples

The following command sets `pg_federation_repeatable_read` to on for a session. The show command shows the value of the set value.

```
set pg_federation_repeatable_read to on;
```

```
show pg_federation_repeatable_read;

pg_federation_repeatable_read
-----------------------------
on
```

query_group

Values (default in bold)

No default; the value can be any character string.

Description

Applies a user-defined label to a group of queries that are run during the same session. This label is captured in the query logs. You can use it to constrain results from the STL_QUERY and STV_INFLIGHT tables and the SVL_QLOG view. For example, you can apply a separate label to every query that you run to uniquely identify queries without having to look up their IDs.

This parameter doesn't exist in the server configuration file and must be set at runtime with a SET command. Although you can use a long character string as a label, the label is truncated to 30 characters in the LABEL column of the STL_QUERY table and the SVL_QLOG view (and to 15 characters in STV_INFLIGHT).

In the following example, query_group is set to **Monday**, then several queries are run with that label.

```
set query_group to 'Monday';
SET
select * from category limit 1;
...
...
select query, pid, substring, elapsed, label
from svl_qlog where label ='Monday'
order by query;

query | pid  |        substring                   |  elapsed  | label
------+------+------------------------------------+-----------+--------
789   | 6084 | select * from category limit 1;    | 65468     | Monday
790   | 6084 | select query, trim(label) from ... | 1260327   | Monday
791   | 6084 | select * from svl_qlog where ..    | 2293547   | Monday
792   | 6084 | select count(*) from bigsales;     | 108235617 | Monday
...
```

search_path

Values (default in bold)

'$user', public, *schema_names*

A comma-separated list of existing schema names. If **'$user'** is present, then the schema having the same name as `SESSION_USER` is substituted, otherwise it is ignored.

Description

Specifies the order in which schemas are searched when an object (such as a table or a function) is referenced by a simple name with no schema component:

- Search paths aren't supported with external schemas and external tables. External tables must be explicitly qualified by an external schema. Datashares behave as external data and are therefore not supported as search paths.
- When objects are created without a specific target schema, they are placed in the first schema listed in the search path. If the search path is empty, the system returns an error.

- When objects with identical names exist in different schemas, the one found first in the search path is used.
- An object that isn't in any of the schemas in the search path can only be referenced by specifying its containing schema with a qualified (dotted) name.
- The system catalog schema, pg_catalog, is always searched. If it is mentioned in the path, it is searched in the specified order. If not, it is searched before any of the path items.
- The current session's temporary-table schema, pg_temp_nnn, is always searched if it exists. It can be explicitly listed in the path by using the alias pg_temp. If it is not listed in the path, it is searched first (even before pg_catalog). However, the temporary schema is only searched for relation names (tables, views). It is not searched for function names.

Example

The following example creates the schema ENTERPRISE and sets the search_path to the new schema.

```
create schema enterprise;
set search_path to enterprise;
show search_path;

 search_path
-------------
 enterprise
(1 row)
```

The following example adds the schema ENTERPRISE to the default search_path.

```
set search_path to '$user', public, enterprise;
show search_path;

         search_path
-----------------------------
 "$user", public, enterprise
(1 row)
```

The following example adds the table FRONTIER to the schema ENTERPRISE.

```
create table enterprise.frontier (c1 int);
```

When the table PUBLIC.FRONTIER is created in the same database, and the user does not specify the schema name in a query, PUBLIC.FRONTIER takes precedence over ENTERPRISE.FRONTIER.

```
create table public.frontier(c1 int);
insert into enterprise.frontier values(1);
select * from frontier;

frontier
----
(0 rows)

select * from enterprise.frontier;

c1
----
1
(1 row)
```

spectrum_enable_pseudo_columns

Values (default in bold)

true, false

Description

You can disable the creation of pseudocolumns for a session by setting the `spectrum_enable_pseudo_columns` configuration parameter to `false`.

Example

The following command disables the creation of pseudocolumns for a session.

```
set spectrum_enable_pseudo_columns to false;
```

enable_spectrum_oid

Values (default in bold)

true, false

Description

You can also disable only the `$spectrum_oid` pseudocolumn by setting the `enable_spectrum_oid` configuration parameter to `false`.

Example

The following command disables the `$spectrum_oid` pseudocolumn by setting the `enable_spectrum_oid` configuration parameter to `false`.

```
set enable_spectrum_oid to false;
```

spectrum_query_maxerror

Values (default in bold)

-1, integer

Description

You can specify an integer to indicate the maximum number of errors to accept before canceling the query. A negative value turns off maximum error data handling. The results are logged in SVL_SPECTRUM_SCAN_ERROR.

Example

The following example assumes ORC data that contains surplus characters and characters that are not valid. The column definition for `my_string` specifies a length of 3 characters. Following is the sample data for this example:

```
my_string
---------------
abcdef
gh�
ab
```

The following commands set the maximum number of errors to 1 and perform the query.

```
set spectrum_query_maxerror to 1;
SELECT my_string FROM orc_data;
```

The query stops and the results are logged in SVL_SPECTRUM_SCAN_ERROR.

statement_timeout

Values (default in bold)

0 (turns off limitation), x milliseconds

Description

Stops any statement that takes over the specified number of milliseconds.

The `statement_timeout` value is the maximum amount of time a query can run before Amazon Redshift terminates it. This time includes planning, queueing in workload management (WLM), and execution time. Compare this time to WLM timeout (max_execution_time) and a QMR (query_execution_time), which include only execution time.

If WLM timeout (max_execution_time) is also specified as part of a WLM configuration, the lower of statement_timeout and max_execution_time is used. For more information, see WLM timeout.

Example

Because the following query takes longer than 1 millisecond, it times out and is canceled.

```
set statement_timeout = 1;

select * from listing where listid>5000;
ERROR:  Query (150) canceled on user's request
```

stored_proc_log_min_messages

Values (default in bold)

LOG, INFO, NOTICE, WARNING, EXCEPTION

Description

Specifies the minimum logging level of raised stored procedure messages. Messages at or above the specified level are logged. The default is LOG (all messages are logged). The order of log levels from highest to lowest is as follows:

1. EXCEPTION
2. WARNING
3. NOTICE
4. INFO
5. LOG

For example if you specify a value of NOTICE, then messages are only logged for NOTICE, WARNING, and EXCEPTION.

timezone

Values (default in bold)

UTC, time zone

Syntax

```
SET timezone { TO | = } [ time_zone | DEFAULT ]

SET time zone [ time_zone | DEFAULT ]
```

Description

Sets the time zone for the current session. The time zone can be the offset from Universal Coordinated Time (UTC) or a time zone name.

> **Note**
>
> You can't set the `timezone` configuration parameter by using a cluster parameter group. The time zone can be set only for the current session by using a SET command. To set the

time zone for all sessions run by a specific database user, use the ALTER USER command. ALTER USER … SET TIMEZONE changes the time zone for subsequent sessions, not for the current session.

When you set the time zone using the `SET timezone` (one word) command with either `TO` or =, you can specify *time_zone* as a time zone name, a POSIX-style format offset, or an ISO-8601 format offset, as shown following.

```
SET timezone { TO | = } time_zone
```

When you set the time zone using the SET time zone command *without* `TO` or =, you can specify *time_zone* using an INTERVAL and also a time zone name, a POSIX-style format offset, or an ISO-8601 format offset, as shown following.

```
SET time zone time_zone
```

Time zone formats

Amazon Redshift supports the following time zone formats:

- Time zone name
- INTERVAL
- POSIX-style time zone specification
- ISO-8601 offset

Because time zone abbreviations, such as PST or PDT, are defined as a fixed offset from UTC and don't include daylight savings time rules, the SET command doesn't support time zone abbreviations.

For more details on time zone formats, see the following.

Time zone name – The full time zone name, such as America/New_York. Full time zone names can include daylight savings rules.

The following are examples of time zone names:

- Etc/Greenwich
- America/New_York
- CST6CDT
- GB

Note

Many time zone names, such as EST, MST, NZ, and UCT, are also abbreviations.

To view a list of valid time zone names, run the following command.

```
select pg_timezone_names();
```

INTERVAL – An offset from UTC. For example, PST is –8:00 or –8 hours.

The following are examples of INTERVAL time zone offsets:

- –8:00
- –8 hours
- 30 minutes

POSIX-style format – A time zone specification in the form *STDoffset* or *STDoffsetDST*, where *STD* is a time zone abbreviation, *offset* is the numeric offset in hours west from UTC, and *DST* is an optional daylight-savings zone abbreviation. Daylight savings time is assumed to be one hour ahead of the given offset.

POSIX-style time zone formats use positive offsets west of Greenwich, in contrast to the ISO-8601 convention, which uses positive offsets east of Greenwich.

The following are examples of POSIX-style time zones:

- PST8
- PST8PDT
- EST5

- EST5EDT

> **Note**
>
> Amazon Redshift doesn't validate POSIX-style time zone specifications, so it is possible to set the time zone to an invalid value. For example, the following command doesn't return an error, even though it sets the time zone to an invalid value.
>
> ```
> set timezone to ‘xxx36’;
> ```

ISO-8601 Offset – The offset from UTC in the form ±`[hh]:[mm]`.

The following are examples of ISO-8601 offsets:

- -8:00
- +7:30

Examples

The following example sets the time zone for the current session to New York.

```
set timezone = 'America/New_York';
```

The following example sets the time zone for the current session to UTC–8 (PST).

```
set timezone to '-8:00';
```

The following example uses INTERVAL to set the time zone to PST.

```
set timezone interval '-8 hours'
```

The following example resets the time zone for the current session to the system default time zone (UTC).

```
set timezone to default;
```

To set the time zone for database user, use an ALTER USER … SET statement. The following example sets the time zone for dbuser to New York. The new value persists for the user for all subsequent sessions.

```
ALTER USER dbuser SET timezone to 'America/New_York';
```

use_fips_ssl

Values (default in bold)

true, **false**

Description

A parameter group value that specifies if FIPS-compliant SSL mode is used. If `use_fips_ssl` is `true`, then FIPS-compliant SSL mode is used. If `use_fips_ssl` is `false`, then FIPS-compliant SSL mode is not used. For more information, see Configuring security options for connections in the *Amazon Redshift Management Guide*.

To configure parameters for an Amazon Redshift provisioned cluster, see About parameter groups in the *Amazon Redshift Management Guide*. To configure parameters for Redshift Serverless, see Configuring a FIPS-compliant SSL connection to Amazon Redshift Serverless in the *Amazon Redshift Management Guide*, and CreateWorkgroup or UpdateWorkgroup in the *Redshift Serverless API Reference*.

wlm_query_slot_count

Values (default in bold)

1, 1 to 50 (cannot exceed number of available slots (concurrency level) for the service class)

Description

Sets the number of query slots that a query uses.

Workload management (WLM) reserves slots in a service class according to the concurrency level set for the queue. For example, if concurrency level is set to 5, then the service class has 5 slots.

WLM allocates the available memory for a service class equally to each slot. For more information, see Workload management.

> **Note**
> If the value of wlm_query_slot_count is larger than the number of available slots (concurrency level) for the service class, the query fails. If you encounter an error, decrease wlm_query_slot_count to an allowable value.

For operations where performance is heavily affected by the amount of memory allocated, such as vacuuming, increasing the value of wlm_query_slot_count can improve performance. In particular, for slow vacuum commands, inspect the corresponding record in the SVV_VACUUM_SUMMARY view. If you see high values (close to or higher than 100) for sort_partitions and merge_increments in the SVV_VACUUM_SUMMARY view, consider increasing the value for wlm_query_slot_count the next time you run Vacuum against that table.

Increasing the value of wlm_query_slot_count limits the number of concurrent queries that can be run. For example, suppose that the service class has a concurrency level of 5 and wlm_query_slot_count is set to 3. While a query is running within the session with wlm_query_slot_count set to 3, a maximum of 2 more concurrent queries can be run within the same service class. Subsequent queries wait in the queue until currently running queries complete and slots are freed.

Examples

Use the SET command to set the value of wlm_query_slot_count for the duration of the current session.

```
set wlm_query_slot_count to 3;
```

Document history

> **Note**
>
> For a description of new features in Amazon Redshift, see What's new.

The following table describes the important documentation changes to the *Amazon Redshift Database Developer Guide* after May 2018. For notification about updates to this documentation, you can subscribe to an RSS feed.

API version: 2012-12-01

For a list of the changes to the *Amazon Redshift Management Guide*, see Amazon Redshift Management Guide Document History.

For more information about new features, including a list of fixes and the associated cluster version numbers for each release, see Cluster Version History.

Change	Description	Date
Support for Amazon DynamoDB zero-ETL integration with Amazon Redshift	You can now create zero-ETL integrations between DynamoDB and Amazon Redshift to enable near real-time analytics on DynamoDB data without traditional ETL processes.	December 1, 2024
Support for Amazon Aurora zero-ETL integrations with Amazon Redshift data filtering	You can now apply data filters to Amazon Aurora zero-ETL integrations to selectively replicate specific data to Amazon Redshift.	June 1, 2024
Support for Multi-AZ deployment for Amazon Redshift	Amazon Redshift now supports Multi-AZ deployments for RA3 clusters, providing	March 1, 2024

	high availability by deploying compute resources across two Availability Zones to continue operating during unexpected events in an AZ.	
Support for Amazon Aurora zero-ETL integrations with Amazon Redshift	You can now create zero-ETL integrations between Aurora and Amazon Redshift to enable near real-tim e analytics and machine learning using Amazon Redshift on petabytes of transactional data from Amazon Aurora.	November 1, 2023
Support for Amazon RDS zero-ETL integrations with Amazon Redshift	You can now create zero-ETL integrations between Amazon RDS and Amazon Redshift to make RDS database data available in Amazon Redshift in near real-time for analytics, ML, and AI workloads.	June 1, 2023
Support for cross-region streaming ingestion	Amazon Redshift streaming ingestion now supports cross-region streaming ingestion where your source Amazon Kinesis Data Streams or Amazon MSK topic can be located in an AWS Region different from your Amazon Redshift cluster.	November 1, 2022

Support for streaming ingestion from Apache Kafka sources	You can now ingest streaming data from Amazon MSK Provisioned, Amazon MSK Serverless, and open-source Apache Kafka clusters directly into Amazon Redshift using materialized views.	July 1, 2022
Support for Amazon Redshift Serverless	Amazon Redshift Serverles s makes it convenient to run and scale analytics without having to provision and manage data warehouse infrastructure. Added comprehensive documenta tion for serverless workgroup s, namespaces, usage monitoring, and serverless-specific system views.	June 29, 2022
Support for streaming ingestion from Amazon Kinesis Data Streams	You can now ingest streaming data from Amazon Kinesis Data Streams directly into Amazon Redshift using materialized views, eliminati ng the need to stage data in Amazon S3 before ingesting into Amazon Redshift.	April 1, 2022
Support for spatial data with GEOMETRY and GEOGRAPHY data types	Amazon Redshift now supports spatial data with GEOMETRY and GEOGRAPHY data types, spatial SQL functions, and the ability to load shapefiles for geospatia l analysis and location-based queries.	March 1, 2022

Support for AQUA (Advanced Query Accelerator)	AQUA is a distributed and hardware-accelerated cache that enables Amazon Redshift to run up to ten times faster than other cloud data warehouses by automatically boosting certain types of queries with custom-designed hardware.	January 1, 2022
Enhanced Amazon Redshift ML capabilities	Added comprehensive documentation for Amazon Redshift ML including CREATE MODEL statement, support for XGBoost, K-means clustering, multi-class classification models, model explainability features, and integration with Amazon SageMaker AI for automated ML.	December 1, 2021
Enhanced support for semistructured data with SUPER data type	Enhanced capabilities for the SUPER data type to store and query semistructured data like JSON, Avro, and Ion with improved performance, dynamic typing, and support for loading semistructured data up to 16 MB in size.	November 1, 2021

Support for enhanced data sharing capabilities	Enhanced data sharing functionality with support for cross-cluster and cross-acc ount data sharing, integrati on with Amazon Redshift Serverless, and standard datashares between different cluster types.	October 1, 2021
Support for spatial 3D and 4D geometries and new spatial functions	You can now use additiona l spatial functions and 3D and 4D geometry support is added to some functions.	August 19, 2021
Support for column compressi on encoding for automatic table optimization	You can specify the ENCODE AUTO option for a table to automatically manage compression encoding for all columns in the table.	August 3, 2021
Support for multiple SQL statements or an SQL statement with parameters using the Amazon Redshift Data API	You can now run multiple SQL statements or a statement with parameters with the Amazon Redshift Data API.	July 28, 2021
Support for case-insensitive collation with column level overrides	You can now use the COLLATE clause within a CREATE DATABASE statement to specify the default collation.	June 24, 2021
Support for data sharing across accounts	You can now share data across AWS accounts.	April 30, 2021
Support for hierarchical data queries with recursive CTE	You can now use a recursive common table expression (CTE) in your SQL.	April 29, 2021

Support for cross-database queries	You can now query data across databases in a cluster.	March 10, 2021
Support for fine-grained access control on COPY and UNLOAD commands	You can now grant the privilege to run COPY and UNLOAD commands to specific users and groups in your Amazon Redshift cluster to create more fine-grained access control policy.	January 12, 2021
Support for native JSON and semi-structured data	You can now define the SUPER data type.	December 9, 2020
Support for federated query to MySQL	You can now write a federated query to a supported MySQL engine.	December 9, 2020
Support for data sharing	You can now share data across Amazon Redshift clusters.	December 9, 2020
Support for automatic table optimization	You can now define automatic distribution and sort keys.	December 9, 2020
Support for Amazon Redshift ML	You can now create, train, and deploy machine learning (ML) models.	December 8, 2020
Support for automatic refresh and query rewrite of materiali zed views	You can now keep materiali zed views up-to-date with automatic refresh and query performance can be improved with automatic rewrite.	November 11, 2020

Support for TIME and TIMETZ data types	You can now create tables with TIME and TIMETZ data types. TIME data type stores the time of day without timezone information, and TIMETZ stores the time of day including timezone informati on	November 11, 2020
Support for Lambda UDFs and tokenization	You can now can write Lambda UDFs to enable external tokenization of data.	October 26, 2020
Support for altering a table column encoding	You can now alter a table column encoding.	October 20, 2020
Support for querying across databases	Amazon Redshift can now query across databases in a cluster.	October 15, 2020
Support for HyperLogLog Sketches	Amazon Redshift can now store and process HyperLogL ogSketches.	October 2, 2020
Support for Apache Hudi and Delta Lake	Enhancements to creating external tables for Redshift Spectrum.	September 24, 2020
Support for enhancements to querying spatial data	Enhancements include loading a shapefile and several new spatial SQL functions.	September 15, 2020
Materialized view support external tables	You can create materialized views in Amazon Redshift that reference external data sources.	June 19, 2020

Support to write to external table	You can write to external tables by running CREATE EXTERNAL TABLE AS SELECT to write to a new external table or INSERT INTO to insert data into an existing external table.	June 8, 2020
Support for storage controls for schemas	Updates to commands and views that manage storage controls for schemas.	June 2, 2020
Support for federated query general availability	Updated information about querying data with federated queries.	April 16, 2020
Support for additional spatial functions	Added descriptions of additional spatial functions.	April 2, 2020
Support for materialized views general availability	Materialized views are generally available starting with cluster version 1.0.13059 .	February 19, 2020
Support for column-level privileges	Column-level privileges are available starting with cluster version 1.0.13059.	February 19, 2020
ALTER TABLE	You can use an ALTER TABLE command with the ALTER DISTSTYLE ALL clause to change the distribution style of a table.	February 11, 2020
Support for federated query	Updated the guide to describe federated query with an updated CREATE EXTERNAL SCHEMA.	December 3, 2019

Support for data lake export	Updated the guide to describe new parameters of the UNLOAD command.	December 3, 2019
Support for spatial data	Updated the guide to describe support for spatial data.	November 21, 2019
Support for the new console	Updated the guide to describe the new Amazon Redshift console.	November 11, 2019
Support for automatic table sort	Amazon Redshift can automatically sort table data.	November 7, 2019
Support for VACUUM BOOST option	You can use the BOOST option when vacuuming tables.	November 7, 2019
Support for default IDENTITY columns	You can create tables with default IDENTITY columns.	September 19, 2019
Support for AZ64 compressi on encoding	You can encode some columns with AZ64 compressi on encoding.	September 19, 2019
Support for query priority	You can set the query priority of an automatic WLM queue.	August 22, 2019
Support for AWS Lake Formation	You can use a Lake Formation Data Catalog with Amazon Redshift Spectrum.	August 8, 2019
COMPUPDATE PRESET	You can use a COPY command with COMPUPDATE PRESET to enable Amazon Redshift to choose the compression encoding.	June 13, 2019

ALTER COLUMN	You can use an ALTER TABLE command with ALTER COLUMN to increase the size of a VARCHAR column.	May 22, 2019
Support for stored procedures	You can define PL/pgSQL stored procedures in Amazon Redshift.	April 24, 2019
Support for an automatic workload management (WLM) configuration	You can enable Amazon Redshift to run with automatic WLM.	April 24, 2019
UNLOAD to Zstandard	You can use the UNLOAD command to apply Zstandard compression to text and comma-separated value (CSV) files unloaded to Amazon S3.	April 3, 2019
Concurrency scaling	When concurrency scaling is enabled, Amazon Redshift automatically adds additional cluster capacity when you need it to process an increase in concurrent read queries.	March 21, 2019
UNLOAD to CSV	You can use the UNLOAD command to unload to a file formatted as CSV text.	March 13, 2019

AUTO distribution style	To enable automatic distribution, you can specify the AUTO distribution style with a CREATE TABLE statement. When you enable automatic distribution, Amazon Redshift assigns an optimal distribution style based on the table data. The change in distribution occurs in the background, in a few seconds.	January 23, 2019
COPY from Parquet supports SMALLINT	COPY now supports loading from Parquet formatted files into columns that use the SMALLINT data type. For more information, see COPY from Columnar Data Formats	January 2, 2019
DROP EXTERNAL DATABASE	You can drop an external database by including the DROP EXTERNAL DATABASE clause with a DROP SCHEMA command.	December 3, 2018
Cross-region UNLOAD	You can UNLOAD to an Amazon S3 bucket in another AWS Region by specifying the REGION parameter.	October 31, 2018

Automatic vacuum delete	Amazon Redshift automatically runs a VACUUM DELETE operation in the background, so you rarely, if ever, need to run a DELETE ONLY vacuum. Amazon Redshift schedules the VACUUM DELETE to run during periods of reduced load and pauses the operation during periods of high load.	October 31, 2018
Automatic distribution	When you don't specify a distribution style with a CREATE TABLE statement, Amazon Redshift assigns an optimal distribution style based on the table data. The change in distribution occurs in the background, in a few seconds.	October 31, 2018
Fine grained access control for the AWS Glue Data Catalog	You can now specify levels of access to data stored in the AWS Glue Data Catalog.	October 15, 2018
UNLOAD with data types	You can specify the MANIFEST VERBOSE option with an UNLOAD command to add metadata to the manifest file, including the names and data types of columns, file sizes, and row counts.	October 10, 2018

Add multiple partitions using a single ALTER TABLE statement	For Redshift Spectrum external tables, you can combine multiple PARTITION clauses in a single ALTER TABLE ADD statement. For more information, see Alter External Table Examples.	October 10, 2018
UNLOAD with header	You can specify the HEADER option with an UNLOAD command to add a header line containing column names at the top of each output file.	September 19, 2018
New system table and views	SVL_S3Retries, SVL_USER_INFO, and STL_DISK_FULL_DIAG documentation added.	August 31, 2018
Support for nested data in Amazon Redshift Spectrum	You can now query nested data stored in Amazon Redshift Spectrum tables. For more information, see Tutorial: Querying Nested Data with Amazon Redshift Spectrum.	August 8, 2018
SQA on by default	Short query acceleration (SQA) is now enabled by default for all new clusters. SQA uses machine learning to provide higher performance, faster results, and better predictability of query execution times. For more information, see Short Query Acceleration.	August 8, 2018

Amazon Redshift Advisor	You can now get tailored recommendations on how to improve cluster performance and reduce operating costs from the Amazon Redshift Advisor. For more information, see Amazon Redshift Advisor.	July 26, 2018
Immediate alias reference	You can now refer to an aliased expression immediately after you define it. For more information, see SELECT List.	July 18, 2018
Specify compression type when creating an external table	You can now specify compression type when creating an external table with Amazon Redshift Spectrum. For more information, see Create External Tables.	June 27, 2018
PG_LAST_UNLOAD_ID	Documentation added for a new System Information function: PG_LAST_UNLOAD_ID. For more information, see PG_LAST_UNLOAD_ID.	June 27, 2018
ALTER TABLE RENAME COLUMN	ALTER TABLE now supports renaming columns for external tables. For more information, see Alter External Table Examples.	June 7, 2018

Earlier updates

The following table describes the important changes in each release of the *Amazon Redshift Database Developer Guide* before June 2018.

Change	Description	Date changed
COPY from Parquet includes SMALLINT	COPY now supports loading from Parquet formatted files into columns that use the SMALLINT data type. For more information, see COPY from columnar data formats	January 2, 2019
COPY from columnar formats	COPY now supports loading from files on Amazon S3 that use Parquet and ORC columnar data formats. For more information, see COPY from columnar data formats	May 17, 2018
Dynamic maximum run time for SQA	By default, workload management (WLM) now dynamically assigns a value for the short query acceleration (SQA) maximum run time based on analysis of your cluster's workload. For more information, see Maximum runtime for short queries.	May 17, 2018
New column in STL_LOAD_COMMITS	The STL_LOAD_COMMITS system table has a new column, `file_format` .	May 10, 2018
New columns in STL_HASHJOIN and other system log tables	The STL_HASHJOIN system table has three new columns, `hash_segment` , `hash_step` , and `checksum`. Also, a `checksum` was added to STL_MERGEJOIN, STL_NESTLOOP, STL_HASH, STL_SCAN, STL_SORT, STL_LIMIT, and STL_PROJECT.	May 17, 2018
New columns in STL_AGGR	The STL_AGGR system table has two new columns, `resizes` and `flushable` .	April 19, 2018
New options for REGEX functions	For the REGEXP_INSTR and REGEXP_SUBSTR functions, you can now specify which occurence of	March 22, 2018

Change	Description	Date changed
	a match to use and whether to perform a case-sens itive match. REGEXP_INSTR also allows you specify whether to return the position of the first character of the match or the position of the first character following the end of the match.	
New columns in system tables	The tombstonedblocks, tossedblocks, and batched_b y columns were added to the STL_COMMIT_STATS system table. The localslice column was added to the STV_SLICES system view.	March 22, 2018
Add and drop columns in external tables	ALTER TABLE now supports ADD COLUMN and DROP COLUMN for Amazon Redshift Spectrum external tables.	March 22, 2018
Redshift Spectrum new AWS Regions	Redshift Spectrum is now available in the Mumbai and São Paulo Regions. For a list of supported Regions, see Amazon Redshift Spectrum Regions.	March 22, 2018
Table limit increased to 20,000	The maximum number of tables is now 20,000 for 8xlarge cluster node types. The limit for large and xlarge node types is 9,900. For more information, see Limits and quotas.	March 13, 2018
Redshift Spectrum support for JSON and Ion	Using Redshift Spectrum, you can reference files with scalar data in JSON or Ion data formats. For more information, see CREATE EXTERNAL TABLE.	February 26, 2018
IAM role chaining for Redshift Spectrum	You can chain AWS Identity and Access Managemen t (IAM) roles so that your cluster can assume other roles not attached to the cluster, including roles belo nging to another AWS account. For more information, see Chaining IAM roles in Amazon Redshift Spectrum.	February 1, 2018
ADD PARTITION supports IF NOT EXISTS	The ADD PARTITION clause for ALTER TABLE now supports an IF NOT EXISTS option. For more information, see ALTER TABLE.	January 11, 2018

Change	Description	Date changed
DATE data for external tables	Redshift Spectrum external tables now support the DATE data type. For more information, see CREATE EXTERNAL TABLE.	January 11, 2018
Redshift Spectrum new AWS Regions	Redshift Spectrum is now available in the Singapore , Sydney, Seoul, and Frankfurt Regions. For a list of supported AWS Regions, see Amazon Redshift Spectrum Regions.	November 16, 2017
Short query acceleration in Amazon Redshift workload management (WLM)	Short query acceleration (SQA) prioritizes selected short-running queries ahead of longer-running queries. SQA executes short-running queries in a dedicated space, so that SQA queries aren't forced to wait in queues behind longer queries. With SQA, short-running queries begin executing more quickly and users see results sooner. For more information, see Short query acceleration.	November 16, 2017
WLM reassigns hopped queries	Instead of canceling and restarting a hopped query, Amazon Redshift workload management (WLM) now reassigns eligible queries to a new queue. When WLM reassigns a query, it moves the query to the new queue and continues execution, which saves time and system resources. Hopped queries that are not eligible to be reassigned are restarted or canceled. For more information, see WLM query queue hopping.	November 16, 2017
System log access for users	In most system log tables that are visible to users, rows generated by another user are invisible to a regular user by default. To permit a regular user to see all rows in user-visible tables, including rows generated by another user, run ALTER USER or CREATE USER and set the SYSLOG ACCESS parameter to UNRESTRICTED.	November 16, 2017

Change	Description	Date changed
Result caching	With Result caching , when you run a query Amazon Redshift caches the result. When you run the query again, Amazon Redshift checks for a valid, cached copy of the query result. If a match is found in the result cache, Amazon Redshift uses the cached result and doesn't run the query. Result caching is turned on by default. To turn off result caching, set the enable_result_cache_for_session configuration parameter to `off`.	November 16, 2017
Column metadata functions	PG_GET_COLS and PG_GET_LATE_BINDING_VIEW_COLS return column metadata for Amazon Redshift tables, views, and late-binding views.	November 16, 2017
WLM queue hopping for CTAS	Amazon Redshift workload management (WLM) now supports query queue hopping for CREATE TABLE AS (CTAS) statements as well as read-only queries, such as SELECT statements. For more information, see WLM query queue hopping.	October 19, 2017
Amazon Redshift Spectrum manifest files	When you create a Redshift Spectrum external table, you can specify a manifest file that lists the locations of data files on Amazon S3. For more information, see CREATE EXTERNAL TABLE.	October 19, 2017
Amazon Redshift Spectrum new AWS Regions	Redshift Spectrum is now available in the EU (Ireland) and Asia Pacific (Tokyo) Regions. For a list of supported AWS Regions, see Amazon Redshift Spectrum limitations.	October 19, 2017
Amazon Redshift Spectrum added file formats	You can now create Redshift Spectrum external tables based on Regex, OpenCSV, and Avro data file formats. For more information, see CREATE EXTERNAL TABLE.	October 5, 2017

Change	Description	Date changed
Pseudocol umns for Amazon Redshift Spectrum external tables	You can select the `$path` and `$size` pseudocolu mns in a Redshift Spectrum external table to view the location and size of the referenced data files in Amazon S3. For more information, see Pseudocol umns.	October 5, 2017
Functions to validate JSON	You can use the IS_VALID_JSON and IS_VALID_ JSON_ARRAY functions to check for valid JSON formatting. The other JSON functions now have an optional `null_if_invalid` argument.	October 5, 2017
LISTAGG DISTINCT	You can use the DISTINCT clause with the LISTAGG aggregate function and the LISTAGG window func tion to eliminate duplicate values from the specified expression before concatenating.	October 5, 2017
View column names in uppercase	To view column names in SELECT results in uppercase , you can set the describe_field_name_in_uppercase configuration parameter to `true`.	October 5, 2017
Skip header lines in external tables	You can set the `skip.header.line.count` property in the CREATE EXTERNAL TABLE command to skip header lines at the beginning of Redshift Spectrum data files.	October 5, 2017
Scan row count	WLM query monitor rules uses the scan_row_count metric to return the number of rows in a scan step. The row count is the total number of rows emitted before filtering rows marked for deletion (ghost rows) and before applying user-defined query filters. For more information, see Query monitoring metrics for Amazon Redshift provisioned.	September 21, 2017

Change	Description	Date changed
SQL user-defined functions	A scalar SQL user-defined function (UDF) incorpora tes a SQL SELECT clause that executes when the function is called and returns a single value. For more information, see Scalar SQL UDFs.	August 31, 2017
Late-binding views	A late-binding view is not bound to the underlyin g database objects, such as tables and user-defi ned functions. As a result, there is no dependency between the view and the objects it references. You can create a view even if the referenced objects don't exist. Because there is no dependency, you can drop or alter a referenced object without affecting the view. Amazon Redshift doesn't check for dependenc ies until the view is queried. To create a late-bind ing view, specify the WITH NO SCHEMA BINDING clause with your CREATE VIEW statement. For more information, see CREATE VIEW.	August 31, 2017
OCTET_LENGTH function	OCTET_LENGTH returns the length of the specified string as the number of bytes.	August 18, 2017
ORC and Grok files types supported	Amazon Redshift Spectrum now supports the ORC and Grok data formats for Redshift Spectrum data files. For more information, see Data files for queries in Amazon Redshift Spectrum.	August 18, 2017
RegexSerDe now supported	Amazon Redshift Spectrum now supports the RegexSerDe data format. For more information, see Data files for queries in Amazon Redshift Spectrum.	July 19, 2017
New columns added to SVV_TABLES and SVV_COLUMNS	The columns `domain_name` and `remarks` were added to SVV_COLUMNS. A remarks column was added to SVV_TABLES.	July 19, 2017

Change	Description	Date changed
SVV_TABLES and SVV_COLUMNS system views	The SVV_TABLES and SVV_COLUMNS system views provide information about columns and other details for local and external tables and views.	July 7, 2017
VPC no longer required for Amazon Redshift Spectrum with Amazon EMR Hive metastore	Redshift Spectrum removed the requirement that the Amazon Redshift cluster and the Amazon EMR cluster must be in the same VPC and the same subnet when using an Amazon EMR Hive metastore. For more information, see Working with external catalogs in Amazon Redshift Spectrum.	July 7, 2017
UNLOAD to smaller file sizes	By default, UNLOAD creates multiple files on Amazon S3 with a maximum size of 6.2 GB. To create smaller files, specify the MAXFILESIZE with the UNLOAD command. You can specify a maximum file size between 5 MB and 6.2 GB. For more information, see UNLOAD.	July 7, 2017
TABLE PROPERTIES	You can now set the TABLE PROPERTIES numRows parameter for CREATE EXTERNAL TABLE or ALTER TABLE to update table statistics to reflect the number of rows in the table.	June 6, 2017
ANALYZE PREDICATE COLUMNS	To save time and cluster resources, you can choose to analyze only the columns that are likely to be used as predicates. When you run ANALYZE with the PREDICATE COLUMNS clause, the analyze operation includes only columns that have been used in a join, filter condition, or group by clause, or are used as a sort key or distribution key. For more information, see Analyzing tables.	May 25, 2017

Change	Description	Date changed
IAM policies for Amazon Redshift Spectrum	To grant access to an Amazon S3 bucket only using Redshift Spectrum, you can include a condition that allows access for the user agent `AWS Redshift/Spectrum`. For more information, see IAM policies for Amazon Redshift Spectrum.	May 25, 2017
Amazon Redshift Spectrum Recursive Scan	Redshift Spectrum now scans files in subfolders as well as the specified folder in Amazon S3. For more information, see External tables for Redshift Spectrum.	May 25, 2017
Query monitoring rules	Using WLM query monitoring rules, you can define metrics-based performance boundaries for WLM queues and specify what action to take when a query goes beyond those boundaries—log, hop, or abort. You define query monitoring rules as part of your workload management (WLM) configuration. For more information, see WLM query monitoring rules.	April 21, 2017
Amazon Redshift Spectrum	Using Redshift Spectrum, you can efficiently query and retrieve data from files in Amazon S3 without having to load the data into tables. Redshift Sp ectrum queries execute very fast against large datasets because Redshift Spectrum scans the data files directly in Amazon S3. Much of the processing occurs in the Amazon Redshift Spectrum layer, and most of the data remains in Amazon S3. Multiple clusters can concurrently query the same dataset on Amazon S3 without the need to make copies of the data for each cluster. For more information, see Amazon Redshift Spectrum	April 19, 2017

Change	Description	Date changed
New system tables to support Redshift Spectrum	The following new system views have been added to support Redshift Spectrum: • SVL_S3QUERY • SVL_S3QUERY_SUMMARY • SVV_EXTERNAL_COLUMNS • SVV_EXTERNAL_DATABASES • SVV_EXTERNAL_PARTITIONS • SVV_EXTERNAL_TABLES • PG_EXTERNAL_SCHEMA	April 19, 2017
APPROXIMATE PERCENTILE_DISC aggregate function	The APPROXIMATE PERCENTILE_DISC aggregate function is now available.	April 4, 2017
Server-side encryption with KMS	You can now unload data to Amazon S3 using server-side encryption with an AWS Key Management Service key (SSE-KMS). In addition, COPY now transparently loads KMS-encrypted data files from Amazon S3. For more information, see UNLOAD.	February 9, 2017

Change	Description	Date changed
New authoriza tion syntax	You can now use the IAM_ROLE, MASTER_SY MMETRIC_KEY, ACCESS_KEY_ID, SECRET_ACCESS_ KEY, and SESSION_TOKEN parameters to provide authorization and access information for COPY, UNLOAD, and CREATE LIBRARY commands. The new authorization syntax provides a more flexible alternative to providing a single string argument to the CREDENTIALS parameter. For more information, see Authorization parameters.	February 9, 2017
Schema limit increase	You can now create up to 9,900 schemas per cluster. For more information, see CREATE SCHEMA.	February 9, 2017
Default table encoding	CREATE TABLE and ALTER TABLE now assign LZO compression encoding to most new columns. Columns defined as sort keys, columns that are defined as BOOLEAN, REAL, or DOUBLE PRECISION data types, and temporary tables are assigned RAW encoding by default. For more information, see ENCODE.	February 6, 2017
ZSTD compressi on encoding	Amazon Redshift now supports ZSTD column compression encoding.	January 19, 2017
PERCENTIL E_CONT and MEDIAN aggregate functions	PERCENTILE_CONT and MEDIAN are now available as aggregate functions as well as window functions.	January 19, 2017

Change	Description	Date changed
User-defined function (UDF) User Logging	You can use the Python logging module to create user-defined error and warning messages in your UDFs. Following query execution, you can query the SVL_UDF_LOG system view to retrieve logged messages. For more information about user-defined messages, see Logging errors and warnings in Python UDFs	December 8, 2016
ANALYZE COMPRESSION estimated reduction	The ANALYZE COMPRESSION command now reports an estimate for percentage reduction in disk space for each column. For more information, see ANALYZE COMPRESSION.	November 10, 2016
Connection limits	You can now set a limit on the number of database connections a user is permitted to have open concurrently. You can also limit the number of concurrent connections for a database. For more information, see CREATE USER and CREATE DATABASE.	November 10, 2016
COPY sort order enhancement	COPY now automatically adds new rows to the table's sorted region when you load your data in sort key order. For specific requirements to enable this enhancement, see Load your data in sort key order	November 10, 2016
CTAS with compression	CREATE TABLE AS (CTAS) now automatically assigns compression encodings to new tables based on the column's data type. For more information, see Inheritance of column and table attributes.	October 28, 2016
Time stamp with time zone data type	Amazon Redshift now supports a timestamp with time zone (TIMESTAMPTZ) data type. Also, several new functions have been added to support the new data type. For more information, see Date and time functions.	September 29, 2016

Change	Description	Date changed
Analyze threshold	To reduce processing time and improve overall system performance for ANALYZE operations, Amazon Redshift skips analyzing a table if the percentage of rows that have changed since the last ANALYZE command run is lower than the analyze threshold specified by the analyze_threshold_percent parameter. By default, `analyze_threshold_percent` is 10.	August 9, 2016
New STL_RESTARTED_SESSIONS system table	When Amazon Redshift restarts a session, STL_RESTARTED_SESSIONS records the new process ID (PID) and the old PID.	August 9, 2016
Updated the Date and Time Functions documentation	Added a summary of functions with links to the Date and time functions, and updated the function references for consistency.	June 24, 2016
New columns in STL_CONNECTION_LOG	The STL_CONNECTION_LOG system table has two new columns to track SSL connections. If you routinely load audit logs to an Amazon Redshift table, you will need to add the following new columns to the target table: sslcompression and sslexpansion.	May 5, 2016
MD5-hash password	You can specify the password for a CREATE USER or ALTER USER command by supplying the MD5-hash string of the password and user name.	April 21, 2016
New column in STV_TBL_PERM	The `backup` column in the STV_TBL_PERM system view indicates whether the table is included in cluster snapshots. For more information, see BACKUP.	April 21, 2016

Change	Description	Date changed
No-backup tables	For tables, such as staging tables, that won't contain critical data, you can specify BACKUP NO in your CREATE TABLE or CREATE TABLE AS statement to prevent Amazon Redshift from including the table in automated or manual snapshots. Using no-backup tables saves processing time when creating snapshots and restoring from snapshots and reduces storage space on Amazon S3.	April 7, 2016
VACUUM delete threshold	By default, the VACUUM command now reclaims space such that at least 95 percent of the remaining rows are not marked for deletion. As a result, VACUUM usually needs much less time for the delete phase compared to reclaiming 100 percent of deleted rows. You can change the default threshold for a single table by including the TO *threshold* PERCENT parameter when you run the VACUUM command.	April 7, 2016
SVV_TRANS ACTIONS system table	The SVV_TRANSACTIONS system view records information about transactions that currently hold locks on tables in the database.	April 7, 2016
Using IAM roles to access other AWS resources	To move data between your cluster and another AWS resource, such as Amazon S3, DynamoDB, Amazon EMR, or Amazon EC2, your cluster must have permission to access the resource and perform the necessary actions. As a more secure alternati ve to providing an access key pair with COPY, UNLOAD, or CREATE LIBRARY commands, you can now you specify an IAM role that your cluster uses for authentication and authorization. For more information, see Role-based access control.	March 29, 2016

Change	Description	Date changed
VACUUM sort threshold	The VACUUM command now skips the sort phase for any table where more than 95 percent of the table's rows are already sorted. You can change the default sort threshold for a single table by including the TO *threshold* PERCENT parameter when you run the VACUUM command.	March 17, 2016
New columns in STL_CONNECTION_LOG	The STL_CONNECTION_LOG system table has three new columns. If you routinely load audit logs to an Amazon Redshift table, you will need to add the following new columns to the target table: sslversion, sslcipher, and mtu.	March 17, 2016
UNLOAD with bzip2 compression	You now have the option to UNLOAD using bzip2 compression.	February 8, 2016
ALTER TABLE APPEND	ALTER TABLE APPEND appends rows to a target table by moving data from an existing source table. ALTER TABLE APPEND is usually much faster than a similar CREATE TABLE AS or INSERT INTO operation because data is moved, not duplicated.	February 8, 2016
WLM query queue hopping	If workload management (WLM) cancels a read-only query, such as a SELECT statement, due to a WLM timeout, WLM attempts to route the query to the next matching queue. For more information, see WLM query queue hopping	January 7, 2016
ALTER DEFAULT PRIVILEGES	You can use the ALTER DEFAULT PRIVILEGES command to define the default set of access privileges to be applied to objects that are created in the future by the specified user.	December 10, 2015
bzip2 file compression	The COPY command supports loading data from files that were compressed using bzip2.	December 10, 2015

Change	Description	Date changed
NULLS FIRST and NULLS LAST	You can specify whether an ORDER BY clause should rank NULLS first or last in the result set. For more information, see ORDER BY clause and Window function syntax summary.	November 19, 2015
REGION keyword for CREATE LIBRARY	If the Amazon S3 bucket that contains the UDF library files does not reside in the same AWS Region as your Amazon Redshift cluster, you can use the REGION option to specify the region in which the data is located. For more information, see CREATE LIBRARY.	November 19, 2015
User-defined scalar functions (UDFs)	You can now create custom user-defined scalar functions to implement non-SQL processing functionality provided either by Amazon Redshift-supported modules in the Python 2.7 Standard Library or your own custom UDFs based on the Python programming language. For more information, see User-defined functions in Amazon Redshift.	September 11, 2015
Dynamic properties in WLM configuration	The WLM configuration parameter now supports applying some properties dynamically. Other properties remain static changes and require that associated clusters be rebooted so that the configuration changes can be applied. For more information, see WLM dynamic and static configuration properties and Workload management.	August 3, 2015
LISTAGG function	The LISTAGG function and LISTAGG window function return a string created by concatenating a set of column values.	July 30, 2015

Change	Description	Date changed
Deprecated parameter	The *max_cursor_result_set_size* configura tion parameter is deprecated. The size of cursor result sets are constrained based on the cluster's node type. For more information, see Cursor constraints.	July 24, 2015
Revised COPY command documentation	The COPY command reference has been extensive ly revised to make the material friendlier and more accessible.	July 15, 2015
COPY from Avro format	The COPY command supports loading data in Avro format from data files on Amazon S3, Amazon EMR, and from remote hosts using SSH. For more information, see AVRO and Copy from Avro examples.	July 8, 2015
STV_START UP_RECOVE RY_STATE	The STV_STARTUP_RECOVERY_STATE system table records the state of tables that are temporarily locked during cluster restart operations. Amazon Redshift places a temporary lock on tables while they are being processed to resolve stale transactions following a cluster restart.	May 25, 2015
ORDER BY optional for ranking functions	The ORDER BY clause is now optional for certain window ranking functions. For more information, see CUME_DIST window function, DENSE_RANK window function, RANK window function, NTILE window function, PERCENT_RANK window function, and ROW_NUMBER window function.	May 25, 2015

Change	Description	Date changed
Interleaved sort keys	Interleaved sort keys give equal weight to each column in the sort key. Using interleaved sort keys instead of the default compound keys significantly improves performance for queries that use restrictive predicates on secondary sort columns, especially for large tables. Interleaved sorting also improves overall performance when multiple queries filter on different columns in the same table. For more information, see Sort keys and CREATE TABLE.	May 11, 2015
Revised tuning query performance topic	Query performance tuning has been expanded to include new queries for analyzing query performance and more examples. Also, the topic has been revised to be clearer and more complete. Amazon Redshift best practices for designing queries has more information about how to write queries to improve performance.	March 23, 2015
SVL_QUERY_QUEUE_INFO	The SVL_QUERY_QUEUE_INFO view summarizes details for queries that spent time in a WLM query queue or commit queue.	February 19, 2015
SVV_TABLE_INFO	You can use the SVV_TABLE_INFO view to diagnose and address table design issues that can influence query performance, including issues with compression encoding, distribution keys, sort style, data distribution skew, table size, and statistics.	February 19, 2015
UNLOAD uses server-side file encryption	The UNLOAD command now automatically uses Amazon S3 server-side encryption (SSE) to encrypt all unload data files. Server-side encryption adds another layer of data security with little or no change in performance.	October 31, 2014

Change	Description	Date changed
CUME_DIST window function	The CUME_DIST window function calculates the cumulative distribution of a value within a window or partition.	October 31, 2014
MONTHS_BETWEEN function	The MONTHS_BETWEEN function determines the number of months between two dates.	October 31, 2014
NEXT_DAY function	The NEXT_DAY function returns the date of the first instance of a specified day that is later than the given date.	October 31, 2014
PERCENT_RANK window function	The PERCENT_RANK window function calculates the percent rank of a given row.	October 31, 2014
RATIO_TO_REPORT window function	The RATIO_TO_REPORT window function calculates the ratio of a value to the sum of the values in a window or partition.	October 31, 2014
TRANSLATE function	The TRANSLATE function replaces all occurrences of specified characters within a given expression with specified substitutes.	October 31, 2014
NVL2 function	The NVL2 function returns one of two values based on whether a specified expression evaluates to NULL or NOT NULL.	October 16, 2014
MEDIAN window function	The MEDIAN window function calculates the median value for the range of values in a window or partition.	October 16, 2014
ON ALL TABLES IN SCHEMA *schema_name* clause for GRANT and REVOKE commands	The GRANT and REVOKE commands have been updated with an ON ALL TABLES IN SCHEMA *schema_name* clause. This clause allows you to use a single command to change privileges for all tables in a schema.	October 16, 2014

Change	Description	Date changed
IF EXISTS clause for DROP SCHEMA, DROP TABLE, DROP USER, and DROP VIEW commands	The DROP SCHEMA, DROP TABLE, DROP USER, and DROP VIEW commands have been updated with an IF EXISTS clause. This clause causes the command to make no changes and return a message rather than terminating with an error if the specified object doesn't exist.	October 16, 2014
IF NOT EXISTS clause for CREATE SCHEMA and CREATE TABLE commands	The CREATE SCHEMA and CREATE TABLE commands have been updated with an IF NOT EXISTS clause. This clause causes the command to make no changes and return a message rather than terminating with an error if the specified object already exists.	October 16, 2014
COPY support for UTF-16 encoding	The COPY command now supports loading from data files that use UTF-16 encoding as well as UTF-8 encoding. For more information, see ENCODING.	September 29, 2014
New workload management tutorial	Tutorial: Configuring manual workload management (WLM) queues walks you through the process of configuring Workload Management (WLM) queues to improve query processing and resource allocation.	September 25, 2014
AES 128-bit encryption	The COPY command now supports AES 128-bit encryption as well as AES 256-bit encryption when loading from data files encrypted using Amazon S3 client-side encryption. For more information, see Loading encrypted data files from Amazon S3.	September 29, 2014
PG_LAST_UNLOAD_COUNT function	The PG_LAST_UNLOAD_COUNT function returns the number of rows that were processed in the most recent UNLOAD operation. For more information, see PG_LAST_UNLOAD_COUNT.	September 15, 2014

Change	Description	Date changed
New troubleshooting queries section	Query troubleshooting provides a quick reference for identifying and addressing some of the most common and most serious issues you are likely to encounter with Amazon Redshift queries.	July 7, 2014
New loading data tutorial	Tutorial: Loading data from Amazon S3 walks you through the process of loading data into your Amazon Redshift database tables from data files in an Amazon S3 bucket, from beginning to end.	July 1, 2014
PERCENTILE_CONT window function	PERCENTILE_CONT window function is an inverse distribution function that assumes a continuous distribution model. It takes a percentile value and a sort specification, and returns an interpolated value that would fall into the given percentile value with respect to the sort specification.	June 30, 2014
PERCENTILE_DISC window function	PERCENTILE_DISC window function is an inverse distribution function that assumes a discrete distribution model. It takes a percentile value and a sort specification and returns an element from the set.	June 30, 2014
GREATEST and LEAST functions	The GREATEST and LEAST functions functions return the largest or smallest value from a list of expressions.	June 30, 2014
Cross-region COPY	The COPY command supports loading data from an Amazon S3 bucket or Amazon DynamoDB table that is located in a different region than the Amazon Redshift cluster. For more information, see REGION in the COPY command reference.	June 30, 2014
Best Practices expanded	Amazon Redshift best practices has been expanded, reorganized, and moved to the top of the navigation hierarchy to make it more discoverable.	May 28, 2014

Change	Description	Date changed
UNLOAD to a single file	The UNLOAD command can optionally unload table data serially to a single file on Amazon S3 by adding the PARALLEL OFF option. If the size of the data is greater than the maximum file size of 6.2 GB, UNLOAD creates additional files.	May 6, 2014
REGEXP functions	The REGEXP_COUNT, REGEXP_INSTR, and REGEXP_REPLACE functions manipulate strings based on regular expression pattern matching.	May 6, 2014
COPY from Amazon EMR	The COPY command supports loading data directly from Amazon EMR clusters. For more information, see Loading data from Amazon EMR.	April 18, 2014
WLM concurrency limit increase	You can now configure workload management (WLM) to run up to 50 queries concurrently in user-defined query queues. This increase gives users more flexibility for managing system performance by modifying WLM configurations. For more information, see Implementing manual WLM	April 18, 2014
New configuration parameter to manage cursor size	The `max_cursor_result_set_size` configuration parameter defines the maximum size of data, in megabytes, that can be returned per cursor result set of a larger query. This parameter value also affects the number of concurrent cursors for the cluster, enabling you to configure a value that increases or decreases the number of cursors for your cluster. For more information, see DECLARE in this guide and Configure Maximum Size of a Cursor Result Set in the *Amazon Redshift Management Guide*.	March 28, 2014

Change	Description	Date changed
COPY from JSON format	The COPY command supports loading data in JSON format from data files on Amazon S3 and from remote hosts using SSH. For more information, see COPY from JSON format usage notes.	March 25, 2014
New system table STL_PLAN_INFO	The STL_PLAN_INFO table supplements the EXPLAIN command as another way to look at query plans.	March 25, 2014
New function REGEXP_SUBSTR	The REGEXP_SUBSTR function returns the character s extracted from a string by searching for a regular expression pattern.	March 25, 2014
New columns for STL_COMMI T_STATS	The STL_COMMIT_STATS table has two new columns: `numxids` and `oldestxid` .	March 6, 2014
COPY from SSH support for gzip and lzop	The COPY command supports gzip and lzop compression when loading data through an SSH connection.	February 13, 2014
New functions	The ROW_NUMBER window function returns the number of the current row. The STRTOL function converts a string expression of a number of the specified base to the equivalent integer value. PG_CANCEL_BACKEND and PG_TERMINATE_BACKE ND enable users to cancel queries and session connections. The LAST_DAY function has been added for Oracle compatibility.	February 13, 2014
New system table	The STL_COMMIT_STATS system table provides metrics related to commit performance, including the timing of the various stages of commit and the number of blocks committed.	February 13, 2014

Change	Description	Date changed
FETCH with single-node clusters	When using a cursor on a single-node cluster, the maximum number of rows that can be fetched using the FETCH command is 1000. FETCH FORWARD ALL is not supported for single-node clusters.	February 13, 2014
DS_DIST_A LL_INNER redistribution strategy	DS_DIST_ALL_INNER in the Explain plan output indicates that the entire inner table was redistrib uted to a single slice because the outer table uses DISTSTYLE ALL. For more information, see Join type examples and Evaluating the query plan.	January 13, 2014
New system tables for queries	Amazon Redshift has added new system tables that customers can use to evaluate query execution for tuning and troubleshooting. For more inform ation, see SVL_COMPILE, STL_SCAN, STL_RETURN, STL_SAVE STL_ALERT_EVENT_LOG.	January 13, 2014
Single-node cursors	Cursors are now supported for single-node clusters. A single-node cluster can have two cursors open at a time, with a maximum result set of 32 GB. On a single-node cluster, we recommend setting the ODBC Cache Size parameter to 1,000. For more informati on, see DECLARE.	December 13, 2013
ALL distribution style	ALL distribution can dramatically shorter execution times for certain types of queries. When a table uses ALL distribution style, a copy of the table is distribut ed to every node. Because the table is effectively collocated with every other table, no redistribution is needed during query execution. ALL distribution is not appropriate for all tables because it increases storage requirements and load time. For more inform ation, see Data distribution for query optimization.	November 11, 2013

Change	Description	Date changed
COPY from remote hosts	In addition to loading tables from data files on Amazon S3 and from Amazon DynamoDB tables, the COPY command can load text data from Amazon EMR clusters, Amazon EC2 instances, and other remote hosts by using SSH connections. Amazon Redshift uses multiple simultaneous SSH connections to read and load data in parallel. For more informati on, see Loading data from remote hosts.	November 11, 2013
WLM memory percent used	You can balance workload by designating a specific percentage of memory for each queue in your workload management (WLM) configuration. For more information, see Implementing manual WLM.	November 11, 2013
APPROXIMATE COUNT(DISTINCT)	Queries that use APPROXIMATE COUNT(DISTINCT) execute much faster, with a relative error of about 2%. The APPROXIMATE COUNT(DISTINCT) function uses a HyperLogLog algorithm. For more information, see the COUNT function.	November 11, 2013
New SQL functions to retrieve recent query details	Four new SQL functions retrieve details about recent queries and COPY commands. The new functions make it easier to query the system log tables, and in many cases provide necessary details without needing to access the system tables. For more information, see PG_BACKEND_PID, PG_LAST_COPY_ID, PG_LAST_COPY_COUNT, PG_LAST_QUERY_ID.	November 1, 2013

Change	Description	Date changed
MANIFEST option for UNLOAD	The MANIFEST option for the UNLOAD command complements the MANIFEST option for the COPY command. Using the MANIFEST option with UNLOAD automatically creates a manifest file that explicitly lists the data files that were created on Amazon S3 by the unload operation. You can then use the same manifest file with a COPY command to load the data. For more information, see Unloading data to Amazon S3 and UNLOAD examples.	November 1, 2013
MANIFEST option for COPY	You can use the MANIFEST option with the COPY command to explicitly list the data files that will be loaded from Amazon S3.	October 18, 2013
System tables for troubleshooting queries	Added documentation for system tables that are used to troubleshoot queries. The STL views for logging section now contains documentation for the following system tables: STL_AGGR, STL_BCAST, STL_DIST, STL_DELETE, STL_HASH, STL_HASHJOIN, STL_INSERT, STL_LIMIT, STL_MERGE, STL_MERGEJOIN, STL_NESTLOOP, STL_PARSE, STL_PROJECT, STL_SCAN, STL_SORT, STL_UNIQUE, STL_WINDOW.	October 3, 2013
CONVERT_TIMEZONE function	The CONVERT_TIMEZONE function converts a timestamp from one time zone to another, with the option to automatically adjust for daylight savings time.	October 3, 2013
SPLIT_PART function	The SPLIT_PART function splits a string on the specified delimiter and returns the part at the specified position.	October 3, 2013
STL_USERLOG system table	STL_USERLOG records details for changes that occur when a database user is created, altered, or deleted.	October 3, 2013

Change	Description	Date changed
LZO column encoding and LZOP file compression.	LZO column compression encoding combines a very high compression ratio with good performance. COPY from Amazon S3 supports loading from files compressed using LZOP compression.	September 19, 2013
JSON, regular expressions, and cursors	Added support for parsing JSON strings, pattern matching using regular expressions, and using cursors to retrieve large data sets over an ODBC connection. For more information, see JSON functions, Pattern-matching conditions, and DECLARE.	September 10, 2013
ACCEPTINVCHAR option for COPY	You can successfully load data that contains invalid UTF-8 characters by specifying the ACCEPTINVCHAR option with the COPY command.	August 29, 2013
CSV option for COPY	The COPY command now supports loading from CSV formatted input files.	August 9, 2013
CRC32	The CRC32 function performs cyclic redundancy checks.	August 9, 2013
WLM wildcards	Workload management (WLM) supports wildcards for adding user groups and query groups to queues. For more information, see Wildcards.	August 1, 2013
WLM timeout	To limit the amount of time that queries in a given WLM queue are permitted to use, you can set the WLM timeout value for each queue. For more information, see WLM timeout.	August 1, 2013
New COPY options 'auto' and 'epochsecs'	The COPY command performs automatic recogniti on of date and time formats. New time formats, 'e pochsecs' and 'epochmillisecs' enable COPY to load data in epoch format.	July 25, 2013

Change	Description	Date changed
CONVERT_TIMEZONE function	The CONVERT_TIMEZONE function converts a timestamp from one timezone to another.	July 25, 2013
FUNC_SHA1 function	The FUNC_SHA1 function converts a string using the SHA1 algorithm.	July 15, 2013
max_execution_time	To limit the amount of time queries are permitted to use, you can set the max_execution_time parameter as part of the WLM configuration. For more information, see Modifying the WLM configuration.	July 22, 2013
Four-byte UTF-8 characters	The VARCHAR data type now supports four-byte UTF-8 characters. Five-byte or longer UTF-8 characters are not supported. For more information, see Storage and ranges.	July 18, 2013
SVL_QERROR	The SVL_QERROR system view has been deprecated.	July 12, 2013
Revised Document History	The Document History page now shows the date the documentation was updated.	July 12, 2013
STL_UNLOAD_LOG	STL_UNLOAD_LOG records the details for an unload operation.	July 5, 2013
JDBC fetch size parameter	To avoid client-side out of memory errors when retrieving large data sets using JDBC, you can enable your client to fetch data in batches by setting the JDBC fetch size parameter. For more information, see Setting the JDBC fetch size parameter.	June 27, 2013
UNLOAD encrypted files	UNLOAD now supports unloading table data to encrypted files on Amazon S3.	May 22, 2013
Temporary credentials	COPY and UNLOAD now support the use of temporary credentials.	April 11, 2013

Change	Description	Date changed
Added clarifica tions	Clarified and expanded discussions of Designing Tables and Loading Data.	February 14, 2013
Added best practices	Added Amazon Redshift best practices for designing tables and Amazon Redshift best practices for loading data.	February 14, 2013
Clarified password constraints	Clarified password constraints for CREATE USER and ALTER USER, various minor revisions.	February 14, 2013
New guide	This is the first release of the *Amazon Redshift Developer Guide*.	February 14, 2013