Amazon Redshift: Database Developer Guide
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<td>STL_COMMIT_STATS</td>
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<tr>
<td>STL_CONNECTION_LOG</td>
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<td>STL_DDLTEXT</td>
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<td>STL_INSERT</td>
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<td>STL_LIMIT</td>
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<td>STL_LOAD_COMMITS</td>
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<td>STL_MERGEJOIN</td>
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<td>STL_MV_STATE</td>
<td>952</td>
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<tr>
<td>STL_NESTLOOP</td>
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<td>STL_PARSE</td>
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<td>STL_PROJECT</td>
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<td>STL_QUERY</td>
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<td>STL_REPLACEMENTS</td>
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<td>STL_RETURN</td>
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<td>STL_S3CLIENT</td>
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<td>STL_S3CLIENT_ERROR</td>
<td>972</td>
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<td>STL_SAVE</td>
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<td>STL_SCAN</td>
<td>974</td>
</tr>
<tr>
<td>STL_SESSIONS</td>
<td>976</td>
</tr>
</tbody>
</table>
Amazon Redshift System Overview

Topics

- Are You a First-Time Amazon Redshift User? (p. 1)
- Are You a Database Developer? (p. 2)
- Prerequisites (p. 3)
- System and Architecture Overview (p. 3)

This is the Amazon Redshift Database Developer Guide.

Amazon Redshift is an enterprise-level, petabyte scale, fully managed data warehousing service.

This guide focuses on using Amazon Redshift to create and manage a data warehouse. If you work with databases as a designer, software developer, or administrator, it gives you the information you need to design, build, query, and maintain your data warehouse.

Are You a First-Time Amazon Redshift User?

If you are a first-time user of Amazon Redshift, we recommend that you begin by reading the following sections.

- Service Highlights and Pricing – The product detail page provides the Amazon Redshift value proposition, service highlights, and pricing.
- Getting Started – Amazon Redshift Getting Started includes an example that walks you through the process of creating an Amazon Redshift data warehouse cluster, creating database tables, uploading data, and testing queries.

After you complete the Getting Started guide, we recommend that you explore one of the following guides:

- Amazon Redshift Cluster Management Guide – The Cluster Management guide shows you how to create and manage Amazon Redshift clusters.

If you are an application developer, you can use the Amazon Redshift Query API to manage clusters programmatically. Additionally, the AWS SDK libraries that wrap the underlying Amazon Redshift API can help simplify your programming tasks. If you prefer a more interactive way of managing clusters, you can use the Amazon Redshift console and the AWS command line interface (AWS CLI). For information about the API and CLI, go to the following manuals:

- API Reference
- CLI Reference

- Amazon Redshift Database Developer Guide (this document) – If you are a database developer, the Database Developer Guide explains how to design, build, query, and maintain the databases that make up your data warehouse.

If you are transitioning to Amazon Redshift from another relational database system or data warehouse application, you should be aware of important differences in how Amazon Redshift is implemented. For
Are You a Database Developer?

If you are a database user, database designer, database developer, or database administrator, the following table will help you find what you’re looking for.

<table>
<thead>
<tr>
<th>If you want to ...</th>
<th>We recommend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quickly start using Amazon Redshift</td>
<td>Begin by following the steps in Amazon Redshift Getting Started to quickly deploy a cluster, connect to a database, and try out some queries. When you are ready to build your database, load data into tables, and write queries to manipulate data in the data warehouse, return here to the Database Developer Guide.</td>
</tr>
<tr>
<td>Learn about the internal architecture of the Amazon Redshift data warehouse.</td>
<td>The System and Architecture Overview (p. 3) gives a high-level overview of Amazon Redshift’s internal architecture. If you want a broader overview of the Amazon Redshift web service, go to the Amazon Redshift product detail page.</td>
</tr>
<tr>
<td>Create databases, tables, users, and other database objects.</td>
<td>Getting Started Using Databases (p. 13) is a quick introduction to the basics of SQL development. The Amazon Redshift SQL (p. 360) has the syntax and examples for Amazon Redshift SQL commands and functions and other SQL elements. Amazon Redshift Best Practices for Designing Tables (p. 21) provides a summary of our recommendations for choosing sort keys, distribution keys, and compression encodings.</td>
</tr>
<tr>
<td>Learn how to design tables for optimum performance.</td>
<td>Designing Tables (p. 43) details considerations for applying compression to the data in table columns and choosing distribution and sort keys.</td>
</tr>
<tr>
<td>Load data.</td>
<td>Loading Data (p. 98) explains the procedures for loading large datasets from Amazon DynamoDB tables or from flat files stored in Amazon S3 buckets. Amazon Redshift Best Practices for Loading Data (p. 24) provides for tips for loading your data quickly and effectively.</td>
</tr>
<tr>
<td>Manage users, groups, and database security.</td>
<td>Managing Database Security (p. 354) covers database security topics.</td>
</tr>
<tr>
<td>Monitor and optimize system performance.</td>
<td>The System Tables Reference (p. 914) details system tables and views that you can query for the status of the database and monitor queries and processes. You should also consult the Amazon Redshift Cluster Management Guide to learn how to use the AWS Management Console to check the system health, monitor metrics, and back up and restore clusters.</td>
</tr>
</tbody>
</table>

Amazon Redshift is based on PostgreSQL 8.0.2. For a detailed list of the differences between Amazon Redshift and PostgreSQL, see Amazon Redshift and PostgreSQL (p. 361).
Prerequisites

Before you use this guide, you should complete these tasks.

- Install a SQL client.
- Launch an Amazon Redshift cluster.
- Connect your SQL client to the cluster master database.

For step-by-step instructions, see Amazon Redshift Getting Started.

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

System and Architecture Overview

Topics

- Data Warehouse System Architecture (p. 3)
- Performance (p. 5)
- Columnar Storage (p. 8)
- Internal Architecture and System Operation (p. 9)
- Workload Management (p. 10)
- Using Amazon Redshift with Other Services (p. 11)

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 execute 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.

Data Warehouse System Architecture

This section introduces the elements of 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 industry-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 (p. 361).

Connections

Amazon Redshift communicates with client applications by using industry-standard JDBC and ODBC drivers for PostgreSQL. For more information, see Amazon Redshift and PostgreSQL JDBC and ODBC (p. 362).

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 (p. 360).
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 execute the compiled code and send intermediate results back to the leader node for final aggregation.

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

Amazon Redshift provides two node types; dense storage nodes and dense compute nodes. Each node provides two storage choices. You can start with a single 160 GB node and scale up to multiple 16 TB nodes to support a petabyte of data or more.

For a more detailed explanation of data warehouse clusters and nodes, see Internal Architecture and System Operation (p. 9).

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 Cluster 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 execute queries efficiently. For information about choosing a distribution key, see Choose the Best Distribution Style (p. 22).

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 execution 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 8.0.2. 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 (p. 361).

Performance

Amazon Redshift achieves extremely fast query execution by employing these performance features.
Massively Parallel Processing

Massively parallel processing (MPP) enables fast execution 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 executing 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 (p. 22).

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 (p. 24).

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. Storing database table information in a columnar fashion reduces the number of disk I/O requests and reduces the amount of data you need to load from disk. Loading less data into memory enables Amazon Redshift to perform more in-memory processing when executing queries. See Columnar Storage (p. 8) for a more detailed explanation.

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 (p. 22).

Data Compression

Data compression reduces storage requirements, thereby reducing disk I/O, which improves query performance. When you execute a query, the compressed data is read into memory, then uncompressed during query execution. 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 (p. 123).

Query Optimizer

The Amazon Redshift query execution 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 Tuning Query Performance (p. 281).
Result Caching

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 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 execute the query. Result caching is transparent to the user.

Result caching is enabled by default. To disable result caching for the current session, set the `enable_result_cache_for_session (p. 1104)` 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 privilege 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 (p. 1043)` 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;
```

<table>
<thead>
<tr>
<th>userid</th>
<th>query</th>
<th>elapsed</th>
<th>source_query</th>
</tr>
</thead>
<tbody>
<tr>
<td>104</td>
<td>629035</td>
<td>27</td>
<td>628919</td>
</tr>
<tr>
<td>104</td>
<td>629034</td>
<td>60</td>
<td>628900</td>
</tr>
<tr>
<td>104</td>
<td>629033</td>
<td>23</td>
<td>628891</td>
</tr>
<tr>
<td>102</td>
<td>629017</td>
<td>1229393</td>
<td>628919</td>
</tr>
<tr>
<td>102</td>
<td>628942</td>
<td>28</td>
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<tr>
<td>102</td>
<td>628941</td>
<td>57</td>
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<tr>
<td>102</td>
<td>628940</td>
<td>26</td>
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<td>628919</td>
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</tr>
<tr>
<td>100</td>
<td>628900</td>
<td>87015637</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>628891</td>
<td>58808694</td>
<td></td>
</tr>
</tbody>
</table>

For details about the queries used to create the results shown in the previous example, see Step 2: Test System Performance to Establish a Baseline (p. 77) in the Tuning Table Design (p. 73) tutorial.

Compiled Code

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

The execution engine compiles different code for the JDBC connection protocol and for ODBC and psql (libq) connection protocols, so two clients using different protocols will each incur the first-time cost of compiling the code. Other clients that use the same protocol, however, will benefit from sharing the cached code.

## Columnar Storage

Columnar storage for database tables is an important factor in optimizing analytic query performance because it drastically reduces the overall disk I/O requirements and 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.

<table>
<thead>
<tr>
<th>SSN</th>
<th>Name</th>
<th>Age</th>
<th>Addr</th>
<th>City</th>
<th>St</th>
</tr>
</thead>
<tbody>
<tr>
<td>101259797</td>
<td>SMITH</td>
<td>88</td>
<td>899 FIRST ST</td>
<td>JUNO</td>
<td>AL</td>
</tr>
<tr>
<td>892375862</td>
<td>CHIN</td>
<td>37</td>
<td>16137 MAIN ST</td>
<td>POMONA</td>
<td>CA</td>
</tr>
<tr>
<td>318370701</td>
<td>HANDU</td>
<td>12</td>
<td>42 JUNE ST</td>
<td>CHICAGO</td>
<td>IL</td>
</tr>
</tbody>
</table>

![Block 1](image1)

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.

<table>
<thead>
<tr>
<th>SSN</th>
<th>Name</th>
<th>Age</th>
<th>Addr</th>
<th>City</th>
<th>St</th>
</tr>
</thead>
<tbody>
<tr>
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<td>16137 MAIN ST</td>
<td>POMONA</td>
<td>CA</td>
</tr>
<tr>
<td>318370701</td>
<td>HANDU</td>
<td>12</td>
<td>42 JUNE ST</td>
<td>CHICAGO</td>
<td>IL</td>
</tr>
</tbody>
</table>

![Block 1](image2)

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 (p. 44).

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 and 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 execution.

Internal Architecture and System Operation

The following diagram shows a high level view of internal components and functionality of the Amazon Redshift data warehouse.
Workload Management

Amazon Redshift workload management (WLM) enables users to flexibly manage priorities within workloads so that short, fast-running queries won't get stuck in queues behind long-running queries.

Amazon Redshift WLM 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.

When you run a query, 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 with a query group label that the user sets at runtime.
Currently, the default for clusters using the default parameter group is to use automatic WLM. Automatic WLM manages query concurrency and memory allocation. For more information, see Implementing Automatic WLM (p. 311).

With manual WLM, Amazon Redshift configures one queue with a concurrency level of five, which enables up to five queries to run concurrently, plus one predefined Superuser queue, with a concurrency level of one. You can define up to eight queues. Each queue can be configured with a maximum concurrency level of 50. The maximum total concurrency level for all user-defined queues (not including the Superuser queue) is 50.

The easiest way to modify the 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 (p. 309).

Using Amazon Redshift with Other Services

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

Moving Data Between Amazon Redshift and Amazon 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 (p. 101).

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 (p. 176).

Using Amazon Redshift with Amazon 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 (p. 120).

Importing Data from Remote Hosts over 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 executes 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 (p. 114).

Automating Data Loads Using AWS Data Pipeline

You can use AWS Data Pipeline to automate data movement and transformation into and out of Amazon Redshift. By using the built-in scheduling capabilities of AWS Data Pipeline, you can schedule and execute recurring jobs without having to write your own complex data transfer or transformation logic. For example, you can set up a recurring job to automatically copy data from Amazon DynamoDB into Amazon Redshift. For a tutorial that walks you through the process of creating a pipeline that periodically moves data from Amazon S3 to Amazon Redshift, see Copy Data to Amazon Redshift Using AWS Data Pipeline in the AWS Data Pipeline Developer Guide.
Migrating Data Using AWS Database Migration Service (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, DynamoDB, Amazon S3, MariaDB, and MySQL. For more information, see Using an Amazon Redshift Database as a Target for AWS Database Migration Service.
Getting Started Using Databases

Topics

• Step 1: Create a Database (p. 13)
• Step 2: Create a Database User (p. 14)
• Step 3: Create a Database Table (p. 14)
• Step 4: Load Sample Data (p. 15)
• Step 5: Query the System Tables (p. 16)
• Step 6: Cancel a Query (p. 18)
• Step 7: Clean Up Your Resources (p. 20)

This section describes the basic steps to begin using the Amazon Redshift database.

The examples in this section assume you have signed up for the Amazon Redshift data warehouse service, created a cluster, and established a connection to the cluster from your SQL query tool. For information about these tasks, see Amazon Redshift Getting Started.

Important
The cluster that you deployed for this exercise will be running in a live environment. As long as it is running, it will accrue charges to your AWS account. For more pricing information, go to the Amazon Redshift pricing page.
To avoid unnecessary charges, you should delete your cluster when you are done with it. The final step of the exercise explains how to do so.

Step 1: Create a Database

After you have verified that your cluster is up and running, you can create your first database. This database is where you will actually create tables, load data, and run queries. A single cluster can host multiple databases. For example, you can have a TICKIT database and an ORDERS database on the same cluster.

After you connect to the initial cluster database, the database you created when you launched the cluster, you use the initial database as the base for creating a new database.

For example, to create a database named tickit, issue the following command:

```sql
create database tickit;
```

For this exercise, we'll accept the defaults. For information about more command options, see CREATE DATABASE (p. 509) in the SQL Command Reference.

After you have created the TICKIT database, you can connect to the new database from your SQL client. Use the same connection parameters as you used for your current connection, but change the database name to tickit.

You do not need to change the database to complete the remainder of this tutorial. If you prefer not to connect to the TICKIT database, you can try the rest of the examples in this section using the default database.
Step 2: Create a Database User

By default, only the master user that you created when you launched the cluster has access to the initial database in the cluster. To grant other users access, you must create one or more user accounts. Database user accounts are global across all the databases in a cluster; they do not belong to individual databases.

Use the CREATE USER command to create a new database user. When you create a new user, you specify the name of the new user and a password. A password is required. It must have between 8 and 64 characters, and it must include at least one uppercase letter, one lowercase letter, and one numeral.

For example, to create a user named GUEST with password ABCd4321, issue the following command:

```sql
create user guest password 'ABCd4321';
```

For information about other command options, see CREATE USER (p. 557) in the SQL Command Reference.

Delete a Database User

You won't need the GUEST user account for this tutorial, so you can delete it. If you delete a database user account, the user will no longer be able to access any of the cluster databases.

Issue the following command to drop the GUEST user:

```sql
drop user guest;
```

The master user you created when you launched your cluster continues to have access to the database.

Important
Amazon Redshift strongly recommends that you do not delete the master user.

For information about command options, see DROP USER (p. 576) in the SQL Reference.

Step 3: Create a Database Table

After you create your new database, you create tables to hold your database data. You specify any column information for the table when you create the table.

For example, to create a table named testtable with a single column named testcol for an integer data type, issue the following command:

```sql
create table testtable (testcol int);
```

The PG_TABLE_DEF system table contains information about all the tables in the cluster. To verify the result, issue the following SELECT command to query the PG_TABLE_DEF system table.

```sql
select * from pg_table_def where tablename = 'testtable';
```

The query result should look something like this:

```
schemaname|tablename|column | type |encoding|distkey|sortkey | notnull
```

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By default, new database objects, such as tables, are created in a schema named "public". For more information about schemas, see Schemas (p. 357) in the Managing Database Security section.

The encoding, distkey, and sortkey columns are used by Amazon Redshift for parallel processing. For more information about designing tables that incorporate these elements, see Amazon Redshift Best Practices for Designing Tables (p. 21).

**Insert Data Rows into a Table**

After you create a table, you can insert rows of data into that table.

**Note**
The INSERT (p. 592) command inserts individual rows into a database table. For standard bulk loads, use the COPY (p. 450) command. For more information, see Use a COPY Command to Load Data (p. 25).

For example, to insert a value of 100 into the testtable table (which contains a single column), issue the following command:

```
insert into testtable values (100);
```

**Select Data from a Table**

After you create a table and populate it with data, use a SELECT statement to display the data contained in the table. The SELECT * statement returns all the column names and row values for all of the data in a table and is a good way to verify that recently added data was correctly inserted into the table.

To view the data that you entered in the testtable table, issue the following command:

```
select * from testtable;
```

The result will look like this:

```
testcol
---------
100
(1 row)
```

For more information about using the SELECT statement to query tables, see SELECT (p. 607) in the SQL Command Reference.

**Step 4: Load Sample Data**

Most of the examples in this guide use the TICKIT sample database. If you want to follow the examples using your SQL query tool, you will need to load the sample data for the TICKIT database.

The sample data for this tutorial is provided in Amazon S3 buckets that give read access to all authenticated AWS users, so any valid AWS credentials that permit access to Amazon S3 will work.
Step 5: Query the System Tables

In addition to the tables that you create, your database contains a number of system tables. These system tables contain information about your installation and about the various queries and processes that are running on the system. You can query these system tables to collect information about your database.

Note

The description for each table in the System Tables Reference indicates whether a table is visible to all users or visible only to superusers. You must be logged in as a superuser to query tables that are visible only to superusers.

Amazon Redshift provides access to the following types of system tables:

- **STL Tables for Logging (p. 915)**
  These system tables are generated from Amazon Redshift log files to provide a history of the system. Logging tables have an STL prefix.
- **STV Tables for Snapshot Data (p. 994)**
  These tables are virtual system tables that contain snapshots of the current system data. Snapshot tables have an STV prefix.
- **System Views (p. 1024)**
  System views contain a subset of data found in several of the STL and STV system tables. Systems views have an SVV or SVL prefix.
- **System Catalog Tables (p. 1087)**
  The system catalog tables store schema metadata, such as information about tables and columns. System catalog tables have a PG prefix.

You may need to specify the process ID associated with a query to retrieve system table information about that query. For information, see Determine the Process ID of a Running Query (p. 18).

View a List of Table Names

For example, to view a list of all tables in the public schema, you can query the PG_TABLE_DEF system catalog table.

```sql
select distinct(tablename) from pg_table_def where schemaname = 'public';
```

The result will look something like this:

```
tablename
--------
category
date
event
listing
sales
testtable
```
You can query the PG_USER catalog to view a list of all database users, along with the user ID (USESYSID) and user privileges.

```sql
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)
```

The user name `rdsdb` is used internally by Amazon Redshift to perform routine administrative and maintenance tasks. You can filter your query to show only user-defined user names by adding `where usesysid > 1` to your select statement.

```sql
select * from pg_user
where usesysid > 1;
usename  | usesysid | usecreatedb | usesuper | usecatupd |  passwd  | valuntil | useconfig
-----------------------------+----------+-------------+----------+-----------+----------+----------+-----------
     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         | ******** |          |
(5 rows)
```

View Recent Queries

In the previous example, you found that the user ID (USESYSID) for masteruser is 100. To list the five most recent queries executed by masteruser, you can query the SVL_QLOG view. The SVL_QLOG view is a friendlier subset of information from the STL_QUERY table. You can use this view to find the query ID (QUERY) or process ID (PID) for a recently run query or to see how long it took a query to complete. SVL_QLOG includes the first 60 characters of the query string (SUBSTRING) to help you locate a specific query. Use the LIMIT clause with your SELECT statement to limit the results to five rows.

```sql
select query, pid, elapsed, substring
from svl_qlog
where userid = 100
order by starttime desc
limit 5;
The result will look something like this:
```

| query   | pid | elapsed | substring |
|---------|-----|---------|-----------|-----------|

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Determine the Process ID of a Running Query

In the previous example you learned how to obtain the query ID and process ID (PID) for a completed query from the SVL_QLOG view.

You might need to find the PID for a query that is still running. For example, you will need the PID if you need to cancel a query that is taking too long to run. You can query the STV_RECENTS system table to obtain a list of process IDs for running queries, along with the corresponding query string. If your query returns multiple PIDs, you can look at the query text to determine which PID you need.

To determine the PID of a running query, issue the following SELECT statement:

```
select pid, user_name, starttime, query
from stv_recent
where status='Running';
```

Step 6: Cancel a Query

If a user issues a query that is taking too long or is consuming excessive cluster resources, you might need to cancel the query. For example, a user might want to create a list of ticket sellers that includes the seller's name and quantity of tickets sold. The following query selects data from the SALES table USERS table and joins the two tables by matching SELLERID and USERID in the WHERE clause.

```
select sellerid, firstname, lastname, sum(qtysold)
from sales, users
where sales.sellerid = users.userid
group by sellerid, firstname, lastname
order by 4 desc;
```

**Note**
This is a complex query. For this tutorial, you don't need to worry about how this query is constructed.

The previous query runs in seconds and returns 2,102 rows.

Suppose the user forgets to put in the WHERE clause.

```
select sellerid, firstname, lastname, sum(qtysold)
from sales, users
group by sellerid, firstname, lastname
order by 4 desc;
```

The result set will include all of the rows in the SALES table multiplied by all the rows in the USERS table (49989*3766). This is called a Cartesian join, and it is not recommended. The result is over 188 million rows and takes a long time to run.

To cancel a running query, use the CANCEL command with the query's PID.
To find the process ID, query the STV_RECENTS table, as shown in the previous step. The following example shows how you can make the results more readable by using the TRIM function to trim trailing spaces and by showing only the first 20 characters of the query string.

```
select pid, trim(user_name), starttime, substring(query,1,20)
from stv_recents
where status='Running';
```

The result looks something like this:

<table>
<thead>
<tr>
<th>pid</th>
<th>btrim</th>
<th>starttime</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>18764</td>
<td>masteruser</td>
<td>2013-03-28 18:39:49.355918</td>
<td>select sellerid, fir</td>
</tr>
</tbody>
</table>
(1 row)

To cancel the query with PID 18764, issue the following command:

```
cancel 18764;
```

**Note**
The CANCEL command will not abort a transaction. To abort or roll back a transaction, you must use the ABORT or ROLLBACK command. To cancel a query associated with a transaction, first cancel the query then abort the transaction.

If the query that you canceled is associated with a transaction, use the ABORT or ROLLBACK command to cancel the transaction and discard any changes made to the data:

```
abort;
```

Unless you are signed on as a superuser, you can cancel only your own queries. A superuser can cancel all queries.

### Cancel a Query from Another Session

If your query tool does not support running queries concurrently, you will need to start another session to cancel the query. For example, SQLWorkbench, which is the query tool we use in the Amazon Redshift Getting Started, does not support multiple concurrent queries. To start another session using SQLWorkbench, select File, New Window and connect using the same connection parameters. Then you can find the PID and cancel the query.

### Cancel a Query Using the Superuser Queue

If your current session has too many queries running concurrently, you might not be able to run the CANCEL command until another query finishes. In that case, you will need to issue the CANCEL command using a different workload management query queue.

Workload management enables you to execute queries in different query queues so that you don’t need to wait for another query to complete. The workload manager creates a separate queue, called the Superuser queue, that you can use for troubleshooting. To use the Superuser queue, you must be logged on a superuser and set the query group to ‘superuser’ using the SET command. After running your commands, reset the query group using the RESET command.

To cancel a query using the Superuser queue, issue these commands:

```
set query_group to 'superuser';
```
cancel 18764;
reset query_group;

For information about managing query queues, see Implementing Workload Management (p. 309).

**Step 7: Clean Up Your Resources**

If you deployed a cluster in order to complete this exercise, when you are finished with the exercise, you should delete the cluster so that it will stop accruing charges to your AWS account.

To delete the cluster, follow the steps in Deleting a Cluster in the Amazon Redshift Cluster Management Guide.

If you want to keep the cluster, you might want to keep the sample data for reference. Most of the examples in this guide use the tables you created in this exercise. The size of the data will not have any significant effect on your available storage.

If you want to keep the cluster, but want to clean up the sample data, you can run the following command to drop the TICKIT database:

```sql
drop database tickit;
```

If you didn't create a TICKIT database, or if you don't want to drop the database, run the following commands to drop just the tables:

```sql
drop table testtable;
drop table users;
drop table venue;
drop table category;
drop table date;
drop table event;
drop table listing;
drop table sales;
```
Amazon Redshift Best Practices

Following, you can find best practices for 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 Getting Started Using Databases (p. 13) 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. You should evaluate all of your options before finalizing a database design. For more information, see Designing Tables (p. 43), Loading Data (p. 98), Tuning Query Performance (p. 281), and the reference chapters.

Topics
- Amazon Redshift Best Practices for Designing Tables (p. 21)
- Amazon Redshift Best Practices for Loading Data (p. 24)
- Amazon Redshift Best Practices for Designing Queries (p. 27)
- Working with Recommendations from Amazon Redshift Advisor (p. 29)

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 presents best practices for optimizing query performance. Designing Tables (p. 43) provides more detailed explanations and examples of table design options.

Topics
- Take the Tuning Table Design Tutorial (p. 22)
- Choose the Best Sort Key (p. 22)
- Choose the Best Distribution Style (p. 22)
- Let COPY Choose Compression Encodings (p. 23)
- Define Primary Key and Foreign Key Constraints (p. 23)
- Use the Smallest Possible Column Size (p. 23)
Take the Tuning Table Design Tutorial

Tutorial: Tuning Table Design (p. 73) walks you step by step through the process of choosing sort keys, distribution styles, and compression encodings, and shows you how to compare system performance before and after tuning.

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.

- 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.

For more information about choosing and specifying sort keys, see Tutorial: Tuning Table Design (p. 73) and Choosing Sort Keys (p. 66).

Choose the Best Distribution Style

When you execute 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 executed.

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 need to 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 let Amazon Redshift choose the appropriate distribution style, don't specify DISTSTYLE.

For more information about choosing distribution styles, see Tutorial: Tuning Table Design (p. 73) and Choosing a Data Distribution Style (p. 55).

**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.

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 (p. 441) 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 Tutorial: Tuning Table Design (p. 73) and Loading Tables with Automatic Compression (p. 123).

**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 Defining Constraints (p. 71) 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 a VARCHAR column, for example, and size your columns accordingly. Because Amazon Redshift compresses column data very effectively, creating
columns much larger than necessary has minimal impact on the size of data tables. During processing for complex queries, however, intermediate query results might need to be stored in temporary tables. Because temporary tables are not compressed, unnecessarily large columns consume excessive memory and temporary disk space, which can affect query performance.

**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 (p. 380).

**Amazon Redshift Best Practices for Loading Data**

**Topics**
- Take the Loading Data Tutorial (p. 24)
- Take the Tuning Table Design Tutorial (p. 24)
- Use a COPY Command to Load Data (p. 25)
- Use a Single COPY Command to Load from Multiple Files (p. 25)
- Split Your Load Data into Multiple Files (p. 25)
- Compress Your Data Files (p. 25)
- Use a Manifest File (p. 25)
- Verify Data Files Before and After a Load (p. 25)
- Use a Multi-Row Insert (p. 26)
- Use a Bulk Insert (p. 26)
- Load Data in Sort Key Order (p. 26)
- Load Data in Sequential Blocks (p. 26)
- Use Time-Series Tables (p. 27)
- Use a Staging Table to Perform a Merge (Upsert) (p. 27)
- Schedule Around Maintenance Windows (p. 27)

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.

**Take the Loading Data Tutorial**

Tutorial: Loading Data from Amazon S3 (p. 156) 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.

**Take the Tuning Table Design Tutorial**

Data loads are heavily influenced by table design, especially compression encodings and distribution styles. Tutorial: Tuning Table Design (p. 73) walks you step-by-step through the process of choosing sort keys, distribution styles, and compression encodings, and shows you how to compare system performance before and after tuning.
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 (p. 101) and Loading Data from an Amazon DynamoDB Table (p. 120).

Use a Single COPY Command to Load from Multiple Files

Amazon Redshift automatically loads in parallel from multiple data files.

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 (p. 101).

Split Your Load Data into Multiple Files

The COPY command loads the data in parallel from multiple files, dividing the workload among the nodes in your cluster. When you load all the data from a single large file, Amazon Redshift is forced to perform a serialized load, which is much slower. Split your load data files so that the files are about equal size, between 1 MB and 1 GB after compression. For optimum parallelism, the ideal size is between 1 MB and 125 MB after compression. The number of files should be a multiple of the number of slices in your cluster. For more information about how to split your data into files and examples of using COPY to load data, see Loading Data from Amazon S3 (p. 101).

Compress Your Data Files

We strongly recommend that you individually compress your load files using gzip, lzop, bzip2, or Zstandard when you have large datasets.

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

<table>
<thead>
<tr>
<th>Command Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>copy time</td>
</tr>
<tr>
<td>from 's3://mybucket/data/timerows.lzo'</td>
</tr>
<tr>
<td>iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'</td>
</tr>
<tr>
<td>lzop</td>
</tr>
<tr>
<td>delimiter '|';</td>
</tr>
</tbody>
</table>

Use a Manifest File

Amazon S3 provides eventual consistency for some operations. Thus, it's possible that new data won't be available immediately after the upload, which can result in an incomplete data load or loading stale data. You can manage data consistency by using a manifest file to load data. For more information, see Managing Data Consistency (p. 103).

Verify Data Files Before and After a Load

When you load data from Amazon S3, first upload your files to your Amazon S3 bucket, then verify that the bucket contains all the correct files, and only those files. For more information, see Verifying That the Correct Files Are Present in Your Bucket (p. 105).
After the load operation is complete, query the STL_LOAD_COMMITS (p. 944) system table to verify that the expected files were loaded. For more information, see Verifying That the Data Was Loaded Correctly (p. 122).

**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.

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

See INSERT (p. 592) for more details and examples.

**Use a Bulk Insert**

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

Use the INSERT (p. 592) and CREATE TABLE AS (p. 550) 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.

```sql
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.

```sql
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 Loading Your Data in Sort Key Order (p. 149).

**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. 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 (p. 27).

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, simply 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 Loading Your Data in Sort Key Order (p. 149).

**Use a Staging Table to Perform a Merge (Upsert)**

You can efficiently update and insert new data by loading your data into a staging table first.

Amazon Redshift doesn't support a single *merge* statement (update or insert, also known as an *upsert*) to insert and update data from a single data source. However, you can effectively perform a merge operation. To do so, load your data into a staging table and then join the staging table with your target table for an UPDATE statement and an INSERT statement. For instructions, see Updating and Inserting New Data (p. 130).

**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 (p. 26) and Vacuuming Tables (p. 142).

**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 (p. 21).

• Avoid using `select *`. Include only the columns you specifically need.

• Use a `CASE Expression` (p. 734) 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 executed 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.

```sql
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` (p. 395) operators are preferable to `LIKE` (p. 400) operators. LIKE operators are still preferable to `SIMILAR TO` (p. 403) or `POSIX Operators` (p. 405).

• 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.

```sql
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.

```sql
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 (p. 580) 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.

```sql
GROUP BY a, b, c
ORDER BY a, b, c
```

Don't use the following approach.

```sql
GROUP BY b, c, a
ORDER BY a, b, c
```

---

**Working with 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**

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

- US East (N. Virginia) Region (us-east-1)
- US West (N. California) Region (us-west-1)
- US West (Oregon) Region (us-west-2)
- 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)
Topics

- Viewing Amazon Redshift Advisor Recommendations on the Console (p. 30)
- Amazon Redshift Advisor Recommendations (p. 31)

Viewing Amazon Redshift Advisor Recommendations on the Console

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

**Note**
A new console is available for Amazon Redshift. Choose either the New Console or the Original Console instructions based on the console that you are using. The New Console instructions are open by default.

**New Console**

**To view Amazon Redshift Advisor recommendations on the console**

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

**Original Console**

**To view Amazon Redshift Advisor recommendations on the console**

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshift/.
2. In the navigation pane, choose **Advisor**.
3. Choose the cluster that you want to get recommendations for.
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 Table Data (p. 31)
- Compress Amazon S3 File Objects Loaded by COPY (p. 33)
- Isolate Multiple Active Databases (p. 33)
- Reallocate Workload Management (WLM) Memory (p. 34)
- Skip Compression Analysis During COPY (p. 35)
- Split Amazon S3 Objects Loaded by COPY (p. 36)
- Update Table Statistics (p. 37)
- Enable Short Query Acceleration (p. 39)
- Replace Single-Column Interleaved Sort Keys (p. 39)
- Alter Distribution Keys on Tables (p. 40)

Compress Table Data

Amazon Redshift is optimized to reduce your storage footprint and improve query performance by using compression encodings. When you don't use compression, data consumes additional space and requires additional disk I/O. Applying compression to large uncompressed columns can have a big impact on your cluster.

Analysis

The compression analysis in Advisor tracks uncompressed storage allocated to permanent user tables. It reviews storage metadata associated with large uncompressed columns that aren't sort key columns. Advisor offers a recommendation to rebuild tables with uncompressed columns when the total amount of uncompressed storage exceeds 15 percent of total storage space, or at the following node-specific thresholds.
# Advisor Recommendations

## Cluster Size

<table>
<thead>
<tr>
<th>Cluster Size</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC2.LARGE</td>
<td>480 GB</td>
</tr>
<tr>
<td>DC2.8XLARGE</td>
<td>2.56 TB</td>
</tr>
<tr>
<td>DS2.XLARGE</td>
<td>4 TB</td>
</tr>
<tr>
<td>DS2.8XLARGE</td>
<td>16 TB</td>
</tr>
</tbody>
</table>

## Recommendation

Addressing uncompressed storage for a single table is a one-time optimization that requires the table to be rebuilt. We recommend that you rebuild any tables that contain uncompressed columns that are both large and frequently accessed. To identify which tables contain the most uncompressed storage, run the following SQL command as a superuser.

```sql
SELECT ti.schema||'.'||ti."table" tablename,
       raw_size.size uncompressed_mb,
       ti.size total_mb
FROM svv_table_info ti
LEFT JOIN (SELECT tbl table_id, COUNT(*) size
            FROM stv_blocklist
            WHERE (tbl,col) IN (
              SELECT attrelid, attnum-1
              FROM pg_attribute
              WHERE attencodingtype IN (0,128)
              AND attnum>0 AND attsortkeyord != 1)
            GROUP BY tbl) raw_size USING (table_id)
WHERE raw_size.size IS NOT NULL
ORDER BY raw_size.size DESC;
```

The data returned in the `uncompressed_mb` column represents the total number of uncompressed 1-MB blocks for all columns in the table.

When you rebuild the tables, use the `ENCODE` parameter to explicitly set column compression.

## Implementation Tips

- Leave any columns that are the first column in a compound sort key uncompressed. The Advisor analysis doesn’t count the storage consumed by those columns.
- Compressing large columns has a higher impact on performance and storage than compressing small columns.
- If you are unsure which compression is best, use the `ANALYZE COMPRESSION` (p. 441) command to suggest a compression.
- To generate the data definition language (DDL) statements for existing tables, you can use the AWS Generate Table DDL utility, found on GitHub.
- To simplify the compression suggestions and the process of rebuilding tables, you can use the Amazon Redshift Column Encoding Utility, found on GitHub.
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 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 S3.

Recommendation

Ensure that each COPY that loads a significant amount of data, or runs for a significant duration, ingests compressed data objects from S3. You can identify the COPY commands that load large uncompressed datasets from 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 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 enables 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.

```sql
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 (p. 316) 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 utilized. To identify these queues, you can compare the peak hourly slot requirements for each queue by running the following SQL command as a superuser.

```sql
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 Cluster 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 is 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 permanently skip this phase 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.
- Disable 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 AWS `ColumnEncodingUtility`, found on GitHub.

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

```sql
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, disable 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 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 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 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.

```sql
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(*)::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 Cluster 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 Splitting Your Data into Multiple Files (p. 101).
- 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. For optimum parallelism, the ideal size is between 1 MB and 125 MB 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 (p. 137).

Enable Short Query Acceleration

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. 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 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 Working with Short Query Acceleration (p. 338).

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 enable 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 enable SQA, WLM sets the maximum run time for short queries to dynamic by default. We recommend keeping the dynamic setting for SQA maximum run time.

Implementation Tips

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

```sql
select * from stv_wlm_service_class_config
where service_class = 14;
```

For more information, see Monitoring SQA (p. 339).

Replace Single-Column Interleaved Sort Keys

Some tables use an interleaved sort key on a single column. In general, such a table is less efficient and consumes more resources than a table that uses a compound sort key on a single column.

Interleaved sorting improves performance in certain cases where multiple columns are used by different queries for filtering. Using an interleaved sort key on a single column is effective only in a particular case. That case is when queries often filter on CHAR or VARCHAR column values that have a long common prefix in the first 8 bytes. For example, URL strings are often prefixed with "https://". For single-column keys, a compound sort is better than an interleaved sort for any other filtering operations. A
compound sort speeds up joins, GROUP BY and ORDER BY operations, and window functions that use PARTITION BY and ORDER BY on the sorted column. An interleaved sort doesn't benefit any of those operations. For more information, see Choosing Sort Keys (p. 66).

Using compound sort 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.

**Analysis**

Advisor tracks tables that use an interleaved sort key on a single column.

**Recommendation**

If a table uses interleaved sorting on a single column, recreate the table to use a compound sort key.

When you create new tables, use a compound sort key for single-column sorts. To find interleaved tables that use a single-column sort key, run the following command.

```sql
SELECT schema AS schemaname, "table" AS tablename
FROM svv_table_info
WHERE table_id IN (
    SELECT attrelid
    FROM pg_attribute
    WHERE attrelid IN (
        SELECT attrelid
        FROM pg_attribute
        WHERE attsortkeyord <> 0
        GROUP BY attrelid
        HAVING MAX(attsortkeyord) = -1
    )
    AND NOT (atttypid IN (1042, 1043) AND atttypmod > 12)
    AND attsortkeyord = -1);
```

For additional information about choosing the best sort style, see the AWS Big Data Blog post Amazon Redshift Engineering's Advanced Table Design Playbook: Compound and Interleaved Sort Keys.

**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 (p. 421) statements that alter the DISTSTYLE and DISTKEY of a table based on its analysis. To realize a significant performance benefit, all SQL statements within a recommendation group must be implemented.

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. More details on optimizing table distribution properties can be found in the Amazon Redshift Engineering's Advanced Table Design Playbook: Distribution Styles and Distribution Keys.

For more information about ALTER DISTSYLE and DISTKEY, see ALTER TABLE (p. 421).

**Note**

- The absence of recommendations does not necessarily imply that the current distribution styles are the most appropriate. Instead, Advisor refrains from recommendations when there is not 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 still 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.
Tutorials for Amazon Redshift

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

• Tutorial: Tuning Table Design (p. 73)
• Tutorial: Loading Data from Amazon S3 (p. 156)
• Tutorial: Querying Nested Data with Amazon Redshift Spectrum (p. 272)
• Tutorial: Configuring Manual Workload Management (WLM) Queues (p. 322)
Designing Tables

Topics

- Choosing a Column Compression Type (p. 43)
- Choosing a Data Distribution Style (p. 55)
- Choosing Sort Keys (p. 66)
- Defining Constraints (p. 71)
- Analyzing Table Design (p. 72)
- Tutorial: Tuning Table Design (p. 73)

A data warehouse system has very different design goals compared to a typical transaction-oriented relational database system. An online transaction processing (OLTP) application is focused primarily on single row transactions, inserts, and updates. Amazon Redshift is optimized for very fast execution of complex analytic queries against very large data sets. Because of the massive amount of data involved in data warehousing, you must specifically design your database to take full advantage of every available performance optimization.

This section explains how to choose and implement compression encodings, data distribution keys, sort keys, and table constraints, and it presents best practices for making these design decisions.

Choosing a Column Compression Type

Topics

- Compression Encodings (p. 44)
- Testing Compression Encodings (p. 51)
- Example: Choosing Compression Encodings for the CUSTOMER Table (p. 53)

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.

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 details about applying automatic compression, see Loading Tables with Automatic Compression (p. 123).

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 if in testing you discover that the compression encodings that are 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 (p. 441) 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:

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

Where 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).

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

You cannot change the compression encoding for a column after the table is created. 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
```

**Compression Encodings**

**Topics**
- Raw Encoding (p. 45)
- AZ64 Encoding (p. 45)
- Byte-Dictionary Encoding (p. 46)
- Delta Encoding (p. 47)
- LZO Encoding (p. 48)
- Mostly Encoding (p. 48)
- Runlength Encoding (p. 49)
- Text255 and Text32k Encodings (p. 50)
- Zstandard Encoding (p. 50)

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

If no compression is specified in a CREATE TABLE or ALTER TABLE statement, 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 data types are assigned AZ64 compression.
- Columns that are defined as CHAR or VARCHAR data types are assigned LZO compression.

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

<table>
<thead>
<tr>
<th>Encoding type</th>
<th>Keyword in CREATE TABLE and ALTER TABLE</th>
<th>Data types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw (no compression)</td>
<td>RAW</td>
<td>All</td>
</tr>
<tr>
<td>AZ64</td>
<td>AZ64</td>
<td>SMALLINT, INTEGER, BIGINT, DECIMAL, DATE, TIMESTAMP, TIMESTAMPTZ</td>
</tr>
<tr>
<td>Encoding type</td>
<td>Keyword in CREATE TABLE and ALTER TABLE</td>
<td>Data types</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Byte dictionary</td>
<td>BYTEDICT</td>
<td>SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ</td>
</tr>
<tr>
<td>Delta</td>
<td>DELTA</td>
<td>SMALLINT, INT, BIGINT, DATE, TIMESTAMP, DECIMAL</td>
</tr>
<tr>
<td>Delta</td>
<td>DELTA32K</td>
<td>INT, BIGINT, DATE, TIMESTAMP, DECIMAL</td>
</tr>
<tr>
<td>LZO</td>
<td>LZO</td>
<td>SMALLINT, INTEGER, BIGINT, DECIMAL, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ</td>
</tr>
<tr>
<td>Mostly</td>
<td>MOSTLY8</td>
<td>SMALLINT, INT, BIGINT, DECIMAL</td>
</tr>
<tr>
<td>Mostly</td>
<td>MOSTLY16</td>
<td>INT, BIGINT, DECIMAL</td>
</tr>
<tr>
<td>Mostly</td>
<td>MOSTLY32</td>
<td>BIGINT, DECIMAL</td>
</tr>
<tr>
<td>Run-length</td>
<td>RUNLENGTH</td>
<td>SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ</td>
</tr>
<tr>
<td>Text</td>
<td>TEXT255</td>
<td>VARCHAR only</td>
</tr>
<tr>
<td>Text</td>
<td>TEXT32K</td>
<td>VARCHAR only</td>
</tr>
<tr>
<td>Zstandard</td>
<td>ZSTD</td>
<td>SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, TIMESTAMP, TIMESTAMPTZ</td>
</tr>
</tbody>
</table>

**Raw Encoding**

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 Encoding**

AZ64 is Amazon's proprietary compression encoding algorithm designed 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 Encoding**

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 when a column contains a limited number of unique values. This encoding is optimal when the data domain of a column is fewer than 256 unique values. Byte-dictionary encoding is especially space-efficient if a CHAR column holds long character strings.

**Note**

Byte-dictionary encoding is not always effective when used with VARCHAR columns. Using BYTEDICT with large VARCHAR columns might cause excessive disk usage. We strongly recommend using a different encoding, such as LZO, for VARCHAR columns.

Suppose 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:

<table>
<thead>
<tr>
<th>Unique data value</th>
<th>Dictionary index</th>
<th>Size (fixed length, 30 bytes per value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>United States of America</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Venezuela</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Argentina</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Japan</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>180</td>
</tr>
</tbody>
</table>

The following table represents the values in the COUNTRY column:

<table>
<thead>
<tr>
<th>Original data value</th>
<th>Original size (fixed length, 30 bytes per value)</th>
<th>Compressed value (index)</th>
<th>New size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>30</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
## Compression Encodings

<table>
<thead>
<tr>
<th>Original data value</th>
<th>Original size (fixed length, 30 bytes per value)</th>
<th>Compressed value (index)</th>
<th>New size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>30</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>United States of America</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>United States of America</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Venezuela</td>
<td>30</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>30</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Argentina</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>30</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>30</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Argentina</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>300</strong></td>
<td></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

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 Encoding

Delta encodings are very useful for datetime 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, if the column contains 10 integers in sequence from 1 to 10, the first will be stored as a 4-byte integer (plus a 1-byte flag), and the next 9 will each be 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:
<table>
<thead>
<tr>
<th>Original data value</th>
<th>Original size (bytes)</th>
<th>Difference (delta)</th>
<th>Compressed value</th>
<th>Compressed size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1+4 (flag + actual value)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>4</td>
<td>45</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>200</td>
<td>4</td>
<td>150</td>
<td>150</td>
<td>1+4 (flag + actual value)</td>
</tr>
<tr>
<td>185</td>
<td>4</td>
<td>-15</td>
<td>-15</td>
<td>1</td>
</tr>
<tr>
<td>220</td>
<td>4</td>
<td>35</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>221</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>28</td>
<td></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

**LZO Encoding**

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, especially free form text, such as product descriptions, user comments, or JSON strings.

**Mostly Encoding**

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 cannot be compressed. Before applying one of these encodings to a column, check that most of the values that you are going to load now (and are likely to load in the future) fit into the ranges shown in the following table.
### Compression Encodings

| 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                                                                 |
| 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, re-creating 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, you would have to run some 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:

<table>
<thead>
<tr>
<th>Original value</th>
<th>Original INT or BIGINT size (bytes)</th>
<th>MOSTLY8 compressed size (bytes)</th>
<th>MOSTLY16 compressed size (bytes)</th>
<th>MOSTLY32 compressed size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>1000</td>
<td>4</td>
<td>Same as raw data size</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>10000</td>
<td>4</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>20000</td>
<td>4</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>40000</td>
<td>8</td>
<td></td>
<td>Same as raw data size</td>
<td>4</td>
</tr>
<tr>
<td>100000</td>
<td>8</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>200000000000</td>
<td>8</td>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

**Runlength Encoding**

Runlength 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, if 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 do not recommend applying runlength 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 runlength encoding works:

<table>
<thead>
<tr>
<th>Original data value</th>
<th>Original size (bytes)</th>
<th>Compressed value (token)</th>
<th>Compressed size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>4</td>
<td>{2,Blue}</td>
<td>5</td>
</tr>
<tr>
<td>Blue</td>
<td>4</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>{3,Green}</td>
<td>6</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Blue</td>
<td>4</td>
<td>{1,Blue}</td>
<td>5</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td>{4,Yellow}</td>
<td>7</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

**Text255 and Text32k Encodings**

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 will yield 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 will benefit from compression because every time those words appear, they will occupy only 1 byte of storage (instead of 5, 6, or 7 bytes, respectively).

**Zstandard Encoding**

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 (p. 47) encoding or Mostly (p. 48) encoding, can potentially use more storage space than no compression, ZSTD is very unlikely to increase disk usage.

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

### 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. Alternatively, you can use the ANALYZE COMPRESSION (p. 441) command to view the suggested encodings for existing data. For details about applying automatic compression, see Loading Tables with Automatic Compression (p. 123).

To perform a meaningful test of data compression, you need a large number of rows. For this example, we will create a table and insert rows by using a statement that selects from two tables; VENUE and LISTING. We will 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, but for this purpose, it is a convenient method of creating a lot of 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 with a different compression encoding: raw, bytedict, lzo, runlength, text255, text32k, and zstd. We populate each column with exactly the same data by executing an INSERT command that selects the data from the first table.

To test compression encodings:

1. (Optional) First, we’ll 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.

```sql
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.

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

```sql
select count(*) from encodingvenue
```

```
38884394
```

5. Query the **STV_BLOCKLIST (p. 996)** 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.

```sql
select col, max(blocknum)
from stv_blocklist b, stv_tbl_perm p
where (b.tbl=p.id) and name='encodingvenue'
and col < 7
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, with a compression ratio of better than 20:1. LZO and ZSTD encoding also produced excellent results. Different data sets will 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
```

If you have data in an existing table, you can use the **ANALYZE COMPRESSION (p. 441)** 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.

```sql
analyze compression cartesian_venue;
```
Example: Choosing Compression Encodings for the CUSTOMER Table

The following statement 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.

```sql
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:

<table>
<thead>
<tr>
<th>Column</th>
<th>Data Type</th>
<th>Encoding</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUSTKEY</td>
<td>int</td>
<td>delta</td>
<td>CUSTKEY consists of unique, consecutive integer values. Since the differences will be one byte, DELTA is a good choice.</td>
</tr>
<tr>
<td>CUSTNAME</td>
<td>varchar(30)</td>
<td>raw</td>
<td>CUSTNAME has a large domain with few repeated values. Any compression encoding would probably be ineffective.</td>
</tr>
<tr>
<td>GENDER</td>
<td>varchar(7)</td>
<td>text255</td>
<td>GENDER is very small domain with many repeated values. Text255 works well with VARCHAR columns in which the same words recur.</td>
</tr>
<tr>
<td>ADDRESS</td>
<td>varchar(200)</td>
<td>text255</td>
<td>ADDRESS is a large domain, but contains many repeated words, such as Street Avenue, North, South, and</td>
</tr>
</tbody>
</table>
### Example: Choosing Compression Encodings for the CUSTOMER Table

<table>
<thead>
<tr>
<th>Column</th>
<th>Data Type</th>
<th>Encoding</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>CITY</td>
<td>varchar(30)</td>
<td>text255</td>
<td>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.</td>
</tr>
<tr>
<td>STATE</td>
<td>char(2)</td>
<td>raw</td>
<td>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, compression might not be worth the overhead of uncompressing the data.</td>
</tr>
<tr>
<td>ZIPCODE</td>
<td>char(5)</td>
<td>bytedict</td>
<td>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.</td>
</tr>
<tr>
<td>START_DATE</td>
<td>date</td>
<td>delta32k</td>
<td>Delta encodings are very useful for datetime columns, especially if the rows are loaded in date order.</td>
</tr>
</tbody>
</table>
Choosing a Data Distribution Style

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 redistribute 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 executed.

This section will introduce you to the principles of data distribution in an Amazon Redshift database and give you a methodology to choose the best distribution style for each of your tables.

Data Distribution Concepts

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 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. For example, each DS1.XL compute node has two slices, and each DS1.8XL compute node has 16 slices. The nodes all participate in parallel query execution, 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, go to About Clusters and Nodes in the Amazon Redshift Cluster 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 need to be located to best execute the query. The data is then physically moved, or redistributed, during execution. 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 during query execution. If the rows that participate in joins or aggregates are already collocated on the nodes with their joining rows in other tables, the optimizer does not need to redistribute as much data during query execution.

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 four 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, Amazon Redshift initially assigns ALL distribution to a small table, then changes to EVEN distribution when the table grows larger. When a table is changed from ALL to EVEN distribution, storage utilization might change slightly. The change in distribution occurs in the background, in a few seconds. To view the distribution style applied to a table, query the PG_CLASS_INFO system catalog view. For more information, see Viewing Distribution Styles (p. 57). 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 does not participate in joins or when there is not 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 so that 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 do not 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 (p. 421). 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 (p. 135)

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 or 11, which indicates whether the effective distribution style is AUTO (ALL) or AUTO (EVEN). If the table uses automatic distribution, the distribution style might initially show AUTO (ALL), then change to AUTO (EVEN) when the table grows.

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

<table>
<thead>
<tr>
<th>RELEFFECTIVEDISTSTYLE</th>
<th>Current Distribution style</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EVEN</td>
</tr>
<tr>
<td>1</td>
<td>KEY</td>
</tr>
<tr>
<td>8</td>
<td>ALL</td>
</tr>
<tr>
<td>10</td>
<td>AUTO (ALL)</td>
</tr>
<tr>
<td>11</td>
<td>AUTO (EVEN)</td>
</tr>
</tbody>
</table>

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) or AUTO (EVEN).

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

```sql
create table dist_key (col1 int)
diststyle key distkey (col1);
create table dist_even (col1 int)
diststyle even;
create table dist_all (col1 int)
diststyle all;
create table dist_auto (col1 int);
select "schema", "table", diststyle from SVV_TABLE_INFO
where "table" like 'dist%';
```

<table>
<thead>
<tr>
<th>schema</th>
<th>table</th>
<th>diststyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>dist_key</td>
<td>KEY(col1)</td>
</tr>
<tr>
<td>public</td>
<td>dist_even</td>
<td>EVEN</td>
</tr>
<tr>
<td>public</td>
<td>dist_all</td>
<td>ALL</td>
</tr>
<tr>
<td>public</td>
<td>dist_auto</td>
<td>AUTO(ALL)</td>
</tr>
</tbody>
</table>
Evaluating Query Patterns

Choosing distribution styles is just one aspect of database design. You should consider distribution styles only 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.

In order to make good choices for distribution styles, you need to 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 are how long the query takes to execute, how much computing resources it consumes, how often it is executed, 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 execution. 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, load them with data that is as close as possible to real data, and 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 execution times in order 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 just the size of the table. The size of the table, if it 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 will also be collocated with the fact table. Your fact table can have only one distribution key. Any tables that join on another key will not be 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 EVEN 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 EVEN distribution.

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

You cannot change the distribution style of a table after it is created. To use a different distribution style, you can recreate the table and populate the new table with a deep copy. For more information, see Performing a Deep Copy (p. 135).

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 execute; specifically, queries that use joins and aggregations. Compare execution times for various design options. When you compare execution times, do not count the first time the query is executed, because the first run time includes the compilation time.

**DS_DIST_NONE**

No redistribution is required, because corresponding slices are collocated on the compute nodes. You will 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_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 will probably have 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**. If distributing the inner table on the join key is not possible because the outer table is
not distributed on the join key, evaluate whether to use ALL distribution for the inner table. If the table is relatively slow moving, that is, it is not updated frequently or extensively, and it is 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 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 execution of the join on a single node instead taking advantage of parallel execution 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, you should evaluate whether changing the distribution key to collocate this join will improve overall performance. If changing the distribution key of the outer table is not 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.

```
<table>
<thead>
<tr>
<th>Plan Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>-&gt; XN Hash Join DS_BCAST_INNER (cost=112.50..3272334142.59 rows=170771 width=84)</td>
</tr>
<tr>
<td>Hash Cond: (&quot;outer&quot;.venueid = &quot;inner&quot;.venueid)</td>
</tr>
<tr>
<td>-&gt; XN Hash Join DS_BCAST_INNER (cost=109.98..3167290276.71 rows=172456 width=47)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
```

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.

```
<table>
<thead>
<tr>
<th>Plan Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>-&gt; XN Hash Join DS_DIST_ALL_NONE (cost=112.50..14142.59 rows=170771 width=84)</td>
</tr>
<tr>
<td>Hash Cond: (&quot;outer&quot;.venueid = &quot;inner&quot;.venueid)</td>
</tr>
<tr>
<td>-&gt; XN Hash Join DS_DIST_ALL_NONE (cost=109.98..10276.71 rows=172456 width=47)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
```

**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 LISTID.

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,
qtsold 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 need to 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
  Hash Cond: ("outer".buyerid = "inner".userid)
- XN Hash Join DS_BCAST_INNER
  Hash Cond: ("outer".venueid = "inner".venueid)
- XN Hash Join DS_BCAST_INNER
  Hash Cond: ("outer".eventid = "inner".eventid)
- XN Merge Join DS_DIST_NONE

One solution is to recreate the tables with DISTSTYLE ALL. You cannot change a table's distribution style after it is created. To recreate tables with a different distribution style, use a deep copy.

First, rename the tables.

```
alter table users rename to userscopy;
alter table venue rename to venuecopy;
alter table category rename to categorycopy;
alter table date rename to datecopy;
alter table event rename to eventcopy;
```

Run the following script to recreate USERS, VENUE, CATEGORY, DATE, EVENT. Don't make any changes to SALES and LISTING.

```
create table users(
  userid integer not null sortkey,
  username char(8),
  firstname varchar(30),
  lastname varchar(30),
  city varchar(30),
  state char(2),
  email varchar(100),
  phone char(14),
  likesports boolean,
  liketheatre boolean,
```
likeconcerts boolean,
likejazz boolean,
likeclassical boolean,
likeopera boolean,
likerock boolean,
likevegas boolean,
likebroadway boolean,
likemusicals boolean,
primary key(userid)) diststyle all;

create table venue(
venueid smallint not null sortkey,
venuename varchar(100),
venuename varchar(30),
venuestate char(2),
venueseats integer,
primary key(venueid)) diststyle all;

create table category(
catid smallint not null,
catgroup varchar(10),
catname varchar(10),
catdesc varchar(50),
primary key(catid)) diststyle all;

create table date(
dateid smallint not null sortkey,
caldate date not null,
day character(3) not null,
week smallint not null,
month character(5) not null,
qtr character(5) not null,
year smallint not null,
holiday boolean default('N'),
primary key(dateid)) diststyle all;

create table event(
eventid integer not null sortkey,
venueid smallint not null,
catid smallint not null,
dateid smallint not null,
eventname varchar(200),
starttime timestamp,
primary key(eventid),
foreign key(venueid) references venue(venueid),
foreign key(catid) references category(catid),
foreign key(dateid) references date(dateid)) diststyle all;

Insert the data back into the tables and run an ANALYZE command to update the statistics.

insert into users select * from userscopy;
insert into venue select * from venuecopy;
insert into category select * from categorycopy;
insert into date select * from datecopy;
insert into event select * from eventcopy;
analyze;

Finally, drop the copies.

drop table userscopy;
drop table venuecopy;
drop table categorycopy;
drop table datecopy;
drop table eventcopy;

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)
  Send to leader
    -> XN Sort  (cost=1000000047117.54..1000000047544.46 rows=170766 width=97)
      Sort Key: category.catname, sum(sales.pricepaid)
       -> XN HashJoin  (cost=117.20..21831.99 rows=170766 width=97)
         Hash Cond: ("outer".buyerid = "inner".userid)
        -> XN Hash Join DS_DIST_ALL_NONE  (cost=117.20..21831.99 rows=170771 width=97)
         Hash Cond: ("outer".catid = "inner".catid)
          -> XN Hash Join DS_DIST_ALL_NONE  (cost=112.64..17985.08 rows=170771)
          Hash Cond: ("outer".dateid = "inner".dateid)
            -> 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=112.50..14142.59 rows=170771 width=84)
              Hash Cond: ("outer".eventid = "inner".eventid)
                -> XN MergeJoin  (cost=0.00..6286.47 rows=172456 width=30)
                  Merge Cond: ("outer".listid = "inner".listid)
                -> XN MergeJoin  (cost=0.00..1924.97 rows=192497 width=14)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on listing
                -> XN MergeJoin  (cost=0.00..1724.56 rows=172456 width=24)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on sales
                -> XN MergeJoin  (cost=0.00..87.98 rows=8798 width=25)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on event
                -> XN MergeJoin  (cost=0.00..87.98 rows=8798 width=25)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on venue
                -> XN MergeJoin  (cost=0.00..202 rows=202 width=11)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on users
                -> XN MergeJoin  (cost=0.00..202 rows=202 width=11)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on users
                -> XN MergeJoin  (cost=0.00..202 rows=202 width=11)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on users
                -> XN MergeJoin  (cost=0.00..202 rows=202 width=11)
                  Merge Cond: ("outer".listid = "inner".listid)
                  -> XN Seq Scan on users
```

**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';
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>none</td>
<td>t</td>
<td>1</td>
</tr>
<tr>
<td>username</td>
<td>character(8)</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>firstname</td>
<td>character varying(30)</td>
<td>text32k</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>slice</th>
<th>col</th>
<th>rows</th>
<th>minvalue</th>
<th>maxvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>12496</td>
<td>4</td>
<td>49987</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>12498</td>
<td>1</td>
<td>49988</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>12497</td>
<td>2</td>
<td>49989</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>12499</td>
<td>3</td>
<td>49990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4 rows)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 will participate in executing 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 examples shows that if you create a new table with the same data as the USERS table, but you set the DISTKEY to the STATE column, the distribution will not be as even. Slice 0 (13,587 rows) holds approximately 30% more rows than slice 3 (10,150 rows). In a much larger table, this amount of distribution skew could 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;
```

<table>
<thead>
<tr>
<th>slice</th>
<th>col</th>
<th>rows</th>
<th>minvalue</th>
<th>maxvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>13587</td>
<td>5</td>
<td>49989</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>11245</td>
<td>2</td>
<td>49990</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>15008</td>
<td>1</td>
<td>49976</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>10150</td>
<td>4</td>
<td>49986</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4 rows)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Choosing Sort Keys

When you create a table, you can 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.

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 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, if a table stores five years of data sorted...
by date and a query specifies a date range of one month, up to 98 percent of the disk blocks can be
eliminated 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. For examples of using compound sort keys and interleaved sort
keys, see Comparing Sort Styles (p. 68).

To understand the impact of the chosen sort key on query performance, use the EXPLAIN (p. 580)
command. For more information, see Query Planning and Execution Workflow (p. 281).

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. An INTERLEAVED sort key can use a maximum
of eight columns.

To view the sort keys for a table, query the SVV_TABLE_INFO (p. 1076) system view.

Topics
- Compound Sort Key (p. 67)
- Interleaved Sort Key (p. 67)
- Comparing Sort Styles (p. 68)

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. You should run a VACUUM operation regularly, especially after large data loads, to re-sort and
re-analyze the data. For more information, see Managing the Size of the Unsorted Region (p. 145).
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 (p. 137).

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, so an interleaved sort is most effective when a table is large enough to require multiple 1 MB blocks per slice and the query processor is able to 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.

**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 needs to 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 [Deciding Whether to Reindex (p. 145)](#).

### Comparing Sort Styles

This section compares the performance differences when using a single-column sort key, a compound sort key, and an interleaved sort key for different types of queries.

For this example, you'll create a denormalized table named `CUST_SALES`, using data from the `CUSTOMER` and `LINEORDER` tables. `CUSTOMER` and `LINEORDER` are part of the SSB dataset, which is used in the [Tutorial: Tuning Table Design (p. 73)](#).

The new `CUST_SALES` table has 480 million rows, which is not large by Amazon Redshift standards, but it is large enough to show the performance differences. Larger tables will tend to show greater differences, especially for interleaved sorting.

To compare the three sort methods, perform the following steps:

1. Create the SSB dataset.
2. Create the `CUST_SALES_DATE` table.
3. Create three tables to compare sort styles.
4. Execute queries and compare the results.
Create the SSB Dataset

If you haven't already done so, follow the steps in Step 1: Create a Test Data Set (p. 74) in the Tuning Table Design tutorial to create the tables in the SSB dataset and load them with data. The data load will take about 10 to 15 minutes.

The example in the Tuning Table Design tutorial uses a four-node cluster. The comparisons in this example use a two-node cluster. Your results will vary with different cluster configurations.

Create the CUST_SALES_DATE Table

The CUST_SALES_DATE table is a denormalized table that contains data about customers and revenues. To create the CUST_SALES_DATE table, execute the following statement.

```sql
create table cust_sales_date as
(select c_custkey, c_nation, c_region, c_mktsegment, d_date::date, lo_revenue
from customer, lineorder, dwdate
where lo_custkey = c_custkey
and lo_orderdate = dwdate.d_datekey
and lo_revenue > 0);
```

The following query shows the row count for CUST_SALES.

```sql
select count(*) from cust_sales_date;

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>480027069</td>
</tr>
</tbody>
</table>
```

Execute the following query to view the first row of the CUST_SALES table.

```sql
select * from cust_sales_date limit 1;

<table>
<thead>
<tr>
<th>c_custkey</th>
<th>c_nation</th>
<th>c_region</th>
<th>c_mktsegment</th>
<th>d_date</th>
<th>lo_revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOROCCO</td>
<td>AFRICA</td>
<td>BUILDING</td>
<td>1994-10-28</td>
<td>1924330</td>
</tr>
</tbody>
</table>
```

Create Tables for Comparing Sort Styles

To compare the sort styles, create three tables. The first will use a single-column sort key; the second will use a compound sort key; the third will use an interleaved sort key. The single-column sort will use the `c_custkey` column. The compound sort and the interleaved sort will both use the `c_custkey`, `c_region`, `c_mktsegment`, and `d_date` columns.

To create the tables for comparison, execute the following CREATE TABLE statements.

```sql
create table cust_sales_date_single
sortkey (c_custkey)
as select * from cust_sales_date;

create table cust_sales_date_compound
compound sortkey (c_custkey, c_region, c_mktsegment, d_date)
as select * from cust_sales_date;

create table cust_sales_date_interleaved
interleaved sortkey (c_custkey, c_region, c_mktsegment, d_date)
as select * from cust_sales_date;
```
Execute Queries and Compare the Results

Execute the same queries against each of the tables to compare execution times for each table. To eliminate differences due to compile time, run each of the queries twice, and record the second time.

1. Test a query that restricts on the \texttt{c\_custkey} column, which is the first column in the sort key for each table. Execute the following queries.

```sql
-- Query 1
select max(lo_revenue), min(lo_revenue)
from cust_sales_date_single
where c_custkey < 100000;

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_compound
where c_custkey < 100000;

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_interleaved
where c_custkey < 100000;
```

2. Test a query that restricts on the \texttt{c\_region} column, which is the second column in the sort key for the compound and interleaved keys. Execute the following queries.

```sql
-- Query 2
select max(lo_revenue), min(lo_revenue)
from cust_sales_date_single
where c_region = 'ASIA'
and c_mktsegment = 'FURNITURE';

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_compound
where c_region = 'ASIA'
and c_mktsegment = 'FURNITURE';

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_interleaved
where c_region = 'ASIA'
and c_mktsegment = 'FURNITURE';
```

3. Test a query that restricts on both the \texttt{c\_region} column and the \texttt{c\_mktsegment} column. Execute the following queries.

```sql
-- Query 3
select max(lo_revenue), min(lo_revenue)
from cust_sales_date_single
where d_date between '01/01/1996' and '01/14/1996'
and c_mktsegment = 'FURNITURE'
and c_region = 'ASIA';

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_compound
where d_date between '01/01/1996' and '01/14/1996'
and c_mktsegment = 'FURNITURE'
and c_region = 'ASIA';

select max(lo_revenue), min(lo_revenue)
from cust_sales_date_interleaved
where d_date between '01/01/1996' and '01/14/1996'
```
and c_mktsegment = 'FURNITURE'
and c_region = 'ASIA';

4. Evaluate the results.

The following table summarizes the performance of the three sort styles.

<table>
<thead>
<tr>
<th>Sort Style</th>
<th>Query 1</th>
<th>Query 2</th>
<th>Query 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>0.25 s</td>
<td>18.37 s</td>
<td>30.04 s</td>
</tr>
<tr>
<td>Compound</td>
<td>0.27 s</td>
<td>18.24 s</td>
<td>30.14 s</td>
</tr>
<tr>
<td>Interleaved</td>
<td>0.94 s</td>
<td>1.46 s</td>
<td>0.80 s</td>
</tr>
</tbody>
</table>

In Query 1, the results for all three sort styles are very similar, because the WHERE clause restricts only on the first column. There is a small overhead cost for accessing an interleaved table.

In Query 2, there is no benefit to the single-column sort key because that column is not used in the WHERE clause. There is no performance improvement for the compound sort key, because the query was restricted using the second and third columns in the sort key. The query against the interleaved table shows the best performance because interleaved sorting is able to efficiently filter on secondary columns in the sort key.

In Query 3, the interleaved sort is much faster than the other styles because it is able to filter on the combination of the d_date, c_mktsegment, and c_region columns.

This example uses a relatively small table, by Amazon Redshift standards, with 480 million rows. With larger tables, containing billions of rows and more, interleaved sorting can improve performance by an order of magnitude or more for certain types of queries.

**Defining Constraints**

Uniqueness, primary key, and foreign key constraints are informational only; they are not enforced by Amazon Redshift. 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, to infer uniqueness and referential relationships that affect subquery decorrelation techniques, to order large numbers of joins, and to eliminate 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. On the other hand, you should 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 (p. 537).
Analyzing Table Design

As you have seen in the previous sections, specifying sort keys, distribution keys, and column encodings can significantly improve storage, I/O, and query performance. This section provides a SQL script that you can run to help you identify tables where these options are missing or performing poorly.

Copy and paste the following code to create a SQL script named `table_inspector.sql`, then execute the script in your SQL client application as superuser.

```sql
SELECT SCHEMA schemaname,
       "table" tablename,
       table_id tableid,
       size size_in_mb,
       CASE
           WHEN diststyle NOT IN ('EVEN','ALL') THEN 1
           ELSE 0
       END has_dist_key,
       CASE
           WHEN sortkey1 IS NOT NULL THEN 1
           ELSE 0
       END has_sort_key,
       CASE
           WHEN encoded = 'Y' THEN 1
           ELSE 0
       END has_col_encoding,
       CAST(max_blocks_per_slice - min_blocks_per_slice AS FLOAT) / GREATEST(NVL(min_blocks_per_slice,0)::int,1) ratio_skew_across_slices,
       CAST(100*dist_slice AS FLOAT) /(SELECT COUNT(DISTINCT slice) FROM stv_slices) pct_slices_populated
FROM svv_table_info ti
JOIN (SELECT tbl,
           MIN(c) min_blocks_per_slice,
           MAX(c) max_blocks_per_slice,
           COUNT(DISTINCT slice) dist_slice
     FROM (SELECT b.tbl,
              b.slice,
              COUNT(*) AS c
     FROM STV_BLOCKLIST b
     GROUP BY b.tbl,
              b.slice)
     WHERE tbl IN (SELECT table_id FROM svv_table_info)
     GROUP BY tbl) iq ON iq.tbl = ti.table_id;
```

The following sample shows the results of running the script with two sample tables, SKEW1 and SKEW2, that demonstrate the effects of data skew.

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>tableid</th>
<th>size_in_mb</th>
<th>has_dist_key</th>
<th>has_sort_key</th>
<th>has_col_encoding</th>
<th>ratio_skew_across_slices</th>
<th>pct_slices_populated</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>category</td>
<td>100553</td>
<td>28</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>date</td>
<td>100555</td>
<td>44</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>event</td>
<td>100558</td>
<td>36</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>listing</td>
<td>100560</td>
<td>44</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>nation</td>
<td>100563</td>
<td>175</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>39.06</td>
</tr>
<tr>
<td>public</td>
<td>region</td>
<td>100566</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.81</td>
</tr>
<tr>
<td>public</td>
<td>sales</td>
<td>100562</td>
<td>52</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>skew1</td>
<td>100547</td>
<td>18978</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.15</td>
</tr>
<tr>
<td>public</td>
<td>skew2</td>
<td>100548</td>
<td>353</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.56</td>
</tr>
<tr>
<td>public</td>
<td>venue</td>
<td>100551</td>
<td>32</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>public</td>
<td>users</td>
<td>100549</td>
<td>82</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

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The following list describes the columns in the result:

- **has_dist_key**: Indicates whether the table has distribution key. 1 indicates a key exists; 0 indicates there is no key. For example, nation does not have a distribution key.
- **has_sort_key**: Indicates whether the table has a sort key. 1 indicates a key exists; 0 indicates there is no key. For example, nation does not have a sort key.
- **has_column_encoding**: Indicates whether the table has any compression encodings defined for any of the columns. 1 indicates at least one column has an encoding. 0 indicates there is no encoding. For example, region has no compression encoding.
- **ratio_skew_across_slices**: An indication of the data distribution skew. A smaller value is good.
- **pct_slices_populated**: The percentage of slices populated. A larger value is good.

Tables for which there is significant data distribution skew will have either a large value in the ratio_skew_across_slices column or a small value in the pct_slices_populated column. This indicates that you have not chosen an appropriate distribution key column. In the example above, the SKEW1 table has a .15 skew ratio across slices, but that's not necessarily a problem. What's more significant is the 1.56% value for the slices populated for the SKEW2 table. The small value is an indication that the SKEW2 table has the wrong distribution key.

Run the `table_inspector.sql` script whenever you add new tables to your database or whenever you have significantly modified your tables.

**Tutorial: Tuning Table Design**

In this tutorial, you will learn how to optimize the design of your tables. You will start by creating tables based on the Star Schema Benchmark (SSB) schema without sort keys, distribution styles, and compression encodings. You will load the tables with test data and test system performance. Next, you will apply best practices to recreate the tables using sort keys and distribution styles. You will load the tables with test data using automatic compression and then you will test performance again so that you can compare the performance benefits of well-designed tables.

**Estimated time:** 60 minutes

**Estimated cost:** $1.00 per hour for the cluster

**Prerequisites**

You will need your AWS credentials (access key ID and secret access key) to load test data from Amazon S3. If you need to create new access keys, go to Administering Access Keys for IAM Users.

**Steps**

- **Step 1: Create a Test Data Set (p. 74)**
Step 1: Create a Test Data Set

Data warehouse databases commonly use a star schema design, in which a central fact table contains the core data for the database and several dimension tables provide descriptive attribute information for the fact table. The fact table joins each dimension table on a foreign key that matches the dimension's primary key.

Star Schema Benchmark (SSB)

For this tutorial, you will use a set of five tables based on the Star Schema Benchmark (SSB) schema. The following diagram shows the SSB data model.

To Create a Test Data Set

You will create a set of tables without sort keys, distribution styles, or compression encodings. Then you will load the tables with data from the SSB data set.

1. (Optional) Launch a cluster.

   If you already have a cluster that you want to use, you can skip this step. Your cluster should have at least two nodes. For the exercises in this tutorial, you will use a four-node cluster.
To launch a dc1.large cluster with four nodes, follow the steps in Amazon Redshift Getting Started, but select Multi Node for Cluster Type and set Number of Compute Nodes to 4.

Follow the steps to connect to your cluster from a SQL client and test a connection. You do not need to complete the remaining steps to create tables, upload data, and try example queries.

2. Create the SSB test tables using minimum attributes.

   **Note**
   If the SSB tables already exist in the current database, you will need to drop the tables first. See Step 6: Recreate the Test Data Set (p. 88) for the DROP TABLE commands.

For the purposes of this tutorial, the first time you create the tables, they will not have sort keys, distribution styles, or compression encodings.

Execute the following CREATE TABLE commands.

```sql
CREATE TABLE part
(
    p_partkey    INTEGER NOT NULL,
    p_name       VARCHAR(22) NOT NULL,
    p_mfgr       VARCHAR(6) NOT NULL,
    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_daynuminmonth      INTEGER NOT NULL
);
```
Step 1: Create a Test Data Set

CREATE TABLE dwdate

3. Load the tables using SSB sample data.

The sample data for this tutorial is provided in an Amazon S3 buckets that give read access to all authenticated AWS users, so any valid AWS credentials that permit access to Amazon S3 will work.

a. Create a new text file named loadssb.sql containing the following SQL.

```sql
COPY customer FROM 's3://awssampledbuswest2/ssbgz/customer'
    CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
    GZIP COMPUPDATE OFF REGION 'us-west-2';

COPY dwdate FROM 's3://awssampledbuswest2/ssbgz/dwdate'
    CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
    GZIP COMPUPDATE OFF REGION 'us-west-2';

COPY lineorder FROM 's3://awssampledbuswest2/ssbgz/lineorder'
    CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
    GZIP COMPUPDATE OFF REGION 'us-west-2';

COPY part FROM 's3://awssampledbuswest2/ssbgz/part'
    CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
    GZIP COMPUPDATE OFF REGION 'us-west-2';

COPY supplier FROM 's3://awssampledbuswest2/ssbgz/supplier'
    CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
    GZIP COMPUPDATE OFF REGION 'us-west-2';
```
b. Replace `<Your-Access-Key-ID>` and `<Your-Secret-Access-Key>` with your own AWS account credentials. The segment of the credentials string that is enclosed in single quotes must not contain any spaces or line breaks.

c. Execute the COPY commands either by running the SQL script or by copying and pasting the commands into your SQL client.

   **Note**
   The load operation will take about 10 to 15 minutes for all five tables.

Your results should look similar to the following.

```
Load into table 'customer' completed, 3000000 record(s) loaded successfully.
0 row(s) affected.
copy executed successfully
Execution time: 10.28s
(Statement 1 of 5 finished)
...
Script execution finished
Total script execution time: 9m 51s
```

4. Sum the execution time for all five tables, or else note the total script execution time. You'll record that number as the load time in the benchmarks table in Step 2, following.

5. To verify that each table loaded correctly, execute the following commands.

```
select count(*) from LINEORDER;
select count(*) from PART;
select count(*) from CUSTOMER;
select count(*) from SUPPLIER;
select count(*) from DWDATE;
```

The following results table shows the number of rows for each SSB table.

<table>
<thead>
<tr>
<th>Table Name</th>
<th>Rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEORDER</td>
<td>600,037,902</td>
</tr>
<tr>
<td>PART</td>
<td>1,400,000</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>3,000,000</td>
</tr>
<tr>
<td>SUPPLIER</td>
<td>1,000,000</td>
</tr>
<tr>
<td>DWDATE</td>
<td>2,556</td>
</tr>
</tbody>
</table>

Next Step

Step 2: Test System Performance to Establish a Baseline (p. 77)
• Load time
• Storage use
• Query performance

The examples in this tutorial are based on using a four-node dw2.large cluster. Your results will be different, even if you use the same cluster configuration. System performance is influenced by many factors, and no two systems will perform exactly the same.

You will record your results using the following benchmarks table.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load time (five tables)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINEORDER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUSTOMER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWDATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPPLIER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query execution time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total execution time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To Test System Performance to Establish a Baseline

1. Note the cumulative load time for all five tables and enter it in the benchmarks table in the Before column.
   This is the value you noted in the previous step.
2. Record storage use.
   Determine how many 1 MB blocks of disk space are used for each table by querying the STV_BLOCKLIST table and record the results in your benchmarks table.

```sql
select stv_tbl_perm.name as table, count(*) as mb
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 in ('lineorder', 'part', 'customer', 'dwdate', 'supplier')
group by stv_tbl_perm.name
order by 1 asc;
```
Your results should look similar to this:

<table>
<thead>
<tr>
<th>table</th>
<th>mb</th>
</tr>
</thead>
<tbody>
<tr>
<td>customer</td>
<td>384</td>
</tr>
<tr>
<td>dwdate</td>
<td>160</td>
</tr>
<tr>
<td>lineorder</td>
<td>51024</td>
</tr>
<tr>
<td>part</td>
<td>200</td>
</tr>
<tr>
<td>supplier</td>
<td>152</td>
</tr>
</tbody>
</table>

3. Test query performance.

The first time you run a query, Amazon Redshift compiles the code, and then sends compiled code to the compute nodes. When you compare the execution times for queries, you should not use the results for the first time you execute the query. Instead, compare the times for the second execution of each query. For more information, see Factors Affecting Query Performance (p. 290).

**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, which invalidates performance comparisons.

To disable result caching for the current session, set the `enable_result_cache_for_session` parameter to `off`, as shown following.

```sql
set enable_result_cache_for_session to off;
```

Run the following queries twice to eliminate compile time. Record the second time for each query in the benchmarks table.

```
-- Query 1
-- Restrictions on only one dimension.
select sum(lo_extendedprice*lo_discount) as revenue
from lineorder, dwdate
where lo_orderdate = d_datekey
and d_year = 1997
and lo_discount between 1 and 3
and lo_quantity < 24;

-- Query 2
-- Restrictions on two dimensions
select sum(lo_revenue), d_year, p_brand1
from lineorder, dwdate, part, supplier
where lo_orderdate = d_datekey
and lo_partkey = p_partkey
and lo_suppkey = s_suppkey
and p_category = 'MFGR#12'
and s_region = 'AMERICA'
group by d_year, p_brand1
order by d_year, p_brand1;

-- Query 3
-- Drill down in time to just one month
select c_city, s_city, d_year, sum(lo_revenue) as revenue
from customer, lineorder, supplier, dwdate
where lo_custkey = c_custkey
and lo_suppkey = s_suppkey
and lo_orderdate = d_datekey
and (c_city='UNITED KI1' or
```
c_city='UNITED KI5')
and (s_city='UNITED KI1' or
s_city='UNITED KI5')
and d_yearmonth = 'Dec1997'
group by c_city, s_city, d_year
order by d_year asc, revenue desc;

Your results for the second time will look something like this:

SELECT executed successfully
Execution time: 6.97s
(Statement 1 of 3 finished)

SELECT executed successfully
Execution time: 12.81s
(Statement 2 of 3 finished)

SELECT executed successfully
Execution time: 13.39s
(Statement 3 of 3 finished)

Script execution finished
Total script execution time: 33.17s

The following benchmarks table shows the example results for the cluster used in this tutorial.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load time (five tables)</td>
<td>10m 23s</td>
<td></td>
</tr>
<tr>
<td><strong>Storage Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINEORDER</td>
<td>51024</td>
<td></td>
</tr>
<tr>
<td>PART</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>384</td>
<td></td>
</tr>
<tr>
<td>DWDATE</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>SUPPLIER</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td><strong>Total storage</strong></td>
<td>51920</td>
<td></td>
</tr>
<tr>
<td><strong>Query execution time</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query 1</td>
<td>6.97</td>
<td></td>
</tr>
<tr>
<td>Query 2</td>
<td>12.81</td>
<td></td>
</tr>
<tr>
<td>Query 3</td>
<td>13.39</td>
<td></td>
</tr>
<tr>
<td><strong>Total execution time</strong></td>
<td>33.17</td>
<td></td>
</tr>
</tbody>
</table>
Step 3: Select Sort Keys

When you create a table, you can specify one or more columns as the sort key. Amazon Redshift stores your data on disk in sorted order according to the sort key. How your data is sorted has an important effect on disk I/O, columnar compression, and query performance.

In this step, you choose sort keys for the SSB tables based on these best practices:

- If recent data is queried most frequently, specify the timestamp column as the leading column for the sort key.
- If you do frequent range filtering or equality filtering on one column, specify that column as the sort key.
- If you frequently join a (dimension) table, specify the join column as the sort key.

To Select Sort Keys

1. Evaluate your queries to find timestamp columns that are used to filter the results.
   For example, LINEORDER frequently uses equality filters using $lo\_orderdate$.
   
   $\text{where } lo\_orderdate = d\_datekey \text{ and } d\_year = 1997$

2. Look for columns that are used in range filters and equality filters. For example, LINEORDER also uses $lo\_orderdate$ for range filtering.
   
   $\text{where } lo\_orderdate = d\_datekey \text{ and } d\_year \geq 1992 \text{ and } d\_year \leq 1997$

3. Based on the first two best practices, $lo\_orderdate$ is a good choice for sort key.
   In the tuning table, specify $lo\_orderdate$ as the sort key for LINEORDER.

4. The remaining tables are dimensions, so, based on the third best practice, specify their primary keys as sort keys.

   The following tuning table shows the chosen sort keys. You fill in the Distribution Style column in Step 4: Select Distribution Styles (p. 82).

<table>
<thead>
<tr>
<th>Table name</th>
<th>Sort Key</th>
<th>Distribution Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEORDER</td>
<td>lo_orderdate</td>
<td></td>
</tr>
<tr>
<td>PART</td>
<td>p_partkey</td>
<td></td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>c_custkey</td>
<td></td>
</tr>
<tr>
<td>SUPPLIER</td>
<td>s_suppkey</td>
<td></td>
</tr>
<tr>
<td>DWDATE</td>
<td>d_datekey</td>
<td></td>
</tr>
</tbody>
</table>
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. The number of slices per node depends on the node size of the cluster. For example, the dc1.large cluster that you are using in this tutorial has four nodes with two slices each, so the cluster has a total of eight slices. The nodes all participate in parallel query execution, working on data that is distributed across the slices.

When you execute a query, the query optimizer redistributes the rows to the compute nodes as needed to perform any joins and aggregations. Redistribution might involve either sending specific rows to nodes for joining or broadcasting an entire table to all of the nodes.

You should assign distribution styles to achieve these goals.

- Collocate the rows from joining tables
  
  When the rows for joining columns are on the same slices, less data needs to be moved during query execution.

- Distribute data evenly among the slices in a cluster.
  
  If data is distributed evenly, workload can be allocated evenly to all the slices.

These goals may conflict in some cases, and you will need to evaluate which strategy is the best choice for overall system performance. For example, even distribution might place all matching values for a column on the same slice. If a query uses an equality filter on that column, the slice with those values will carry a disproportionate share of the workload. If tables are collocated based on a distribution key, the rows might be distributed unevenly to the slices because the keys are distributed unevenly through the table.

In this step, you evaluate the distribution of the SSB tables with respect to the goals of data distribution, and then select the optimum distribution styles for the tables.

**Distribution Styles**

When you create a table, you designate one of three distribution styles: KEY, ALL, or EVEN.

**KEY distribution**

The rows are distributed according to the values in one column. The leader node will attempt to place 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 so that 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.

**EVEN distribution**

The rows are distributed across the slices in a round-robin fashion, regardless of the values in any particular column. EVEN distribution is appropriate when a table does not participate in joins or when there is not a clear choice between KEY distribution and ALL distribution. EVEN distribution is the default distribution style.
For more information, see Distribution Styles (p. 56).

To Select Distribution Styles

When you execute a query, the query optimizer redistributes the rows to the compute nodes as needed to perform any joins and aggregations. By locating the data where it needs to be before the query is executed, you can minimize the impact of the redistribution step.

The first goal is to distribute the data so that the matching rows from joining tables are collocated, which means that the matching rows from joining tables are located on the same node slice.

1. To look for redistribution steps in the query plan, execute an EXPLAIN command followed by the query. This example uses Query 2 from our set of test queries.

   ```sql
   explain
   select sum(lo_revenue), d_year, p_brand1
   from lineorder, dwdate, part, supplier
   where lo_orderdate = d_datekey
   and lo_partkey = p_partkey
   and lo_suppkey = s_suppkey
   and p_category = 'MFGR#12'
   and s_region = 'AMERICA'
   group by d_year, p_brand1
   order by d_year, p_brand1;
   ```

   The following shows a portion of the query plan. Look for labels that begin with DS_BCAST or DS_DIST labels.

   ```sql
   QUERY PLAN
   XN Merge  (cost=1038007224737.84..1038007224738.54 rows=280 width=20)
      Merge Key: dwdate.d_year, part.p_brand1
      ->  XN Network  (cost=1038007224737.84..1038007224738.54 rows=280 width=20)
         Send to leader
         ->  XN Sort  (cost=1038007224737.84..1038007224738.54 rows=280 width=20)
              Sort Key: dwdate.d_year, part.p_brand1
              ->  XN HashAggregate  (cost=38007224725.76..38007224726.46 rows=280)
                  ->  XN Hash Join DS_BCAST_INNER  (cost=30674.95..38007188507.46)
                      Hash Cond: ("outer".lo_orderdate = "inner".d_datekey)
                      ->  XN Hash Join DS_BCAST_INNER
                          (cost=30643.00..37598188507.46)
                          Hash Cond: ("outer".lo_suppkey = "inner".s_suppkey)
                          ->  XN Hash Join DS_BCAST_INNER
                              (cost=30643.00..37598188507.46)
                              Hash Cond: ("outer".lo_partkey = "inner".p_partkey)
                              ->  XN Seq Scan on lineorder
                              ->  XN Hash  (cost=17500.00..17500.00 rows=56000)
                                  Filter: ((p_category)::text = 'AMERICA'::text)
      (cost=0.00..17500.00)
      ->  XN Hash  (cost=12500.00..12500.00 rows=201200)
          Filter: ((s_region)::text = 'AMERICA'::text)
      (cost=0.00..12500.00)
      ->  XN Seq Scan on supplier
      (cost=0.00..12500.00)
      ->  XN Hash  (cost=25.56..25.56 rows=2556)
          Filter: ((s_region)::text = 'AMERICA'::text)
      (cost=0.00..12500.00)
      ->  XN Seq Scan on dwdate  (cost=0.00..25.56 rows=2556)
      (cost=30643.00..37598119820.65)
      DS_BCAST_INNER indicates that the inner join table was broadcast to every slice. A DS_DIST_BOTH label, if present, would indicate that both the outer join table and the inner join table were redistributed across the slices. Broadcasting and redistribution can be expensive steps in terms of query performance. You want to select distribution strategies that reduce or eliminate broadcast
and distribution steps. For more information about evaluating the EXPLAIN plan, see Evaluating Query Patterns (p. 58).

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

The following diagram shows the relationships between the fact table, LINEORDER, and the dimension tables in the SSB schema.

![Diagram showing relationships between LINEORDER, PART, CUSTOMER, SUPPLIER, and DWDATE]

Each table can have only one distribution key, which means that only one pair of tables in the schema can be collocated on their common columns. The central fact table is the clear first choice. For the second table in the pair, choose the largest dimension that commonly joins the fact table. In this design, LINEORDER is the fact table, and PART is the largest dimension. PART joins LINEORDER on its primary key, p_partkey.

Designate lo_partkey as the distribution key for LINEORDER and p_partkey as the distribution key for PART so that the matching values for the joining keys will be collocated on the same slices when the data is loaded.

3. 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 often improve query performance significantly by distributing the entire table to all of the nodes. ALL distribution guarantees that the joining rows will be collocated on every slice. You should weigh all factors before choosing ALL distribution. Using ALL distribution multiplies storage space requirements and increases load times and maintenance operations.

CUSTOMER, SUPPLIER, and DWDATE also join the LINEORDER table on their primary keys; however, LINEORDER will be collocated with PART, so you will set the remaining tables to use DISTSTYLE ALL. Because the tables are relatively small and are not updated frequently, using ALL distribution will have minimal impact on storage and load times.

4. Use EVEN distribution for the remaining tables.

All of the tables have been assigned with DISTKEY or ALL distribution styles, so you won’t assign EVEN to any tables. After evaluating your performance results, you might decide to change some tables from ALL to EVEN distribution.

The following tuning table shows the chosen distribution styles.

<table>
<thead>
<tr>
<th>Table name</th>
<th>Sort Key</th>
<th>Distribution Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEORDER</td>
<td>lo_orderdate</td>
<td>lo_partkey</td>
</tr>
<tr>
<td>PART</td>
<td>p_partkey</td>
<td>p_partkey</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>c_custkey</td>
<td>ALL</td>
</tr>
</tbody>
</table>
Step 5: Review Compression Encodings

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.

By default, Amazon Redshift stores data in its raw, uncompressed format. When you create tables in an Amazon Redshift database, you can define a compression type, or encoding, for the columns. For more information, see Compression Encodings (p. 44).

You can apply compression encodings to columns in tables manually when you create the tables, or you can use the COPY command to analyze the load data and apply compression encodings automatically.

To Review Compression Encodings

1. Find how much space each column uses.

   Query the STV_BLOCKLIST system view to find the number of 1 MB blocks each column uses. The MAX aggregate function returns the highest block number for each column. This example uses \( \text{col} < 17 \) in the WHERE clause to exclude system-generated columns.

   Execute the following command.

   ```sql
   select col, max(blocknum) 
   from stv_blocklist b, stv_tbl_perm p 
   where (b.tbl=p.id) and name = 'lineorder' 
   and \( \text{col} < 17 \) 
   group by name, col 
   order by col;
   ```

   Your results will look similar to the following.

<table>
<thead>
<tr>
<th>col</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>572</td>
</tr>
<tr>
<td>1</td>
<td>572</td>
</tr>
<tr>
<td>2</td>
<td>572</td>
</tr>
<tr>
<td>3</td>
<td>572</td>
</tr>
<tr>
<td>4</td>
<td>572</td>
</tr>
<tr>
<td>5</td>
<td>572</td>
</tr>
<tr>
<td>6</td>
<td>1659</td>
</tr>
<tr>
<td>7</td>
<td>715</td>
</tr>
<tr>
<td>8</td>
<td>572</td>
</tr>
</tbody>
</table>
2. Experiment with the different encoding methods.

In this step, you create a table with identical columns, except that each column uses a different compression encoding. Then you insert a large number of rows, using data from the p_name column in the PART table, so that every column has the same data. Finally, you will examine the table to compare the effects of the different encodings on column sizes.

a. Create a table with the encodings that you want to compare.

```
cREATE TABLE encodingshipmode (
  moderaw varchar(22) encode raw,
  modebytedict varchar(22) encode bytedict,
  modelzo varchar(22) encode lzo,
  moderunlength varchar(22) encode runlength,
  modetext255 varchar(22) encode text255,
  modetext32k varchar(22) encode text32k);
```

b. Insert the same data into all of the columns using an INSERT statement with a SELECT clause. The command will take a couple minutes to execute.

```
INSERT INTO encodingshipmode
SELECT lo_shipmode as moderaw, lo_shipmode as modebytedict, lo_shipmode as modelzo,
  lo_shipmode as moderunlength, lo_shipmode as modetext255,
  lo_shipmode as modetext32k
FROM lineorder WHERE lo_orderkey < 20000000;
```

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

```
SELECT col, max(blocknum)
FROM stv_blocklist b, stv_tbl_perm p
WHERE (b.tbl = p.id) AND name = 'encodingshipmode'
  AND col < 6
GROUP BY name, col
ORDER BY col;
```

The query returns results similar to the following. Depending on how your cluster is configured, your results will be different, but the relative sizes should be similar.

```
col | max
---+-----
 0 | 221
 1 |  26
 2 |  61
 3 | 192
 4 |  54
 5 | 105
 (6 rows)
```

The columns show the results for the following encodings:
Step 5: Review Compression Encodings

- Raw
- Bytedict
- LZO
- Runlength
- Text255
- Text32K

You can see that Bytedict encoding on the second column produced the best results for this data set, with a compression ratio of better than 8:1. Different data sets will produce different results, of course.

3. Use the ANALYZE COMPRESSION command to view the suggested encodings for an existing table.

Execute the following command.

```
analyze compression lineorder;
```

Your results should look similar to the following.

<table>
<thead>
<tr>
<th>Table</th>
<th>Column</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>lineorder</td>
<td>lo_orderkey</td>
<td>delta</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_linenumber</td>
<td>delta</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_custkey</td>
<td>raw</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_partkey</td>
<td>raw</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_suppkey</td>
<td>raw</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_orderdate</td>
<td>delta32k</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_orderpriority</td>
<td>bytedict</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_shippriority</td>
<td>runlength</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_quantity</td>
<td>delta</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_extendedprice</td>
<td>lzo</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_ordertotalprice</td>
<td>lzo</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_discount</td>
<td>delta</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_revenue</td>
<td>lzo</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_supplycost</td>
<td>delta32k</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_tax</td>
<td>delta</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_commitdate</td>
<td>delta32k</td>
</tr>
<tr>
<td>lineorder</td>
<td>lo_shipmode</td>
<td>bytedict</td>
</tr>
</tbody>
</table>

Notice that ANALYZE COMPRESSION chose BYTEDICT encoding for the lo_shipmode column.

For an example that walks through choosing manually applied compression encodings, see Example: Choosing Compression Encodings for the CUSTOMER Table (p. 53).

4. Apply automatic compression to the SSB tables.

By default, the COPY command automatically applies compression encodings when you load data into an empty table that has no compression encodings other than RAW encoding. For this tutorial, you will let the COPY command automatically select and apply optimal encodings for the tables as part of the next step, Recreate the test data set.

For more information, see Loading Tables with Automatic Compression (p. 123).

Next Step

Step 6: Recreate the Test Data Set (p. 88)
Step 6: Recreate the Test Data Set

Now that you have chosen the sort keys and distribution styles for each of the tables, you can create the tables using those attributes and reload the data. You will allow the COPY command to analyze the load data and apply compression encodings automatically.

To Recreate the Test Data Set

1. You need to drop the SSB tables before you run the CREATE TABLE commands.

   Execute the following commands.

   ```sql
   drop table part cascade;
drop table supplier cascade;
drop table customer cascade;
drop table dwdate cascade;
drop table lineorder cascade;
   ```

2. Create the tables with sort keys and distribution styles.

   Execute the following set of SQL CREATE TABLE commands.

   ```sql
   CREATE TABLE part (
     p_partkey integer not null sortkey distkey,
     p_name varchar(22) not null,
     p_mfgr varchar(6) not null,
     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 sortkey,
     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
   ) diststyle all;
   CREATE TABLE customer (
     c_custkey integer not null sortkey,
     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;
   CREATE TABLE dwdate (
     d_datekey integer not null sortkey,
     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_quarternum integer not null,
     d_dayinweek integer not null,
     d_yearquarternum integer not null
   ) diststyle all;
   ```
3. Load the tables using the same sample data.
   a. Open the loadssb.sql script that you created in the first step.
   b. Delete compupdate off from each COPY statement. This time, you will allow COPY to apply compression encodings.

For reference, the edited script should look like the following:

```sql
copy customer from 's3://awssampledbuswest2/ssbgz/customer' credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' gzip region 'us-west-2';
copy dwdate from 's3://awssampledbuswest2/ssbgz/dwdate' credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' gzip region 'us-west-2';
copy lineorder from 's3://awssampledbuswest2/ssbgz/lineorder' credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' gzip region 'us-west-2';
copy part from 's3://awssampledbuswest2/ssbgz/part' credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' gzip region 'us-west-2';
copy supplier from 's3://awssampledbuswest2/ssbgz/supplier' credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
```
Step 7: Retest System Performance After Tuning

c. Save the file.

d. Execute the COPY commands either by running the SQL script or by copying and pasting the commands into your SQL client.

   **Note**
   The load operation will take about 10 to 15 minutes. This might be a good time to get another cup of tea or feed the fish.

Your results should look similar to the following.

```
Warnings:
Load into table 'customer' completed, 3000000 record(s) loaded successfully.
...
...
Script execution finished
Total script execution time: 12m 15s
```

e. Record the load time in the benchmarks table.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load time (five tables)</td>
<td>10m 23s</td>
<td>12m 15s</td>
</tr>
</tbody>
</table>

**Storage Use**

<table>
<thead>
<tr>
<th>Table</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINEORDER</td>
<td>51024</td>
</tr>
<tr>
<td>PART</td>
<td>384</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>200</td>
</tr>
<tr>
<td>DWDATE</td>
<td>160</td>
</tr>
<tr>
<td>SUPPLIER</td>
<td>152</td>
</tr>
<tr>
<td><strong>Total storage</strong></td>
<td><strong>51920</strong></td>
</tr>
</tbody>
</table>

**Query execution time**

<table>
<thead>
<tr>
<th>Query</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query 1</td>
<td>6.97</td>
</tr>
<tr>
<td>Query 2</td>
<td>12.81</td>
</tr>
<tr>
<td>Query 3</td>
<td>13.39</td>
</tr>
<tr>
<td><strong>Total execution time</strong></td>
<td><strong>33.17</strong></td>
</tr>
</tbody>
</table>

**Next Step**

Step 7: Retest System Performance After Tuning (p. 90)

**Step 7: Retest System Performance After Tuning**

After recreating the test data set with the selected sort keys, distribution styles, and compressions encodings, you will retest the system performance.
To Retest System Performance After Tuning

1. Record storage use.

Determine how many 1 MB blocks of disk space are used for each table by querying the STV_BLOCKLIST table and record the results in your benchmarks table.

```
select stv_tbl_perm.name as "table", count(*) as "blocks (mb)"
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 in ('customer', 'part', 'supplier', 'dwdate', 'lineorder')
group by stv_tbl_perm.name
order by 1 asc;
```

Your results will look similar to this:

<table>
<thead>
<tr>
<th>table</th>
<th>blocks (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>customer</td>
<td>604</td>
</tr>
<tr>
<td>dwdate</td>
<td>160</td>
</tr>
<tr>
<td>lineorder</td>
<td>27151</td>
</tr>
<tr>
<td>part</td>
<td>200</td>
</tr>
<tr>
<td>supplier</td>
<td>236</td>
</tr>
</tbody>
</table>

2. Check for distribution skew.

Uneven distribution, or data distribution skew, forces some nodes to do more work than others, which limits query performance.

To check for distribution skew, query the SVV_DISKUSAGE system view. Each row in SVV_DISKUSAGE records the statistics for one disk block. The `num_values` column gives the number of rows in that disk block, so `sum(num_values)` returns the number of rows on each slice.

Execute the following query to see the distribution for all of the tables in the SSB database.

```
select trim(name) as table, slice, sum(num_values) as rows, min(minvalue),
       max(maxvalue)
from svv_diskusage
where name in ('customer', 'part', 'supplier', 'dwdate', 'lineorder')
and col =0
group by name, slice
order by name, slice;
```

Your results will look something like this:

<table>
<thead>
<tr>
<th>table</th>
<th>slice</th>
<th>rows</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>customer</td>
<td>0</td>
<td>3000000</td>
<td>1</td>
<td>3000000</td>
</tr>
<tr>
<td>customer</td>
<td>2</td>
<td>3000000</td>
<td>1</td>
<td>3000000</td>
</tr>
<tr>
<td>customer</td>
<td>4</td>
<td>3000000</td>
<td>1</td>
<td>3000000</td>
</tr>
<tr>
<td>customer</td>
<td>6</td>
<td>3000000</td>
<td>1</td>
<td>3000000</td>
</tr>
<tr>
<td>dwdate</td>
<td>0</td>
<td>2555</td>
<td>19920101</td>
<td>19981230</td>
</tr>
<tr>
<td>dwdate</td>
<td>2</td>
<td>2555</td>
<td>19920101</td>
<td>19981230</td>
</tr>
<tr>
<td>dwdate</td>
<td>4</td>
<td>2555</td>
<td>19920101</td>
<td>19981230</td>
</tr>
<tr>
<td>dwdate</td>
<td>6</td>
<td>2555</td>
<td>19920101</td>
<td>19981230</td>
</tr>
<tr>
<td>lineorder</td>
<td>0</td>
<td>75029991</td>
<td>3</td>
<td>599999975</td>
</tr>
<tr>
<td>lineorder</td>
<td>1</td>
<td>75059242</td>
<td>7</td>
<td>600000000</td>
</tr>
<tr>
<td>lineorder</td>
<td>2</td>
<td>75238172</td>
<td>1</td>
<td>599999975</td>
</tr>
<tr>
<td>lineorder</td>
<td>3</td>
<td>75065416</td>
<td>1</td>
<td>599999973</td>
</tr>
</tbody>
</table>
Step 7: Retest System Performance After Tuning

The following chart illustrates the distribution of the three largest tables. (The columns are not to scale.) Notice that because CUSTOMER uses ALL distribution, it was distributed to only one slice per node.

The distribution is relatively even, so you don't need to adjust for distribution skew.

3. Run an EXPLAIN command with each query to view the query plans.

The following example shows the EXPLAIN command with Query 2.

```
explain
select sum(lo_revenue), d_year, p_brand1
from lineorder, dwdate, part, supplier
where lo_orderdate = d_datekey
and lo_partkey = p_partkey
and lo_suppkey = s_suppkey
and p_category = 'MFGR#12'
and s_region = 'AMERICA'
group by d_year, p_brand1
order by d_year, p_brand1;
```

In the EXPLAIN plan for Query 2, notice that the DS_BCAST_INNER labels have been replaced by DS_DIST_ALL_NONE and DS_DIST_NONE, which means that no redistribution was required for those steps, and the query should run much more quickly.
4. Run the same test queries again.

If you reconnected to the database since your first set of tests, disable result caching for this session. To disable result caching for the current session, set the `enable_result_cache_for_session` (p. 1104) parameter to `off`, as shown following.

```
set enable_result_cache_for_session to off;
```

As you did earlier, run the following queries twice to eliminate compile time. Record the second time for each query in the benchmarks table.

```
-- Query 1
-- Restrictions on only one dimension.
select sum(lo_extendedprice*lo_discount) as revenue
from lineorder, dwdate
where lo_orderdate = d_datekey
and d_year = 1997
and lo_discount between 1 and 3
and lo_quantity < 24;

-- Query 2
-- Restrictions on two dimensions
select sum(lo_revenue), d_year, p_brand1
from lineorder, dwdate, part, supplier
where lo_orderdate = d_datekey
and lo_partkey = p_partkey
and lo_suppkey = s_suppkey
and p_category = 'MFGR#12'
and s_region = 'AMERICA'
group by d_year, p_brand1
order by d_year, p_brand1;

-- Query 3
```
Step 8: Evaluate the Results

You tested load times, storage requirements, and query execution times before and after tuning the tables, and recorded the results.

The following table shows the example results for the cluster that was used for this tutorial. Your results will be different, but should show similar improvements.
### Load time

Load time increased by 17.5%.

Sorting, compression, and distribution increase load time. In particular, in this case, you used automatic compression, which increases the load time for empty tables that don't already have compression encodings. Subsequent loads to the same tables would be faster. You also increased load time by using ALL distribution. You could reduce load time by using EVEN or DISTKEY distribution instead for some of the tables, but that decision needs to be weighed against query performance.

### Storage requirements

Storage requirements were reduced by 45.4%.

Some of the storage improvement from using columnar compression was offset by using ALL distribution on some of the tables. Again, you could improve storage use by using EVEN or DISTKEY distribution instead for some of the tables, but that decision needs to be weighed against query performance.

### Distribution

You verified that there is no distribution skew as a result of your distribution choices.

By checking the EXPLAIN plan, you saw that data redistribution was eliminated for the test queries.

### Query execution time

Total query execution time was reduced by 31.4%.

The improvement in query performance was due to a combination of optimizing sort keys, distribution styles, and compression. Often, query performance can be improved even further by rewriting...
queries and configuring workload management (WLM). For more information, see Tuning Query Performance (p. 281).

Next Step

Step 9: Clean Up Your Resources (p. 96)

Step 9: 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.

If you want to keep the cluster, but recover the storage used by the SSB tables, execute the following commands.

```
drop table part cascade;
drop table supplier cascade;
drop table customer cascade;
drop table dwdate cascade;
drop table lineorder cascade;
```

Next Step

Summary (p. 96)

Summary

In this tutorial, you learned how to optimize the design of your tables by applying table design best practices.

You chose sort keys for the SSB tables based on these best practices:

- If recent data is queried most frequently, specify the timestamp column as the leading column for the sort key.
- If you do frequent range filtering or equality filtering on one column, specify that column as the sort key.
- If you frequently join a (dimension) table, specify the join column as the sort key.

You applied the following best practices to improve the distribution of the tables.

- Distribute the fact table and one dimension table on their common columns
- Change some dimension tables to use ALL distribution

You evaluated the effects of compression on a table and determined that using automatic compression usually produces the best results.

For more information, see the following links:

- Amazon Redshift Best Practices for Designing Tables (p. 21)
- Choose the Best Sort Key (p. 22)
- Choosing a Data Distribution Style (p. 55)
- Choosing a Column Compression Type (p. 43)
• Analyzing Table Design (p. 72)

Next Step

For your next step, if you haven't done so already, we recommend taking Tutorial: Loading Data from Amazon S3 (p. 156).
Loading Data

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 cluster 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, your cluster must have permission to access those resources and to perform the necessary actions to access the data. You can use Identity and Access Management (IAM) to limit the access users have to your cluster 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.

This section explains how to load data and troubleshoot data loads and presents best practices for loading data.

Using a COPY Command to Load Data

Topics
- Credentials and Access Permissions (p. 99)
- Preparing Your Input Data (p. 100)
- Loading Data from Amazon S3 (p. 101)
- Loading Data from Amazon EMR (p. 110)
- Loading Data from Remote Hosts (p. 114)
- Loading Data from an Amazon DynamoDB Table (p. 120)
- Verifying That the Data Was Loaded Correctly (p. 122)
- Validating Input Data (p. 122)
- Loading Tables with Automatic Compression (p. 123)
- Optimizing Storage for Narrow Tables (p. 125)
- Loading Default Column Values (p. 125)
- Troubleshooting Data Loads (p. 125)
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.

**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 (p. 592) or CREATE TABLE AS (p. 550).

To load data from another AWS resource, your cluster 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 execute 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.

You can compress the files using gzip, lzop, or bzip2 to save time uploading the files. COPY can then speed up the load process by uncompressing the files as they are read.

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.

**Credentials and Access Permissions**

To load or unload data using 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 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, your cluster 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 (p. 485).

**Role-Based Access Control**

With role-based access control, your cluster temporarily assumes an AWS Identity and Access Management (IAM) role on your behalf. Then, based on the authorizations granted to the role, your cluster 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 cluster. The role must have, at a minimum, the permissions listed in IAM Permissions for COPY, UNLOAD, and CREATE LIBRARY (p. 488). 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 Cluster 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 Cluster Management Guide.

When you create an IAM role, IAM returns an Amazon Resource Name (ARN) for the role. To execute 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://mybucket/mydata'
iam_role 'arn:aws:iam::12345678901:role/MyRedshiftRole';
```

### 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.

**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 IAM user credentials, replace `<access-key-id>` and `<secret-access-key>` with an authorized user's access key ID and full secret access key for the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters as shown following.

```
ACCESS_KEY_ID '<<access-key-id>'
SECRET_ACCESS_KEY '<<secret-access-key>>';
```

The AWS IAM user must have, at a minimum, the permissions listed in IAM Permissions for COPY, UNLOAD, and CREATE LIBRARY (p. 488).

### 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 NULL (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 quotes 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 (p. 493). 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 (p. 369). For information about multibyte character errors, see Multibyte Character Load Errors (p. 128).

Loading Data from Amazon S3

Topics

- Splitting Your Data into Multiple Files (p. 101)
- Uploading Files to Amazon S3 (p. 102)
- Using the COPY Command to Load from Amazon S3 (p. 105)

The COPY command leverages the Amazon Redshift massively parallel processing (MPP) architecture to read and load data in parallel from files in an Amazon S3 bucket. You can take maximum advantage of parallel processing by splitting your data into multiple files and by setting distribution keys on your tables. For more information about distribution keys, see Choosing a Data Distribution Style (p. 55).

Data from the 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 file 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 (p. 125).

Follow this general process to load data from Amazon S3:

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

The rest of this section explains these steps in detail.

Splitting Your Data into Multiple Files

You can load table data from a single file, or you can 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.
Note
We strongly recommend that you divide your data into multiple files to take advantage of parallel processing.

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 DS1.XL compute node has two slices, and each DS1.8XL compute node has 32 slices. For more information about the number of slices that each node size has, go to About Clusters and Nodes in the Amazon Redshift Cluster Management Guide.

The nodes all participate in parallel query execution, working on data that is distributed as evenly as possible across the slices. If you have a cluster with two DS1.XL nodes, you might split your data into four files or some multiple of four. Amazon Redshift does not take file size into account when dividing the workload, so you need to ensure that the files are roughly the same size, between 1 MB and 1 GB after compression.

If you intend to use object prefixes to identify the load files, name each file with a common prefix. 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
```

If you put multiple files in a folder in your bucket, you can specify the folder name as the prefix and COPY will load 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 (p. 496).

Uploading Files to Amazon S3

Topics
- Managing Data Consistency (p. 103)
- Uploading Encrypted Data to Amazon S3 (p. 103)
- Verifying That the Correct Files Are Present in Your Bucket (p. 105)

After splitting your files, you can upload them to your bucket. You can optionally compress or encrypt the files before you load them.

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 Developer Guide.

Amazon S3 provides eventual consistency for some operations, so it is possible that new data will not be available immediately after the upload. For more information see, Managing Data Consistency (p. 103)

Important
The Amazon S3 bucket that holds the data files must be created in the same region as your cluster unless you use the REGION (p. 458) option to specify the region in which the Amazon S3 bucket is located.

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.

Managing Data Consistency

Amazon S3 provides eventual consistency for some operations, so it is possible that new data will not be available immediately after the upload, which could result in an incomplete data load or loading stale data. COPY operations where the cluster and the bucket are in different regions are eventually consistent. All regions provide read-after-write consistency for uploads of new objects with unique object keys. For more information about data consistency, see Amazon S3 Data Consistency Model in the Amazon Simple Storage Service Developer Guide.

To ensure that your application loads the correct data, we recommend the following practices:

- Create new object keys.
  
  Amazon S3 provides eventual consistency in all regions for overwrite operations. Creating new file names, or object keys, in Amazon S3 for each data load operation provides strong consistency in all regions.

- Use a manifest file with your COPY operation.
  
  The manifest explicitly names the files to be loaded. Using a manifest file enforces strong consistency.

The rest of this section explains these steps in detail.

Creating New Object Keys

Because of potential data consistency issues, we strongly recommend creating new files with unique Amazon S3 object keys for each data load operation. If you overwrite existing files with new data, and then issue a COPY command immediately following the upload, it is possible for the COPY operation to begin loading from the old files before all of the new data is available. For more information about eventual consistency, see Amazon S3 Data Consistency Model in the Amazon S3 Developer Guide.

Using a Manifest File

You can explicitly specify which files to load by using a manifest file. When you use a manifest file, COPY enforces strong consistency by searching secondary servers if it does not find a listed file on the primary server. The manifest file can be configured with an optional mandatory flag. If mandatory is true and the file is not found, COPY returns an error.

For more information about using a manifest file, see the copy_from_s3_manifest_file (p. 456) option for the COPY command and Example: COPY from Amazon S3 using a manifest (p. 496) in the COPY examples.

Because Amazon S3 provides eventual consistency for overwrites in all regions, it is possible to load stale data if you overwrite existing objects with new data. As a best practice, never overwrite existing files with new data.

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 Developer 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 master 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 Developer 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 master symmetric key** – A master key encrypts the envelope key. You pass the master 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 Developer 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 (p. 109).

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 Example 1: Encrypt and Upload a File Using a Client-Side Symmetric Master Key in the Amazon Simple Storage Service Developer Guide.

The example 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 master symmetric key.

This example provides example code using the AWS SDK for Java to create a 256-bit AES symmetric master 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 mybucket holds a file named venue.txt.back, that file will be loaded, perhaps unintentionally, by the following command:

```
copy venue from 's3://mybucket/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 (p. 456)` option for the COPY command and Example: COPY from Amazon S3 using a manifest (p. 496) 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**

**Topics**
- Using a Manifest to Specify Data Files (p. 107)
- Loading Compressed Data Files from Amazon S3 (p. 108)
- Loading Fixed-Width Data from Amazon S3 (p. 108)
- Loading Multibyte Data from Amazon S3 (p. 109)
- Loading Encrypted Data Files from Amazon S3 (p. 109)

Use the `COPY (p. 450)` 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 (p. 537)` in the SQL Reference.

The values for `authorization` provide the AWS authorization your cluster needs to access the Amazon S3 objects. For information about required permissions, see IAM Permissions for COPY, UNLOAD, and CREATE LIBRARY (p. 488). 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. Alternatively, you can specify the `ACCESS_KEY_ID` and `SECRET_ACCESS_KEY` parameters and provide the access key ID and secret access key for an authorized IAM user as plain text. For more information, see Role-Based Access Control (p. 485) or Key-Based Access Control (p. 486).
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://mybucket/mydata'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

To authenticate using IAM user credentials, replace `<access-key-id>` and `<secret-access-key>` with an authorized user's access key ID and full secret access key for the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters as shown following.

```
ACCESS_KEY_ID '<access-key-id>'
SECRET_ACCESS_KEY '<secret-access-key>'
```

The following example shows authentication using IAM user credentials.

```
copy customer
from 's3://mybucket/mydata'
access_key_id '<access-key-id>'
secret_access_key '<secret-access-key>';
```

For more information about other authorization options, see Authorization Parameters (p. 465)

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 Splitting Your Data into Multiple Files (p. 101).

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 `mybucket`.

```
Note
The Amazon S3 bucket `mybucket` in the following examples does not exist. For sample COPY commands that use real data in an existing Amazon S3 bucket, see Step 4: Load Sample Data (p. 15).
```

```
copy venue from 's3://mybucket/venue'
```
If no Amazon S3 objects with the key prefix 'venue' exist, the load fails.

### Using a Manifest to Specify Data Files

You can use a manifest to ensure 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 [Using a Manifest to Specify Data Files](p. 496).

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

```json
{
  "entries": [ 
    {
      "url": "s3://mybucket-alpha/2013-10-04-custdata", "mandatory":true,
    },
    {
      "url": "s3://mybucket-alpha/2013-10-05-custdata", "mandatory":true,
    },
    {
      "url": "s3://mybucket-beta/2013-10-04-custdata", "mandatory":true,
    },
    {
      "url": "s3://mybucket-beta/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`.

```sql
copy customer
from 's3://mybucket/cust.manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest;
```

### Using a Manifest Created by UNLOAD

A manifest created by an UNLOAD (p. 642) 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 datafiles 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.

```json
{
  "entries": [
    {
      "url": "s3://mybucket/unload/manifest_0000_part_00", "meta": { "content_length": 5956875 }
    },
    {
      "url": "s3://mybucket/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](p. 496).
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.

COPY does not support files compressed using the lzop --filter option.

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

```
copy customer from 's3://mybucket/customer.lzo'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|' lzop;
```

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://mybucket/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 above 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
```
Loading Data from Amazon S3

from 's3://mybucket/data/venue_fw.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
fixedwidth 'venueid:3,venuename:25,venuecity:12,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 (p. 369).

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

```bash
$ 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-managed keys (SSE-KMS)
- Client-side encryption using a client-side symmetric master 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-managed customer master key
- Client-side encryption using a customer-provided asymmetric master 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 Developer Guide.

The UNLOAD (p. 642) 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 (p. 179)

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 master key by specifying the ENCRYPTED option and providing the key value. For more information, see Uploading Encrypted Data to Amazon S3 (p. 103).

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

```sql
copy customer from 's3://mybucket/encrypted/customer'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<master_key>'
encrypted
```
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) in the form of fixed-width files, character-delimited files, CSV files, or JSON-formatted files.

Loading Data From Amazon EMR Process

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

- **Step 1: Configure IAM Permissions (p. 110)**
  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 (p. 111)**
  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 master 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 (p. 111)**
  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 (p. 113)**
  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 (p. 113)**
  Modify the Amazon EMR instance's security groups to add ingress rules to accept the Amazon Redshift IP addresses.

- **Step 6: Run the COPY Command to Load the Data (p. 113)**
  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 IAM 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 IAM user that will execute 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 Cluster 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 executes.

   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 master 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

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. Click 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.

To retrieve the cluster public key and cluster node IP addresses for your cluster using the Amazon Redshift CLI, execute 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"
        }
      ]
    }
  ]
}
```
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...uA705nMHCaMiRdmvsDOedZD0edZ 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 (p. 111). 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 (p. 450) 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.

```sql
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 executes 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 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 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 (p. 100)

- Access to the hosts from your computer.

For an Amazon EC2 instance, you will use an SSH connection to access the host. You will need to 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.

### Loading Data Process

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

- **Step 1: Retrieve the Cluster Public Key and Cluster Node IP Addresses (p. 115)**
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 (p. 117)**

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 (p. 117)**

For Amazon EC2, modify the instance's security groups to add ingress 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 (p. 118)**

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

- **Step 5: Create a Manifest File (p. 118)**

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 (p. 119)**

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 (p. 458) option to specify the region in which the data is located.

- **Step 7: Run the COPY Command to Load the Data (p. 119)**

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

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. Click 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, execute 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"
                }
            ]
        }
    ]
}
```
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 AAAACTP3isxgGzVWoIWpbVVRCo2YdWifMrh... uA70BnMHCaM1RdmvsDOedZDOedZ 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 (p. 115). 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 Cluster 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 executes 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 will be executed 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 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 quotes are required as shown, both for the field names and the values. The only value that does not need double quotes is the Boolean value `true` or `false` for the mandatory field.

The following table describes the fields in the manifest file.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>endpoint</td>
<td>The URL address or IP address of the host. For example, &quot;ec2-111-222-333.compute-1.amazonaws.com&quot; or &quot;22.33.44.56&quot;</td>
</tr>
<tr>
<td>command</td>
<td>The command that will be executed by the host to generate text or binary (gzip, lzop, or bzip2) output. The command can be any command that the user &quot;host_user_name&quot; 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</td>
</tr>
</tbody>
</table>
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 (p. 100).

public_key

(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 AbcBaxxx...xxxDHKJ root@amazon.com enter the following text in the publickey field: AbcBaxxx...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 execute 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 execute 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 region as your Amazon Redshift cluster, you must use the REGION (p. 458) option to specify the region in which the manifest is located. For information about creating an Amazon S3 bucket and uploading a file, see Amazon Simple Storage Service Getting Started Guide.

Step 7: Run the COPY Command to Load the Data

Run a COPY (p. 450) 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://mybucket/ssh_manifest' credentials 
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 will execute the remote command twice. The first read is to provide a sample for 
compression analysis, then the second read actually loads the data. If executing the remote 
command twice might cause a problem because of potential side effects, you should disable 
automatic compression. To disable automatic compression, run the COPY command with the 
COMPPUPDATE option set to OFF. For more information, see Loading Tables with Automatic 
Compression (p. 123).

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 region as your 
cluster unless you use the REGION (p. 458) option to specify the region in which the Amazon 
DynamoDB table is located.

The COPY command leverages 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 Choosing a Data Distribution Style (p. 55).

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 (p. 450) 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:
The values for authorization are the AWS credentials needed to access the Amazon DynamoDB table. If these credentials correspond to an IAM user, that IAM 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 (p. 488). 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. Alternatively, you can specify the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters and provide the access key ID and secret access key for an authorized IAM user as plain text. For more information, see Role-Based Access Control (p. 485) or Key-Based Access Control (p. 486).

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';

To authenticate using IAM user credentials, replace <access-key-id> and <secret-access-key> with an authorized user's access key ID and full secret access key for the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters as shown following.

ACCESS_KEY_ID '<access-key-id>'
SECRET_ACCESS_KEY '<secret-access-key>'

The following example shows authentication using IAM user credentials.

copy favoritemovies
from 'dynamodb://ProductCatalog'
access_key_id '<access-key-id>'
secret_access_key '<secret-access-key>'

For more information about other authorization options, see Authorization Parameters (p. 465)

If you want to validate your data without actually loading the table, use the NOLOAD option with the COPY (p. 450) 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 (p. 123).

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 (p. 369).

Verifying That the Data Was Loaded Correctly

After the load operation is complete, query the STL_LOAD_COMMITS (p. 944) system table to verify that the expected files were loaded. You should execute 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:

```sql
select query, trim(filename) as filename, curtime, status
from stl_load_commits
where filename like '%tickit%'
order by query;
```

```
query |           btrim           |          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 (p. 450) command. Use NOLOAD with the same COPY commands and options you would use to actually 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 would occur if you had attempted 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
Loading Tables with Automatic Compression

Topics

- How Automatic Compression Works (p. 123)
- Automatic Compression Example (p. 124)

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 the COMPUPDATE parameter 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 will perform 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 (p. 441) command against an already populated table. For example, you can run the ANALYZE COMPRESSION command when you want to analyze compression on a table for future use, while preserving the existing DDL.

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 will choose a less efficient compression encoding to keep the sort key columns balanced with other columns. However, ANALYZE COMPRESSION does not take sort keys into account, so it might recommend a different encoding for the sort key than what automatic compression would choose. If you use ANALYZE COMPRESSION, consider changing the encoding to 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 disable 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 Choosing a Column Compression Type (p. 43).

**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. Ensure that the table is empty. You can apply automatic compression only to an empty table:

   ```sql
   truncate biglist;
   ```

2. Load the table with a single COPY command. Although the table is empty, some earlier encoding might have been specified. To ensure that Amazon Redshift performs a compression analysis, set the COMPUPDATE parameter to ON.

   ```sql
   copy biglist from 's3://mybucket/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.

   ```sql
   select "column", type, encoding
   from pg_table_def where tablename = 'biglist';
   ```

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>listid</td>
<td>integer</td>
<td>delta</td>
</tr>
<tr>
<td>sellerid</td>
<td>integer</td>
<td>delta32k</td>
</tr>
<tr>
<td>eventid</td>
<td>integer</td>
<td>delta32k</td>
</tr>
<tr>
<td>dateid</td>
<td>smallint</td>
<td>delta</td>
</tr>
<tr>
<td>+numtickets</td>
<td>smallint</td>
<td>delta</td>
</tr>
<tr>
<td>priceperticket</td>
<td>numeric(8,2)</td>
<td>delta32k</td>
</tr>
<tr>
<td>totalprice</td>
<td>numeric(8,2)</td>
<td>mostly32</td>
</tr>
<tr>
<td>listtime</td>
<td>timestamp without time zone</td>
<td>none</td>
</tr>
</tbody>
</table>

4. Verify that the expected number of rows were loaded:

   ```sql
   select count(*) from biglist;
   ```

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>124</td>
</tr>
</tbody>
</table>
When rows are later appended to this table using COPY or INSERT statements, the same compression encodings will be 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 will need to 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

**Topics**

- S3ServiceException Errors (p. 126)
- System Tables for Troubleshooting Data Loads (p. 127)
- Multibyte Character Load Errors (p. 128)
- Load Error Reference (p. 129)
This section provides information about identifying and resolving data loading errors.

### 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 regions, and insufficient Amazon S3 privileges.

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 quotes.

#### 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 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* (p. 102).
For more information about Amazon S3 regions, see Accessing a Bucket in the Amazon Simple Storage Service Developer Guide.

Alternatively, you can specify the region using the REGION (p. 458) option with the COPY command.

Access Denied

The user account identified by the credentials must have LIST and GET access to the Amazon S3 bucket. If the user does not have sufficient privileges, you will receive the following error message:

```
ERROR: S3ServiceException:Access Denied,Status 403,Error AccessDenied
```

For information about managing user access to buckets, see Access Control in the Amazon S3 Developer 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 (p. 946) to discover the errors that occurred during specific loads.
- Query STL_FILE_SCAN (p. 937) to view load times for specific files or to see if a specific file was even read.
- Query STL_S3CLIENT_ERROR (p. 972) 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.

   ```sql
   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:

   ```sql
   select * from loadview where table_name='venue';
   ```

<table>
<thead>
<tr>
<th>tbl</th>
<th>table_name</th>
<th>query</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>100551</td>
<td>venue</td>
<td>20974</td>
<td>2013-01-29 19:05:58.365391</td>
</tr>
<tr>
<td></td>
<td>input</td>
<td>line_number</td>
<td>colname</td>
</tr>
<tr>
<td></td>
<td>venue_pipe.txt</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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 quotes. Amazon Redshift supports both single and double quotes; however, these quotes 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 (p. 378).

If a line in your load data contains a character that is invalid 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 invalid characters in your load data is to replace the invalid characters during the load process. To replace invalid UTF-8 characters, specify the ACCEPTINVCHARS option with the COPY command. For more information, see ACCEPTINVCHARS (p. 477).

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 invalid 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.

<table>
<thead>
<tr>
<th>Error code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The UTF-8 byte sequence exceeds the four-byte maximum supported by VARCHAR.</td>
</tr>
<tr>
<td>2</td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>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).</td>
</tr>
<tr>
<td>4</td>
<td>The value of the trailing byte in the byte sequence is out of range. The continuation byte must be between 128 and 191 (inclusive).</td>
</tr>
<tr>
<td>5</td>
<td>The UTF-8 character is reserved as a surrogate. Surrogate code points (U+D800 through U+DFFF) are invalid.</td>
</tr>
<tr>
<td>6</td>
<td>The character is not a valid UTF-8 character (code points 0xFDD0 to 0xFDEF).</td>
</tr>
</tbody>
</table>
### Error code | Description
--- | ---
7 | The character is not a valid UTF-8 character (code points 0xFFFE and 0xFFFF).
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 (p. 946)` 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

<table>
<thead>
<tr>
<th>Error code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>Unknown parse error. Contact support.</td>
</tr>
<tr>
<td>1201</td>
<td>Field delimiter was not found in the input file.</td>
</tr>
<tr>
<td>1202</td>
<td>Input data had more columns than were defined in the DDL.</td>
</tr>
<tr>
<td>1203</td>
<td>Input data had fewer columns than were defined in the DDL.</td>
</tr>
<tr>
<td>1204</td>
<td>Input data exceeded the acceptable range for the data type.</td>
</tr>
<tr>
<td>1205</td>
<td>Date format is invalid. See DATEFORMAT and TIMEFORMAT Strings (p. 493) for valid formats.</td>
</tr>
<tr>
<td>1206</td>
<td>Timestamp format is invalid. See DATEFORMAT and TIMEFORMAT Strings (p. 493) for valid formats.</td>
</tr>
<tr>
<td>1207</td>
<td>Data contained a value outside of the expected range of 0-9.</td>
</tr>
<tr>
<td>1208</td>
<td>FLOAT data type format error.</td>
</tr>
<tr>
<td>1209</td>
<td>DECIMAL data type format error.</td>
</tr>
<tr>
<td>1210</td>
<td>BOOLEAN data type format error.</td>
</tr>
<tr>
<td>1211</td>
<td>Input line contained no data.</td>
</tr>
<tr>
<td>1212</td>
<td>Load file was not found.</td>
</tr>
<tr>
<td>1213</td>
<td>A field specified as NOT NULL contained no data.</td>
</tr>
<tr>
<td>1214</td>
<td>Delimiter not found.</td>
</tr>
<tr>
<td>1215</td>
<td>CHAR field error.</td>
</tr>
<tr>
<td>1216</td>
<td>Invalid input line.</td>
</tr>
<tr>
<td>1217</td>
<td>Invalid identity column value.</td>
</tr>
<tr>
<td>1218</td>
<td>When using NULL AS '\0', a field containing a null terminator (NUL, or UTF-8 0000) contained more than one byte.</td>
</tr>
<tr>
<td>1219</td>
<td>UTF-8 hexadecimal contains an invalid digit.</td>
</tr>
</tbody>
</table>
### Error codes and descriptions

<table>
<thead>
<tr>
<th>Error code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1220</td>
<td>String contains invalid or unsupported UTF-8 codepoints.</td>
</tr>
<tr>
<td>1221</td>
<td>Encoding of the file is not the same as that specified in the COPY command.</td>
</tr>
</tbody>
</table>

### Updating 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 (p. 450) 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 (p. 592) or CREATE TABLE AS (p. 550).

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 (p. 137) and Vacuuming Tables (p. 142).

### Updating and Inserting New Data

You can efficiently add new data to an existing table by using a combination of updates and inserts from a staging table. While Amazon Redshift does not support a single merge, or upsert, command to update a table from a single data source, you can 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.

**Topics**

- Merge Method 1: Replacing Existing Rows (p. 130)
- Merge Method 2: Specifying a Column List (p. 131)
- Creating a Temporary Staging Table (p. 131)
- Performing a Merge Operation by Replacing Existing Rows (p. 131)
- Performing a Merge Operation by Specifying a Column List (p. 132)
- Merge Examples (p. 133)

**Note**

You should run the entire merge operation, except for creating and dropping the temporary staging table, in a single transaction so that the transaction will roll back if any step fails. Using a single transaction also reduces the number of commits, which saves time and resources.

### Merge Method 1: Replacing Existing Rows

If you are overwriting all of the columns in the target table, the fastest method for performing a merge is by replacing the existing rows because it 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 along 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, described in the following section.

If you will not use all of the rows in the staging table, you can filter the DELETE and INSERT statements by using a WHERE clause to leave out rows that are not actually 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

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. 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.

### 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` (p. 542) 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 [Choosing a Data Distribution Style](p. 55)

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:

```sql
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` (p. 580) and check for `DS_DIST_NONE` on all of the joins. For more information, see [Evaluating the Query Plan](p. 59)

### Performing a Merge Operation by Replacing Existing Rows

**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.
Performing a Merge Operation by Specifying a Column List

To perform a merge operation by specifying a column list

1. Put the entire operation in a single transaction block so that if there is a problem, everything will be rolled back.

```sql
begin transaction;
...
end transaction;
```

2. Create a staging table, and then populate it with data to be merged, as shown in the following pseudocode.

```sql
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 (p. 580) and check for DS_DIST_NONE on all of the joins. For more information, see Evaluating the Query Plan (p. 59).

- If your target table is sorted by time stamp, 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 (p. 27).

- If you will not use all of the rows in the merge, add a clause to filter the rows that need to be changed. 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:

```sql
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.

```sql
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.

```sql
insert into target
(select col1, col2, 'expression'
from stage);
end transaction;
```

6. Drop the staging table.

```sql
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.

**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 sales_update as
select * from sales;

-- Change every fifth row so we have updates
update 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 so we have insert examples
-- This example creates a duplicate of every fourth row
insert into sales_update
select (salesid + 172456) as salesid, listid, sellerid, buyerid, eventid, dateid, qtysold,
pricepaid, commission, getdate() as saletime
from sales_update
where saletime > '2008-11-30'
and mod(sellerid, 4) = 0;
```

**Example of a merge that replaces existing rows**

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 deletes rows in the SALES table that have updates so they can be replaced with the updated rows in the staging table. The staging table should contain only rows that will participate in the merge, so the CREATE TABLE statement includes a filter to exclude rows that have not changed.

```
-- Create a staging table and populate it with updated rows from SALES_UPDATE
create temp table stagesales as
select * from sales_update
where sales_update.saletime > '2008-11-30'
and sales_update.salesid = (select sales.salesid from sales
where sales.salesid = sales_update.salesid
and sales.listid = sales_update.listid
and (sales_update.qtysold != sales.qtysold
or sales_update.pricepaid != sales.pricepaid));

-- Start a new transaction
begin transaction;

-- Delete any rows from SALES that exist in STAGESALES, because they are updates
-- The join includes a redundant predicate to collocate on the distribution key
-- A filter on saletime enables a range-restricted scan on SALES
delete from sales
using stagesales
where sales.salesid = stagesales.salesid
and sales.listid = stagesales.listid
and sales.saletime > '2008-11-30';

-- Insert all the rows from the staging table into the target table
insert into sales
select * from 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. The trade off is that
you should not make concurrent updates during a deep copy operation unless you can track it and move
the delta updates into the new table after the process has completed. 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.

  Note
  If the original DDL is not available, you might be able to recreate the DDL by running a script called v_generate_tbl_ddl. You can download the script from amazon-redshift-utils, which is part of the Amazon Web Services - Labs git hub repository.

- 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, distkey, sortkey, and notnull 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 (p. 421).

- Create a temporary table and truncate the original table.

  If you need to retain the primary key and foreign key attributes of the parent table, or 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 terminates before the subsequent INSERT completes, the data is lost. If data loss is unacceptable, use a permanent table.

**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. Drop the original table.
5. Use an ALTER TABLE statement to rename the copy to the original table name.

The following example performs a deep copy on the SALES table using a duplicate of SALES named SALESCOPY.

```sql
create table salescopy ( ... );
insert into salescopy (select * from sales);
drop table sales;
alter table salescopy rename to sales;
```

**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. Drop the current table.
4. Use an ALTER TABLE statement to rename the new table to the original table name.
The following example performs a deep copy on the SALES table using CREATE TABLE LIKE.

```sql
create table likesales (like sales);
insert into likesales (select * from sales);
drop table sales;
alter table likesales rename to sales;
```

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:

```sql
create temp table salestemp as select * from sales;
truncate sales;
insert into sales (select * from salestemp);
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 (p. 439) command.

Topics
- Automatic Analyze (p. 137)
- Analysis of New Table Data (p. 138)
- ANALYZE Command History (p. 141)

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 disable 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 (p. 1093) system catalog table.

You can specify the scope of the ANALYZE (p. 439) 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 (p. 1102) 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 (p. 636) 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.

```sql
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, needs to 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 execution plans and long execution times. 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,
```
### Analysis of New Table Data

```sql
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 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.

```sql
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.

```sql
SELECT * FROM predicate_columns
WHERE table_name = 'listing';
```

<table>
<thead>
<tr>
<th>schema_name</th>
<th>table_name</th>
<th>col_num</th>
<th>col_name</th>
<th>is.predicate</th>
<th>first_predicate_use</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>listing</td>
<td>1</td>
<td>listid</td>
<td>true</td>
<td>2017-05-05 19:27:59</td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>2</td>
<td>sellerid</td>
<td>false</td>
<td></td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>3</td>
<td>eventid</td>
<td>true</td>
<td>2017-05-16 20:54:32</td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>4</td>
<td>dateid</td>
<td>false</td>
<td></td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>5</td>
<td>numtickets</td>
<td>false</td>
<td></td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>6</td>
<td>priceperticket</td>
<td>false</td>
<td></td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>7</td>
<td>totalprice</td>
<td>false</td>
<td></td>
</tr>
<tr>
<td></td>
<td>listing</td>
<td>8</td>
<td>listtime</td>
<td>true</td>
<td>2017-05-16 20:54:32</td>
</tr>
</tbody>
</table>

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.

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 executes 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 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;
```

<table>
<thead>
<tr>
<th>xid</th>
<th>name</th>
<th>status</th>
<th>rows</th>
<th>modified_rows</th>
<th>starttime</th>
<th>endtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1582</td>
<td>users</td>
<td>Full</td>
<td>49990</td>
<td>49990</td>
<td>2016-09-22 22:02:23</td>
<td>2016-09-22 22:02:28</td>
</tr>
<tr>
<td>245439</td>
<td>users</td>
<td>Skipped</td>
<td>49984</td>
<td>1982</td>
<td>2016-10-04 23:00:13</td>
<td>2016-10-04 23:00:13</td>
</tr>
</tbody>
</table>

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;
```

---

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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 the table owner or a superuser can effectively vacuum a table. If you don't have owner or superuser privileges for a table, a VACUUM operation that specifies a single table fails. If you run a VACUUM of the entire database without specifying a table name, the operation completes successfully. However, the operation has no effect on tables for which you don't have owner or superuser privileges.
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 (p. 1076).

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 (p. 1076). 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>
<thead>
<tr>
<th>table</th>
<th>unsorted</th>
<th>vacuum_sort_benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales</td>
<td>85.71</td>
<td>5.00</td>
</tr>
</tbody>
</table>
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 (p. 143)
- Sort Stage and Merge Stage (p. 143)
- Vacuum Threshold (p. 144)
- Vacuum Types (p. 144)
- Managing Vacuum Times (p. 144)

VACUUM Frequency

You should vacuum as often as you need to in order 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.
- 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 need to be re-sorted, query the SVV_INTERLEAVED_COLUMNS (p. 1039) 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 off line during the vacuum, the partially vacuumed table or database will be in a consistent state, but you will need to 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 Managing the Volume of Merged Rows (p. 146).

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 execute 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.

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

You can run a full vacuum, a delete only vacuum, a sort only vacuum, or a reindex with full vacuum.

- **VACUUM FULL**
  
  VACUUM FULL re-sorts rows and reclaims space from deleted rows. Amazon Redshift automatically performs VACUUM DELETE ONLY operations in the background, so for most applications, VACUUM FULL and VACUUM SORT ONLY are equivalent. VACUUM FULL is the same as VACUUM. Full vacuum is the default vacuum operation.

- **VACUUM DELETE ONLY**
  
  A DELETE ONLY vacuum is the same as a full vacuum except that it skips the sort. Amazon Redshift automatically performs a DELETE ONLY vacuum in the background, so you rarely, if ever, need to run a DELETE ONLY vacuum.

- **VACUUM SORT ONLY**
  
  A SORT ONLY doesn't reclaim disk space. In most cases there is little benefit compared to a full vacuum.

- **VACUUM REINDEX**
  
  Use VACUUM REINDEX for tables that use interleaved sort keys. For more information about interleaved sort keys, see Interleaved Sort Key (p. 67).

  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.

  REINDEX reanalyzes the distribution of the values in the table's sort key columns, then performs a full VACUUM operation. VACUUM REINDEX takes significantly longer than VACUUM FULL because it needs to take an extra analysis pass over the data, and because merging in new interleaved data can involve touching all the data blocks.

  If a VACUUM REINDEX operation terminates before it completes, the next VACUUM resumes the reindex operation before performing the vacuum.

Managing Vacuum Times

Depending on the nature of your data, we recommend following the practices in this section to minimize vacuum times.

**Topics**

- Deciding Whether to Reindex (p. 145)
Deciding 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 (p. 1039) view.

For example, the following query shows details for tables that use interleaved sort keys.

```sql
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;
```

<table>
<thead>
<tr>
<th>tbl_id</th>
<th>table_name</th>
<th>col</th>
<th>interleaved_skew</th>
<th>last_reindex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>3.65</td>
<td>2015-04-22 22:05:45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2.65</td>
<td>2015-04-22 22:05:45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1.65</td>
<td>2015-04-22 22:05:45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1.00</td>
<td>2015-04-22 22:05:45</td>
</tr>
</tbody>
</table>

(4 rows)

The value for `interleaved_skew` is a ratio that indicates the amount of skew. A value of 1 means 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.

Managing 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 (p. 27).

Managing 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.

Prior to 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 only 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>
<thead>
<tr>
<th>table_name</th>
<th>xid</th>
<th>sort_</th>
<th>merge_</th>
<th>elapsed_</th>
<th>row_</th>
<th>sortedrow_</th>
<th>block_</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>max_merge_</td>
<td>partitions</td>
<td>increments</td>
<td>time</td>
<td>delta</td>
<td>delta</td>
<td>delta</td>
<td></td>
</tr>
<tr>
<td>-----------+------------+-------------+-------+-------+-------+-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------+---------------+-----------------+---------+-------+-------+-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>7072</td>
<td>3</td>
<td>2</td>
<td>143918314</td>
<td>0</td>
<td>88297472</td>
<td>1524</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>7122</td>
<td>3</td>
<td>3</td>
<td>164157882</td>
<td>0</td>
<td>88297472</td>
<td>772</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>7212</td>
<td>3</td>
<td>4</td>
<td>187433171</td>
<td>0</td>
<td>88297472</td>
<td>767</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>7289</td>
<td>3</td>
<td>4</td>
<td>255482945</td>
<td>0</td>
<td>88297472</td>
<td>770</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>7420</td>
<td>3</td>
<td>5</td>
<td>316583833</td>
<td>0</td>
<td>88297472</td>
<td>769</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>custsales</td>
<td>9007</td>
<td>3</td>
<td>6</td>
<td>306685472</td>
<td>0</td>
<td>88297472</td>
<td>772</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6 rows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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, that is an indication that each vacuum operation is remerging an increasing number of rows in the table because the existing and newly sorted regions overlap.

**Loading Your Data in Sort Key Order**

If you load your data in sort key order using a COPY command, you might reduce or even eliminate 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 eliminating the need to vacuum.
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

Topics

- Serializable Isolation (p. 151)
- Write and Read-Write Operations (p. 154)
- Concurrent Write Examples (p. 154)

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.

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 executed SQL command commits individually. If you enclose a set of commands in a transaction block (defined by BEGIN (p. 442) and END (p. 578) 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:
Serializable Isolation

- 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 would produce the same results as their concurrent execution, those transactions are deemed "serializable" and can be run safely. If no serial execution of those transactions would produce the same results, the transaction that executes a statement that would break serializability is aborted 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. If T2 returns a list of tables by selecting from the PG_TABLES catalog table, and then T1 drops table A and commits, and then T2 lists the tables again, table A is 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 is not subject to the same isolation rules as operations against user tables.

Transactions for updates to these tables run in a read committed isolation mode. PG-prefix catalog tables do not 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 do not reference any table will not create a new transaction database snapshot, nor will any INSERT, DELETE, or UPDATE statements that operate solely on system catalog tables (PG).

How to Fix Serializable Isolation Errors

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:

- 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.
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.

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.

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 (p. 596)` 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.
- Retry the aborted transaction.

A transaction can encounter a serializable isolation error if it conflicts with operations performed by another concurrent transaction. If the conflicting transactions don't need to run at the same time, simply retrying the aborted transaction might succeed. If the issue persists, try one of the other methods.
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, but DELETE and UPDATE operations are read-write operations. (In order 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. COPY and INSERT operations against the same table are held in a wait state until the lock is released, then they proceed as normal.

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

Whenever 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 does not 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 will not be able to proceed because T2 still holds the lock on B. Conversely, 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.

In order 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.

Concurrent Write Examples

The following pseudo-code examples demonstrate how transactions either proceed or wait when they are run concurrently.

Concurrent COPY Operations into the Same Table

Transaction 1 copies rows into the LISTING table:

```sql
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.

```sql
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**

Transaction 1 deletes rows from a table:

```sql
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.

```sql
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**

In this example, transaction 1 deletes rows from the USERS table, reloads the table, runs a COUNT(*) query, and then ANALYZE, before committing:

```sql
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:

```sql
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.
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.

**Estimated time:** 60 minutes

**Estimated cost:** $1.00 per hour for the cluster

**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 (an access key ID and secret access key) to load test data from Amazon S3. If you need to create new access keys, go to Administering Access Keys for IAM Users.
- 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** walks you through the process of creating an Amazon Redshift cluster and loading sample data.
- **Tutorial: Tuning Table Design (p. 73)** walks you step by step through the process of designing and tuning tables, including choosing sort keys, distribution styles, and compression encodings, and evaluating system performance before and after tuning.

**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 (p. 24)
• Loading Data from Amazon EMR (p. 110)
• Loading Data from Remote Hosts (p. 114)
• Loading Data from an Amazon DynamoDB Table (p. 120)

Steps

• Step 1: Create a Cluster (p. 157)
• Step 2: Download the Data Files (p. 158)
• Step 3: Upload the Files to an Amazon S3 Bucket (p. 159)
• Step 4: Create the Sample Tables (p. 160)
• Step 5: Run the COPY Commands (p. 162)
• Step 6: Vacuum and Analyze the Database (p. 173)
• Step 7: Clean Up Your Resources (p. 174)

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.

New Console

To create a cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshift/.

   Important
   If you use IAM user credentials, make sure that you have the necessary permissions to perform the cluster operations. For more information, see Controlling Access to IAM Users in the Amazon Redshift Cluster Management Guide.

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. Choose dc2.large for the node type in the Compute optimized section. Then choose 4 for the Nodes.

5. In the Cluster details section, specify values for Cluster identifier, Database port, Master user name, and Master user password.

6. 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 Add IAM role to add it to the list of Attached IAM roles for the cluster.

7. Choose Create cluster.

Original Console

Follow the steps in Amazon Redshift Getting Started, but choose Multi Node for Cluster Type and set Number of Compute Nodes to 4.
Follow the Amazon Redshift Getting Started 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.

Next Step

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
```

```bash
customer-fw.tbl-004
```
Next Step

Step 3: Upload the Files to an Amazon S3 Bucket (p. 159)

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.
   a. Sign in to the AWS Management Console and open the Amazon S3 console at https://console.aws.amazon.com/s3/.
   b. Click Create Bucket.
   c. In the Bucket Name box of the Create a Bucket dialog box, type 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 Developer Guide.

   d. Select a region.

   Create the bucket in the same region as your cluster. If your cluster is in the Oregon region, click Oregon.

   e. Click Create.

   When Amazon S3 successfully creates your bucket, the console displays your empty bucket in the Buckets panel.

2. Create a folder.
   a. Click the name of the new bucket.
   b. Click the Actions button, and click Create Folder in the drop-down list.
   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. Click the name of the data folder.
   b. In the Upload - Select Files wizard, click Add Files.
      A file selection dialog box opens.
   c. Select all of the files you downloaded and extracted, and then click Open.
   d. Click Start 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.

Next Step
Step 4: Create the Sample Tables (p. 160)

Step 4: Create the Sample Tables
For this tutorial, you use a set of five 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, execute the following commands in your SQL client.

   ```sql
   drop table part cascade;
drop table supplier;
drop table customer;
drop table dwdate;
drop table lineorder;
```

2. Execute the following CREATE TABLE commands in your SQL client.

   ```sql
   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,
```
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.

**Topics**
- COPY Command Syntax (p. 162)
- Loading the SSB Tables (p. 164)

**COPY Command Syntax**

The basic COPY (p. 450) command syntax is as follows.

```sql
COPY table_name [ column_list ] FROM data_source CREDENTIALS access_credentials [options]
```

To execute 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 (p. 467) 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 an AWS user or an IAM user with sufficient privileges. These credentials are an access key ID and a secret access key. To load data from Amazon S3, the credentials must include ListBucket and GetObject permissions. Additional credentials are required if your data is encrypted or if you are using temporary access credentials. For more information, see Authorization Parameters (p. 465) in the COPY command reference. For more information about managing access, go to Managing Access Permissions to Your Amazon S3 Resources. If you do not have an access key ID and secret access key, you need to get them. For more information, go to Administering Access Keys for IAM Users.

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 (p. 164)
- CSV Format (p. 165)
- NULL AS (p. 166)
- REGION (p. 167)
- Fixed-Width Format (p. 167)
- MAXERROR (p. 168)
- ACCEPTINVCHARS (p. 170)
- MANIFEST (p. 170)
- DATEFORMAT (p. 171)
- GZIP, LZOP and BZIP2 (p. 172)
- COMPUPDATE (p. 172)
- Multiple Files (p. 172)
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 (p. 164)
2. Load the PART Table Using NULL AS (p. 164)
3. Load the SUPPLIER table Using REGION (p. 166)
4. Load the CUSTOMER Table Using MANIFEST (p. 167)
5. Load the DWDATE Table Using DATEFORMAT (p. 171)
6. Load the LINEORDER Table Using Multiple Files (p. 171)

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_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
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 (p. 458) option with the COPY command.
2. Replace `<Your-Access-Key-ID>` and `<Your-Secret-Access-Key>` with your own AWS IAM account credentials. The segment of the credentials string that is enclosed in single quotation marks must not contain any spaces or line breaks.

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 Split Your Load Data into Multiple Files (p. 25).

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://mybucket/load/part-csv.tbl'` loads the following set of the files in the load folder.
Step 5: Run the COPY Commands

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 quote character for COPY from CSV format is a double quotation mark (""), but you can specify another quote character by using the QUOTE AS option. When you use the quote character within the field, escape the character with an additional quote 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. Execute the following command to load the PART table.

```
COPY part FROM 's3://<your-bucket-name>/load/part-csv.tbl' CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' CSV;
```

You should get an error message similar to the following.

```
An error occurred when executing the SQL command:
COPY part FROM 's3://mybucket/load/part-csv.tbl' CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' CSV;
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>filename</th>
<th>line</th>
<th>column</th>
<th>type</th>
<th>pos</th>
</tr>
</thead>
</table>
The `part-csv.tbl` data files use the NUL terminator character (\x00 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 \x00 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, execute the following COPY command.

```sql
COPY part FROM 's3://<your-bucket-name>/load/part-csv.tbl'
  credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
  csv
  null as '\000';
```

To verify that COPY loaded NULL values, execute the following command to select only the rows that contain NULL.

```sql
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)
```

**Load the SUPPLIER table Using REGION**

In this step, you use the DELIMITER and REGION options to load the SUPPLIER table.

**Note**

The files for loading the SUPPLIER table are provided in an AWS sample bucket. You don’t need to upload files for this step.

**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.
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, minimize eventual consistency issues, and avoid cross-region data transfer costs. For more information, see Amazon Redshift Best Practices for Loading Data (p. 24).

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 (p. 458).

If your cluster is in the US East (N. Virginia) region, execute the following command to load the SUPPLIER table from pipe-delimited data in an Amazon S3 bucket located in the US West (Oregon) region. For this example, do not change the bucket name.

```sql
COPY supplier FROM 's3://awssampledbuswest2/ssbgz/supplier.tbl'
CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
DELIMITER '|'
GZIP
REGION 'us-west-2';
```

If your cluster is not in the US East (N. Virginia) region, execute the following command to load the SUPPLIER table from pipe-delimited data in an Amazon S3 bucket located in the US East (N. Virginia) region. For this example, do not change the bucket name.

```sql
COPY supplier FROM 's3://awssampledb/ssbgz/supplier.tbl'
CREDENTIALS 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
DELIMITER '|'
GZIP
REGION 'us-east-1';
```

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 MOROCCO AFRICA  25-705
2 Customer#000000002  XSTf4,NCwDVaWNe6tE  JORDAN JORDAN MIDDLE EAST  23-453
3 Customer#000000003  MG9kdTD  ARGENTINA ARGENTINA AMERICA  11-783
```

The order of the label/width pairs must match the order of the table columns exactly. For more information, see FIXEDWIDTH (p. 469).
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, execute the following command.

```
copy customer
from 's3://<your-bucket-name>/load/customer-fw.tbl'
credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
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://mybucket/load/customer-fw.tbl'  
credentials 'aws_access_key_id=...  
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, execute the following command.

```
copy customer  
from 's3://<your-bucket-name>/load/customer-fw.tbl'  
credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'  
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 STT_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,
```

168
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 | error_reason |
|-------+----------+-------+--------+------|-----+--------------|
|       |          |       |        |      |     |  | customer-fw.tbl.log | 2 | c_custkey | int4 | -1 | customer-fw.tbl | Invalid digit, Value 'c', Pos 0, Type: Integ |
|       |          |       |        |      |     |  | Complete | 6 | c_custkey | int4 | -1 | Complete | Invalid digit, Value 'C', Pos 0, Type: Integ |
|       |          |       |        |      |     |  | Total rows | 3 | c_custkey | int4 | -1 | Total row | Invalid digit, Value '#', Pos 0, Type: Integ |
|       |          |       |        |      |     |  | Status | 5 | c_custkey | int4 | -1 | Status | Invalid digit, Value '#', Pos 0, Type: Integ |
|       |          |       |        |      |     |  | Load file | 1 | c_custkey | int4 | -1 | Load file | Invalid digit, Value '#', Pos 0, Type: Integ |

(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, execute the following command to query the CUSTOMER table.

```sql
select c_custkey, c_name, c_address
from customer
order by c_custkey
limit 10;
```

<table>
<thead>
<tr>
<th>c_custkey</th>
<th>c_name</th>
<th>c_address</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Customer#000000002</td>
<td>XSTf4,NCwDVaWN6w6E</td>
</tr>
<tr>
<td>2</td>
<td>Customer#000000002</td>
<td>XSTf4,NCwDVaWN6w6E</td>
</tr>
<tr>
<td>3</td>
<td>Customer#000000003</td>
<td>MG9kdTD</td>
</tr>
<tr>
<td>3</td>
<td>Customer#000000003</td>
<td>MG9kdTD</td>
</tr>
<tr>
<td>4</td>
<td>Customer#000000004</td>
<td>XXVSJsL</td>
</tr>
<tr>
<td>4</td>
<td>Customer#000000004</td>
<td>XXVSJsL</td>
</tr>
<tr>
<td>5</td>
<td>Customer#000000005</td>
<td>KvpyuHCplrB84WgAi</td>
</tr>
</tbody>
</table>
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 (p. 128).

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://mybucket/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 (p. 457).

The following shows the customer-fw-manifest text.

```json
{
  "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"},
    
```
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. Execute the following COPY command.

   ```sql
   copy customer from 's3://<your-bucket-name>/load/customer-fw-manifest' 
   credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
   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 time stamps. 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.

<table>
<thead>
<tr>
<th>Date</th>
<th>Format</th>
<th>Day</th>
<th>Month</th>
<th>Year</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>19920112</td>
<td>January 12, 1992</td>
<td>Monday</td>
<td>January</td>
<td>1992</td>
<td>199201</td>
<td></td>
</tr>
<tr>
<td>19920120</td>
<td>January 20, 1992</td>
<td>Tuesday</td>
<td>January</td>
<td>1992</td>
<td>199201</td>
<td></td>
</tr>
</tbody>
</table>

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 (p. 494).

To load the DWDATE table, execute the following COPY command.

   ```sql
   copy dwdate from 's3://<your-bucket-name>/load/dwdate-tab.tbl' 
   credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>'
   delimiter '\t'
   dateformat 'auto';
   ```

Load the LINEORDER Table Using Multiple Files

This step uses the GZIP and COMPUPDATE options to load the LINEORDER table.
In this exercise, you load the LINEORDER table from a single data file and then load it again from multiple files. Doing this enables you to compare the load times for the two methods.

**Note**
The files for loading the LINEORDER table are provided in an AWS sample bucket. You don’t need to upload files for this step.

**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, go to About Clusters and Nodes in the Amazon Redshift Cluster Management Guide.

For example, the dc1.large compute nodes used in this tutorial have two slices each, so the four-node cluster has eight slices. In previous steps, the load data was contained in eight files, even though the files are very small. In this step, you compare the time difference between loading from a single large file and loading from multiple files.

The files you use for this tutorial contain about 15 million records and occupy about 1.2 GB. These files are very small in Amazon Redshift scale, but sufficient to demonstrate the performance advantage of loading from multiple files. The files are large enough that the time required to download them and then upload them to Amazon S3 is excessive for this tutorial. Thus, you load the files directly from an AWS sample bucket.

The following screenshot shows the data files for LINEORDER.
To evaluate the performance of COPY with multiple files

1. Execute the following command to COPY from a single file. Do not change the bucket name.

   ```sql
   copy lineorder from 's3://awssampledb/load/lo/lineorder-single.tbl' 
   credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' 
   gzip 
   compupdate off 
   region 'us-east-1';
   ```

2. Your results should be similar to the following. 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. Execute the following command to COPY from multiple files. Do not change the bucket name.

   ```sql
   copy lineorder from 's3://awssampledb/load/lo/lineorder-multi.tbl' 
   credentials 'aws_access_key_id=<Your-Access-Key-ID>;aws_secret_access_key=<Your-Secret-Access-Key>' 
   gzip 
   compupdate off 
   region 'us-east-1';
   ```

4. Your results should be similar to the following. 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 example, 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.

Next Step

Step 6: Vacuum and Analyze the Database (p. 173)

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
The ANALYZE command updates the statistics metadata, which enables the query optimizer to generate more accurate query plans. For more information, see Vacuuming Tables (p. 142).

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, execute the following commands.

```sql
vacuum;
analyze;
```

Next Step

Step 7: Clean Up Your Resources (p. 174)

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.

If you want to keep the cluster, but recover the storage used by the SSB tables, execute the following commands.

```sql
drop table part;
drop table supplier;
drop table customer;
drop table dwdate;
drop table lineorder;
```

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 (p. 25)
• Split Your Load Data into Multiple Files (p. 25)
• Use a Single COPY Command to Load from Multiple Files (p. 25)
• Compress Your Data Files (p. 25)
• Use a Manifest File (p. 25)
• Verify Data Files Before and After a Load (p. 25)

For more information about Amazon Redshift best practices, see the following links:

• Amazon Redshift Best Practices for Loading Data (p. 24)
• Amazon Redshift Best Practices for Designing Tables (p. 21)
• Amazon Redshift Best Practices for Designing Queries (p. 27)

Next Step

For your next step, if you haven't done so already, we recommend taking Tutorial: Tuning Table Design (p. 73).
Unloading Data

Topics

- Unloading Data to Amazon S3 (p. 176)
- Unloading Encrypted Data Files (p. 179)
- Unloading Data in Delimited or Fixed-Width Format (p. 180)
- Reloading Unloaded Data (p. 181)

To unload data from database tables to a set of files in an Amazon S3 bucket, you can use the UNLOAD (p. 642) 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.

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 (p. 642) 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 quotes (enclosing literal values, for example), you need to escape them in the query text (\'). For more information, see the SELECT (p. 607) command reference. For more information about using a LIMIT clause, see the Usage Notes (p. 647) for the UNLOAD command.

For example, the following UNLOAD command sends the contents of the VENUE table to the Amazon S3 bucket s3://mybucket/tickit/unload/.

```
unload ('select * from venue') to 's3://mybucket/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://mybucket/tickit/unload/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```
unload ('select * from venue')
to 's3://mybucket/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://mybucket/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://mybucket/tickit/unload/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';

You can limit the access users have to your data by using temporary security credentials. Temporary security credentials provide enhanced security because they have short life spans and cannot be reused after they expire. A user who has these temporary security credentials can access your resources only until the credentials expire. For more information, see Temporary Security Credentials (p. 487). To unload data using temporary access credentials, use the following syntax:

unload ('select * from venue')
to 's3://mybucket/tickit/venue_'
access_key_id '<access-key-id>'
secret_access_key '<secret-access-key>'
session_token '<temporary-token>';

**Important**
The temporary security credentials must be valid for the entire duration of the UNLOAD statement. If the temporary security credentials expire during the load process, the UNLOAD will fail and the transaction will be rolled back. For example, if temporary security credentials expire after 15 minutes and the UNLOAD requires one hour, the UNLOAD will fail before it completes.

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://mybucket/tickit/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest;

The following example shows a manifest for four unload files.

```json
{
}
```
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 (p. 107).

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:

```
mybucket/ticket/venue_0000_part_00
mybucket/ticket/venue_0001_part_00
mybucket/ticket/venue_0002_part_00
mybucket/ticket/venue_0003_part_00
mybucket/ticket/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; 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 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;
```

```
<table>
<thead>
<tr>
<th>query</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0000_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0001_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0002_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0003_part_00</td>
</tr>
</tbody>
</table>
```

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 quotes are escaped (=\'\'OH\'\').
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.

```
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';

unload ('select * from venue')
  to 's3://mybucket/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 (CSE-CMK). UNLOAD doesn't support Amazon S3 server-side encryption using a customer-supplied key (SSE-C). 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.

```
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';

unload ('select venuename, venuecity from venue')
  to 's3://mybucket/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 master symmetric key.
2. You issue an UNLOAD command that includes your master 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 master 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 master key value to the credentials string and include the ENCRYPTED option. If you use the MANIFEST option, the manifest file is also encrypted.

```
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';

unload ('select venuename, venuecity from venue')
  to 's3://mybucket/encrypted/venue_
  iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
encrypted;
```

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 master key value to the credentials string and include the ENCRYPTED option. If you use the MANIFEST option, the manifest file is also encrypted.
To unload encrypted data files that are GZIP compressed, include the GZIP option along with the master key value and the ENCRYPTED option.

```
unload ('select venuename, venuecity from venue')
to 's3://mybucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<master_key>'
encrypted gzip;
```

To load the encrypted data files, add the MASTER_SYMMETRIC_KEY parameter with the same master key value and include the ENCRYPTED option.

```
copy venue from 's3://mybucket/encrypted/venue_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
master_symmetric_key '<master_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://mybucket/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://mybucket/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:

```sql
unload ('select * from venue')
to 's3://mybucket/ticket/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 | ON 0 |
| 60 | Rexall Place      | Edmonton | AB 0 |
| 100U.S. Cellular Field | Chicago | IL | 40615 |
| 200A Hirschfeld Theatre | New York City | NY | 0 |
| 240San Jose Repertory Theatre | San Jose | CA 0 |
| 300Kennedy Center Opera House | Washington | DC 0 |

For more details about FIXEDWIDTH specifications, see the UNLOAD (p. 642) 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.

```sql
unload ('select * from venue order by venueid')
to 's3://mybucket/ticket/venue/reload_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest
delimiter '|';
truncate venue;
copy venue
from 's3://mybucket/ticket/venue/reload_manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest
delimiter '|';
```

After it is reloaded, the VENUE table looks like this:

```sql
select * from venue order by venueid limit 5;

<table>
<thead>
<tr>
<th>venuede</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toyota Park</td>
<td>Bridgeview</td>
<td>IL</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Columbus Crew Stadium</td>
<td>Columbus</td>
<td>OH</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>RFK Stadium</td>
<td>Washington</td>
<td>DC</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>CommunityAmerica Ballpark</td>
<td>Kansas City</td>
<td>KS</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Foxborough</td>
<td>MA</td>
<td>68756</td>
</tr>
</tbody>
</table>
```

(5 rows)
Creating User-Defined Functions

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, 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 (p. 185).

By default, all users can execute UDFs. For more information about privileges, see UDF Security and Privileges (p. 182).

Topics
- UDF Security and Privileges (p. 182)
- Creating a Scalar SQL UDF (p. 182)
- Creating a Scalar Python UDF (p. 183)
- Naming UDFs (p. 188)
- Logging Errors and Warnings in UDFs (p. 189)

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, 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.

```sql
revoke usage on language sql from PUBLIC;
grant usage on language sql to group udf_devs;
```

To execute 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 from PUBLIC for the function. Then grant the privilege to specific individuals or groups.

The following example revokes execution on function \( f_{\text{py_greater}} \) from PUBLIC. Then it grants usage to the user group udf_devs.

```sql
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 (p. 585) and REVOKE (p. 600).

Creating a Scalar SQL UDF

A scalar SQL UDF incorporates a SQL SELECT clause that executes when the function is called and returns a single value. The CREATE FUNCTION (p. 525) 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 (p. 525).

```sql
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.

```sql
select f_sql_greater(commission, pricepaid*0.20) from sales;
```

### Creating a Scalar Python UDF

A scalar Python UDF incorporates a Python program that executes when the function is called and returns a single value. The CREATE FUNCTION (p. 525) 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 can be SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, DOUBLE PRECISION, BOOLEAN, CHAR, VARCHAR, DATE, or TIMESTAMP. In addition, Python UDFs can use the data
type ANYELEMENT, which Amazon Redshift automatically converts to a standard data type based on the arguments supplied at run time. For more information, see ANYELEMENT Data Type (p. 185).

When an Amazon Redshift query calls a scalar UDF, the following steps occur at run time.

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 (p. 184).

2. The function executes 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.

## 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 (p. 525).

```python
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.

```sql
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 run time. Scalar UDFs can return a data type of ANYELEMENT. For more information, see ANYELEMENT Data Type (p. 185).

During execution, Amazon Redshift converts the arguments from Amazon Redshift data types to Python data types for processing, and 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 (p. 369).

The following table maps Amazon Redshift data types to Python data types.

<table>
<thead>
<tr>
<th>Amazon Redshift Data Type</th>
<th>Python Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>smallint</td>
<td>int</td>
</tr>
<tr>
<td>integer</td>
<td></td>
</tr>
</tbody>
</table>
ANYELEMENT Data Type

ANYELEMENT is a *polymorphic data type*, which 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 will be 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
You can also import your own custom Python modules and make them available for use in UDFs by executing a CREATE LIBRARY (p. 529) command. For more information, see Importing Custom Python Library Modules (p. 186).

Important
Amazon Redshift blocks all network access and write access to the file system through UDFs.

Importing Custom Python Library Modules

You define scalar functions using Python language syntax. In addition to the native Python Standard Library modules and Amazon Redshift preinstalled modules, you can create your own custom Python library modules and import the libraries into your clusters, or use existing libraries provided by 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 (p. 1092) system catalog to view information about the libraries installed on your cluster.

To Import 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 Console 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.

```sql
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](https://docs.python.org/3/tutorial/modules.html) 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`.

```python
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 (p. 529).

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).

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 (p. 667).

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.
- The number of Python UDFs that can run concurrently per cluster is limited to one-fourth of the total concurrency level for the cluster. For example, if the cluster is configured with a concurrency of 15, a maximum of three UDFs can run concurrently. After the limit is reached, UDFs are queued for execution within workload management queues. SQL UDFs don't have a concurrency limit. For more information, see Implementing Workload Management (p. 309).

Naming UDFs

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 execute 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.

Preventing UDF Naming Conflicts

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. When you call a function that is not explicitly qualified with a schema name, Amazon Redshift searches the pg_catalog schema first by default, so a built-in function will run 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 so that 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.

Logging Errors and Warnings in 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.

```python
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.

```sql
select funcname, node, slice, trim(message) as message
from svl_udf_log;

<table>
<thead>
<tr>
<th>funcname</th>
<th>query</th>
<th>node</th>
<th>slice</th>
<th>message</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_pyerror</td>
<td>12345</td>
<td>1</td>
<td>1</td>
<td>Your info message here</td>
</tr>
</tbody>
</table>
```
Creating Stored Procedures in Amazon Redshift

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 is available for any user with sufficient privileges to run.

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 (p. 533)
- ALTER PROCEDURE (p. 419)
- DROP PROCEDURE (p. 571)
- SHOW PROCEDURE (p. 640)
- CALL (p. 444)
- GRANT (p. 585)
- REVOKE (p. 600)
- ALTER DEFAULT PRIVILEGES (p. 416)

Topics

- Overview of Stored Procedures in Amazon Redshift (p. 191)
- PL/pgSQL Language Reference (p. 202)

Overview of Stored Procedures in Amazon Redshift

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 permission to insert data into a table. Instead of granting a user permissions on the underlying tables, you can create a stored procedure that performs the task. You then give the user permission 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 permissions of the user that calls the procedure.
To create a stored procedure, use the CREATE PROCEDURE (p. 533) command. To run a procedure, use the CALL (p. 444) command. Examples follow later in this section.

**Note**
Some clients might throw 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 using SQL Workbench/J, we recommend version 124. When using SQL Workbench/J version 125, consider specifying an alternate delimiter as a workaround. Because the CREATE PROCEDURE contains SQL statements delimited with a semicolon (;), defining an alternate delimiter such as a forward slash (/) and placing it at the end of the CREATE PROCEDURE statement sends the entire statement to the Amazon Redshift server for processing. As shown in the following example.

```
CREATE OR REPLACE PROCEDURE test()
AS ##
BEGIN
  SELECT 1 a;
END;
##
LANGUAGE plpgsql
;
/
```

For more information, see Alternate delimiter in the SQL Workbench/J documentation. Or use a client with better support for parsing CREATE PROCEDURE statements, such as the Query Editor in the Amazon Redshift console or TablePlus.

**Topics**
- Naming Stored Procedures (p. 193)
- Security and Privileges for Stored Procedures (p. 194)
- Returning a Result Set (p. 194)
- Managing Transactions (p. 196)
- Trapping Errors (p. 201)
- Logging Stored Procedures (p. 201)
- Limits and Differences for Stored Procedure Support (p. 201)

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');
```
The following example shows a procedure with output arguments. Arguments are input (IN), input and output (INOUT), and output (OUT).

```sql
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

If you define a procedure with the same name and different input argument data types, or signature, you create a new procedure. In other words, the procedure name is overloaded. For more information, see Overloading Procedure Names (p. 193). Amazon Redshift doesn't enable procedure overloading based on output arguments. In other words, 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 (p. 571) and CREATE PROCEDURE (p. 533).

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 (p. 533).
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 ensure that your procedure name won't conflict with any existing or future Amazon Redshift procedure names.

Security and Privileges for Stored Procedures

By default, all users have permission to create a procedure. To create a procedure, you must have USAGE permission on the language PL/pgSQL, which is granted to PUBLIC by default. Only superusers and owners have the permission 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 permission on the procedure. By default, EXECUTE permission for new procedures is granted to the procedure owner and superusers. For more information, see GRANT (p. 585).

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. 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, take care to ensure that the procedure can't be misused. To ensure 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 needs to 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 (p. 533).

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.

```sql
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

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.

```sql
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.

```sql
BEGIN;
CALL get_result_set(1, 'mycursor');
```

After the cursor is opened, you can fetch from the cursor, as the following example shows.

```sql
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.

```sql
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 (p. 564).

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.

```java
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

The default 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 (p. 151).

However, when you call a stored procedure from within a user specified transaction block (defined by BEGIN...COMMIT), 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 (p. 450).
- **ROLLBACK** – rolls back the work done in the current transaction and implicitly begins a new transaction. For more information, see ROLLBACK (p. 606).

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 (p. 641).

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 Limits and Differences for Stored Procedure Support (p. 201).

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 (p. 208).

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 (p. 203).

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;
```

<table>
<thead>
<tr>
<th>userid</th>
<th>xid</th>
<th>pid</th>
<th>type</th>
<th>stmt_text</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>UTILITY</td>
<td>Begin;</td>
</tr>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>QUERY</td>
<td>insert into test_table_a values (1);</td>
</tr>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>UTILITY</td>
<td>Call sp_insert_table_a(2);</td>
</tr>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>QUERY</td>
<td>INSERT INTO test_table_a values (1)</td>
</tr>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>QUERY</td>
<td>insert into test_table_a values (3);</td>
</tr>
<tr>
<td>103</td>
<td>3382</td>
<td>599</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
</tbody>
</table>

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;  

<table>
<thead>
<tr>
<th>userid</th>
<th>xid</th>
<th>pid</th>
<th>type</th>
<th>stmt_text</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>3388</td>
<td>599</td>
<td>QUERY</td>
<td>insert into test_table_a values (1);</td>
</tr>
<tr>
<td>103</td>
<td>3388</td>
<td>599</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
<tr>
<td>103</td>
<td>3389</td>
<td>599</td>
<td>UTILITY</td>
<td>Call sp_insert_table_a(2);</td>
</tr>
<tr>
<td>103</td>
<td>3389</td>
<td>599</td>
<td>QUERY</td>
<td>INSERT INTO test_table_a values (1)</td>
</tr>
<tr>
<td>103</td>
<td>3389</td>
<td>599</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
<tr>
<td>103</td>
<td>3390</td>
<td>599</td>
<td>UTILITY</td>
<td>insert into test_table_a values (3);</td>
</tr>
<tr>
<td>103</td>
<td>3390</td>
<td>599</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
</tbody>
</table>

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.

```sql
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;  

<table>
<thead>
<tr>
<th>userid</th>
<th>xid</th>
<th>pid</th>
<th>type</th>
<th>stmt_text</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>3335</td>
<td>23636</td>
<td>UTILITY</td>
<td>Call sp_truncate_proc(1,2);</td>
</tr>
<tr>
<td>103</td>
<td>3335</td>
<td>23636</td>
<td>QUERY</td>
<td>INSERT INTO test_table_a values (1)</td>
</tr>
<tr>
<td>103</td>
<td>3335</td>
<td>23636</td>
<td>UTILITY</td>
<td>TRUNCATE test_table_b</td>
</tr>
<tr>
<td>103</td>
<td>3335</td>
<td>23636</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
<tr>
<td>103</td>
<td>3336</td>
<td>23636</td>
<td>QUERY</td>
<td>INSERT INTO test_table_b values (1)</td>
</tr>
<tr>
<td>103</td>
<td>3336</td>
<td>23636</td>
<td>UTILITY</td>
<td>COMMIT</td>
</tr>
</tbody>
</table>

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 ends.

```sql
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
```

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);
```

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.

```sql
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
```

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.

```sql
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);
```
```
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                          |
|--------+------+-------+---------|------------------------------------|
|        | 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                               |
|        | 3345 | 23636 | QUERY   | INSERT INTO inner_table values ( $1 ) |
|        | 3345 | 23636 | QUERY   | INSERT INTO outer_table values ( $1 ) |
|        | 3345 | 23636 | UTILITY | COMMIT                               |
```

The following example shows that cursor `cur1` was closed when the TRUNCATE statement committed.

```sql
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.

```sql
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 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 ) |
Trapping Errors

An error encountered during the execution of a stored procedure ends the execution flow and ends the transaction. You can trap errors using an EXCEPTION block. The only supported condition is OTHERS, which matches every error type except query cancellation.

```sql
[ <<label>> ]
[ DECLARE
  declarations ]
BEGIN
  statements
EXCEPTION
  WHEN OTHERS THEN
    handler_statements
END;
```

In an Amazon Redshift stored procedure, the only supported handler_statement is RAISE. Any error encountered during the execution automatically ends the entire stored procedure call and rolls back the transaction. This occurs because subtransactions are not supported.

If an error occurs in the exception handling block, it is propagated out and can be caught by an outer exception handling block, if one exists.

Logging Stored Procedures

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 (p. 1074).
- 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 (p. 1043).
- STL_UTILITYTEXT – stored procedure calls are logged after they are completed. For more information, see STL_UTILITYTEXT (p. 985).
- PG_PROC_INFO – this system catalog view shows information about stored procedures. For more information, see PG_PROC_INFO (p. 1093).

Limits and Differences for Stored Procedure Support

The following constraints 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.
Limits

The following are limits on stored procedures in Amazon Redshift:

- 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 (p. 564).
- 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 are VACUUM, ALTER TABLE APPEND, and CREATE EXTERNAL TABLE.
- 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 (p. 194).

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 8.0 documentation.

Topics

- PL/pgSQL Reference Conventions (p. 202)
- Structure of PL/pgSQL (p. 203)
- Supported PL/pgSQL Statements (p. 207)

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.

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPS</td>
<td>Words in capital letters are keywords.</td>
</tr>
<tr>
<td>[ ]</td>
<td>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.</td>
</tr>
<tr>
<td>{}</td>
<td>Braces indicate that you are required to choose one of the arguments inside the braces.</td>
</tr>
<tr>
<td></td>
<td>Pipes indicate that you can choose between the arguments.</td>
</tr>
</tbody>
</table>
Structure of PL/pgSQL

PL/pgSQL is a procedural language with many of the same constructs as other procedural languages.

Topics
- Block (p. 203)
- Variable Declaration (p. 204)
- Alias Declaration (p. 205)
- Built-in Variables (p. 205)
- Record Types (p. 206)

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.

```plaintext
[ <<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.

```sql
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;
  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, with the exception of loop variables, in the block's DECLARE section. Variables can use any valid Amazon Redshift data type. For supported data types, see Data Types (p. 369).

PL/pgSQL variables can be any Amazon Redshift supported data type, plus RECORD and refcursor. For more information about RECORD, see Record Types (p. 206). For more information about refcursor, see Cursors (p. 215).

```
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. So, 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 (p. 194).

**Alias Declaration**

If stored procedure's signature omits the argument name, you can declare an alias for the argument.

```sql
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 execution of the loop, FOUND isn't modified by the FOR statement. However, it can be changed by the execution of other statements within the loop body.

The following shows an example.

```sql
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
```
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 throw an error if used.

The following shows an example.

```sql
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.

```sql
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.

```sql
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
  ```
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 modification 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 (p. 412). In addition, the following PL/pgSQL statements are supported by Amazon Redshift.

Topics

- Assignment (p. 207)
- SELECT INTO (p. 207)
- No-op (p. 208)
- Dynamic SQL (p. 208)
- Return (p. 209)
- Conditionals: IF (p. 210)
- Conditionals: CASE (p. 211)
- Loops (p. 212)
- Cursors (p. 215)
- RAISE (p. 217)
- Transaction Control (p. 217)

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 nondeterministic.

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 (p. 196).

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.

```sql
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 quotes 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.

```sql
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.

```sql
RETURN;
```

The following shows an example.

```sql
CREATE OR REPLACE PROCEDURE return_example(a int) AS $$
BEGIN
  FOR b in 1..10 LOOP
    IF b < a THEN
      RAISE INFO 'b = %', b;
    ELSE
      RETURN;
    END IF;
  END LOOP;
END;
$$
```
## Conditionals: IF

The IF conditional statement can take the following forms in the PL/pgSQL language that Amazon Redshift uses:

- **IF ... THEN**

  ```sql
  IF boolean-expression THEN
    statements
  END IF;
  ```

  The following shows an example.

  ```sql
  IF v_user_id <> 0 THEN
    UPDATE users SET email = v_email WHERE user_id = v_user_id;
  END IF;
  ```

- **IF ... THEN ... ELSE**

  ```sql
  IF boolean-expression THEN
    statements
  ELSE
    statements
  END IF;
  ```

  The following shows an example.

  ```sql
  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.

  ```sql
  IF boolean-expression THEN
    statements
    [ ELSIF boolean-expression THEN
      statements
    [ ELSIF boolean-expression THEN
      statements
      ... ] ]
    [ ELSE
      statements ]
  END IF;
  ```

  The following shows an example.

  ```sql
  IF number = 0 THEN
    result := 'zero';
  ELSIF number > 0 THEN
    ```
result := 'positive';
ELSE IF 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.

```plpgsql
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**

  ```plpgsql
  [<<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.

  ```sql
  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**

  ```plpgsql
  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 $$
DECLARE i INTEGER := 0;
BEGIN
  LOOP
    RAISE INFO 'i %', i;
    i := i + 1;
    EXIT simple_loop_when WHEN (i >= x);
  END LOOP;
END;
$$;
```

• 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>>]
```
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 $$
DECLARE
  reports RECORD;
BEGIN
  PERFORM cs_log('Refreshing reports...');
  FOR reports IN SELECT * FROM cs_reports ORDER BY sort_key LOOP
    -- Now "reports" has one record from cs_reports
    PERFORM cs_log('Refreshing report ' || quote_ident(reports.report_name) || ' ...');
    EXECUTE 'TRUNCATE TABLE ' || quote_ident(reports.report_name);
    EXECUTE 'INSERT INTO ' || quote_ident(reports.report_name) || ' ' || reports.report_query;
  END LOOP;
  PERFORM cs_log('Done refreshing reports.');
  RETURN;
END;
$$ LANGUAGE plpgsql;
```

• FOR loop with dynamic SQL
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.

```sql
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 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
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.

  ```sql
  OPEN cursor_name FOR SELECT ...;
  ```

  The following shows an example.

  ```sql
  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.

  ```sql
  OPEN cursor_name FOR EXECUTE query_string;
  ```

  The following shows an example.

  ```sql
  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.

  ```sql
  OPEN bound_cursor_name [ ( argument_values ) ];
  ```

  The following shows an example.

  ```sql
  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.

  ```sql
  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 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 aborts 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;

**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 (p. 196).
Creating Materialized Views in Amazon Redshift

In a data warehouse environment, applications often need to perform complex queries on large tables—for example, SELECT statements that perform multiple-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 database tables (such as aggregates or multiple-table 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 a collection of charts, such as Amazon QuickSight. This use case is ideal for a materialized view, because the queries are predictable and repeated over and over again.

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 store the result set. The result set eventually becomes stale, as data is inserted, updated, and deleted in the base table or tables. To address this issue, you can refresh the materialized view at any time. Amazon Redshift has two strategies for refreshing a materialized view:

- In many cases, Amazon Redshift can perform an incremental refresh. In an incremental refresh, changes to the data in the base tables are quickly identified, and then the data in the materialized view is updated with these changes.
- 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.

To use materialized views during the preview:

- To use materialized views, you must confirm that your Amazon Redshift cluster is using the cluster maintenance track for Preview with the track named preview_features. The current cluster maintenance version for the preview track is 1.0.11746. For more information, see Choosing Cluster Maintenance Tracks in the Amazon Redshift Cluster Management Guide.
- Create a cluster to work with the preview. For more information, see Creating a Cluster in the Amazon Redshift Cluster Management Guide.
- The materialized view preview period is expected to run until March 15, 2020, although it might be extended.
- For any questions, issues, or feedback related to the preview features during the preview period, email redshiftpreviews@amazon.com or open a support case with AWS Support.

For details about SQL commands used to create and manage materialized views, see the following command topics:

- CREATE MATERIALIZED VIEW (p. 532)
Querying a Materialized View

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. There are no limitations to using materialized views in queries.

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 latest changes from corresponding base tables of the materialized view.

**Note**

If other users want to query the materialized view, the owner of the materialized view grants the SELECT privilege to those users. The other users don't need to have the SELECT privilege on the underlying base tables. The owner of the materialized view can also revoke the SELECT privilege from other users, to prevent them from querying the materialized view. If the owner of the materialized view no longer has the SELECT privilege on the underlying base tables, then the following is true:

- The owner can no longer query the materialized view.
- Other users who have the SELECT privilege on the materialized view can no longer 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 (p. 532).

```sql
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`.

Limitations and Usage Notes for Materialized Views

When using materialized views in Amazon Redshift, be aware of the following limitations:

- You can't define a materialized view that references or includes any of the following:
  - Any other materialized view.
  - A standard view. (However, you can define a standard view that references materialized views.)
• An external table, such as used by Amazon Redshift Spectrum or a federated query.
• System tables or views.
• Temporary tables.
• User-defined functions.
• The ORDER BY clause.
• The LIMIT clause.
• The OFFSET clause.
• A materialized view can't support incremental refreshes if it uses any of the following SQL elements:
  • OUTER JOIN (RIGHT, LEFT, or FULL).
  • Set operations: UNION, INTERSECT, EXCEPT, MINUS.
  • Aggregate functions: AVG, MEDIAN, PERCENTILE_CONT, MAX, MIN, LISTAGG, STDDEV_SAMP,
    STDDEV_POP, APPROXIMATE COUNT, APPROXIMATE PERCENTILE, and bitwise aggregate functions.

Note
The COUNT and SUM aggregate functions are supported.
• DISTINCT aggregate functions, such as DISTINCT COUNT, DISTINCT SUM, and so on.
• Window functions.
• System administration functions. For a list, see System Administration Functions (p. 890).
• System information functions. For a list, see System Information Functions (p. 897).
• Leader node-only functions: CURRENT_SCHEMA, CURRENT_SCHEMAS, HAS_DATABASE_PRIVILEGE,
  HAS_SCHEMA_PRIVILEGE, HAS_TABLE_PRIVILEGE, AGE, CURRENT_TIME, CURRENT_TIMESTAMP,
  LOCALTIME, NOW.
• Date functions: CURRENT_DATE, DATE, DATE_PART, DATE_TRUNC, DATE_CMP_TIMESTAMPTZ,
  SYSDATE, TIMEOFDAY, TO_TIMESTAMP.
• Math functions: RANDOM.
• Date type formatting functions: TO_CHAR WITH TIMESTAMPTZ.
• A query that uses temporary tables for query optimization, such as optimizing common
  subexpressions.
• Subqueries in any place other than the FROM clause.
• If you want to modify any of the base tables for a materialized view, note the following:
  • You can add columns to a base table without affecting any materialized views that reference the
table. Other operations can cause the materialized view to 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.
  • You can perform data manipulation language (DML) operations on the base tables (INSERT, UPDATE,
    and DELETE). However, data changes aren't reflected in associated materialized views until you
  refresh the views.
  • In general, you can't alter a materialized view's definition (its SQL statement). You can't rename a
    materialized view.
  • Materialized views compute their result and store it when created. This functionality means that
    you can't perform late binding when creating materialized views. 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. In addition, you must ensure that the SELECT privilege has been granted before issuing the
    CREATE MATERIALIZED VIEW statement. Amazon Redshift runs the SQL query as part of creating the
    materialized view.
  • 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 more information about events and state changes, see
    STL_MV_STATE (p. 952).
• 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. For more information about events and state changes, see STL_MV_STATE (p. 952).
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** data type, which contains spatial data and optionally its spatial reference system identifier (SRID).

Spatial data contains geometric data that can be used 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.

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) geometry primitives. Currently, Amazon Redshift doesn't support 3D or 4D geometry primitives. For more information about geometry primitives, see [Well-known text representation of geometry](#) in Wikipedia.

The **GEOMETRY** data type has 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)

For details about SQL functions to query spatial data, see [Spatial Functions](p. 779).

Topics

- Limitations When Using Spatial Data with Amazon Redshift (p. 223)
Limitations When Using Spatial Data with Amazon Redshift

The following are limitations when using spatial data with Amazon Redshift:

- The maximum size of a GEOMETRY 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 column.
- Data types for Python user-defined functions (UDFs) don't support the GEOMETRY data type.
- You can't use a GEOMETRY column as a sort key or a distribution key of an Amazon Redshift table.
- You can't use GEOMETRY columns in SQL ORDER BY, GROUP BY, or DISTINCT clauses.
- You can't use GEOMETRY columns in many SQL functions.
- You can't perform an UNLOAD operation on geometry columns into every format. You can UNLOAD GEOMETRY columns to text or CSV, which writes GEOMETRY 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 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 objects. The ResultSetMetadata operation returns type VARCHAR.

The following nonspatial functions can accept an input of type GEOMETRY or columns of type GEOMETRY:

- The aggregate function COUNT
- The conditional expressions COALESCE and NVL
- CASE expressions
Federated Query in Amazon Redshift (Preview)

You can query data in Amazon RDS for PostgreSQL and Amazon Aurora with PostgreSQL compatibility from Amazon Redshift using external schemas. This type of query is called a federated query. You can use this capability to combine the data queried from one or more Amazon RDS PostgreSQL and Amazon Aurora PostgreSQL databases with data already in Amazon Redshift. You can also combine such data with data in Amazon S3 tables.

Amazon Redshift exposes RDS PostgreSQL and Aurora PostgreSQL metadata with the information schema (`information_schema`) in Amazon Redshift. Doing this enables business intelligence (BI) tools, such as Tableau and Micro-strategy to view data referenced by the external schema.

An Amazon Redshift external schema references a database in an external RDS PostgreSQL or Aurora PostgreSQL. When it does so, these limitations apply:

- When creating an external schema referencing Aurora, the Aurora PostgreSQL database must be at version 9.6, 10.4, 10.5, 10.6, or 10.7.
- When creating an external schema referencing Amazon RDS, the Amazon RDS PostgreSQL database must be at version 9.3 to 9.6, or 10.1 to 10.9, or 11.0 to 11.4, or 12.

To create a federated query, you follow this general workflow:

1. Set up your RDS PostgreSQL and Aurora PostgreSQL instances in the same VPC as your Amazon Redshift clusters.
2. Create an instance in RDS PostgreSQL or Aurora PostgreSQL in the same VPC as your Amazon Redshift cluster. If the instance is publicly accessible, configure its security group’s inbound rule to: `Type: PostgreSQL, Protocol: TCP, Port Range: 5432, Source: 0.0.0.0/0`. Otherwise, if the instance is not publicly accessible, you don’t need to configure an inbound rule.
3. 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 Create a Secret and an IAM Role for Federated Query (p. 225).
4. Create an Amazon Redshift cluster. When you create the cluster, switch off `Use defaults`. Then in the `Network and security` section, choose `Cluster subnet group`, and choose a subnet group in your VPC that is set up for RDS PostgreSQL or Aurora PostgreSQL. For information about how to set up your subnet, see Working with a DB Instance in a VPC in the Amazon RDS User Guide.

The cluster you use to work with the preview can be a new cluster or a cluster restored from a snapshot created from a cluster with a cluster maintenance version no later than 1.0.11420.

To use federated query, you must confirm that your Amazon Redshift cluster is using the cluster maintenance track for `Preview` with the track named `preview_features`. The current cluster...
maintenance version for the preview track is 1.0.11746. For more information, see Choosing Cluster Maintenance Tracks in the Amazon Redshift Cluster Management Guide. For more information about creating a cluster, see Creating a Cluster in the Amazon Redshift Cluster Management Guide.

5. Apply the IAM role you previously created to the Amazon Redshift cluster. For more information, see Create a Secret and an IAM Role for Federated Query (p. 225).

6. Connect to your RDS PostgreSQL and Aurora PostgreSQL databases with an external schema. For more information, see CREATE EXTERNAL SCHEMA (p. 227).

7. Run your SQL queries referencing the external schema that references RDS PostgreSQL and Aurora PostgreSQL databases. Amazon Redshift intelligently pushes down the execution of predicate and aggregate functions to RDS PostgreSQL and Aurora PostgreSQL.

**Note**
When working with the preview:

- Amazon Redshift clusters must be on a **Preview** maintenance track.
- Use the new Amazon Redshift console.
- The federated query preview period is expected to run until February 15, 2020. Although, it might be extended.
- For any questions, issues, or feedback related to the preview features during the preview period, email redshiftpreviews@amazon.com or open a support case with Amazon Support.

**Topics**

- Create a Secret and an IAM Role for Federated Query (p. 225)
- CREATE EXTERNAL SCHEMA (p. 227)
- Example Using Federated Query (p. 230)
- Data Type Differences Between Amazon Redshift and Supported RDS PostgreSQL or Aurora PostgreSQL Databases (p. 231)
- Limitations and Considerations When Accessing Federated Data with Amazon Redshift (p. 233)

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Create a Secret and an IAM Role for Federated Query

*This is prerelease documentation for the federated query feature for Amazon Redshift, 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.*

The following steps show how to create a secret and an IAM role to use with federated query.

**Prerequisites**

You must have the following prerequisites to create a secret and an IAM role to use with federated query:

- An RDS PostgreSQL or Aurora PostgreSQL instance with user name and password authentication.
- An Amazon Redshift cluster with a cluster maintenance version that supports federated query.
• Connectivity between RDS PostgreSQL or Aurora PostgreSQL and Amazon Redshift. Your RDS PostgreSQL or Aurora PostgreSQL instance must be able to accept connections from the Amazon Redshift cluster (both leader node and compute nodes). This ability is controlled by the security group attached to the RDS PostgreSQL or Aurora PostgreSQL instance.

To create a secret (user name and password) with Secrets Manager

1. Sign in to the Secrets Manager console with the account that owns your RDS PostgreSQL or Aurora PostgreSQL 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 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"
         ],
       },
       {
         "Sid": "VisualEditor1",
         "Effect": "Allow",
         "Action": [
           "secretsmanager:GetRandomPassword",
           "secretsmanager:ListSecrets"
         ],
         "Resource": "*"
       }
     ]
   }
   ```

You need list and read actions to retrieve the secret. We recommend that you restrict the resource to the specific secret that you created by using the 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 it 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/redshift/.
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.

CREATE EXTERNAL SCHEMA

This is prerelease documentation for the federated query feature for Amazon Redshift, 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.

This command creates an external schema in the current database. You use this external schema to connect to RDS PostgreSQL and Aurora PostgreSQL databases.

All external tables must be created in an external schema. You can't create local tables in external schemas.

Syntax

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] local_schema_name
FROM POSTGRES
DATABASE 'database_name' [SCHEMA 'schema_name']
URI 'hostname' [ PORT port_number ]
[ OPTIONS 'options_list' ]
IAM_ROLE 'iam-role-arn-string'
SECRET_ARN 'ssm-secret-arn'
```

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 external schema when you reference it from Amazon Redshift. For more information about valid names, see Names and Identifiers (p. 367).

FROM POSTGRES

A keyword that indicates where the external database is located.

POSTGRES indicates that the external database is defined in RDS PostgreSQL or Aurora PostgreSQL.

DATABASE 'database_name' [SCHEMA 'schema_name']

A keyword that indicates the name of the external database in RDS PostgreSQL or Aurora PostgreSQL.

The schema_name indicates the schema in RDS PostgreSQL or Aurora PostgreSQL. The default schema_name is public.

URI 'hostname' [ PORT port_number ]

The hostname URI and port_number of an RDS PostgreSQL or Aurora PostgreSQL. The hostname is the headnode of the replica set. The endpoint must be reachable (routable) from the Amazon Redshift cluster that runs on your VPC by using a public IP address. The default port_number is 5432.

Note

The RDS PostgreSQL or Aurora PostgreSQL must be in the same VPC as your Amazon Redshift cluster. Create a security group linking Amazon Redshift and RDS PostgreSQL or Aurora PostgreSQL.

[ OPTIONS 'options_list' ]

The options_list is a list of supported driver options specified as key-value pairs separated by an ampersand (&). Supported options are application_name and fallback_application_name.

IAM_ROLE 'iam-role-arm-string'

The Amazon Resource Name (ARN) for an IAM role that your cluster uses for authentication and authorization.

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. Attach to this IAM role 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"
      ],
    }
  ]
}
```
For the steps to create an IAM role to use with federated query, see Create a Secret and an IAM Role for Federated Query (p. 225).

SECRETARN 'ssm-secret-arn'

The ssm-secret-arn is the ARN of an RDS PostgreSQL or Aurora PostgreSQL secret created using AWS Secrets Manager. For information about how to create and retrieve a SecretARN value, see Creating a Basic Secret and Retrieving the Secret Value Secret in the AWS Secrets Manager User Guide.

To use AWS Secrets Manager to manage access to hostname by Amazon Redshift, follow this general flow:

- Create an IAM role in the RDS PostgreSQL or Aurora PostgreSQL database instance and give it permission to access the appropriate schemas and tables.
- Publish the credentials of this IAM role to Secrets Manager.
- In Amazon Redshift, create an external schema that references the external RDS PostgreSQL or Aurora PostgreSQL database (this command).
- In Amazon Redshift, you can manage access to this external schema with iam-role-arn-string.

Usage Notes

Use this command to register an external schema with Amazon Redshift. To unregister the schema, use the DROP SCHEMA (p. 572) command.

To view details for external schemas, query the following system views:

- SVV_EXTERNAL_SCHEMAS (p. 1037)
- SVV_EXTERNAL_TABLES (p. 1038)
- SVV_EXTERNAL_COLUMNS (p. 1036)

Examples

The following example creates an external schema that references an Aurora PostgreSQL database.

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] myRedshiftSchema
FROM POSTGRES
DATABASE 'aurora database name' SCHEMA 'aurora_schema'
URI 'endpoint to aurora hostname' PORT 5432
OPTIONS 'application_name=tableau'
IAM_ROLE 'arn:aws:iam::123456789012:role/MyAuroraRole'
```
Example Using Federated Query

---

*This is prerelease documentation for the federated query feature for Amazon Redshift, 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.*

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 query works. To run it, you need to change it to fit your environment. See the general workflow outlined in Federated Query in Amazon Redshift (Preview) (p. 224) for prerequisites to set up the environment.

Create an external schema that references an Aurora PostgreSQL database.

```
CREATE EXTERNAL SCHEMA apg
FROM POSTGRES
DATABASE 'database-1' SCHEMA 'myschema'
URI 'xxx.xxx.x.xxx'
IAM_ROLE 'arn:aws:iam::123456789012:role/Redshift-SecretsManager-RO'
```

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_lt_part;
```

```
  count
  --------
  6144008876
```
Create a view of the tables from Amazon Redshift, Aurora PostgreSQL, and Amazon S3. This view is used to run federated queries.

```
CREATE VIEW lineitem_all AS
  SELECT
    l_orderkey,l_partkey,l_suppkey,l_linenumber,l_quantity,l_extendedprice,l_discount,l_tax,l_returnflag,l_linestatus,
    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
```

Data Type Differences Between Amazon Redshift and Supported RDS PostgreSQL or Aurora PostgreSQL Databases

This is prerelease documentation for the federated query feature for Amazon Redshift, 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.
The following table shows the mapping of an Amazon Redshift data type to a corresponding Amazon RDS PostgreSQL or Aurora PostgreSQL data type.

<table>
<thead>
<tr>
<th>Amazon Redshift Data Type</th>
<th>RDS PostgreSQL or Aurora PostgreSQL Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALLINT</td>
<td>SMALLINT</td>
<td>Signed two-byte integer</td>
</tr>
<tr>
<td>INTEGER</td>
<td>INTEGER</td>
<td>Signed four-byte integer</td>
</tr>
<tr>
<td>BIGINT</td>
<td>BIGINT</td>
<td>Signed eight-byte integer</td>
</tr>
<tr>
<td>DECIMAL</td>
<td>DECIMAL</td>
<td>Exact numeric of selectable precision</td>
</tr>
<tr>
<td>REAL</td>
<td>REAL</td>
<td>Single precision floating-point number</td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>DOUBLE PRECISION</td>
<td>Double precision floating-point number</td>
</tr>
<tr>
<td>BOOLEAN</td>
<td>BOOLEAN</td>
<td>Logical Boolean (true/false)</td>
</tr>
<tr>
<td>CHAR</td>
<td>CHAR</td>
<td>Fixed-length character string</td>
</tr>
<tr>
<td>VARCHAR</td>
<td>VARCHAR</td>
<td>Variable-length character string with a user-defined limit</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
<td>Calendar date (year, month, day)</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TIMESTAMP</td>
<td>Date and time (without time zone)</td>
</tr>
<tr>
<td>TIMESTAMPTZ</td>
<td>TIMESTAMPTZ</td>
<td>Date and time (with time zone)</td>
</tr>
<tr>
<td>GEOMETRY</td>
<td>PostGIS GEOMETRY</td>
<td>Spatial data</td>
</tr>
</tbody>
</table>

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 and TIME
- Enumerated types
- Monetary types
Limitations and Considerations When Accessing Federated Data with Amazon Redshift

This is prerelease documentation for the federated query feature for Amazon Redshift, 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.

The following are limitations and considerations when using federated query with Amazon Redshift:

- This feature supports 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 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. For example, when using this feature to access Aurora, Aurora charges are based on IOPS.
- This feature doesn't enable access to Amazon Redshift from RDS PostgreSQL or Aurora PostgreSQL.
- This feature currently doesn't support access through materialized views.
- This feature is only available in AWS Regions where both Amazon Redshift and Amazon RDS or Aurora are available.
- This feature currently doesn't support ALTERT SCHEMA. You must DROP and then CREATE EXTERNAL SCHEMA.
- Concurrency scaling is not supported.
Querying External Data Using Amazon Redshift Spectrum

Using Amazon Redshift Spectrum, you can efficiently query and retrieve structured and semistructured data from files in Amazon S3 without having to load the data into Amazon Redshift tables. Redshift Spectrum queries employ massive parallelism to execute 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 (p. 234)
• Getting Started with Amazon Redshift Spectrum (p. 236)
• IAM Policies for Amazon Redshift Spectrum (p. 243)
• Using Redshift Spectrum with AWS Lake Formation (p. 252)
• Creating Data Files for Queries in Amazon Redshift Spectrum (p. 253)
• Creating External Schemas for Amazon Redshift Spectrum (p. 254)
• Creating External Tables for Amazon Redshift Spectrum (p. 260)
• Improving Amazon Redshift Spectrum Query Performance (p. 268)
• Monitoring Metrics in Amazon Redshift Spectrum (p. 270)
• Troubleshooting Queries in Amazon Redshift Spectrum (p. 270)
• Tutorial: Querying Nested Data with Amazon Redshift Spectrum (p. 272)

Amazon Redshift Spectrum Overview

Amazon Redshift Spectrum resides on dedicated Amazon Redshift servers that are independent of your cluster. Redshift Spectrum 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.

After your Redshift Spectrum tables have been defined, you can query and join the tables just as you do any other Amazon Redshift table. Amazon Redshift 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 (p. 1094)`, `STV_TBL_PERM (p. 1013)`, `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 (p. 1038)` and `SVV_EXTERNAL_COLUMNS (p. 1036)`.

## Amazon Redshift Spectrum Regions

Redshift Spectrum 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)
- Asia Pacific (Hong Kong) Region (ap-east-1)
- 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 (Tokyo) Region (ap-northeast-2)
- Canada (Central) Region (ca-central-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)
- Middle East (Bahrain) Region (me-south-1)
- South America (São Paulo) Region (sa-east-1)
- AWS GovCloud (US-West) (us-gov-west-1)

## Amazon Redshift Spectrum Considerations

Note the following considerations when you use Amazon Redshift Spectrum:

- The Amazon Redshift cluster and the Amazon S3 bucket must be in the same AWS Region.
• If your cluster uses Enhanced VPC Routing, you might need to perform additional configuration steps. For more information, see Using Amazon Redshift Spectrum with Enhanced VPC Routing.

• External tables are read-only. You can’t perform insert, update, or delete operations on external tables.

• 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 Lake Formation, see Using Redshift Spectrum with AWS Lake Formation (p. 252).

• 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.

```sql
grant temp on database spectrumdb to group spectrumusers;
```

For more information, see GRANT (p. 585).

• When using the Athena data catalog or AWS Glue Data Catalog as a metadata store, see Quotas and Limits in the Amazon Redshift Cluster Management Guide.

---

## 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 in ten minutes or less.

**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 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 execute SQL commands. The cluster and the data files in Amazon S3 must be in the same AWS Region. For this example, the sample data is in the US West (Oregon) Region (us-west-2), so you need a cluster that is also in us-west-2. If you don’t have an Amazon Redshift cluster, you can create a new cluster in us-west-2 and install a SQL client by following the steps in Getting Started with Amazon Redshift.

### Steps to Get Started

To get started using Amazon Redshift Spectrum, follow these steps:

- **Step 1. Create an IAM Role for Amazon Redshift** (p. 236)
- **Step 2: Associate the IAM Role with Your Cluster** (p. 239)
- **Step 3: Create an External Schema and an External Table** (p. 240)
- **Step 4: Query Your Data in Amazon S3** (p. 241)

### 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. You provide that authorization by referencing 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 (p. 237).
- 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 (p. 238)
  - To grant SELECT permissions on the table to query in the Lake Formation database (p. 238)

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, and then choose Redshift.
5. Under Select your use case, choose Redshift - Customizable and then choose Next: Permissions.
6. The Attach 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: Review.

   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:::awssampledbuswest2/*"
   } 
   ]
   }
   ```

7. For Role name, enter a name for your role, for example mySpectrumRole.
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 mySpectrumPolicy 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 create a role and apply the policy.
8. In the navigation pane of the IAM console, choose Roles, and then choose Create role.
9. For Select type of trusted entity, choose AWS service.
10. Choose the Amazon Redshift service to assume this role.
11. Choose the Redshift Customizable use case for your service. Then choose Next: Permissions.
12. Choose the permissions policy that you created, mySpectrumPolicy, to attach to the role.
15. For Role name, enter the name mySpectrumRole.
16. (Optional) For Role description, enter a description for the new role.
17. Review the role, and then choose Create role.

To grant SELECT permissions on the table to query in the Lake Formation database

2. In the navigation pane, choose Permissions, and then choose Grant.
3. Provide the following information:
   
   - For IAM role, choose the IAM role you created, mySpectrumRole. 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.
- For Database, choose your Lake Formation database.
- For Table, choose a table within the database to query.
- For Columns, choose All Columns.
- Choose the Select permission.

4. Choose Save.

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.

Note
A new console is available for Amazon Redshift. Choose either the New Console or the Original Console instructions based on the console that you are using. The New Console instructions are open by default.

New Console

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/redshift/.
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.

Original Console

To associate the IAM role with your cluster

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshift/.
2. In the navigation pane, choose Clusters.
3. In the list, choose the cluster that you want to manage IAM role associations for.
4. Choose Manage IAM Roles.
5. For Available roles, choose your IAM role.
6. Choose Apply Changes to update the IAM roles that are associated with the cluster.

Step 3: Create an External Schema and an External Table

External tables must be created 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 Creating External Schemas for Amazon Redshift Spectrum (p. 254).

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 (p. 236). Then run the command in your SQL client.

```sql
create external schema spectrum
from data catalog
database 'spectrumdb'
iam_role 'arn:aws:iam::123456789012:role/mySpectrumRole'
create external database if not exists;
```

2. To create an external table, run the following CREATE EXTERNAL TABLE command.

   **Note**
   The Amazon S3 bucket with the sample data for this example is located in the us-west-2 region. Your cluster and the Redshift Spectrum files must be in the same AWS Region, so, for this example, your cluster must also be located in us-west-2. To use this example in a different AWS Region, you can copy the sales data with an Amazon S3 copy command. Then update the location of the bucket in the example CREATE EXTERNAL TABLE command.

```sql
aws s3 cp s3://awssampledbuswest2/ticket/spectrum/sales/ s3://bucket-name/ticket/spectrum/sales/ --recursive
```

```sql
create external table spectrum.sales(
salesid integer,
listid integer,
sellerid integer,
buyerid integer,
eventid integer,
dateid smallint,
qtsold smallint,
pricepaid decimal(8,2),
commission decimal(8,2),
saletime timestamp)
row format delimited
fields terminated by '\t'
stored as textfile
location 's3://awssampledbuswest2/ticket/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 SPECTRUM.SALES table.

```sql
select count(*) from spectrum.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 Getting Started with Amazon Redshift, you have a table named EVENT in your database. If not, create the EVENT table by using the following command.

```sql
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 (p. 236).

```sql
copy event from 's3://awssampledbuswest2/ticket/allevents_pipe.txt'
iam_role 'arn:aws:iam::123456789012:role/mySpectrumRole'
delimiter '|' timeformat 'YYYY-MM-DD HH:MI:SS' region 'us-west-2';
```

The following example joins the external table SPECTRUM.SALES with the local table EVENT to find the total sales for the top 10 events.

```sql
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;
```

```
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
```
4. View the query plan for the previous query. Note the S3 Scan, S3 HashAggregate, and S3 Query Scan steps that were executed against the data on Amazon S3.

```sql
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://awssampledbuswest2/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)
```

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IAM Policies for Amazon 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 (p. 246).

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 catalog. For more information, see Encrypting Your AWS Glue Data Catalog in the AWS Glue Developer Guide.

**Topics**
- Amazon S3 Permissions (p. 243)
- Cross-Account Amazon S3 Permissions (p. 244)
- Policies to Grant or Restrict Redshift Spectrum Access (p. 244)
- Policies to Grant Minimum Permissions (p. 245)
- Chaining IAM Roles in Amazon Redshift Spectrum (p. 246)
- Controlling Access to the AWS Glue Data Catalog (p. 246)

**Note**
If you currently have Redshift Spectrum external tables in the 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 IAM policies. For more information, see Upgrading to the AWS Glue Data Catalog in the Athena User Guide.

### 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:GetObject", "s3:ListObject"],
        "Resource": "*"
    }]
}
```
The following policy grants GET and LIST access to your Amazon S3 bucket named myBucket.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["s3:Get*", "s3:List*"],
      "Resource": "arn:aws:s3:::myBucket/*"
    }
  ]
}
```

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::redshift-account: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 Redshift Spectrum Access

To grant access to an Amazon S3 bucket only using Redshift Spectrum, include a condition that allows access for the user agent AWS Redshift/Spectrum. The following policy allows access to Amazon S3 buckets only for Redshift Spectrum. It excludes other access, such as COPY operations.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["s3:Get*", "s3:List*"],
      "Resource": "arn:aws:s3:::myBucket/*",
      "Condition": {"StringEquals": {"aws:UserAgent": "AWS Redshift/Spectrum"}}
    }
  ]
}
```

Similarly, you might want to create an IAM role that allows access for COPY operations, but excludes Redshift Spectrum access. To do so, include a condition that denies access for the user agent "AWS
Redshift/Spectrum. The following policy allows access to an Amazon S3 bucket with the exception of Redshift Spectrum.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["s3:Get*", "s3:List*"],
            "Resource": "arn:aws:s3:::myBucket/*",
            "Condition": {
                "StringNotEquals": {
                    "aws:UserAgent": "AWS Redshift/Spectrum"
                }
            }
        }
    ]
}
```

**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",
            "Resource": ["arn:aws:s3:::bucketname", "arn:aws:s3:::bucketname/folder1/folder2/*"]
        },
        {
            "Effect": "Allow",
        }
    ],
    "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.

```
{
  "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 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 (p. 247)](#)
- [Policy for Table Operations (p. 248)](#)
- [Policy for Partition Operations (p. 250)](#)
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.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabase",
        "glue:CreateDatabase"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:redshift-account:catalog"
      ]
    }
  ]
}
```

The following example query lists the current databases.

```
SELECT * FROM SVV_EXTERNALDATABASES WHERE
databasename = 'example_db1' or databasename = 'example_db2';
```

The following IAM policy gives the minimum permissions required to list the current databases.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:GetDatabases"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:redshift-account: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.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:CreateTable"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:redshift-account:table/example_db/example_tbl0"
      ]
    }
  ]
}
```

The following example queries each list the current external tables.

```
SELECT * FROM ssv_external_tables
WHERE tablename = 'example_tbl0' OR
    tablename = 'example_tbl1';

SELECT * FROM ssv_external_columns
WHERE tablename = 'example_tbl0' OR
    tablename = 'example_tbl1';

SELECT parameters FROM ssv_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:redshift-account:table/example_db/example_tbl0",
        "arn:aws:glue:us-west-2:redshift-account:table/example_db/example_tbl1"
      ]
    }
  ]
}
```

The following example query alters an existing table.

```sql
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:redshift-account:table/example_db/example_tbl0"
      ]
    }
  ]
}
```

The following example query drops an existing table.

```sql
DROP TABLE example_db.example_tbl0;
```
The following IAM policy gives the minimum permissions required to drop an existing table.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:DeleteTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:redshift-account: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.

```sql
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.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetTable",
                "glue:BatchCreatePartition"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:redshift-account: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.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:GetPartitions",
        "glue:GetTables",
        "glue:GetTable"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:redshift-account: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.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:GetPartition",
        "glue:UpdatePartition"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:redshift-account: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:redshift-account:table/example_db/example_tbl0"
]
}
]
}
```

Using Redshift Spectrum with AWS Lake Formation

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](https://docs.aws.amazon.com/opensearchservice/latest/developerguide/endpoint-access.html) 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 [Lake Formation Permissions](https://docs.aws.amazon.com/opensearchservice/latest/developerguide/permissionmanagement.html).

- 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.

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.
When you use Redshift Spectrum with a Data Catalog enabled for Lake Formation, an IAM role associated with the cluster must have permission to the Data Catalog.

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 prior steps in the tutorial.

Creating Data Files for Queries in Amazon Redshift Spectrum

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 Amazon 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 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 (p. 235).

Redshift Spectrum supports the following structured and semistructured data formats:

- AVRO
- PARQUET
- TEXTFILE
- SEQUENCEFILE
- RCFILE
- RegexSerDe
- Optimized row columnar (ORC)
- Grok
- OpenCSV
- Ion
- JSON

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 Parquet. With a columnar storage file format, you can minimize data transfer out of Amazon S3 by selecting only the columns you need.

Compression
To reduce storage space, improve performance, and minimize costs, we strongly recommend compressing your data files. Redshift Spectrum recognizes file compression types based on the file extension.
Redshift Spectrum supports the following compression types and extensions:

- gzip – .gz
- Snappy – .snappy
- bzip2 – .bz2

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, see Protecting Data Using Server-Side Encryption.

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 the following practices:

- Break large files into many smaller files. We recommend using file sizes of 64 MB or larger. Store files for a table in the same folder.
- Keep all the files about the same size. If some files are much larger than others, Redshift Spectrum can’t distribute the workload evenly.

Creating External Schemas for Amazon Redshift Spectrum

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 (p. 243).

**Note**

If you currently have Redshift Spectrum external tables in the Athena data catalog, you can migrate your Athena data catalog to an AWS Glue Data Catalog. To use an 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.
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.

```sql
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.

```sql
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.

```sql
create external schema hive_schema
from hive metastore
database 'hive_db'
url '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.

```sql
select * from svv_external_schemas
```

For the full command syntax and examples, see CREATE EXTERNAL SCHEMA (p. 510).

**Working with Amazon Redshift Spectrum External Catalogs**

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

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 Athena data catalog. The metadata for external tables that you create qualified by the external schema is also stored in your Athena data catalog.

Athena maintains a data catalog for each supported AWS Region. To view table metadata, log on to the Athena console and choose **Catalog Manager**. The following example shows the Athena Catalog Manager for the US West (Oregon) Region.

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`.

```sql
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.

```sql
select * from svv_external_tables;
```
### 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.

To enable your Amazon Redshift cluster to access your Amazon EMR cluster

1. In Amazon Redshift, make a note of your cluster's security group name.

   **Note**
   A new console is available for Amazon Redshift. Choose either the New Console or the Original Console instructions based on the console that you are using. The New Console instructions are open by default.

   **New Console**
   To display the security group, do the following:
   a. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshift/.
   b. On the navigation menu, choose CLUSTERS, then choose the cluster from the list to open its details. Choose Properties and view the Network and security section.
   c. Find your security group in VPC security group.

   **Original Console**
   In the Amazon Redshift console, choose your cluster. Find your cluster security groups in the Cluster Properties group.

---

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>athena_sample</td>
<td>elb_logs</td>
<td>s3://athena-examples/elb/plaintext</td>
</tr>
<tr>
<td>athena_sample</td>
<td>lineitem_1t_csv</td>
<td>s3://myspectrum/tpch/1000/lineitem_csv</td>
</tr>
<tr>
<td>athena_sample</td>
<td>lineitem_1t_part</td>
<td>s3://myspectrum/tpch/1000/lineitem_partition</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>s3://awssampledbuswest2/tickit/spectrum/sales</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>s3://awssampledbuswest2/tickit/spectrum/sales_part</td>
</tr>
</tbody>
</table>
2. In Amazon EMR, make a note of the EMR master node security group name.

3. 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**.
   2. Choose **Create Security Group**.
   3. If using VPC, choose the VPC that both your Amazon Redshift and Amazon EMR clusters are in.
   4. Add an inbound rule.
   5. For **Type**, choose **TCP**.
   6. For **Port Range**, enter **5439**.

      **Note**
      The default port for Amazon Redshift is 5439.

   7. For **Source**, choose **Custom**.
   8. Enter the name of your Amazon Redshift security group.
   9. Add another inbound rule.
   10. For **Type**, choose **TCP**.
   11. 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.

   12. For **Source**, choose **Custom**.
13. Enter the name of your Amazon EMR security group.
14. Choose Create.

4. Add the Amazon EC2 security group you created in the previous step to your Amazon Redshift cluster and to your Amazon EMR cluster:

1. In Amazon Redshift, choose your cluster.
2. Choose Cluster, Modify.
3. In VPC Security Groups, add the new security group by pressing CTRL and choosing the new security group name.
4. In Amazon EMR, choose your cluster.
5. Under Hardware, choose the link for the Master node.
6. Choose the link in the EC2 Instance ID column.

7. For Actions, choose Networking, Change Security Groups.
8. Choose the new security group.
Amazon Redshift Spectrum uses external tables to query data that is stored in Amazon S3. You can query an external table using the same SELECT syntax you use with other Amazon Redshift tables. External tables are read-only. You can't write to an external table.

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 (p. 420) 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.

```sql
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 User 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 Creating External Schemas for Amazon Redshift Spectrum (p. 254).

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:

```sql
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.

```sql
select count(*) from athena_schema.lineitem_athena;
```

To define an external table in Amazon Redshift, use the CREATE EXTERNAL TABLE (p. 513) 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.

```sql
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://awssampledbuswest2/ticket/spectrum/sales/'
table properties ('numRows'='172000');
```

To view external tables, query the SVV_EXTERNAL_TABLES (p. 1038) system view.

**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...
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.

```sql
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 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.

```sql
select distinct "$path", "$size"
from spectrum.sales_part;
```

<table>
<thead>
<tr>
<th>$path</th>
<th>$size</th>
</tr>
</thead>
<tbody>
<tr>
<td>s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-01/</td>
<td>1616</td>
</tr>
<tr>
<td>s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-02/</td>
<td>1444</td>
</tr>
<tr>
<td>s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-03/</td>
<td>1644</td>
</tr>
</tbody>
</table>

### 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=2017-04-30`, `saledate=2017-04-30`, 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 ALTERTABLE (p. 421) ... 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 '2008-02'.

```sql
alter table spectrum.sales_part add partition(saledate='2008-01-01') location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/'
partition(saledate='2008-02-01') location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-02/';
```

**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 West (Oregon) Region (us-west-2). To access the data using Redshift Spectrum, your cluster must also be in us-west-2. To list the folders in Amazon S3, run the following command.

```sh
aws s3 ls s3://awssampledbuswest2/tickit/spectrum/sales_partition/
```

```sh
PRE saledate=2008-01/
PRE saledate=2008-02/
PRE saledate=2008-03/
```

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.

```sql
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.

```sql
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://awssampledbuswest2/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://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-01/'
partition(saledate='2008-02')
  location 's3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-02/'
partition(saledate='2008-03')
  location 's3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-03/';
```

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 (p. 1037)` 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://awssampledbuswest2/tickit/spectrum/
sales_partition/saledate=2008-01
spectrum   | sales_part | ["2008-02"] | s3://awssampledbuswest2/tickit/spectrum/
sales_partition/saledate=2008-02
spectrum   | sales_part | ["2008-03"] | s3://awssampledbuswest2/tickit/spectrum/
sales_partition/saledate=2008-03
```

**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://awssampledbuswest2/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://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-01/event=101/'
partition(salesmonth='2008-01', event='102')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-01/event=102/'
partition(salesmonth='2008-01', event='103')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-01/event=103/'
partition(salesmonth='2008-02', event='101')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-02/event=101/'
partition(salesmonth='2008-02', event='102')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-02/event=102/'
partition(salesmonth='2008-02', event='103')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-02/event=103/'
partition(salesmonth='2008-03', event='101')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-03/event=101/'
partition(salesmonth='2008-03', event='102')
location 's3://awssampledbuswest2/tickit/spectrum/salesevent/salesmonth=2008-03/event=102/'
partition(salesmonth='2008-03', event='103')
location 's3://awssampledbuswest2/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;

<table>
<thead>
<tr>
<th>salesmonth</th>
<th>eventname</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-02</td>
<td>The Magic Flute</td>
<td>5062.00</td>
</tr>
</tbody>
</table>
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 (p. 272).

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 (p. 266)
- Mapping by column name (p. 267)

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
  - ‘int_col’ : int
  - ‘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.

<table>
<thead>
<tr>
<th>External Table Column Name</th>
<th>ORC Column ID</th>
<th>ORC Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>int_col</td>
<td>1</td>
<td>int_col</td>
</tr>
<tr>
<td>float_col</td>
<td>2</td>
<td>float_col</td>
</tr>
<tr>
<td>nested_col</td>
<td>3</td>
<td>nested_col</td>
</tr>
<tr>
<td>nested_col.int_col</td>
<td>4</td>
<td>int_col</td>
</tr>
<tr>
<td>nested_col.map_col</td>
<td>5</td>
<td>map_col</td>
</tr>
<tr>
<td>nested_col.map_col.key</td>
<td>6</td>
<td>NA</td>
</tr>
<tr>
<td>nested_col.map_col.value</td>
<td>7</td>
<td>NA</td>
</tr>
<tr>
<td>nested_col.map_col.value.item</td>
<td>8</td>
<td>NA</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>External Table Column Name</th>
<th>ORC Column ID</th>
<th>ORC Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>int_col</td>
<td>1</td>
<td>struct</td>
</tr>
<tr>
<td>float_col</td>
<td>7</td>
<td>int_col</td>
</tr>
<tr>
<td>nested_col</td>
<td>8</td>
<td>float_col</td>
</tr>
</tbody>
</table>
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.

## Improving Amazon 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 executed against the data on Amazon S3.

```sql
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://awssampledbuswest2/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 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 the fewest columns possible in your queries.
- 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.
- 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 (p. 513) or ALTER TABLE (p. 421) 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 (p. 262).

Query SVL_S3PARTITION (p. 1061) to view total partitions and qualified partitions.

**Monitoring Metrics in Amazon Redshift Spectrum**

You can monitor Amazon Redshift Spectrum queries using the following system views:

- **SVL_S3QUERY (p. 1064)**
  
  Use the SVL_S3QUERY view to get details about Redshift Spectrum queries (S3 queries) at the segment and node slice level.

- **SVL_S3QUERY_SUMMARY (p. 1068)**
  
  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.

**Troubleshooting Queries in Amazon Redshift Spectrum**

Following, you can find a quick reference that identifies and addresses some common issues you might encounter with Amazon Redshift Spectrum queries. To view errors generated by Redshift Spectrum queries, query the SVL_S3LOG (p. 1060) system table.

**Topics**
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: S3Query Exception (Fetch), 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.

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 (p. 1037) 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 AWS Identity and Access Management (IAM) role allows access to Athena resources. For more information, see IAM Policies for Amazon Redshift Spectrum (p. 243).

Incompatible Data Formats

For a columnar file format, such as 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:

```
Task failed due to an internal error.
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 (p. 1060) system view.

The following example queries SVL_S3LOG for the last query executed.
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
S3 Query Exception (Fetch). Task failed due to an internal error.
File 'https://s3bucket/location/file has an incompatible
Parquet schema for column ' s3bucket/location.col1'.
Column type: VARCHAR, Parquet schema:
optional int64 l_orderkey [i:0 d:1 r:0]
```

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 (p. 585).

**Tutorial: Querying Nested Data with Amazon Redshift Spectrum**

**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.
Step 1: Create an External Table That Contains Nested Data

You can use Redshift Spectrum to query this data. The following tutorial shows you how to do so.

For tutorial prerequisites, steps, and nested data use cases, see the following topics:

- Prerequisites (p. 273)
- Step 1: Create an External Table That Contains Nested Data (p. 273)
- Step 2: Query Your Nested Data in Amazon S3 with SQL Extensions (p. 274)
- Nested Data Use Cases (p. 277)
- Nested Data Limitations (p. 279)

Prerequisites

If you are not using Redshift Spectrum yet, follow the steps in the Getting Started with Amazon Redshift Spectrum (p. 236) tutorial before continuing.

Step 1: Create an External Table That Contains Nested Data

To create the external table for this tutorial, run the following command.

```sql
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://awssampledbuswest2/nested_example/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 LOCATION parameter has to refer to the Amazon S3 folder that contains the nested data or files.

Note

Amazon Redshift doesn't support complex data types in an Amazon Redshift database table. You can use complex data types only with Redshift Spectrum external tables.
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.

```
<table>
<thead>
<tr>
<th>id</th>
<th>given</th>
<th>family</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>John</td>
<td>Smith</td>
</tr>
<tr>
<td>2</td>
<td>Jenny</td>
<td>Doe</td>
</tr>
<tr>
<td>3</td>
<td>Andy</td>
<td>Jones</td>
</tr>
</tbody>
</table>
(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.

Note
You use structs only to describe the path to the fields that they contain. You can't access them directly in a query or return them from a query.

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't reference array elements by position, such as c.orders[0].

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 executing 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.
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.

<table>
<thead>
<tr>
<th>id</th>
<th>given</th>
<th>family</th>
<th>shipdate</th>
<th>price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>John</td>
<td>Smith</td>
<td>2018-03-01 11:59:59</td>
<td>100.5</td>
</tr>
<tr>
<td>2</td>
<td>John</td>
<td>Smith</td>
<td>2018-03-01 09:10:00</td>
<td>99.12</td>
</tr>
<tr>
<td>2</td>
<td>Jenny</td>
<td>Doe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Andy</td>
<td>Jones</td>
<td>2018-03-02 08:02:15</td>
<td>13.5</td>
</tr>
</tbody>
</table>

(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 simply 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.

```sql
CREATE EXTERNAL TABLE spectrum.customers (
    id int,
    name struct<given:varchar(20), family:varchar(20)>,
    phones map<varchar(20), varchar(20)>>,
    orders array<struct<shipdate:timestamp, price:double precision>>
)
```

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.

```sql
CREATE EXTERNAL TABLE spectrum.customers (
    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>>
)
```

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.

```sql
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

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 (p. 277)
- Aggregating Nested Data with Subqueries (p. 278)
- Joining Amazon Redshift and Nested Data (p. 278)

### 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.

<table>
<thead>
<tr>
<th>given</th>
<th>family</th>
<th>ordercount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jenny</td>
<td>Doe</td>
<td>0</td>
</tr>
<tr>
<td>John</td>
<td>Smith</td>
<td>2</td>
</tr>
<tr>
<td>Andy</td>
<td>Jones</td>
<td>1</td>
</tr>
</tbody>
</table>

(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 (  
...  
) WITH (  
...  
)  
```
### Nested Data Limitations

The following limitations apply to nested data:

- An array can only contain scalars or `struct` types. Array types can't contain array or map types.
- Redshift Spectrum supports complex data types only as external tables.
- Query and subquery result columns must be scalar.
- 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, you can use the parent only in the `FROM` clause. You can't use the query in any other clauses, such as a `SELECT` or `WHERE` clause. For example, the following query isn't executed.

```sql
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.

```sql
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.
Tuning Query Performance

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 Analyzing and Improving Queries sections. Then you can apply this information in combination with diagnostic tools to identify and eliminate 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 Troubleshooting Queries section.

Topics
- Query Processing
- Analyzing and Improving Queries
- Troubleshooting Queries

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
- Query Plan
- Reviewing Query Plan Steps
- Factors Affecting Query Performance

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 (p. 580) command to view the query plan. The query plan is a fundamental tool for analyzing and tuning complex queries. For more information, see Query Plan (p. 283).

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 parcelled out over the available compute node slices.

   The execution engine generates compiled C++ code based on steps, segments, and streams. Compiled code executes 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 (p. 290).

6. The compute node slices execute the query segments in parallel. As part of this process, Amazon Redshift takes advantage of optimized network communication, memory, and disk management.

   ![Query Planning and Execution Workflow Diagram]

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to pass intermediate results from one query plan step to the next, which 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.

Query Plan

You can use the query plan to get information on the individual operations required to execute 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 (p. 281).

To create a query plan, run the EXPLAIN (p. 580) 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 (p. 439) 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 (p. 294).

The following example shows the EXPLAIN output for a simple GROUP BY query on the EVENT table:

```sql
explain select eventname, count(*) from event group by eventname;
```

```
QUERY PLAN
-------------------------------------------------------------------
| XN HashAgg (cost=131.97..133.41 rows=576 width=17) |
->  XN Seq Scan on event  (cost=0.00..87.98 rows=8798 width=17) |
```

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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 (p. 580) 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` (p. 1076) system table.
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**
  Eliminates 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.

```sql
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).

```sql
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)
```
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.

```sql
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 executes 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.

```sql
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 HashJoin 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)
    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)
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
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 Query Plan (p. 283).

```sql
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)
```
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 (p. 281).

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 (p. 580).

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 (p. 3).

• **Node types** – An Amazon Redshift cluster can use either dense storage or dense compute nodes. The dense storage node types are recommended for substantial data storage needs, while dense compute node types are optimized for performance-intensive workloads. 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 on node types, see Amazon Redshift Pricing.

• **Data distribution** – Amazon Redshift stores table data on the compute nodes according to a table's distribution style. When you execute 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 Choosing a Data Distribution Style (p. 55).

• **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 Choosing Sort Keys (p. 66).

• **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 Implementing Workload Management (p. 309).

• **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 (p. 27).

• **Code compilation** – Amazon Redshift generates and compiles code for each query execution plan.

The compiled code executes faster because it eliminates 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 a query a second time to determine its typical performance.

Similarly, be careful about comparing the performance of the same query sent from different clients. The execution engine generates different code for the JDBC connection protocols and ODBC and psql (libpq) connection protocols. If two clients use different protocols, each client incurs the first-time cost of generating compiled code, even for the same query. Other clients that use the same protocol, however, benefit from sharing the cached code. A client that uses ODBC and a client running psql with libpq can share the same compiled code.

The compiled code segments are stored locally on the cluster and remotely in an AWS account level cache. Subsequent executions of the same query can run faster because it can skip the compilation phase. The cache persists after cluster reboots, but is wiped by maintenance upgrades.

When there is a local cache miss, the remote shared cache is used. If there is a remote cache hit, the cached item is fetched to the local cache. The remote cache is shared across clusters within the same AWS account. Thus, the query can run faster:
- When the query is run on different clusters of the same account.
- When the query is run in different sessions across a cluster.
- And often, when the query has different query parameters but the same execution plan.

Analyzing and Improving Queries

Retrieving information from an Amazon Redshift data warehouse involves executing complex queries on extremely large amounts of data, which can take a long time to process. To ensure queries process as quickly as possible, there are a number of tools you can use to identify potential performance issues.

Topics
- Query Analysis Workflow (p. 291)
- Reviewing Query Alerts (p. 292)
- Analyzing the Query Plan (p. 293)
- Analyzing the Query Summary (p. 294)
- Improving Query Performance (p. 299)
- Diagnostic Queries for Query Tuning (p. 301)

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 (p. 302).

1. Make sure your tables are designed according to best practices. For more information, see Amazon Redshift Best Practices for Designing Tables (p. 21).
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 need to be scanned and distributed.
3. Run the VACUUM (p. 663) 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 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 (p. 290).

6. Check the `STL_ALERT_EVENT_LOG` table to identify and correct possible issues with your query. For more information, see Reviewing Query Alerts (p. 292).

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 (p. 293).

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 (p. 294).

Sometimes a query that should execute 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 (p. 303). For more information about configuring query queues, see Implementing Workload Management (p. 309).

## 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:

```sql
select query, elapsed, substring
from svl_qlog
order by query
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:

```sql
Select * from stl_alert_event_log where query = MyQueryID;
```

3. Evaluate the results for your query. Use the following table to locate potential solutions for any issues that you have identified.
Analyzing the 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 Query Plan (p. 283) before proceeding.

Run the EXPLAIN (p. 580) command to get a query plan. 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:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Event Value</th>
<th>Solution Value</th>
<th>Recommended Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics for the tables in the query are missing or out of date.</td>
<td>Missing query planner statistics</td>
<td>Run the ANALYZE command</td>
<td>See Table Statistics Missing or Out of Date (p. 299).</td>
</tr>
<tr>
<td>There is a nested loop join (the least optimal join) in the query plan.</td>
<td>Nested Loop Join in the query plan</td>
<td>Review the join predicates to avoid Cartesian products</td>
<td>See Nested Loop (p. 299).</td>
</tr>
<tr>
<td>The 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.</td>
<td>Scanned a large number of deleted rows</td>
<td>Run the VACUUM command to reclaim deleted space</td>
<td>See Ghost Rows or Uncommitted Rows (p. 300).</td>
</tr>
<tr>
<td>More than 1,000,000 rows were redistributed for a hash join or aggregation.</td>
<td>Distributed a large number of rows across the network:RowCount rows were distributed in order to process the aggregation</td>
<td>Review the choice of distribution key to collocate the join or aggregation</td>
<td>See Suboptimal Data Distribution (p. 300).</td>
</tr>
<tr>
<td>More than 1,000,000 rows were broadcast for a hash join.</td>
<td>Broadcasted a large number of rows across the network</td>
<td>Review the choice of distribution key to collocate the join and consider using distributed tables</td>
<td>See Suboptimal Data Distribution (p. 300).</td>
</tr>
<tr>
<td>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.</td>
<td>DS_DIST_ALL_INNER for Hash Join in the query plan</td>
<td>Review the choice of distribution strategy to distribute the inner, rather than outer, table</td>
<td>See Suboptimal Data Distribution (p. 300).</td>
</tr>
</tbody>
</table>
• **Nested Loop**: Such joins usually occur because a join condition was omitted. For recommended solutions, see Nested Loop (p. 299).

• **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 (p. 299).

• **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 (p. 299).

4. See if there are any high-cost sort operations. If there are, see Unsorted or Missorted Rows (p. 300) for recommended solutions.

5. Look for the following broadcast operators where there are high-cost operations:
   - **DS_BCAST_INNER**: Indicates the table is broadcast to all the compute nodes, which 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 (p. 300).

---

**Analyzing the Query Summary**

To get execution steps and statistics in more detail than in the query plan that EXPLAIN (p. 580) produces, use the SVL_QUERY_SUMMARY (p. 1055) and SVL_QUERY_REPORT (p. 1049) 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 (p. 294)
- Using the SVL_QUERY_REPORT View (p. 296)
- Mapping the Query Plan to the Query Summary (p. 297)

**Using the SVL_QUERY_SUMMARY View**

To analyze query summary information by stream, do the following:

1. Run the following query to determine your query ID:

   ```sql
   select query, elapsed, substring
   from svl_qlog
   order by query
   desc limit $;
   ```

   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;
```

3. Map the steps to the operations in the query plan using the information in Mapping the Query Plan to the Query Summary (p. 297). 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 (p. 299) 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 (p. 301) for recommended solutions.

5. 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 (p. 300).
   - **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 (p. 299) for recommended solutions.
   - **SCAN/SORT**: Look for a SCAN, SORT, SCAN, MERGE sequence of steps just prior to 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 (p. 301).

   If the `maxtime` value for the SCAN step is high, see Suboptimal WHERE Clause (p. 301) for recommended solutions.
If the rows value for the SORT step is not zero, see Unsorted or Missorted Rows (p. 300) 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 being returned to the client. This process can be a bit of an art.

For example, in the following query summary, you can see that 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:

If you are returning an unusually large volume of data, see Very Large Result Set (p. 301) 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 (p. 301).

Using the SVL_QUERY_REPORT View

To analyze query summary information by slice, do the following:

1. Run the following to determine your query ID:

   ```sql
   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:

   ```sql
   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:
Also check to see that all slices are taking approximately the same amount of time:

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 (p. 300).

Mapping the Query Plan to the Query Summary

It helps to map the operations from the query plan to the steps (identified by the label field values) in the query summary to get further details on them:

<table>
<thead>
<tr>
<th>Query Plan Operation</th>
<th>Label Field Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>AGGR</td>
<td>Evaluates aggregate functions and GROUP BY conditions.</td>
</tr>
<tr>
<td>HashAggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GroupAggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS_BCAST_INNER</td>
<td>BCAST (broadcast)</td>
<td>Broadcasts an entire table or some set of rows (such as a filtered set of rows from a table) to all nodes.</td>
</tr>
<tr>
<td>DELETE</td>
<td></td>
<td>Deletes rows from tables.</td>
</tr>
<tr>
<td>DS_DIST_NONE</td>
<td>DIST (distribute)</td>
<td>Distributes rows to nodes for parallel joining purposes or other parallel processing.</td>
</tr>
<tr>
<td>DS_DIST_ALL_NONE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DS_DIST_INNER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query Plan Operation</td>
<td>Label Field Value</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DS_DIST_ALL_INNER</td>
<td>DS_DIST_ALL_INNER</td>
<td>Builds hash table for use in hash joins.</td>
</tr>
<tr>
<td>DS_DIST_ALL_BOTH</td>
<td>DS_DIST_ALL_BOTH</td>
<td></td>
</tr>
<tr>
<td>HASH</td>
<td>HASH</td>
<td>Builds hash table for use in hash joins.</td>
</tr>
<tr>
<td>Hash Join</td>
<td>HJOIN (hash join)</td>
<td>Executes a hash join of two tables or intermediate result sets.</td>
</tr>
<tr>
<td>Doesn't appear in query plan</td>
<td>INSERT</td>
<td>Inserts rows into tables.</td>
</tr>
<tr>
<td>Limit</td>
<td>LIMIT</td>
<td>Applies a LIMIT clause to result sets.</td>
</tr>
<tr>
<td>Merge</td>
<td>MERGE</td>
<td>Merges rows derived from parallel sort or join operations.</td>
</tr>
<tr>
<td>Merge Join</td>
<td>MJOIN (merge join)</td>
<td>Executes a merge join of two tables or intermediate result sets.</td>
</tr>
<tr>
<td>Nested Loop</td>
<td>NLOOP (nested loop)</td>
<td>Executes a nested loop join of two tables or intermediate result sets.</td>
</tr>
<tr>
<td>Doesn't appear in query plan</td>
<td>PARSE</td>
<td>Parses strings into binary values for loading.</td>
</tr>
<tr>
<td>Project</td>
<td>PROJECT</td>
<td>Evaluates expressions.</td>
</tr>
<tr>
<td>Network</td>
<td>RETURN</td>
<td>Returns rows to the leader or the client.</td>
</tr>
<tr>
<td>Doesn't appear in query plan</td>
<td>SAVE</td>
<td>Materializes rows for use in the next processing step.</td>
</tr>
<tr>
<td>Seq Scan</td>
<td>SCAN</td>
<td>Scans tables or intermediate result sets.</td>
</tr>
<tr>
<td>Sort</td>
<td>SORT</td>
<td>Sorts rows or intermediate result sets as required by other subsequent operations (such as joins or aggregations) or to satisfy an ORDER BY clause.</td>
</tr>
<tr>
<td>Unique</td>
<td>UNIQUE</td>
<td>Applies a SELECT DISTINCT clause or removes duplicates as required by other operations.</td>
</tr>
<tr>
<td>Window</td>
<td>WINDOW</td>
<td>Computes aggregate and ranking window functions.</td>
</tr>
</tbody>
</table>
Improving Query Performance

Following are some common issues that affect query performance, with instructions on ways to diagnose and resolve them.

Topics

- Table Statistics Missing or Out of Date (p. 299)
- Nested Loop (p. 299)
- Hash Join (p. 299)
- Ghost Rows or Uncommitted Rows (p. 300)
- Unsorted or Missorted Rows (p. 300)
- Suboptimal Data Distribution (p. 300)
- Insufficient Memory Allocated to the Query (p. 301)
- Suboptimal WHERE Clause (p. 301)
- Insufficiently Restrictive Predicate (p. 301)
- Very Large Result Set (p. 301)
- Large SELECT List (p. 301)

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 (p. 292).

To fix this issue, run ANALYZE (p. 439).

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 (p. 303). For more information, see Reviewing Query Alerts (p. 292).

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 executed 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 (p. 293).
- 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 (p. 294).

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 (p. 292).

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 (p. 663) 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 (p. 292).

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 (p. 302).

To fix this issue, you can take a couple of approaches:
• Run VACUUM (p. 663) 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 Choosing Sort Keys (p. 66).

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 (p. 292).
• Slices are not processing approximately the same number of rows for a given step. For more information, see Using the SVL_QUERY_REPORT View (p. 296).
• Slices are not taking approximately the same amount of time for a given step. For more information, see Using the SVL_QUERY_REPORT View (p. 296).

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 (p. 302).

To fix this issue, take another look at 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 Choosing a Data Distribution Style (p. 55).
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 (p. 294).

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 (p. 1110).

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 (p. 294).

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 (p. 21).

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 (p. 294).

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 (p. 642) 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 (p. 294).

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 (p. 294).

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 in conjunction with the query tuning processes discussed in Analyzing and Improving Queries (p. 291).
Identifying Queries That Are Top Candidates for Tuning

The following query identifies the top 50 most time-consuming statements that have been executed in the last 7 days. You can use the results to identify queries that are taking unusually long, and also to 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 (p. 292).

```
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 (p. 300).

If a table has a pct_unsorted value greater than 20 percent, consider running the VACUUM (p. 663) command. For more information, see Unsorted or Missorted Rows (p. 300).

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 ensure 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.

```sql
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)
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 (p. 299).

```sql
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 being executed. 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 (p. 316).

```sql
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
from stv_queue w
inner join stl_query q on w.query = q.query
where w.slot_count = 1
```

303
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 (p. 439) or VACUUM (p. 663) 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 (p. 439) 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;

Troubleshooting Queries

This section 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.

Topics
- Connection Fails (p. 305)
- Query Hangs (p. 305)
- Query Takes Too Long (p. 306)
- Load Fails (p. 307)
• Load Takes Too Long (p. 307)
• Load Data Is Incorrect (p. 307)
• Setting the JDBC Fetch Size Parameter (p. 308)

These suggestions give you a starting point for troubleshooting. You can also refer to the following resources for more detailed information.

• Accessing Amazon Redshift Clusters and Databases

• Designing Tables (p. 43)

• Loading Data (p. 98)

• Tutorial: Tuning Table Design (p. 73)

• Tutorial: Loading Data from Amazon S3 (p. 156)

Connection Fails

Your query connection can fail 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 Cluster 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 Cluster 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 Cluster 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 Cluster 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 (p. 564) and Performance Considerations When Using Cursors (p. 565).

**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 (p. 308).

**There Is a Potential Deadlock**

If there is a potential deadlock, try the following:

- View the STV_LOCKS (p. 1003) and STL_TR_CONFLICT (p. 980) system tables to find conflicts involving updates to more than one table.
- Use the PG_CANCEL_BACKEND (p. 894) function to cancel one or more conflicting queries.
- Use the PG_TERMINATE_BACKEND (p. 895) 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 (p. 151).

**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 Designing Tables (p. 43) and Tutorial: Tuning Table Design (p. 73).

**Query Is Writing to Disk**

Your queries might be writing to disk for at least part of the query execution. For more information, see Improving Query Performance (p. 299).

**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 Implementing Workload Management (p. 309).

**Queries Are Not Optimized**

Analyze the explain plan to find opportunities for rewriting queries or optimizing the database. For more information, see Query Plan (p. 283).

**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 (p. 1110).
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 (p. 142).

Load Fails

Your data load can fail for the following reasons; we suggest the following troubleshooting approaches.

Data Source Is in a Different Region

By default, the Amazon S3 bucket or Amazon DynamoDB table specified in the COPY command must be in the same 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 the same Region. You can specify a different Region by using the REGION (p. 458) 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 and more issues with eventual consistency.

COPY Command Fails

Query STL_LOAD_ERRORS to discover the errors that occurred during specific loads. For more information, see STL_LOAD_ERRORS (p. 946).

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 (p. 27).

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.

Not All Files Are Loaded

Eventual consistency can cause a discrepancy in some cases between the files listed using an Amazon S3 ListBuckets action and the files available to the COPY command. For more information, see Verifying That the Data Was Loaded Correctly (p. 122).
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.
Implementing Workload Management

You can use workload management (WLM) to define multiple query queues and to route queries to the appropriate queues at runtime.

In some cases, you might have multiple sessions or users running queries at the same time. In these cases, some queries might consume cluster resources for long periods of time and affect the performance of other queries. For example, suppose that one group of users submits occasional complex, long-running queries that select and sort rows from several large tables. Another group frequently submits short queries that select only a few rows from one or two tables and run in a few seconds. In this situation, the short-running queries might have to wait in a queue for a long-running query to complete. WLM helps manage this situation.

You can configure Amazon Redshift WLM to run with either automatic WLM or manual WLM.

- 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. You can enable automatic WLM using the Amazon Redshift console by choosing **Switch WLM mode** and then choosing **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**. You can specify a priority that reflects the business priority of the workload or users that map to each queue. The default priority of queries is set to **Normal**. For information about how to change the priority of queries in a queue, see **Query Priority (p. 313)**. For more information, see **Implementing Automatic WLM (p. 311)**.

At runtime, you can route queries to these queues according to user groups or query groups. You can also configure a query monitoring rule (QMR) to limit long-running queries.

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 **Working with Concurrency Scaling (p. 336)**.

**Note**

We recommend that you create a parameter group and choose automatic WLM to manage your query resources. For details about how to migrate from manual WLM to automatic WLM, see **Migrating from Manual WLM to Automatic WLM (p. 310)**.

- Manual WLM

Alternatively, you can manage system performance and your users’ experience by modifying your WLM configuration to create separate queues for the long-running queries and the short-running queries. At runtime, you can route queries to these queues according to user groups or query groups. You can enable this manual configuration using the Amazon Redshift console by 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. 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 (p. 316)**.
Note
We recommend configuring your manual WLM query queues with a total of 15 or fewer query slots. For more information, see Concurrency Level (p. 318).

Topics
- Modifying the WLM Configuration (p. 310)
- Implementing Automatic WLM (p. 311)
- Implementing Manual WLM (p. 316)
- Working with Concurrency Scaling (p. 336)
- Working with Short Query Acceleration (p. 338)
- WLM Queue Assignment Rules (p. 340)
- Assigning Queries to Queues (p. 343)
- WLM Dynamic and Static Configuration Properties (p. 344)
- WLM Query Monitoring Rules (p. 347)
- WLM System Tables and Views (p. 351)

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 Cluster 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 Cluster 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 (p. 344).

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 just hard to figure out, but 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 executing every 6 hours.

With query priorities, 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 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 ensure 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 (p. 347).

• The QMR action, HOP, is not applicable to automatic WLM. Instead, use the change priority action. For more information, see WLM Query Monitoring Rules (p. 347).

• Within a parameter group, avoid mixing automatic WLM queues and manual WLM queues. 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. Up to eight queues are created with the service class identifiers 100–107. Each queue has a priority. For more information, see Query Priority (p. 313).

In contrast, manual WLM requires you to specify values for query concurrency and memory allocation. The default for manual WLM is concurrency of five queries, and memory is divided equally between all five. 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.

For details about how to migrate from manual WLM to automatic WLM, see Migrating from Manual WLM to Automatic WLM (p. 310).

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 Working with Short Query Acceleration (p. 338).

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 (p. 310).

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 (p. 313).

### 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 queries. Write operations continue as normal on your main cluster. 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 line. For more information, see Working with Concurrency Scaling (p. 336).

### 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 Wildcards (p. 312).

### 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 Wildcards (p. 312).

### 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
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 aborts 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 (p. 347).

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.

```sql
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 to 107.

```sql
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.

```sql
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

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 (p. 311), 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 (p. 891),
CHANGE_SESSION_PRIORITY (p. 891), and CHANGE_USER_PRIORITY (p. 893). 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 (p. 891).

Note
Only one CRITICAL query can run at a time.

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 (p. 336) 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. The default queue priority is 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 Cluster
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.

```json
[
  {
    "user_group": [
      "ingest"
    ],
    "priority": "highest",
    "queue_type": "auto"
  },
  {
    "user_group": [
      "reporting"
    ],
    "priority": "normal",
    "queue_type": "auto"
  },
  {
    "user_group": [
      "analytics"
    ],
    "priority": "low",
    "queue_type": "auto"
  }
]
```
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 (p. 347).

For example, you can define a rule to abort any query classified as high priority that runs for more than 10 minutes.

```json
"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.

```json
"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.

<table>
<thead>
<tr>
<th>query</th>
<th>service_class</th>
<th>wlm_start_time</th>
<th>state</th>
<th>queue_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2673299</td>
<td>102</td>
<td>2019-06-24 17:35:38.866356</td>
<td>QueuedWaiting</td>
<td>265116</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2673236</td>
<td>101</td>
<td>2019-06-24 17:35:33.313854</td>
<td>Running</td>
<td>0</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2673265</td>
<td>102</td>
<td>2019-06-24 17:35:33.523332</td>
<td>Running</td>
<td>0</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>2673284</td>
<td>102</td>
<td>2019-06-24 17:35:38.477366</td>
<td>Running</td>
<td>0</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2673288</td>
<td>102</td>
<td>2019-06-24 17:35:38.621819</td>
<td>Running</td>
<td>0</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2673310</td>
<td>103</td>
<td>2019-06-24 17:35:39.068513</td>
<td>QueuedWaiting</td>
<td>62970</td>
</tr>
<tr>
<td>Highest</td>
<td></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>2673303</td>
<td>102</td>
<td>2019-06-24 17:35:38.968921</td>
<td>QueuedWaiting</td>
<td>162560</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2673306</td>
<td>102</td>
<td>2019-06-24 17:35:39.002733</td>
<td>QueuedWaiting</td>
<td>128691</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To list query priority for completed queries, see the `query_priority` column in the `stl_wlm_query` system table.

```sql
select query, service_class as svclass, service_class_start_time as starttime, query_priority
from stl_wlm_query order by 3 desc limit 10;
```

<table>
<thead>
<tr>
<th>query</th>
<th>svclass</th>
<th>starttime</th>
<th>query_priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>2723254</td>
<td>100</td>
<td>2019-06-24 18:14:50.780094</td>
<td>Normal</td>
</tr>
<tr>
<td>2723251</td>
<td>102</td>
<td>2019-06-24 18:14:50.749961</td>
<td>Highest</td>
</tr>
<tr>
<td>2723246</td>
<td>102</td>
<td>2019-06-24 18:14:50.725275</td>
<td>Highest</td>
</tr>
<tr>
<td>2723244</td>
<td>103</td>
<td>2019-06-24 18:14:50.719241</td>
<td>High</td>
</tr>
<tr>
<td>2723243</td>
<td>101</td>
<td>2019-06-24 18:14:50.699325</td>
<td>Low</td>
</tr>
<tr>
<td>2723242</td>
<td>102</td>
<td>2019-06-24 18:14:50.692573</td>
<td>Highest</td>
</tr>
<tr>
<td>2723239</td>
<td>101</td>
<td>2019-06-24 18:14:50.668535</td>
<td>Low</td>
</tr>
<tr>
<td>2723237</td>
<td>102</td>
<td>2019-06-24 18:14:50.661918</td>
<td>Highest</td>
</tr>
<tr>
<td>2723236</td>
<td>102</td>
<td>2019-06-24 18:14:50.643636</td>
<td>Highest</td>
</tr>
</tbody>
</table>

Implementing Manual WLM

With manual WLM, you can manage system performance and your users' experience by modifying your WLM configuration to create separate queues for the long-running queries and the 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
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 queries. Write operations continue as normal on your main cluster. 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 line. For more information, see Working with Concurrency Scaling (p. 336).
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 Cluster Management Guide.

In an automatic WLM configuration, the concurrency level is set to Auto. For more information, see Implementing Automatic WLM (p. 311).

In a manual WLM configuration, each queue can be configured with up to 50 query slots. The maximum WLM query slot count for all user-defined queues is 50. The limit includes the default queue, but doesn't include the reserved Superuser queue. By default, Amazon Redshift allocates an equal, fixed share of available memory to each queue. Amazon Redshift also allocates by default an equal, fixed share of a queue's memory to each query slot in the queue. The proportion of memory allocated to each queue is defined in the WLM configuration using the memory_percent_to_use property. At runtime, you can temporarily override the amount of memory assigned to a query by setting the wlm_query_slot_count parameter to specify the number of slots allocated to the query.

By default, 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 Working with Short Query Acceleration (p. 338)

- If you have multiple queries that each access data on a single slice, set up a separate WLM queue to execute those queries concurrently. Amazon Redshift assigns concurrent queries to separate slices, which allows multiple queries to execute 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.

As a best practice, we recommend using a total query slot count of 15 or lower. All of the compute nodes in a cluster, and all of the slices on the nodes, participate in parallel query execution. By increasing concurrency, you increase the contention for system resources and limit the overall throughput.

The memory that is allocated to each queue is divided among the query slots in that queue. The amount of memory available to a query is the memory allocated to the query slot in which the query is running. This is true regardless of the number of queries that are actually running concurrently. A query that can run entirely in memory when the slot count is 5 might need to write intermediate results to disk if the slot count is increased to 20. The additional disk I/O could degrade performance.

If a specific query needs more memory than is allocated to a single query slot, you can increase the available memory by increasing the wlm_query_slot_count (p. 1110) parameter. The following example sets wlm_query_slot_count to 10, performs a vacuum, and then resets wlm_query_slot_count to 1.

```sql
set wlm_query_slot_count to 10;
vacuum;
set wlm_query_slot_count to 1;
```
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 Wildcards (p. 319)

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 Wildcards (p. 319)

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 disabled 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 (p. 311).

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 (p. 347).

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 execute 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 (p. 320).

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 (p. 1019) system table. COPY statements and maintenance operations, such as ANALYZE and VACUUM, are not subject to WLM timeout.

The function of WLM timeout is similar to the statement_timeout (p. 1107) 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 (p. 1107) 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 aborts 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 (p. 347).

WLM Query Queue Hopping

A query can be hopped due to a WLM timeout (p. 319) or a query monitoring rule (QMR) hop action (p. 347). 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 (p. 340). 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.

<table>
<thead>
<tr>
<th>Query Type</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSERT, UPDATE, and DELETE</td>
<td>Cancel</td>
</tr>
<tr>
<td>User-defined functions (UDFs)</td>
<td>Cancel</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>Cancel</td>
</tr>
<tr>
<td>COPY</td>
<td>Continue execution</td>
</tr>
<tr>
<td>Maintenance operations</td>
<td>Continue execution</td>
</tr>
<tr>
<td>Read-only queries in a returning state</td>
<td>Continue execution</td>
</tr>
<tr>
<td>Read-only queries in a running state</td>
<td>Reassign or restart</td>
</tr>
<tr>
<td>CREATE TABLE AS (CTAS), SELECT INTO</td>
<td>Reassign or restart</td>
</tr>
</tbody>
</table>
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 (p. 1019) 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 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 (p. 1019) 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 (p. 1110) 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.

<table>
<thead>
<tr>
<th>Query Type</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPY</td>
<td>Continue execution</td>
</tr>
<tr>
<td>Query Type</td>
<td>Action</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Maintenance operations</td>
<td>Continue execution</td>
</tr>
<tr>
<td>User-defined functions (UDFs)</td>
<td>Continue execution</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>Reassign or continue execution</td>
</tr>
<tr>
<td>INSERT, UPDATE, and DELETE</td>
<td>Reassign or continue execution</td>
</tr>
<tr>
<td>Read-only queries in a returning state</td>
<td>Reassign or continue execution</td>
</tr>
<tr>
<td>Read-only queries in a running state</td>
<td>Reassign or restart</td>
</tr>
<tr>
<td>CREATE TABLE AS (CTAS), SELECT INTO</td>
<td>Reassign or restart</td>
</tr>
</tbody>
</table>

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**

**Overview**

We recommend configuring automatic workload management (WLM) in Amazon Redshift. For more information about automatic WLM, see Implementing Workload Management (p. 309). 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 psql client tool. If you do not already have these set up, go to Amazon Redshift Getting Started and Connect to Your Cluster by Using the psql Tool.

Sections

• Section 1: Understanding the Default Queue Processing Behavior (p. 323)
• Section 2: Modifying the WLM Query Queue Configuration (p. 327)
• Section 3: Routing Queries to Queues Based on User Groups and Query Groups (p. 331)
• Section 4: Using wlm_query_slot_count to Temporarily Override Concurrency Level in a Queue (p. 334)
• Section 5: Cleaning Up Your Resources (p. 336)

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 Reference (p. 914).

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 (p. 1017)
• STV_WLM_SERVICE_CLASS_CONFIG (p. 1022)
• STV_WLM_SERVICE_CLASS_STATE (p. 1023)

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.

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue</td>
<td>The number associated with the row that represents a queue. Queue number determines the order of the queues in the database.</td>
</tr>
<tr>
<td>Column</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>description</td>
<td>A value that describes whether the queue is available only to certain user groups, to certain query groups, or all types of queries.</td>
</tr>
<tr>
<td>slots</td>
<td>The number of slots allocated to the queue.</td>
</tr>
<tr>
<td>mem</td>
<td>The amount of memory, in MB per slot, allocated to the queue.</td>
</tr>
<tr>
<td>max_execution_time</td>
<td>The amount of time a query is allowed to run before it is terminated.</td>
</tr>
<tr>
<td>user_*</td>
<td>A value that indicates whether wildcard characters are allowed in the WLM configuration to match user groups.</td>
</tr>
<tr>
<td>query_*</td>
<td>A value that indicates whether wildcard characters are allowed in the WLM configuration to match query groups.</td>
</tr>
<tr>
<td>queued</td>
<td>The number of queries that are waiting in the queue to be processed.</td>
</tr>
<tr>
<td>executing</td>
<td>The number of queries that are currently executing.</td>
</tr>
<tr>
<td>executed</td>
<td>The number of queries that have executed.</td>
</tr>
</tbody>
</table>

To Create the WLM_QUEUE_STATE_VW View

1. Open psql and connect to your TICKIT sample database. If you do not have this database, see Prerequisites (p. 323).
2. Run the following query to create the WLM_QUEUE_STATE_VW view.

```sql
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.

```sql
select * from wlm_queue_state_vw;
```

The following is an example result.
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 (p. 1019) 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.

<table>
<thead>
<tr>
<th>Column</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>The query ID.</td>
</tr>
<tr>
<td>queue</td>
<td>The queue number.</td>
</tr>
<tr>
<td>slot_count</td>
<td>The number of slots allocated to the query.</td>
</tr>
<tr>
<td>start_time</td>
<td>The time that the query started.</td>
</tr>
<tr>
<td>state</td>
<td>The state of the query, such as executing.</td>
</tr>
<tr>
<td>queue_time</td>
<td>The number of microseconds that the query has spent in the queue.</td>
</tr>
<tr>
<td>exec_time</td>
<td>The number of microseconds that the query has been executing.</td>
</tr>
</tbody>
</table>

To Create the WLM_QUERY_STATE_VW View

1. In psql, run the following query to create the WLM_QUERY_STATE_VW view.

```sql
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.

```sql
select * from wlm_query_state_vw;
```

The following is an example result.

```
<table>
<thead>
<tr>
<th>query</th>
<th>queue</th>
<th>slot_count</th>
<th>start_time</th>
<th>state</th>
<th>queue_time</th>
<th>exec_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1249</td>
<td>1</td>
<td>1</td>
<td>2014-09-24 20:19:16</td>
<td>Executing</td>
<td>0</td>
<td>515</td>
</tr>
</tbody>
</table>
```

Step 3: Run Test Queries

In this step, you run queries from multiple connections in psql and review the system tables to determine how the queries were routed for processing.

For this step, you need two psql windows open:

- In psql window 1, you run queries that monitor the state of the queues and queries using the views you already created in this tutorial.
- In psql window 2, you run long-running queries to change the results you find in psql window 1.

To Run the Test Queries

1. Open two psql 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 psql window 1, run the following query.

```sql
select * from wlm_query_state_vw;
```

The following is an example result.

```
1580 | 1 | 1204-09-24 23:21:08 | Executing 0 | 1000
```

This query returns a self-referential result. The query that is currently executing 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 psql 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 disable result caching for the current session, set the `enable_result_cache_for_session` parameter to `off`, as shown following.

```sql
set enable_result_cache_for_session to off;
```

In psql window 2, run the following query.

```sql
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid < 100000;
```

4. In psql window 1, query WLM_QUEUE_STATE_VW and WLM_QUERY_STATE_VW and compare the results to your earlier results.

```sql
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

```
<table>
<thead>
<tr>
<th>query</th>
<th>slot_count</th>
<th>start_time</th>
<th>state</th>
<th>queue_time</th>
<th>exec_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1257</td>
<td>1</td>
<td>1204-09-24 23:21:08</td>
<td>Executing 0</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>1255</td>
<td>1</td>
<td>1204-09-24 23:21:08</td>
<td>Executing 0</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>
```

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.

**Note**
A new console is available for Amazon Redshift. Choose either the [New Console](https://console.aws.amazon.com/redshift/) or the [Original Console](https://console.aws.amazon.com/redshift/) instructions based on the console that you are using. The [New Console](https://console.aws.amazon.com/redshift/) instructions are open by default.

**New Console**

**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/redshift/](https://console.aws.amazon.com/redshift/).
2. On the navigation menu, choose **CONFIG**, 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.
    - Don't make any 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/redshift/](https://console.aws.amazon.com/redshift/).
2. On the navigation menu, choose **CLUSTERS**, then choose **Clusters** to display a list of your clusters.
3. Choose your cluster, such as `examplecluster`, and for **Actions** choose **Modify**.
4. In the **Database configuration** section, choose the `wlmtutorial` parameter group that you created for **Parameter groups**.
5. Choose **Modify cluster** 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.
6. Choose your cluster, and then choose **Reboot cluster** for **Actions**.

After the cluster is rebooted, its status returns to **Available**.

**Original Console**

To create a manual WLM configuration and associate it to a cluster.

**Step 1: Create a Parameter Group**

In this step, you create a new parameter group to use to configure WLM for this tutorial.

**To Create a Parameter Group**

1. Sign in to the AWS Management Console and open the Amazon Redshift console at https://console.aws.amazon.com/redshift/.
2. In the navigation pane, choose **Workload management**.
3. Choose **Create parameter group**.
4. In the **Create Cluster Parameter Group** dialog box, enter `wlmtutorial` for **Parameter group name** and enter `WLM tutorial` for **Description**. You can leave the **Parameter group family** setting as is. Then choose **Create**.

![Create Cluster Parameter Group](image)

**Step 2: Configure WLM**

In this step, you modify the default settings of your new parameter group. You add two new query queues to the WLM configuration and specify different settings for each queue.

**To Modify Parameter Group Settings**

1. On the **Parameter Groups** page of the Amazon Redshift console, choose `wlmtutorial`. Doing this opens the **Parameters** page for `wlmtutorial`. 

2. Choose **Switch WLM mode**. On the **WLM settings** page, choose **Manual WLM** and **Save**.

3. Choose the **Workload Management** tab. Choose **Add queue** twice to add two new queues to this WLM configuration. Configure the queues with the following values:
   - For queue 1, enter 2 for **Concurrency on main**, test for **Query groups**, and 30 for **Memory (%)**. Leave the other settings with their default values.
   - For queue 2, enter 3 for **Concurrency on main**, admin for **User groups**, and 40 for **Memory (%)**. Leave the other settings with their default values.
   - Don't make any changes to the **Default queue**. WLM assigns unallocated memory to the default queue.

4. Choose **Save**.

**Step 3: Associate the Parameter Group with Your Cluster**

In this step, you open your sample cluster and associate it with the new parameter group. After you do this, you reboot the cluster so that Amazon Redshift can apply the new settings to the database.

**To Associate the Parameter Group with Your Cluster**

1. In the navigation pane, choose **Clusters**, and then click your cluster to open it. If you are using the same cluster from *Amazon Redshift Getting Started*, your cluster is named *examplecluster*.

2. On the **Configuration** tab, choose **Modify** for **Cluster**.

3. In the **Modify Cluster** dialog box, choose **wlmtutorial** for **Cluster Parameter Group**, and then choose **Modify**.
The statuses shown in the **Cluster Parameter Group** and **Parameter Group Apply Status** change from in-sync to applying as shown in the following.

After the new parameter group is applied to the cluster, the **Cluster Properties** and **Cluster Status** show the new parameter group that you associated with the cluster. You need to reboot the cluster so that these settings can be applied to the database also.
4. For Cluster, choose Reboot. The status shown in Cluster Status changes from available to rebooting. After the cluster is rebooted, the 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 psql 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 (p. 323). If you already had a session connected to the database prior to the cluster reboot, you need to reconnect.

```sql
select * from wlm_queue_state_vw;
```

The following is an example result.
Compare these results to the results you received in Step 1: Create the WLM_QUEUE_STATE_VW View (p. 323). 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.

```sql
select * from wlm_query_state_vw;
```

The following is an example result.

<table>
<thead>
<tr>
<th>query</th>
<th>queue</th>
<th>slot_count</th>
<th>start_time</th>
<th>state</th>
<th>queue_time</th>
<th>exec_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:34d</td>
<td>3</td>
<td>12:04:24</td>
<td>2014-09-24 12:04:24</td>
<td>Executing 0</td>
<td>00:01:50</td>
<td></td>
</tr>
</tbody>
</table>

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.

```sql
set query_group to test;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

2. From the other psql window, run the following query.

```sql
select * from wlm_query_state_vw;
```

The following is an example result.

<table>
<thead>
<tr>
<th>query</th>
<th>queue</th>
<th>slot_count</th>
<th>start_time</th>
<th>state</th>
<th>queue_time</th>
<th>exec_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:16d</td>
<td>1</td>
<td>2014-09-24 22:54:12</td>
<td>Executing 0</td>
<td>00:02:09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:17d</td>
<td>3</td>
<td>2014-09-24 23:34:24</td>
<td>Executing 0</td>
<td>00:01:47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The query was routed to the test query group, which is queue 1 now.

3. Select all from the queue state view.

```sql
select * from wlm_queue_state_vw;
```

You see a result similar to the following.

<table>
<thead>
<tr>
<th>queue</th>
<th>description</th>
<th>slots</th>
<th>mem</th>
<th>max_mem</th>
<th>user_u</th>
<th>query_u</th>
<th>query_e</th>
<th>queued</th>
<th>executing</th>
<th>executed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(super user)</td>
<td>357</td>
<td>0</td>
<td>0</td>
<td>false</td>
<td>false</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>(query_group superuser)</td>
<td>627</td>
<td>0</td>
<td>0</td>
<td>false</td>
<td>false</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>(query_group admin)</td>
<td>357</td>
<td>0</td>
<td>0</td>
<td>false</td>
<td>false</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>(querytype any)</td>
<td>357</td>
<td>0</td>
<td>0</td>
<td>false</td>
<td>false</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

4. Now, reset the query group and run the long query again:

```sql
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.

```sql
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.
Tutorial: Configuring Manual WLM Queues

The result should be that the query is now running in queue 3 again.

Step 3: Create a Database User and Group

In Step 1: Create a Parameter Group (p. 328), you configured one of your query queues with a user group named admin. 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 on with psql using the new user’s credentials and run queries. You need to run queries as a superuser, such as the masteruser, 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 a psql window.

   ```sql
   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.

   ```sql
   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 psql window 2, run the following queries to switch to the adminwlm account and run a query as that user.

   ```sql
   set session authorization 'adminwlm';
   select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
   ```

2. In psql window 1, run the following query to see the query queue that the queries are routed to.

   ```sql
   select * from wlm_query_state_vw;
   select * from wlm_queue_state_vw;
   ```

The following are example results.
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 (p. 340).

3. Now run the following query from psql window 2.

```sql
set query_group to test;
select avg(l.priceperticket*s.qtysold) from listing l, sales s where l.listid <40000;
```

4. In psql window 1, run the following query to see the query queue that the queries are routed to.

```sql
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

5. When you're done, reset the query group.

```sql
reset query_group;
```

### Section 4: Using `wlm_query_slot_count` to Temporarily Override 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` (p. 1110).

#### 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.

```sql
set wlm_query_slot_count to 3;
```
2. Now, query WLM_QUERY_STATE_VW use the masteruser account to see how the query is running.

```
select * from wlm_query_state_vw;
```

The following is an example result.

```
+--------+-------------+---------------+----------+----------+----------+---------------+----------+----------------+
<table>
<thead>
<tr>
<th>query</th>
<th>queue</th>
<th>slot_count</th>
<th>start_time</th>
<th>state</th>
<th>query_time</th>
<th>exec_time</th>
<th>queued</th>
<th>executing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2240</td>
<td>2</td>
<td>3</td>
<td>2014-09-25 09:40:38</td>
<td>Executing</td>
<td>0</td>
<td>372414</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2240</td>
<td>3</td>
<td>3</td>
<td>2014-09-25 09:40:38</td>
<td>Executing</td>
<td>0</td>
<td>50s</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

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.

```
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.

```
```

Step 2: Run Queries from Different Sessions

Next, run queries from different sessions.

To Run Queries from Different Sessions

1. In psql window 1 and 2, run the following to use the test query group.

```
set query_group to test;
```

2. In psql 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 psql 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.

```sql
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 psql window and query the views to see the results.

```sql
select * from wlm_queue_state_vw;
select * from wlm_query_state_vw;
```

The following are example results.

![Example results](image)

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*.

For more information about WLM, see *Implementing Workload Management* (p. 309).

Working with Concurrency Scaling

With the Concurrency Scaling feature, you can support virtually unlimited concurrent users and concurrent queries, with consistently fast query performance. When concurrency scaling is enabled, Amazon Redshift automatically adds additional cluster capacity when you need it to process an increase in concurrent read queries. Write operations continue as normal on your main cluster. Users always see the most current data, whether the queries run on the main cluster or on a concurrency scaling cluster. You're charged for concurrency scaling clusters only for the time they're in use. For more information about pricing, see *Amazon Redshift pricing*. 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 line.

Concurrency Scaling Regions

The Concurrency Scaling feature is available only in the following AWS Regions:

- US East (N. Virginia) Region (us-east-1)
- US East (Ohio) Region (us-east-2)
Concurrency Scaling Candidates

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`, `ds2.8xlarge`, `dc2.large`, `ds2.xlarge`, or `ra3.16xlarge`
- Maximum of 32 compute nodes for clusters with `8xlarge` node types
- Not a single-node cluster

A query must meet all the following criteria to be a candidate for concurrency scaling:

- The query must be a read-only query.
- The query doesn’t reference tables that use an interleaved sort key (p. 67).
- The query doesn’t reference user-defined temporary tables.

Configuring Concurrency Scaling Queues

You route queries to concurrency scaling clusters by enabling a workload manager (WLM) queue as a concurrency scaling queue. To enable concurrency scaling on a queue, set the Concurrency Scaling mode value to auto.

When the number of queries routed to a concurrency scaling queue exceeds the queue’s configured concurrency, eligible queries are sent to the concurrency scaling cluster. When slots become available, queries are run on the main cluster. The number of queues is limited only by the number of queues permitted per 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. You can also route queries by defining WLM Query Monitoring Rules (p. 347). For example, you might route all queries that take longer than 5 seconds to a concurrency scaling queue.

Monitoring Concurrency Scaling

You can see whether a query is running on the main cluster or a concurrency scaling cluster by viewing the Amazon Redshift console, navigating to Cluster, and choosing a cluster. Then choose the Queries tab and view the values in the column Executed on to determine the cluster where the query ran.
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.

```sql
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 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;
```

Concurrency Scaling System Views

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 tables or SVL views:

- `SVCS_ALERT_EVENT_LOG` (p. 1026)
- `SVCS_COMPILE` (p. 1029)
- `SVCS_EXPLAIN` (p. 1034)
- `SVCS_PLAN_INFO` (p. 1041)
- `SVCS_QUERY_SUMMARY` (p. 1053)
- `SVCS_STREAM_SEGS` (p. 1075)

The following views are specific to concurrency scaling.

- `SVCS_CONCURRENCY_SCALING_USAGE` (p. 1031)

For more information about concurrency scaling, see the following topics in the *Amazon Redshift Cluster Management Guide*.

- Viewing Concurrency Scaling Data
- Viewing Cluster Performance During Query Execution
- Viewing Query Details

Working with 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 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.

CREATE TABLE AS (p. 550) (CTAS) statements and read-only queries, such as SELECT (p. 607) 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. In some cases, the query's predicted runtime might be less than the defined SQA maximum runtime. In such cases, the query thus needs to wait in a queue. Here, 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 (p. 340). 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 Cluster 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.

```sql
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.

```sql
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.

```sql
select final_state, service_class, count(*), avg(total_exec_time),
```
To find which queries were picked up by SQA and completed successfully, run the following query.

```sql
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.

```sql
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;
```

**WLM Queue Assignment Rules**

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 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.
Queue Assignments Example

The following table shows a WLM configuration with the superuser queue and four user-defined queues.

<table>
<thead>
<tr>
<th>Queue</th>
<th>Concurrency</th>
<th>User Groups</th>
<th>Query Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superuser</td>
<td>1</td>
<td>superuser</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>UG_1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td></td>
<td>QG_B</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>UG_2</td>
<td>QG_C</td>
</tr>
<tr>
<td>Default</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 (p. 343) later in this section.

1. User: masteruser

```
create group UG_1 with user admin1;
create user analyst1 in group UG_2 password 'NewPass11';
alter group UG_3 add user user1, user2;
```

```
Default Queue
```

2. User: masteruser

```
set query_group to 'superuser';
select query, trim(label) from stl_query;
reset query_group;
```

```
Superuser Queue
```

3. User: admin1

```
vacuum;
```

```
Queue 1
```

4. User: vp1

```
set query_group to 'QG_B';
execute last_qtr (Q1, 'now()');
reset query_group;
```

```
Queue 2
```

5. User: analyst1

```
set query_group to 'QG_B';
execute last_qtr (Q1, 'now()');
reset query_group;
```

```
Queue 2
```

6. User: ralph

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

```
Default Queue
```

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 executed by the user masteruser, 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 masteruser is a superuser and the query group is set to 'superuser', so the query is assigned to the superuser queue.
3. The user admin1 is a member of the user group listed in queue 1, so the query is assigned to queue 1.
4. 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.
5. 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.
6. 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

The following examples assign queries to queues according to user groups and query groups.

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 (p. 557), CREATE GROUP (p. 529), and ALTER GROUP (p. 418).

```
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 (p. 636) and RESET (p. 600) 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` (p. 1105) 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.

<table>
<thead>
<tr>
<th>WLM Property</th>
<th>Automatic WLM</th>
<th>Manual WLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query groups</td>
<td>Dynamic</td>
<td>Static</td>
</tr>
<tr>
<td>Query group wildcard</td>
<td>Dynamic</td>
<td>Static</td>
</tr>
<tr>
<td>User groups</td>
<td>Dynamic</td>
<td>Static</td>
</tr>
<tr>
<td>User group wildcard</td>
<td>Dynamic</td>
<td>Static</td>
</tr>
<tr>
<td>Concurrency on main</td>
<td>Not applicable</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Concurrency Scaling mode</td>
<td>Dynamic</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Enable short query acceleration</td>
<td>Not applicable</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Maximum runtime for short queries</td>
<td>Dynamic</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Percent of memory to use</td>
<td>Not applicable</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Timeout</td>
<td>Not applicable</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Priority</td>
<td>Dynamic</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Adding or removing queues</td>
<td>Dynamic</td>
<td>Static</td>
</tr>
</tbody>
</table>

**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](#).
When using automatic WLM, timeout is ignored.

Topics
- WLM Dynamic Memory Allocation (p. 345)
- Dynamic WLM Example (p. 345)

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 (p. 1022) system table.

Dynamic WLM Example

Suppose that your cluster WLM is configured with two queues, using the following dynamic properties.

<table>
<thead>
<tr>
<th>Queue</th>
<th>Concurrency</th>
<th>% Memory to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>50%</td>
</tr>
</tbody>
</table>

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.

\[
\frac{(200 \text{ GB} \times 50\%)}{4 \text{ slots}} = 25 \text{ GB}
\]

Next, you change your WLM to use the following dynamic properties.
As the following equation shows, the new memory allocation for each slot in queue 1 is 50 GB.

\[(200 \text{ GB} \times 75\%) / 3 \text{ slots} = 50 \text{ GB}\]

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.

<table>
<thead>
<tr>
<th>Step</th>
<th>Queries Running</th>
<th>Current Slot Count</th>
<th>Target Slot Count</th>
<th>Allocated Memory</th>
<th>Available Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1, A2, A3, A4</td>
<td>4</td>
<td>0</td>
<td>100 GB</td>
<td>50 GB</td>
</tr>
<tr>
<td>2</td>
<td>A2, A3, A4</td>
<td>3</td>
<td>0</td>
<td>75 GB</td>
<td>75 GB</td>
</tr>
<tr>
<td>3</td>
<td>A3, A4</td>
<td>2</td>
<td>0</td>
<td>50 GB</td>
<td>100 GB</td>
</tr>
<tr>
<td>4</td>
<td>A3, A4, B1</td>
<td>2</td>
<td>1</td>
<td>100 GB</td>
<td>50 GB</td>
</tr>
<tr>
<td>5</td>
<td>A4, B1</td>
<td>1</td>
<td>1</td>
<td>75 GB</td>
<td>75 GB</td>
</tr>
<tr>
<td>6</td>
<td>A4, B1, B2</td>
<td>1</td>
<td>2</td>
<td>125 GB</td>
<td>25 GB</td>
</tr>
<tr>
<td>7</td>
<td>B1, B2</td>
<td>0</td>
<td>2</td>
<td>100 GB</td>
<td>50 GB</td>
</tr>
<tr>
<td>8</td>
<td>B1, B2, B3</td>
<td>0</td>
<td>3</td>
<td>150 GB</td>
<td>0 GB</td>
</tr>
</tbody>
</table>

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 aborts 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. If more than one rule is triggered during the same period, WLM initiates the most severe action—abort, then hop, then log. 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.

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 Cluster 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 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 (p. 320).
• Abort – Log the action and terminate the query. QMR doesn’t abort COPY statements and maintenance operations, such as 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.

```json
"max_execution_time": 50000
```

But we recommend instead that you define an equivalent query monitoring rule that sets query_execution_time to 50 seconds as shown in the following JSON snippet.

```json
"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 Cluster Management Guide.

You can find more information about query monitoring rules in the following topics:
• Query Monitoring Metrics (p. 348)
• Query Monitoring Rules Templates (p. 350)
• Creating a Rule Using the Console
• Configuring Workload Management
• System Tables and Views for Query Monitoring Rules (p. 351)

**Query Monitoring Metrics**

The following table describes the metrics used in query monitoring rules. (These metrics are distinct from the metrics stored in the STV_QUERY_METRICS (p. 1006) and STLQUERY_METRICS (p. 962) 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 (p. 281).

**Note**
The WLM Timeout (p. 319) parameter is distinct from query monitoring rules.
<table>
<thead>
<tr>
<th>Metric</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query CPU time</td>
<td>query_cpu_time</td>
<td>CPU time used by the query, in seconds. CPU time is distinct from query execution time. Valid values are 0–999,999.</td>
</tr>
<tr>
<td>Blocks read</td>
<td>query_blocks_read</td>
<td>Number of 1 MB data blocks read by the query. Valid values are 0–1,048,575.</td>
</tr>
<tr>
<td>Scan row count</td>
<td>scan_row_count</td>
<td>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.</td>
</tr>
<tr>
<td>Query execution time</td>
<td>query_execution_time</td>
<td>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.</td>
</tr>
<tr>
<td>Query queue time</td>
<td>query_queue_time</td>
<td>Time spent waiting in a queue, in seconds. Valid values are 0–86,399.</td>
</tr>
<tr>
<td>CPU usage</td>
<td>query_cpu_usage_percent</td>
<td>Percent of CPU capacity used by the query. Valid values are 0–6,399.</td>
</tr>
<tr>
<td>Memory to disk</td>
<td>query_temp_blocks_to_disk</td>
<td>Temporary disk space used to write intermediate results, in 1 MB blocks. Valid values are 0–31,981,567.</td>
</tr>
<tr>
<td>CPU skew</td>
<td>cpu_skew</td>
<td>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.</td>
</tr>
<tr>
<td>I/O skew</td>
<td>io_skew</td>
<td>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.</td>
</tr>
<tr>
<td>Rows joined</td>
<td>join_row_count</td>
<td>The number of rows processed in a join step. Valid values are 0–999,999,999,999,999.</td>
</tr>
<tr>
<td>Nested loop join row count</td>
<td>nested_loop_join_row_count</td>
<td>The number of rows in a nested loop join. Valid values are 0–999,999,999,999,999.</td>
</tr>
<tr>
<td>Return row count</td>
<td>return_row_count</td>
<td>The number of rows returned by the query. Valid values are 0–999,999,999,999,999.</td>
</tr>
</tbody>
</table>
### Metric Name | Description
--- | ---
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.
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_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 (p. 1046) view shows the metrics for completed queries. The SVL_QUERY_METRICS_SUMMARY (p. 1047) 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 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.

<table>
<thead>
<tr>
<th>Template Name</th>
<th>Predicates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nested loop join</td>
<td><code>nested_loop_join_row_count &gt; 100</code></td>
<td>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.</td>
</tr>
<tr>
<td>Template Name</td>
<td>Predicates</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Query returns a high number of rows</td>
<td>return_row_count &gt; 1000000</td>
<td>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.</td>
</tr>
<tr>
<td>Join with a high number of rows</td>
<td>join_row_count &gt; 1000000000</td>
<td>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 queue that’s intended for quick, simple queries, you might use a lower number.</td>
</tr>
<tr>
<td>High disk usage when writing intermediate results</td>
<td>query_temp_blocks_to_disk &gt; 100000</td>
<td>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.</td>
</tr>
<tr>
<td>Long running query with high I/O skew</td>
<td>segment_execution_time &gt; 120 and io_skew &gt; 1.30</td>
<td>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.</td>
</tr>
</tbody>
</table>

### 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 (p. 992) 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 (p. 1006) table displays the metrics for currently running queries.
- The STL_QUERY_METRICS (p. 962) table records the metrics for completed queries.
- The SVL_QUERY_METRICS (p. 1046) view shows the metrics for completed queries.
- The SVL_QUERY_METRICS_SUMMARY (p. 1047) 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>
<thead>
<tr>
<th>Table Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL_WLM_ERROR (p. 991)</td>
<td>Contains a log of WLM-related error events.</td>
</tr>
<tr>
<td>STL_WLM_QUERY (p. 993)</td>
<td>Lists queries that are being tracked by WLM.</td>
</tr>
<tr>
<td>STV_WLM_CLASSIFICATION_CONFIG</td>
<td>Shows the current classification rules for WLM.</td>
</tr>
<tr>
<td>STV_WLM_QUERY_QUEUE_STATE (p. 1017)</td>
<td>Records the current state of the query queues.</td>
</tr>
</tbody>
</table>
| STV_WLM_QUERY_STATE (p. 1019) | Provides a snapshot of the current state of queries that are
being tracked by WLM. |
| STV_WLM_QUERY_TASK_STATE (p. 1021) | Contains the current state of query tasks. |
| STV_WLM_SERVICE_CLASS_CONFIG (p. 1022) | Records the service class configurations for WLM. |
| STV_WLM_SERVICE_CLASS_STATE (p. 1023) | Contains the current state of the service classes. |

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_
|-----|------|-------|----------|-----------|-------|--------|--------
| 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.

<table>
<thead>
<tr>
<th>ID</th>
<th>Service class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–4</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>5</td>
<td>Used by the superuser queue.</td>
</tr>
<tr>
<td>6–13</td>
<td>Used by manual WLM queues that are defined in the WLM configuration.</td>
</tr>
<tr>
<td>14</td>
<td>Used by short query acceleration.</td>
</tr>
<tr>
<td>15</td>
<td>Reserved for maintenance activities run by Amazon Redshift.</td>
</tr>
<tr>
<td>100–107</td>
<td>Used by automatic WLM queue when <code>auto_wlm</code> is true.</td>
</tr>
</tbody>
</table>
Managing Database Security

You manage database security by controlling which users have access to which database objects.

Access to database objects depends on the privileges that you grant to user accounts or groups. The following guidelines summarize how database security works:

- By default, privileges are granted only to the object owner.
- Amazon Redshift database users are named user accounts that can connect to a database. A user account is granted privileges explicitly, by having those privileges assigned directly to the account, or implicitly, by being a member of a group that is granted privileges.
- Groups are collections of users that can be collectively assigned privileges for easier 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.

For examples of security implementation, see Example for Controlling User and Group Access (p. 358).

For more information about protecting your data, see Security in Amazon Redshift in the Amazon Redshift Cluster 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 Management Console is controlled by your AWS account privileges. 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 enable 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 (p. 103).

• **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.

### Default Database User Privileges

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 privileges on the object. For users to use an object, you must grant the necessary privileges to the user or the group that contains the user. Database superusers have the same privileges as database owners.

Amazon Redshift supports the following privileges: SELECT, INSERT, UPDATE, DELETE, REFERENCES, CREATE, TEMPORARY, and USAGE. Different privileges are associated with different object types. For information on database object privileges supported by Amazon Redshift, see the GRANT (p. 585) command.

The right to modify or destroy an object is always the privilege of the owner only.

To revoke a privilege that was previously granted, use the REVOKE (p. 600) command. The privileges of the object owner, such as DROP, GRANT, and REVOKE privileges, are implicit and cannot be granted or revoked. Object owners can revoke their own ordinary privileges, for example, to make a table read-only for themselves as well as others. Superusers retain all privileges regardless of GRANT and REVOKE commands.

### Superusers

Database superusers have the same privileges as database owners for all databases.

The *masteruser*, 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 System Tables and Views (p. 914).

Superusers can view all PostgreSQL catalog tables. For information, see System Catalog Tables (p. 1087).

A database superuser bypasses all permission checks. Be very careful when using a superuser role. We recommend that you do most of your work as a role that is not a superuser. Superusers retain all privileges regardless of GRANT and REVOKE commands.

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 privilege.
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 that 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 user accounts can only be created and dropped by a database superuser. Users are authenticated when they login to Amazon Redshift. They can own databases and database objects (for example, tables) and can grant privileges 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 privileges to those databases. Superusers have database ownership privileges for all databases.

Creating, Altering, and Deleting Users

Database users accounts are global across a data warehouse cluster (and not per individual database).

- To create a user use the CREATE USER (p. 557) command.
- To create a superuser use the CREATE USER (p. 557) command with the CREATEUSER option.
- To remove an existing user, use the DROP USER (p. 576) command.
- To make changes to a user account, such as changing a password, use the ALTER USER (p. 435) command.
- To view a list of users, query the PG_USER catalog table:

```
select * from pg_user;
```

<table>
<thead>
<tr>
<th>usename</th>
<th>usesysid</th>
<th>usecreatedb</th>
<th>usesuper</th>
<th>usecatupd</th>
<th>passwd</th>
<th>valuntil</th>
<th>useconfig</th>
</tr>
</thead>
<tbody>
<tr>
<td>rdsdb</td>
<td>1</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>********</td>
<td></td>
<td></td>
</tr>
<tr>
<td>masteruser</td>
<td>100</td>
<td>t</td>
<td>t</td>
<td>f</td>
<td>********</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dwuser</td>
<td>101</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>********</td>
<td></td>
<td></td>
</tr>
<tr>
<td>simpleuser</td>
<td>102</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>********</td>
<td></td>
<td></td>
</tr>
<tr>
<td>poweruser</td>
<td>103</td>
<td>f</td>
<td>t</td>
<td>f</td>
<td>********</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dbuser</td>
<td>104</td>
<td>t</td>
<td>f</td>
<td>f</td>
<td>********</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(6 rows)

Groups

Groups are collections of users who are all granted whatever privileges are associated with the group. You can use groups to assign privileges by role. 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 require for their work. You can grant or revoke privileges 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;
```

### 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` (p. 529) command.
- To add users to or remove users from an existing group, use the `ALTER GROUP` (p. 418) command.
- To delete a group, use the `DROP GROUP` (p. 569) command. This command only drops the group, not its member users.

### 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 privileges 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 (p. 358)` later in this section.

Schemas can help with organization and concurrency issues in a multi-user environment in the following ways:

- To allow many developers to 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.

### 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` (p. 536) command.
- To change the owner of a schema, use the `ALTER SCHEMA` (p. 420) command.
- To delete a schema and its objects, use the `DROP SCHEMA` (p. 572) 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';
```

## 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` (p. 636) command.

For more information, see the `search_path` (p. 1106) description in the Configuration Reference.

## Schema-Based Privileges

Schema-based privileges are determined by the owner of the schema:

- By default, all users have CREATE and USAGE privileges on the PUBLIC schema of a database. To disallow users from creating objects in the PUBLIC schema of a database, use the `REVOKE` (p. 600) command to remove that privilege.
- Unless they are granted the USAGE privilege by the object owner, users cannot access any objects in schemas they do not own.
- If users have been granted the CREATE privilege to a schema that was created by another user, those users can create objects in that schema.

## Example for Controlling User and Group Access

This example creates user groups and user accounts and then grants them various privileges 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.

1. Create the groups where the user accounts 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 user accounts with different privileges and add them to the groups.
   a. Create two users and add them to the WEBAPPUSERS group:

   ```
   ```
Example for Controlling User and Group Access

create user webappuser1 password 'webAppuser1pass'
in group webappusers;
create user webappuser2 password 'webAppuser2pass'
in group webappusers;

b. Create an account for a web developer and adds it to the WEBDEVUSERS group:

create user webdevuser1 password 'webDevuser2pass'
in group webdevusers;
create user webdevuser2 password 'webDevuser2pass'
in group webdevusers;

c. Create a superuser account. 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 privileges to the WEBAPPUSERS group:

   grant usage on schema webapp to group webappusers;

   c. Grant USAGE privileges to the WEBPOWERUSERS group:

   grant usage on schema webapp to group webpowerusers;

   d. Grant ALL privileges to the WEBDEVUSERS group:

   grant all on schema webapp to group webdevusers;

The basic users and groups are now set up. You can now make changes to 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;
SQL Reference

Topics
- Amazon Redshift SQL (p. 360)
- Using SQL (p. 366)
- SQL Commands (p. 412)
- SQL Functions Reference (p. 667)
- Reserved Words (p. 911)

Amazon Redshift SQL

Topics
- SQL Functions Supported on the Leader Node (p. 360)
- Amazon Redshift and PostgreSQL (p. 361)

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 executed on the compute nodes, and other queries execute 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 execute 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 (p. 667) for a list of functions that run exclusively on the leader node.

Examples

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.

```sql
select current_schema();
```
The result is as follows.

```
current_schema
-------------
public       
(1 row)
```

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
(1 row)
```

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.

Amazon Redshift and PostgreSQL

Topics
- Amazon Redshift and PostgreSQL JDBC and ODBC (p. 362)
- Features That Are Implemented Differently (p. 362)
- Unsupported PostgreSQL Features (p. 363)
- Unsupported PostgreSQL Data Types (p. 364)
- Unsupported PostgreSQL Functions (p. 364)

Amazon Redshift is based on PostgreSQL 8.0.2. 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 System and Architecture Overview (p. 3) 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 8.0.2 that you must be aware of. This section highlights the differences between Amazon Redshift and PostgreSQL 8.0.2 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 Cluster 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 (p. 308).

Amazon Redshift does not recognize the JDBC maxRows parameter. Instead, specify a LIMIT (p. 630) clause to restrict the result set. You can also use an OFFSET (p. 630) 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 (p. 412) to understand the often subtle differences.

One example in particular is the VACUUM (p. 663) 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 (p. 142) 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 System Tables and Views (p. 914) for more information.

The following list includes some examples of SQL features that are implemented differently in Amazon Redshift.

- **CREATE TABLE (p. 537)**

  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 (p. 513) command.

- **ALTER TABLE (p. 421)**

  Only a subset of ALTER COLUMN actions are supported.

  ADD COLUMN supports adding only one column in each ALTER TABLE statement.

- **COPY (p. 450)**

  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 (p. 98) section and the COPY command reference for details.
- INSERT (p. 592), UPDATE (p. 658), and DELETE (p. 566)
  WITH is not supported.
- VACUUM (p. 663)
  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 (p. 379).

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 (p. 412) to understand the often subtle differences.

- Only the 8.x version of the PostgreSQL query tool psql 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.

- Database roles
- Inheritance
- Postgres system columns

Amazon Redshift SQL does not implicitly define system columns. However, the PostgreSQL system column names cannot be used as names of user-defined columns. 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 (p. 391).

- Value expressions
  - Subscripted expressions
  - Array constructors
  - Row constructors
- Triggers
- Management of External Data (SQL/MED)
- Table functions
• VALUES list used as constant tables
• Recursive common table expressions
• Sequences
• Full text search

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 (p. 360).

For a list of the supported data types, see Data Types (p. 369).

These PostgreSQL data types are not supported in Amazon Redshift.

• Arrays
• BIT, BIT VARYING
• BYTEA
• Composite Types
• Date/Time Types
  • INTERVAL
  • TIME
• Enumerated Types
• Geometric Types
• 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* (p. 412) to understand the often subtle differences.

For more information, see SQL Functions Supported on the Leader Node (p. 360).

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()
• 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_NONNULLable()
  • 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_LISTENINGCHANNELS()
  • 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
• SQL Reference Conventions (p. 367)
• Basic Elements (p. 367)
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.

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPS</td>
<td>Words in capital letters are key words.</td>
</tr>
<tr>
<td>[ ]</td>
<td>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 <strong>SELECT</strong> (p. 607).</td>
</tr>
<tr>
<td>{}</td>
<td>Braces indicate that you are required to choose one of the arguments inside the braces.</td>
</tr>
<tr>
<td></td>
<td>Pipes indicate that you can choose between the arguments.</td>
</tr>
<tr>
<td>italics</td>
<td>Words in italics indicate placeholders. You must insert the appropriate value in place of the word in italics.</td>
</tr>
<tr>
<td>. . .</td>
<td>An ellipsis indicates that you can repeat the preceding element.</td>
</tr>
<tr>
<td>'</td>
<td>Words in single quotes indicate that you must type the quotes.</td>
</tr>
</tbody>
</table>

**Basic Elements**

**Topics**

- Names and Identifiers (p. 367)
- Literals (p. 369)
- Nulls (p. 369)
- Data Types (p. 369)
- Collation Sequences (p. 391)

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 (p. 1103)` configuration parameter to `true`.

**Standard Identifiers**

Standard SQL identifiers adhere to a set of rules and must:

- Begin with an 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 quotes 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 quote 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 quote in a string, you must precede it with another double quote character.

**Examples**

This table shows examples of delimited identifiers, the resulting output, and a discussion:

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Result</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;group&quot;</td>
<td>group</td>
<td>GROUP is a reserved word, so usage of it within an identifier requires double quotes.</td>
</tr>
<tr>
<td>&quot;&quot;WHERE&quot;&quot;</td>
<td>&quot;where&quot;</td>
<td>WHERE is also a reserved word. To include quotation marks in the string, escape each double quote character with additional double quote characters.</td>
</tr>
<tr>
<td>&quot;This name&quot;</td>
<td>this name</td>
<td>Double quotes are required in order to preserve the space.</td>
</tr>
<tr>
<td>&quot;This &quot;IS IT&quot;&quot;</td>
<td>this &quot;is it&quot;</td>
<td>The quotes surrounding IS IT must each be preceded by an extra quote in order to become part of the name.</td>
</tr>
</tbody>
</table>

To create a table named group with a column named this "is it":

```sql
create table "group" (
  "This "IS IT"" char(10));
```

The following queries return the same result:

```sql
select "This "IS IT"
from "group";
```
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 (p. 375).
- 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 and Timestamp Literals (p. 383) and Interval Literals (p. 384).

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 except concatenation 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 (p. 370)
- Numeric Types (p. 371)
- Character Types (p. 378)
- Datetime Types (p. 380)
- Boolean Type (p. 386)
- Type Compatibility and Conversion (p. 388)
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.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Aliases</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALLINT</td>
<td>INT2</td>
<td>Signed two-byte integer</td>
</tr>
<tr>
<td>INTEGER</td>
<td>INT, INT4</td>
<td>Signed four-byte integer</td>
</tr>
<tr>
<td>BIGINT</td>
<td>INT8</td>
<td>Signed eight-byte integer</td>
</tr>
<tr>
<td>DECIMAL</td>
<td>NUMERIC</td>
<td>Exact numeric of selectable precision</td>
</tr>
<tr>
<td>REAL</td>
<td>FLOAT4</td>
<td>Single precision floating-point number</td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>FLOAT8, FLOAT</td>
<td>Double precision floating-point number</td>
</tr>
<tr>
<td>BOOLEAN</td>
<td>BOOL</td>
<td>Logical Boolean (true/false)</td>
</tr>
<tr>
<td>CHAR</td>
<td>CHARACTER, NCHAR, BPCHAR</td>
<td>Fixed-length character string</td>
</tr>
<tr>
<td>VARCHAR</td>
<td>CHARACTER VARYING, NVARCHAR, TEXT</td>
<td>Variable-length character string with a user-defined limit</td>
</tr>
<tr>
<td>DATE</td>
<td></td>
<td>Calendar date (year, month, day)</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TIMESTAMP WITHOUT TIME ZONE</td>
<td>Date and time (without time zone)</td>
</tr>
<tr>
<td>TIMESTAMPTZ</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Date and time (with time zone)</td>
</tr>
<tr>
<td>GEOMETRY</td>
<td></td>
<td>Spatial data</td>
</tr>
</tbody>
</table>

**Note**
For information about unsupported data types, such as "char" (notice that char is enclosed in quotation marks), see Unsupported PostgreSQL Data Types (p. 364).

**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.

VARCHAR does not support the following invalid UTF-8 codepoints:

- 0xD800 - 0xDFFF
  (Byte sequences: ED A0 80 - ED BF BF)
- 0xFDD0 - 0xFDEF, 0xFFFE, and 0xFFFF
  (Byte sequences: EF B7 90 - EF B7 AF, EF BF BE, and EF BF BF)
The CHAR data type does not support multibyte characters.

**Numeric Types**

**Topics**
- **Integer Types** (p. 371)
- **DECIMAL or NUMERIC Type** (p. 371)
- **Notes About Using 128-bit DECIMAL or NUMERIC Columns** (p. 372)
- **Floating-Point Types** (p. 372)
- **Computations with Numeric Values** (p. 373)
- **Integer and Floating-Point Literals** (p. 375)
- **Examples with Numeric Types** (p. 376)

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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALLINT or INT2</td>
<td>2 bytes</td>
<td>-32768 to +32767</td>
</tr>
<tr>
<td>INTEGER, INT, or INT4</td>
<td>4 bytes</td>
<td>-2147483648 to +2147483647</td>
</tr>
<tr>
<td>BIGINT or INT8</td>
<td>8 bytes</td>
<td>-9223372036854775808 to 9223372036854775807</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Storage</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable, up to 128 bits for uncompressed DECIMAL types.</td>
<td>128-bit signed integers with up to 38 digits of precision.</td>
</tr>
</tbody>
</table>

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.

```sql
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 $-9223372036854775807$. 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 derive from the internal storage of `DECIMAL` values as 8-byte integers. Amazon Redshift recommends that you do not define `DECIMAL` values with 19 digits of precision unless that precision is necessary.

**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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAL or FLOAT4</td>
<td>4 bytes</td>
<td>6 significant digits of precision</td>
</tr>
<tr>
<td>DOUBLE PRECISION, FLOAT8, or FLOAT</td>
<td>8 bytes</td>
<td>15 significant digits of precision</td>
</tr>
</tbody>
</table>
For example, note the results of the following inserts into a REAL column:

```sql
create table real1(realcol real);
insert into real1 values(12345.12345);
insert into real1 values(123456.12345);
select * from real1;
realcol
---------
123456
12345.1
(2 rows)
```

These inserted values are truncated to meet the limitation of 6 significant digits of precision for REAL columns.

**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* (p. 669).

**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.

<table>
<thead>
<tr>
<th>INT2</th>
<th>INT4</th>
<th>INT8</th>
<th>DECIMAL</th>
<th>FLOAT4</th>
<th>FLOAT8</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT2</td>
<td>INT2</td>
<td>INT4</td>
<td>INT8</td>
<td>DECIMAL</td>
<td>FLOAT8</td>
</tr>
<tr>
<td>INT4</td>
<td>INT4</td>
<td>INT4</td>
<td>INT8</td>
<td>DECIMAL</td>
<td>FLOAT8</td>
</tr>
<tr>
<td>INT8</td>
<td>INT8</td>
<td>INT8</td>
<td>INT8</td>
<td>DECIMAL</td>
<td>FLOAT8</td>
</tr>
<tr>
<td>DECIMAL</td>
<td>DECIMAL</td>
<td>DECIMAL</td>
<td>DECIMAL</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
</tr>
<tr>
<td>FLOAT4</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT4</td>
</tr>
<tr>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
<td>FLOAT8</td>
</tr>
</tbody>
</table>

**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, \( p_1 \) and \( s_1 \) 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:

\[
\text{Precision} = 8-2 + 2 + \max(4,2+8-2+1) \\
= 6 + 2 + 9 = 17 \\
\text{Scale} = \max(4,2+8-2+1) = 9 \\
\text{Result} = \text{DECIMAL}(17,9)
\]

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:

\[
\text{Scale} = \max(s1, s2) \\
\text{Precision} = \min(\max(p1-s1, p2-s2)+\text{scale},19)
\]

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;

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>c1</td>
<td>NUMERIC(15,3)</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

In the above example, the formula is applied as follows:

\[
\text{Precision} = \min(\max(7-2,15-3) + \max(2,3), 19) \\
= 12 + 3 = 15
\]
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: \(\text{max}(38 + \text{scale} - \text{precision}), \text{min}(4, 100)\)

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:

  ```sql
  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.

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**

\[ [ + | - ] \text{ digit ...} \]

**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**

\[ [ + | - ] \text{ digit ... } [ . ] [ \text{ digit ...} ] \]  
\[ [ e | \text{E} ] [ + | - ] \text{ digit ... } \]

**Arguments**

\( e \) | \( \text{E} \)

\( e \) or \( \text{E} \) 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 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 than 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(1999.99);
insert into film(replacement_cost) values(19999.99);
select replacement_cost from film;
replacement_cost
------------------
20000
1999.99
...
```

The value 19999.99 is converted to 20000 to meet the 6-digit precision requirement for the column. The value 1999.99 is loaded as is.
Character Types

Topics
- Storage and Ranges (p. 378)
- CHAR or CHARACTER (p. 378)
- VARCHAR or CHARACTER VARYING (p. 379)
- NCHAR and NVARCHAR Types (p. 379)
- TEXT and BPCHAR Types (p. 379)
- Significance of Trailing Blanks (p. 379)
- Examples with Character Types (p. 379)

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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage</th>
<th>Range (Width of Column)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAR, CHARACTER or NCHAR</td>
<td>Length of string, including trailing blanks (if any)</td>
<td>4096 bytes</td>
</tr>
<tr>
<td>VARCHAR, CHARACTER VARYING, or NVARCHAR</td>
<td>4 bytes + total bytes for characters, where each character can be 1 to 4 bytes.</td>
<td>65535 bytes (64K -1)</td>
</tr>
<tr>
<td>BPCHAR</td>
<td>Converted to fixed-length CHAR(256).</td>
<td>256 bytes</td>
</tr>
<tr>
<td>TEXT</td>
<td>Converted to VARCHAR(256).</td>
<td>260 bytes</td>
</tr>
</tbody>
</table>

Note

The CREATE TABLE syntax supports the MAX keyword for character data types. For example:

```sql
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.

```sql
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, the default length is 256.

**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:

```sql
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*.

```sql
insert into address(address1) values('9516 Magnolia Boulevard');
insert into address(address1) values('9516 Magnolia Boulevard  ');
```

```sql
select count(*) from address where address1='9516 Magnolia Boulevard';
```

```
<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
```

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;
```

```
<table>
<thead>
<tr>
<th>length</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
</tr>
<tr>
<td>25</td>
</tr>
</tbody>
</table>
```

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**
Datetime data types include DATE, TIMESTAMP, and TIMESTAMPTZ.

**Storage and Ranges**

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>4 bytes</td>
<td>4713 BC to 294276 AD</td>
<td>1 day</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>8 bytes</td>
<td>4713 BC to 294276 AD</td>
<td>1 microsecond</td>
</tr>
<tr>
<td>TIMESTAMPTZ</td>
<td>8 bytes</td>
<td>4713 BC to 294276 AD</td>
<td>1 microsecond</td>
</tr>
</tbody>
</table>

**DATE**

Use the DATE data type to store simple calendar dates without time stamps.

**TIMESTAMP**

TIMESTAMP is an alias of TIMESTAMP WITHOUT TIME ZONE.

Use the TIMESTAMP data type to store complete time stamp values that include the date and the time of day.

TIMESTAMP columns store values with up to a maximum of 6 digits of precision for fractional seconds.

If you insert a date into a TIMESTAMP column, or a date with a partial time stamp value, the value is implicitly converted into a full time stamp value with default values (00) for missing hours, minutes, and seconds. Time zone values in input strings are ignored.

By default, TIMESTAMP values are Coordinated Universal Time (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 time stamp 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 Coordinated Universal Time (UTC) and stores the UTC value.

To view a list of supported time zone names, execute the following command.

```sql
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, execute the following command.

```sql
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.

<table>
<thead>
<tr>
<th>Format</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>day mon hh:mm:ss yyyy tz</code></td>
<td>17 Dec 07:37:16 1997 PST</td>
</tr>
<tr>
<td><code>mm/dd/yyyy hh:mm:ss tz</code></td>
<td>12/17/1997 07:37:16.00 PST</td>
</tr>
<tr>
<td><code>mm/dd/yyyy hh:mm:ss.ss tz</code></td>
<td>12/17/1997 07:37:16.00 US/Pacific</td>
</tr>
<tr>
<td><code>yyyy-mm-dd hh:mm:ss+-tz</code></td>
<td>1997-12-17 07:37:16-08</td>
</tr>
<tr>
<td><code>dd.mm.yyyy hh:mm:ss tz</code></td>
<td>17.12.1997 07:37:16.00 PST</td>
</tr>
</tbody>
</table>

TIMESTAMPTZ columns store values with up to a maximum of 6 digits of precision for fractional seconds. If you insert a date into a TIMESTAMPTZ column, or a date with a partial time stamp, the value is implicitly converted into a full time stamp value with default values (00) for missing hours, minutes, and seconds.

TIMESTAMPTZ values are UTC in user tables.

**Examples with Datetime Types**

**Date Examples**

Insert dates that have different formats and display the output:

```sql
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;
```

<table>
<thead>
<tr>
<th>start_date</th>
<th>end_date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-06-01</td>
<td>2008-12-31</td>
</tr>
<tr>
<td>2008-06-01</td>
<td>2008-12-31</td>
</tr>
</tbody>
</table>

If you insert a time stamp value into a DATE column, the time portion is ignored and only the date loaded.

**Time Stamp Examples**

Insert timestamps that have different formats and display the output:

```sql
create table tstamp(timeofday timestamp, timeofdaytz timestamptz);
```

TIMESTAMP values are UTC in user tables.
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');

timeofday
---------------------
2008-06-01 09:59:59
2008-12-31 18:20:00
(2 rows)

Date and Timestamp Literals

Dates

The following input dates are all valid examples of literal date values that you can load into Amazon Redshift tables. The default MDY DateStyle mode is assumed to be in effect, which means that the month value precedes the day value in strings such as 1999–01–08 and 01/02/00.

**Note**

A date or time stamp literal must be enclosed in quotes when you load it into a table.

<table>
<thead>
<tr>
<th>Input date</th>
<th>Full Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 8, 1999</td>
<td>January 8, 1999</td>
</tr>
<tr>
<td>1999-01-08</td>
<td>January 8, 1999</td>
</tr>
<tr>
<td>1/8/1999</td>
<td>January 8, 1999</td>
</tr>
<tr>
<td>01/02/00</td>
<td>January 2, 2000</td>
</tr>
<tr>
<td>2000-Jan-31</td>
<td>January 31, 2000</td>
</tr>
<tr>
<td>Jan-31-2000</td>
<td>January 31, 2000</td>
</tr>
<tr>
<td>31-Jan-2000</td>
<td>January 31, 2000</td>
</tr>
<tr>
<td>20080215</td>
<td>February 15, 2008</td>
</tr>
<tr>
<td>080215</td>
<td>February 15, 2008</td>
</tr>
<tr>
<td>2008.366</td>
<td>December 31, 2008 (3-digit part of date must be between 001 and 366)</td>
</tr>
</tbody>
</table>

Timestamps

The following input timestamps are all valid examples of literal time values that you can load into Amazon Redshift tables. All of the valid date literals can be combined with the following time literals.

<table>
<thead>
<tr>
<th>Input Timestamps (Concatenated Dates and Times)</th>
<th>Description (of Time Part)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20080215 04:05:06.789</td>
<td>4:05 am and 6.789 seconds</td>
</tr>
<tr>
<td>20080215 04:05:06</td>
<td>4:05 am and 6 seconds</td>
</tr>
<tr>
<td>20080215 04:05</td>
<td>4:05 am exactly</td>
</tr>
<tr>
<td>20080215 040506</td>
<td>4:05 am and 6 seconds</td>
</tr>
</tbody>
</table>
### Input Timestamps (Concatenated Dates and Times)

<table>
<thead>
<tr>
<th>Description</th>
<th>Input Timestamps</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:05 am exactly; AM is optional</td>
<td>20080215 04:05 AM</td>
</tr>
<tr>
<td>4:05 pm exactly; hour value must be &lt; 12.</td>
<td>20080215 04:05 PM</td>
</tr>
<tr>
<td>4:05 05 pm exactly</td>
<td>20080215 16:05</td>
</tr>
<tr>
<td>Midnight (by default)</td>
<td>20080215</td>
</tr>
</tbody>
</table>

### Special Datetime Values

The following special values can be used as datetime literals and as arguments to date functions. They require single quotes and are converted to regular timestamp values during query processing.

<table>
<thead>
<tr>
<th>Description</th>
<th>Special Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluates to the start time of the current transaction and returns a timestamp with microsecond precision.</td>
<td>now</td>
</tr>
<tr>
<td>Evaluates to the appropriate date and returns a timestamp with zeroes for the timeparts.</td>
<td>today</td>
</tr>
</tbody>
</table>

The following examples show how `now` and `today` work in conjunction with the `DATEADD` function:

```sql
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 Literals

Use an interval literal to identify specific periods of time, such as 12 hours or 6 weeks. You can use these interval literals in conditions and calculations that involve datetime expressions.

**Note**

You cannot use the INTERVAL data type for columns in Amazon Redshift tables.

An interval is expressed as a combination of the INTERVAL keyword with a numeric quantity and a supported datepart; for example: `INTERVAL '7 days'` or `INTERVAL '59 minutes'`. Several quantities and units can be connected 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 do not specify a datepart, the interval value represents seconds. You can specify the quantity value as a fraction (for example: 0.5 days).

**Examples**

The following examples show a series of calculations with different interval values.

**Add 1 second to the specified date:**

```sql
select caldate + interval '1 second' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 00:00:01
(1 row)
```

**Add 1 minute to the specified date:**

```sql
select caldate + interval '1 minute' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2008-12-31 00:01:00
(1 row)
```

**Add 3 hours and 35 minutes to the specified date:**

```sql
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)
```

**Add 52 weeks to the specified date:**

```sql
select caldate + interval '52 weeks' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
2009-12-30 00:00:00
(1 row)
```

**Add 1 week, 1 hour, 1 minute, and 1 second to the specified date:**

```sql
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)
```

**Add 12 hours (half a day) to the specified date:**

```sql
select caldate + interval '0.5 days' as dateplus from date
where caldate='12-31-2008';
dateplus
---------------------
```

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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.

<table>
<thead>
<tr>
<th>State</th>
<th>Valid Literal Values</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>True</td>
<td>TRUE 't' 'true' 'y' 'yes' '1'</td>
<td>1 byte</td>
</tr>
<tr>
<td></td>
<td>FALSE 'f' 'false' 'n' 'no' '0'</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>NULL</td>
<td>1 byte</td>
</tr>
</tbody>
</table>

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.

**Note**
We recommend always checking Boolean values explicitly, as shown in the examples following. Implicit comparisons, such as WHERE flag or WHERE NOT flag might return unexpected results.

**Examples**

You could use a BOOLEAN column to store an "Active/Inactive" state for each customer in a CUSTOMER table.

```sql
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:

```sql
select firstname, lastname, likesports, liketheatre
from users
where likesports is true and liketheatre is false
order by userid limit 10;
```
The following example selects users from the USERS table for whom it is unknown whether they like rock music.

```sql
select firstname, lastname, likerock
from users
where likerock is unknown
order by userid limit 10;
```

<table>
<thead>
<tr>
<th>firstname</th>
<th>lastname</th>
<th>likerock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rafael</td>
<td>Taylor</td>
<td></td>
</tr>
<tr>
<td>Vladimir</td>
<td>Humphrey</td>
<td></td>
</tr>
<tr>
<td>Barry</td>
<td>Roy</td>
<td></td>
</tr>
<tr>
<td>Tamekah</td>
<td>Juarez</td>
<td></td>
</tr>
<tr>
<td>Mufutau</td>
<td>Watkins</td>
<td></td>
</tr>
<tr>
<td>Naida</td>
<td>Calderon</td>
<td></td>
</tr>
<tr>
<td>Anika</td>
<td>Huff</td>
<td></td>
</tr>
<tr>
<td>Bruce</td>
<td>Beck</td>
<td></td>
</tr>
<tr>
<td>Mallory</td>
<td>Farrell</td>
<td></td>
</tr>
<tr>
<td>Scarlett</td>
<td>Mayer</td>
<td></td>
</tr>
</tbody>
</table>

(10 rows)

The following example returns an error because it uses an IS comparison in the SELECT list.

```sql
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.

```sql
select firstname, lastname, likerock = true as "check"
from users
order by userid limit 10;
```

<table>
<thead>
<tr>
<th>firstname</th>
<th>lastname</th>
<th>check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rafael</td>
<td>Taylor</td>
<td></td>
</tr>
<tr>
<td>Vladimir</td>
<td>Humphrey</td>
<td></td>
</tr>
<tr>
<td>Lars</td>
<td>Ratliff</td>
<td>true</td>
</tr>
<tr>
<td>Barry</td>
<td>Roy</td>
<td></td>
</tr>
<tr>
<td>Reagan</td>
<td>Hodge</td>
<td>true</td>
</tr>
<tr>
<td>Victor</td>
<td>Hernandez</td>
<td>true</td>
</tr>
<tr>
<td>Tamekah</td>
<td>Juarez</td>
<td></td>
</tr>
<tr>
<td>Colton</td>
<td>Roy</td>
<td>false</td>
</tr>
<tr>
<td>Mufutau</td>
<td>Watkins</td>
<td></td>
</tr>
</tbody>
</table>
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 (p. 389)). 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, 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, 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 numeric values with character strings, the numeric values are converted to character strings. To enforce the opposite conversion (converting character strings to numeric values), use an explicit function, such as CAST and CONVERT (p. 881).

- 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, DATE or TIMESTAMP are assumed to use the current session time zone. The session time zone is UTC by default. For more information about setting the session time zone, see timezone (p. 1108).

• Similarly, TIMESTAMPTZ is converted to DATE 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 time stamp with time zone specified are converted to TIMESTAMPTZ using the specified time zone. If the time zone is omitted, the current session time zone is used, 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.

<table>
<thead>
<tr>
<th>From Type</th>
<th>To Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIGINT (INT8)</td>
<td>BOOLEAN</td>
</tr>
<tr>
<td></td>
<td>CHAR</td>
</tr>
<tr>
<td></td>
<td>DECIMAL (NUMERIC)</td>
</tr>
<tr>
<td></td>
<td>DOUBLE PRECISION (FLOAT8)</td>
</tr>
<tr>
<td></td>
<td>INTEGER (INT, INT4)</td>
</tr>
<tr>
<td></td>
<td>REAL (FLOAT4)</td>
</tr>
<tr>
<td></td>
<td>SMALLINT (INT2)</td>
</tr>
<tr>
<td></td>
<td>VARCHAR</td>
</tr>
<tr>
<td>CHAR</td>
<td>VARCHAR</td>
</tr>
<tr>
<td>DATE</td>
<td>CHAR</td>
</tr>
<tr>
<td></td>
<td>VARCHAR</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td>TIMESTAMPTZ</td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td>BIGINT (INT8)</td>
</tr>
<tr>
<td></td>
<td>CHAR</td>
</tr>
<tr>
<td></td>
<td>DOUBLE PRECISION (FLOAT8)</td>
</tr>
<tr>
<td></td>
<td>INTEGER (INT, INT4)</td>
</tr>
<tr>
<td></td>
<td>REAL (FLOAT4)</td>
</tr>
<tr>
<td></td>
<td>SMALLINT (INT2)</td>
</tr>
<tr>
<td>From Type</td>
<td>To Type</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>VARCHAR</td>
<td></td>
</tr>
<tr>
<td>BIGINT (INT8)</td>
<td></td>
</tr>
<tr>
<td>CHAR</td>
<td></td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td></td>
</tr>
<tr>
<td>INTEGER (INT, INT4)</td>
<td></td>
</tr>
<tr>
<td>REAL (FLOAT4)</td>
<td></td>
</tr>
<tr>
<td>SMALLINT (INT2)</td>
<td></td>
</tr>
<tr>
<td>VARCHAR</td>
<td></td>
</tr>
<tr>
<td>BIGINT (INT8)</td>
<td></td>
</tr>
<tr>
<td>BOOLEAN</td>
<td></td>
</tr>
<tr>
<td>CHAR</td>
<td></td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td></td>
</tr>
<tr>
<td>DOUBLE PRECISION (FLOAT8)</td>
<td></td>
</tr>
<tr>
<td>REAL (FLOAT4)</td>
<td></td>
</tr>
<tr>
<td>SMALLINT (INT2)</td>
<td></td>
</tr>
<tr>
<td>VARCHAR</td>
<td></td>
</tr>
<tr>
<td>BIGINT (INT8)</td>
<td></td>
</tr>
<tr>
<td>CHAR</td>
<td></td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td></td>
</tr>
<tr>
<td>INTEGER (INT, INT4)</td>
<td></td>
</tr>
<tr>
<td>SMALLINT (INT2)</td>
<td></td>
</tr>
<tr>
<td>VARCHAR</td>
<td></td>
</tr>
<tr>
<td>BIGINT (INT8)</td>
<td></td>
</tr>
<tr>
<td>CHAR</td>
<td></td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td></td>
</tr>
<tr>
<td>DOUBLE PRECISION (FLOAT8)</td>
<td></td>
</tr>
<tr>
<td>INTEGER (INT, INT4)</td>
<td></td>
</tr>
<tr>
<td>REAL (FLOAT4)</td>
<td></td>
</tr>
<tr>
<td>SMALLINT (INT2)</td>
<td></td>
</tr>
<tr>
<td>VARCHAR</td>
<td></td>
</tr>
<tr>
<td>BIGINT (INT8)</td>
<td></td>
</tr>
<tr>
<td>CHAR</td>
<td></td>
</tr>
<tr>
<td>DECIMAL (NUMERIC)</td>
<td></td>
</tr>
<tr>
<td>DOUBLE PRECISION (FLOAT8)</td>
<td></td>
</tr>
<tr>
<td>INTEGER (INT, INT4)</td>
<td></td>
</tr>
<tr>
<td>REAL (FLOAT4)</td>
<td></td>
</tr>
<tr>
<td>SMALLINT (INT2)</td>
<td></td>
</tr>
<tr>
<td>VARCHAR</td>
<td>CHAR</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td></td>
</tr>
</tbody>
</table>
## Collation Sequences

Amazon Redshift does not 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

### Simple Expressions (p. 391)

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 may be nested using parentheses.

### Examples

Examples of compound expressions include:

```
('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;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>American Airlines Arena</td>
<td>Miami</td>
<td>FL</td>
<td>0</td>
</tr>
<tr>
<td>54</td>
<td>St. Pete Times Forum</td>
<td>Tampa</td>
<td>FL</td>
<td>0</td>
</tr>
<tr>
<td>91</td>
<td>Raymond James Stadium</td>
<td>Tampa</td>
<td>FL</td>
<td>65647</td>
</tr>
</tbody>
</table>

(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 executed 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:

```sql
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;
```

<table>
<thead>
<tr>
<th>qtr</th>
<th>avg_saleprice_per_qtr</th>
<th>avg_saleprice_yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>647.64</td>
<td>642.28</td>
</tr>
<tr>
<td>2</td>
<td>646.86</td>
<td>642.28</td>
</tr>
<tr>
<td>3</td>
<td>636.79</td>
<td>642.28</td>
</tr>
<tr>
<td>4</td>
<td>638.26</td>
<td>642.28</td>
</tr>
</tbody>
</table>

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.
- `expression` Any expression(s) matching the data type and parameter count expected by the function.

Examples

```
abs (variable)
```
Conditions

Topics
- Syntax (p. 395)
- Comparison Condition (p. 395)
- Logical Conditions (p. 397)
- Pattern-Matching Conditions (p. 400)
- BETWEEN Range Condition (p. 408)
- Null Condition (p. 409)
- EXISTS Condition (p. 410)
- IN Condition (p. 411)

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

<table>
<thead>
<tr>
<th>comparison_condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>logical_condition</td>
</tr>
<tr>
<td>range_condition</td>
</tr>
<tr>
<td>pattern_matching_condition</td>
</tr>
<tr>
<td>null_condition</td>
</tr>
<tr>
<td>EXISTS_condition</td>
</tr>
<tr>
<td>IN_condition</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Syntax</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>a &lt; b</td>
<td>Value a is less than value b.</td>
</tr>
<tr>
<td>&gt;</td>
<td>a &gt; b</td>
<td>Value a is greater than value b.</td>
</tr>
<tr>
<td>&lt;=</td>
<td>a &lt;= b</td>
<td>Value a is less than or equal to value b.</td>
</tr>
<tr>
<td>&gt;=</td>
<td>a &gt;= b</td>
<td>Value a is greater than or equal to value b.</td>
</tr>
<tr>
<td>=</td>
<td>a = b</td>
<td>Value a is equal to value b.</td>
</tr>
<tr>
<td>&lt;&gt; or !=</td>
<td>a &lt;&gt; b or a != b</td>
<td>Value a is not equal to value b.</td>
</tr>
<tr>
<td>ANY</td>
<td>SOME</td>
<td>a = ANY(subquery)</td>
</tr>
</tbody>
</table>
### Conditions

<table>
<thead>
<tr>
<th>Operator</th>
<th>Syntax</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>a &lt;&gt; ALL or != ALL (subquery)</td>
<td>Value a is not equal to any value returned by the subquery.</td>
</tr>
<tr>
<td>IS TRUE</td>
<td>a IS TRUE</td>
<td>Value a is Boolean TRUE.</td>
</tr>
</tbody>
</table>

#### 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 (p. 411) 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 (p. 386) data type.

#### Examples

Here are some simple examples of comparison conditions:

```sql
a = 5
a < b
min(x) >= 5
qtsold = any (select qtsold from sales where dateid = 1882)
```

The following query returns venues with more than 10000 seats from the VENUE table:

```sql
select venueid, venuename, venueseats from venue
where venueseats > 10000
order by venueseats desc;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>FedExField</td>
<td>91704</td>
</tr>
<tr>
<td>6</td>
<td>New York Giants Stadium</td>
<td>80242</td>
</tr>
<tr>
<td>79</td>
<td>Arrowhead Stadium</td>
<td>79451</td>
</tr>
<tr>
<td>78</td>
<td>INVESCO Field</td>
<td>76125</td>
</tr>
<tr>
<td>69</td>
<td>Dolphin Stadium</td>
<td>74916</td>
</tr>
<tr>
<td>67</td>
<td>Ralph Wilson Stadium</td>
<td>73967</td>
</tr>
<tr>
<td>76</td>
<td>Jacksonville Municipal Stadium</td>
<td>73800</td>
</tr>
<tr>
<td>89</td>
<td>Bank of America Stadium</td>
<td>73298</td>
</tr>
<tr>
<td>72</td>
<td>Cleveland Browns Stadium</td>
<td>73200</td>
</tr>
<tr>
<td>86</td>
<td>Lambeau Field</td>
<td>72922</td>
</tr>
</tbody>
</table>
This example selects the users (USERID) from the USERS table who like rock music:

```sql
select userid from users where likerock = 't' order by 1 limit 5;
```

<table>
<thead>
<tr>
<th>userid</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>16</td>
</tr>
</tbody>
</table>

(5 rows)

This example selects the users (USERID) from the USERS table where it is unknown whether they like rock music:

```sql
select firstname, lastname, likerock
from users
where likerock is unknown
order by userid limit 10;
```

<table>
<thead>
<tr>
<th>firstname</th>
<th>lastname</th>
<th>likerock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rafael</td>
<td>Taylor</td>
<td></td>
</tr>
<tr>
<td>Vladimir</td>
<td>Humphrey</td>
<td></td>
</tr>
<tr>
<td>Barry</td>
<td>Roy</td>
<td></td>
</tr>
<tr>
<td>Tamekah</td>
<td>Juarez</td>
<td></td>
</tr>
<tr>
<td>Mufutau</td>
<td>Watkins</td>
<td></td>
</tr>
<tr>
<td>Naida</td>
<td>Calderon</td>
<td></td>
</tr>
<tr>
<td>Anika</td>
<td>Huff</td>
<td></td>
</tr>
<tr>
<td>Bruce</td>
<td>Beck</td>
<td></td>
</tr>
<tr>
<td>Mallory</td>
<td>Farrell</td>
<td></td>
</tr>
<tr>
<td>Scarlett</td>
<td>Mayer</td>
<td></td>
</tr>
</tbody>
</table>

(10 rows)

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:

<table>
<thead>
<tr>
<th>E1</th>
<th>E2</th>
<th>E1 AND E2</th>
<th>E1 OR E2</th>
<th>NOT E2</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
</tbody>
</table>


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:

```sql
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 | DMJ24GUS
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.

```sql
select userid, username from users
where likevegas = 1 or likesports = 1
order by userid;
```

```
userid | username
--------+----------
1 | JSG99FHE
2 | PGL08LJI
3 | IFT66TXU
```
The following query uses parentheses around the OR condition to find venues in New York or California where Macbeth was performed:

```sql
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;
```

<table>
<thead>
<tr>
<th>venuename</th>
<th>venuecity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geffen Playhouse</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>Greek Theatre</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>Royce Hall</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>American Airlines Theatre</td>
<td>New York City</td>
</tr>
<tr>
<td>August Wilson Theatre</td>
<td>New York City</td>
</tr>
<tr>
<td>Belasco Theatre</td>
<td>New York City</td>
</tr>
<tr>
<td>Bernard B. Jacobs Theatre</td>
<td>New York City</td>
</tr>
</tbody>
</table>

Removing the parentheses in this example changes the logic and results of the query.

The following example uses the NOT operator:

```sql
select * from category
where not catid=1
order by 1;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Sports</td>
<td>MLS</td>
<td>Major League Soccer</td>
</tr>
</tbody>
</table>

The following example uses a NOT condition followed by an AND condition:

```sql
select * from category
where (not catid=1) and catgroup='Sports'
order by catid;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Sports</td>
<td>MLS</td>
<td>Major League Soccer</td>
</tr>
</tbody>
</table>
Pattern-Matching Conditions

Topics

- LIKE (p. 400)
- SIMILAR TO (p. 403)
- POSIX Operators (p. 405)

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 executes several times faster than the query that uses a regular expression:

```sql
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**

```sql
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 (p. 850) 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.

**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:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Matches any sequence of zero or more characters.</td>
</tr>
<tr>
<td>_</td>
<td>Matches any single character.</td>
</tr>
</tbody>
</table>

**Examples**

The following table shows examples of pattern matching using LIKE:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>'abc' LIKE 'abc'</td>
<td>True</td>
</tr>
<tr>
<td>'abc' LIKE 'a%'</td>
<td>True</td>
</tr>
<tr>
<td>'abc' LIKE '<em>B</em>'</td>
<td>False</td>
</tr>
<tr>
<td>'abc' ILIKE '<em>B</em>'</td>
<td>True</td>
</tr>
<tr>
<td>'abc' LIKE 'c%'</td>
<td>False</td>
</tr>
</tbody>
</table>

The following example finds all cities whose names start with "E":

```sql
select distinct city from users
where city like 'E%' order by city;

city
---------------
East Hartford
East Lansing
East Rutherford
East St. Louis
```
The following example finds users whose last name contains "ten":

```sql
select distinct lastname from users
where lastname like '%ten%' order by lastname;
```

<table>
<thead>
<tr>
<th>lastname</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christensen</td>
</tr>
<tr>
<td>Wooten</td>
</tr>
</tbody>
</table>

The following example finds cities whose third and fourth characters are "ea". The command uses ILIKE to demonstrate case insensitivity:

```sql
select distinct city from users where city ilike '__EA%'
order by city;
```

<table>
<thead>
<tr>
<th>city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brea</td>
</tr>
<tr>
<td>Clearwater</td>
</tr>
<tr>
<td>Great Falls</td>
</tr>
<tr>
<td>Ocean City</td>
</tr>
<tr>
<td>Olean</td>
</tr>
<tr>
<td>Wheaton</td>
</tr>
</tbody>
</table>

(6 rows)

The following example uses the default escape string (\) to search for strings that include ":

```sql
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_time    |

(5 rows)

The following example specifies '^' as the escape character, then uses the escape character to search for strings that include "_":

```sql
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_time    |

(5 rows)
**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 (p. 400) 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 executes several times faster than the query that uses a regular expression:

```sql
select count(*) from event where eventname SIMILAR TO '%(Ring|Die)%';
select count(*) from event where eventname LIKE '%Ring%' OR eventname LIKE '%Die %';
```

**Syntax**

```sql
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:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Matches any sequence of zero or more characters.</td>
</tr>
<tr>
<td>_</td>
<td>Matches any single character.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>Repeat the previous item zero or more times.</td>
</tr>
</tbody>
</table>
Amazon Redshift Database Developer Guide

Conditions

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Repeat the previous item one or more times.</td>
</tr>
<tr>
<td>?</td>
<td>Repeat the previous item zero or one time.</td>
</tr>
<tr>
<td>{m}</td>
<td>Repeat the previous item exactly m times.</td>
</tr>
<tr>
<td>{m,}</td>
<td>Repeat the previous item m or more times.</td>
</tr>
<tr>
<td>{m,n}</td>
<td>Repeat the previous item at least m and not more than n times.</td>
</tr>
<tr>
<td>( )</td>
<td>Parentheses group items into a single logical item.</td>
</tr>
<tr>
<td>[ ... ]</td>
<td>A bracket expression specifies a character class, just as in POSIX regular expressions.</td>
</tr>
</tbody>
</table>

Examples

The following table shows examples of pattern matching using SIMILAR TO:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>'abc' SIMILAR TO 'abc'</td>
<td>True</td>
</tr>
<tr>
<td>'abc' SIMILAR TO '<em>b</em>'</td>
<td>True</td>
</tr>
<tr>
<td>'abc' SIMILAR TO '<em>A</em>'</td>
<td>False</td>
</tr>
<tr>
<td>'abc' SIMILAR TO '%(b</td>
<td>d)%'</td>
</tr>
<tr>
<td>'abc' SIMILAR TO '(b</td>
<td>c)%'</td>
</tr>
<tr>
<td>'AbcAbcdefefgl2efefg12' SIMILAR TO '((Ab)?c)+d((efg)+(12))+'</td>
<td>True</td>
</tr>
<tr>
<td>'aaaaaab11l1xy' SIMILAR TO 'a{6}_[0-9]{5}(x</td>
<td>y){2}'</td>
</tr>
<tr>
<td>'$0.87' SIMILAR TO '$[0-9]+(.[0-9][0-9])?'</td>
<td>True</td>
</tr>
</tbody>
</table>

The following example finds all cities whose names contain "E" or "H":

```sql
select distinct city from users
where city similar to '%E%|%H%' order by city;
```

<table>
<thead>
<tr>
<th>city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agoura Hills</td>
</tr>
<tr>
<td>Auburn Hills</td>
</tr>
<tr>
<td>Benton Harbor</td>
</tr>
<tr>
<td>Beverly Hills</td>
</tr>
<tr>
<td>Chicago Heights</td>
</tr>
<tr>
<td>Chino Hills</td>
</tr>
<tr>
<td>Citrus Heights</td>
</tr>
<tr>
<td>East Hartford</td>
</tr>
</tbody>
</table>

The following example uses the default escape string (\__) to search for strings that include "_":

```sql
select distinct city from users
where city similar to '%E%H% order by city;
```

<table>
<thead>
<tr>
<th>city</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agoura Hills</td>
</tr>
<tr>
<td>Auburn Hills</td>
</tr>
<tr>
<td>Benton Harbor</td>
</tr>
<tr>
<td>Beverly Hills</td>
</tr>
<tr>
<td>Chicago Heights</td>
</tr>
<tr>
<td>Chino Hills</td>
</tr>
<tr>
<td>Citrus Heights</td>
</tr>
<tr>
<td>East Hartford</td>
</tr>
</tbody>
</table>

404
The following example specifies "^" as the escape string, then uses the escape string to search for strings that include "_":

```sql
select tablename, "column" from pg_table_def
where "column" similar to '%start^_%' escape '^'
limit 5;
```

<table>
<thead>
<tr>
<th>tablename</th>
<th>column</th>
</tr>
</thead>
<tbody>
<tr>
<td>stl_s3client</td>
<td>start_time</td>
</tr>
<tr>
<td>stl_tr_conflict</td>
<td>xact_start_ts</td>
</tr>
<tr>
<td>stl_undone</td>
<td>undo_start_ts</td>
</tr>
<tr>
<td>stl_unload_log</td>
<td>start_time</td>
</tr>
<tr>
<td>stl_vacuum_detail</td>
<td>start_row</td>
</tr>
</tbody>
</table>

(5 rows)

**POSIX Operators**

POSIX regular expressions provide a more powerful means for pattern matching than the **LIKE** (p. 400) and **SIMILAR TO** (p. 403) 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 executes several times faster than the query that uses a regular expression:

```sql
select count(*) from event where eventname ~ '.*(Ring|Die).* ';  
select count(*) from event where eventname LIKE '%Ring%' OR eventname LIKE '%Die%';
```

**Syntax**

```sql
expression [ ! ] ~ pattern
```

**Arguments**

`expression`

A valid UTF-8 character expression, such as a column name.

`!`

Negation operator.

`~`

Perform a case-sensitive match for any substring of `expression`. 

---

405
pattern

A string literal that represents a SQL standard regular expression pattern.

If \textit{pattern} does not contain wildcard characters, then the pattern only represents the string itself.

To search for strings that include metacharacters, such as \texttt{. * | ?}, and so on, escape the character using two backslashes (\texttt{\\}). Unlike \texttt{SIMILAR TO} and \texttt{LIKE}, POSIX regular expression syntax does not support a user-defined escape character.

Either of the character expressions can be \texttt{CHAR} or \texttt{VARCHAR} data types. If they differ, Amazon Redshift converts \textit{pattern} to the data type of \textit{expression}.

All of the character expressions can be \texttt{CHAR} or \texttt{VARCHAR} data types. If the expressions differ in data type, Amazon Redshift converts them to the data type of \textit{expression}.

POSIX pattern matching supports the following metacharacters:

<table>
<thead>
<tr>
<th>POSIX</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.</td>
<td>Matches any single character.</td>
</tr>
<tr>
<td>*</td>
<td>Matches zero or more occurrences.</td>
</tr>
<tr>
<td>+</td>
<td>Matches one or more occurrences.</td>
</tr>
<tr>
<td>?</td>
<td>Matches zero or one occurrence.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>^</td>
<td>Matches the beginning-of-line character.</td>
</tr>
<tr>
<td>$</td>
<td>Matches the end-of-line character.</td>
</tr>
<tr>
<td>$</td>
<td>Matches the end of the string.</td>
</tr>
<tr>
<td>[ ]</td>
<td>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.</td>
</tr>
<tr>
<td>( )</td>
<td>Parentheses group items into a single logical item.</td>
</tr>
<tr>
<td>{m}</td>
<td>Repeat the previous item exactly \textit{m} times.</td>
</tr>
<tr>
<td>{m,}</td>
<td>Repeat the previous item \textit{m} or more times.</td>
</tr>
<tr>
<td>{m, n}</td>
<td>Repeat the previous item at least \textit{m} and not more than \textit{n} times.</td>
</tr>
<tr>
<td>[: : ]</td>
<td>Matches any character within a POSIX character class. In the following character classes, Amazon Redshift supports only ASCII characters: [[:alnum:]], [[:alpha:]], [[:lower:]], [[:upper:]]</td>
</tr>
</tbody>
</table>

Amazon Redshift supports the following POSIX character classes:

<table>
<thead>
<tr>
<th>Character Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[[:alnum:]]]</td>
<td>All ASCII alphanumeric characters</td>
</tr>
<tr>
<td>[[[:alpha:]]]</td>
<td>All ASCII alphabetic characters</td>
</tr>
</tbody>
</table>
Character Class | Description
--- | ---
[[\[:blank:\]]] | All blank space characters
[[\[:cntrl:\]]] | 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 (``\``).

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Equivalent character class expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>\d</td>
<td>A digit character</td>
<td>[[[:digit:]]]</td>
</tr>
<tr>
<td>\D</td>
<td>A nondigit character</td>
<td>[^[[:digit:]]]</td>
</tr>
<tr>
<td>\w</td>
<td>A word character</td>
<td>[[[:word:]]]</td>
</tr>
<tr>
<td>\W</td>
<td>A nonword character</td>
<td>[^[[:word:]]]</td>
</tr>
<tr>
<td>\s</td>
<td>A white space character</td>
<td>[[[:space:]]]</td>
</tr>
<tr>
<td>\S</td>
<td>A non–white space character</td>
<td>[^[[:space:]]]</td>
</tr>
</tbody>
</table>

**Examples**

The following table shows examples of pattern matching using POSIX operators:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<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</td>
<td>d).*'</td>
</tr>
<tr>
<td>'abc' - '(b</td>
<td>c).*'</td>
</tr>
<tr>
<td>'AbcAbcdefgefgefg12efgefg12' - '((Ab)?c)+d((efg)+(12))+''</td>
<td>True</td>
</tr>
<tr>
<td>'aaaaab11111xy' - 'a{6}.[1]{5}(x</td>
<td>y){2}''</td>
</tr>
<tr>
<td>'#0.87' - '\$[0-9]+(.[0-9][0-9])?'</td>
<td>True</td>
</tr>
</tbody>
</table>
### Conditions

<table>
<thead>
<tr>
<th>Expression</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

The following example finds all cities whose names contain E or H:

```sql
select distinct city from users
where city ~ '.*E.*|.*H.*' order by city;
```

```plaintext
city
------------
Agoura Hills
Auburn Hills
Benton Harbor
Beverly Hills
Chicago Heights
Chino Hills
Citrus Heights
East Hartford
```

The following example uses the escape string ('\') to search for strings that include a period.

```sql
select venuename from venue
where venuename ~ '.*\..*';
```

```plaintext
venuename
------------------------
Bernard B. Jacobs Theatre
E.J. Nutter Center
Hubert H. Humphrey Metrodome
Jobing.com Arena
St. James Theatre
St. Pete Times Forum
Superpages.com Center
U.S. Cellular Field
```

### BETWEEN Range Condition

A BETWEEN condition tests expressions for inclusion in a range of values, using the keywords BETWEEN and AND.

#### Syntax

```sql
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:

```sql
select count(*) from sales
```

408
where qtysold between 2 and 4;

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>104021</td>
</tr>
</tbody>
</table>

(1 row)

The range condition includes the begin and end values.

select min(dateid), max(dateid) from sales
where dateid between 1900 and 1910;

<table>
<thead>
<tr>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>1910</td>
</tr>
</tbody>
</table>

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;

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

(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;

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>172456</td>
</tr>
</tbody>
</table>

(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;

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>116</td>
<td>Busch Stadium</td>
<td>49660</td>
</tr>
<tr>
<td>106</td>
<td>Rangers BallPark in Arlington</td>
<td>49115</td>
</tr>
<tr>
<td>96</td>
<td>Oriole Park at Camden Yards</td>
<td>48876</td>
</tr>
</tbody>
</table>

... (22 rows)

**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;
```
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
```

...
SQL Commands

Topics

- ABORT (p. 413)
- ALTER DATABASE (p. 415)
- ALTER DEFAULT PRIVILEGES (p. 416)
- ALTER GROUP (p. 418)
- ALTER PROCEDURE (p. 419)
- ALTER SCHEMA (p. 420)
- ALTER TABLE (p. 421)
- ALTER TABLE APPEND (p. 432)
- ALTER USER (p. 435)
- ANALYZE (p. 439)
- ANALYZE COMPRESSION (p. 441)
- BEGIN (p. 442)
- CALL (p. 444)
- CANCEL (p. 446)
- CLOSE (p. 448)
- COMMENT (p. 448)
- COMMIT (p. 450)
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- CREATE DATABASE (p. 509)
- CREATE EXTERNAL SCHEMA (p. 510)
- CREATE EXTERNAL TABLE (p. 513)
- CREATE FUNCTION (p. 525)
- CREATE GROUP (p. 529)
- CREATE LIBRARY (p. 529)
- CREATE MATERIALIZED VIEW (p. 532)
- CREATE PROCEDURE (p. 533)
- CREATE SCHEMA (p. 536)
- CREATE TABLE (p. 537)
- CREATE TABLE AS (p. 550)
- CREATE USER (p. 557)
- CREATE VIEW (p. 561)
- DEALLOCATE (p. 563)
- DECLARE (p. 564)
- DELETE (p. 566)
- DROP DATABASE (p. 568)
- DROP FUNCTION (p. 568)
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• DROP MATERIALIZED VIEW (p. 570)
• DROP PROCEDURE (p. 571)
• DROP SCHEMA (p. 572)
• DROP TABLE (p. 573)
• DROP USER (p. 576)
• DROP VIEW (p. 577)
• END (p. 578)
• EXECUTE (p. 579)
• EXPLAIN (p. 580)
• FETCH (p. 584)
• GRANT (p. 585)
• INSERT (p. 592)
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• PREPARE (p. 597)
• REFRESH MATERIALIZED VIEW (p. 599)
• RESET (p. 600)
• REVOKE (p. 600)
• ROLLBACK (p. 606)
• SELECT (p. 607)
• SELECT INTO (p. 635)
• SET (p. 636)
• SET SESSION AUTHORIZATION (p. 639)
• SET SESSION CHARACTERISTICS (p. 639)
• SHOW (p. 639)
• SHOW PROCEDURE (p. 640)
• START TRANSACTION (p. 641)
• TRUNCATE (p. 641)
• UNLOAD (p. 642)
• UPDATE (p. 658)
• VACUUM (p. 663)

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.

**Note**
Amazon Redshift is based on PostgreSQL 8.0.2. 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 (p. 361).

**Note**
The maximum size for a single SQL statement is 16 MB.

**ABORT**

Aborts 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. See ROLLBACK (p. 606) for more detailed documentation.
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:

```
<table>
<thead>
<tr>
<th>name</th>
<th>gross</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raiders of the Lost Ark</td>
<td>23400000</td>
</tr>
<tr>
<td>Star Wars</td>
<td>10000000</td>
</tr>
</tbody>
</table>
```

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;
```

```
<table>
<thead>
<tr>
<th>name</th>
<th>gross</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

(0 rows)
ALTER DATABASE

Changes the attributes of a database.

Syntax

```
ALTER DATABASE  database_name  
|  RENAME TO  new_name  
|  OWNER TO  new_owner  
|  CONNECTION LIMIT { limit | UNLIMITED } ]
```

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 (p. 367). You can't rename the dev, padb_harvest, template0, or template1 databases, and you can't rename the current database. Only the database owner or a superuser (p. 355) 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. See GRANT (p. 585) for more information about user privileges.

`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 (p. 557). The default is UNLIMITED. To view current connections, query the STV_SESSIONS (p. 1011) 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.

Usage Notes

ALTER DATABASE commands apply to subsequent sessions not current sessions. You need to 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;
```

ALTER DEFAULT PRIVILEGES

Defines the default set of access privileges 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 privileges. Only a superuser can specify default privileges for other users.

You can apply default privileges to users or user groups. You can set default privileges globally for all objects created in the current database, or for objects created only in the specified schemas.

Default privileges apply only to new objects. Running ALTER DEFAULT PRIVILEGES doesn't change privileges on existing objects.

For more information about privileges, see GRANT (p. 585).

To view information about the default privileges for database users, query the PG_DEFAULT_ACL (p. 1090) system catalog table.

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 | REFERENCES } [, ...] | ALL [ PRIVILEGES ] }
  ON TABLES
  TO { user_name [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
  ON FUNCTIONS
  TO { user_name [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [, ...]

GRANT { EXECUTE | ALL [ PRIVILEGES ] }
  ON PROCEDURES
  TO { user_name [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [, ...]

REVOKE [ GRANT OPTION FOR ] { { SELECT | INSERT | UPDATE | DELETE | REFERENCES } [, ...] | ALL [ PRIVILEGES ] }
  ON TABLES
  FROM user_name [, ...] [ CASCADE | RESTRICT ]

REVOKE { { SELECT | INSERT | UPDATE | DELETE | REFERENCES } [, ...] | ALL [ PRIVILEGES ] }
  ON TABLES
  FROM { GROUP group_name | PUBLIC } [, ...] [ CASCADE | RESTRICT ]

REVOKE [ GRANT OPTION FOR ] { EXECUTE | ALL [ PRIVILEGES ] }
  ON FUNCTIONS
```
<table>
<thead>
<tr>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOR USER target_user</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>IN SCHEMA schema_name</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>GRANT</td>
</tr>
<tr>
<td>The set of privileges to grant to 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 GRANT clause that you can with the GRANT (p. 585) command.</td>
</tr>
<tr>
<td>WITH GRANT OPTION</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>TO user_name</td>
</tr>
<tr>
<td>The name of the user or user group to which the specified default privileges are applied.</td>
</tr>
<tr>
<td>REVOKE</td>
</tr>
<tr>
<td>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 (p. 600) command.</td>
</tr>
<tr>
<td>GRANT OPTION FOR</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

## Examples

Suppose that you want to allow any user in the user group report_readers to view all tables created by the user report_admin. In this case, execute the following command as a superuser.
In the following example, the first command grants SELECT privileges on all new tables you create.

```
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, execute the following commands.

```
alter default privileges revoke execute on functions from public;
alter default privileges grant execute on functions to group dev_test;
```

## 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 (p. 367).

new_name

New name of the user group.

Examples

The following example adds a user named DWUSER to the ADMIN_GROUP group:

```sql
alter group admin_group
add user dwuser;
```

The following example renames the group ADMIN_GROUP to ADMINISTRATORS:

```sql
alter group admin_group
rename to administrators;
```

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

```sql
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 (p. 536).

Syntax

```
ALTER SCHEMA schema_name
{
  RENAME TO new_name |
  OWNER TO new_owner
}
```

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 (p. 367).
  - OWNER TO
    - A clause that changes the owner of the schema.
  - new_owner
    - The new owner of the schema.
Examples

The following example renames the SALES schema to US_SALES.

```sql
alter schema sales
rename to us_sales;
```

The following example gives ownership of the US_SALES schema to the user DWUSER.

```sql
alter schema us_sales
owner to dwuser;
```

ALTER TABLE

Topics
- Syntax (p. 421)
- Parameters (p. 422)
- ALTER TABLE Examples (p. 427)
- Alter External Table Examples (p. 429)
- ALTER TABLE ADD and DROP COLUMN Examples (p. 430)

Changes the definition of a database table or Amazon Redshift Spectrum external table. This command updates the values and properties set by CREATE TABLE or CREATE EXTERNAL TABLE.

You can't run ALTER TABLE on an external table within a transaction block (BEGIN ... END). For more information about transactions, see Serializable Isolation (p. 151).

Note
ALTER TABLE locks the table for read and write operations until the transaction enclosing the ALTER TABLE operation completes.

Syntax

```sql
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 new_data_type
| ALTER DISTKEY column_name
| ALTER DISTSTYLE ALL
| ALTER DISTSTYLE KEY DISTKEY column_name
| ALTER [COMPOUND] SORTKEY ( column_name [, ...] )
| ADD [ COLUMN ] column_name column_type
| [ DEFAULT default_expr ]
| [ ENCODE encoding ]
| [ NOT NULL | NULL ]
| DROP [ COLUMN ] column_name [ RESTRICT | CASCADE ]
}

where table_constraint is:

[ CONSTRAINT constraint_name ]
| UNIQUE ( column_name [, ... ] )
```
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 [, ... ] )

### 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 are 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 (p. 367).

**ADD table_constraint**

A clause that adds the specified constraint to the table. For descriptions of valid `table_constraint` values, see CREATE TABLE (p. 537).

**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** `new_data_type`

A clause that changes the size of a column defined as 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* (p. 151).

**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.

For more information about DISTSTYLE ALL, see *CREATE TABLE* (p. 537).

**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.

When specifying DISTSTYLE KEY, the data is distributed by the values in the DISTKEY column. For more information about DISTSTYLE, see *CREATE TABLE* (p. 537).

**ALTER [COMPOUND] SORTKEY ( column_name [,...] )**

A clause that changes or adds the sort key used for a table. Consider the following:

- You can define a maximum of 400 columns for a sort key per table.
- You can only alter a compound sort key. You can't alter an interleaved sort key.

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* (p. 537).

**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* (p. 367).
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 (p. 513).

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 1,048,577 bytes.

Amazon Redshift supports the following Data Types (p. 369):
- SMALLINT (INT2)
- INTEGER (INT, INT4)
- BIGINT (INT8)
- DECIMAL (NUMERIC)
- REAL (FLOAT4)
- DOUBLE PRECISION (FLOAT8)
- BOOLEAN (BOOL)
- CHAR (CHARACTER)
- VARCHAR (CHARACTER VARYING)
- DATE
- TIMESTAMP
- GEOMETRY

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. If no compression is selected, Amazon Redshift automatically assigns 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, or GEOMETRY 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.

**Note**

If you don't want a column to be compressed, explicitly specify RAW encoding.

The following compression encodings (p. 44) are supported:

- AZ64
- BYTEDICT
- DELTA
- DELTA32K
- LZO
- MOSTLY8
- MOSTLY16
- MOSTLY32
- RAW (no compression)
- RUNLENGTH
- TEXT255
- TEXT32K
- ZSTD

**Note**

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.

**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.

For more information, see CREATE EXTERNAL TABLE (p. 513).

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 Considerations (p. 235). For more information about using a manifest file, see LOCATION in the CREATE EXTERNAL TABLE Parameters (p. 514) 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.

**ALTER TABLE Examples**

The following examples demonstrate basic usage of the ALTER TABLE command.

**Rename a Table**

The following command renames the USERS table to USERS_BKUP:

```sql
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:

```sql
alter table venue
owner to dwuser;
```

The following commands create a view, then change its owner:

```sql
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**

```sql
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.

```sql
select constraint_name, constraint_type
from information_schema.table_constraints
where constraint_schema = 'public'
and table_name = 'category';
```

```sql
constraint_name | constraint_type
----------------+----------------
category_pkey   | PRIMARY KEY
```

```sql
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).

```sql
alter table event alter column eventname type varchar(300);
```

**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.

```sql
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;
```

```sql
Insert into inventory values(1,1,1,1);
```

```sql
select "table", "diststyle" from svv_table_info;
```

```sql
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.

```sql
alter table inventory alter diststyle key distkey inv_warehouse_sk;
```
ALTER TABLE

```sql
select "table", "diststyle" from svv_table_info;

<table>
<thead>
<tr>
<th>table</th>
<th>diststyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>inventory</td>
<td>KEY(inv_warehouse_sk)</td>
</tr>
</tbody>
</table>
```

Alter the table DISTKEY to `inv_item_sk`. The SVV_TABLE_INFO view shows the `inv_item_sk` column as the resulting distribution key.

```sql
alter table inventory alter distkey inv_item_sk;
```

```sql
select "table", "diststyle" from svv_table_info;

<table>
<thead>
<tr>
<th>table</th>
<th>diststyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>inventory</td>
<td>KEY(inv_item_sk)</td>
</tr>
</tbody>
</table>
```

**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.

```sql
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);

```sql
select "table", "diststyle" from svv_table_info;

<table>
<thead>
<tr>
<th>table</th>
<th>diststyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>inventory</td>
<td>EVEN</td>
</tr>
</tbody>
</table>
```

Alter the table DISTSTYLE to ALL. The SVV_TABLE_INFO view shows the changed DISTSTYLE.

```sql
alter table inventory alter diststyle all;
```

```sql
select "table", "diststyle" from svv_table_info;

<table>
<thead>
<tr>
<th>table</th>
<th>diststyle</th>
</tr>
</thead>
<tbody>
<tr>
<td>inventory</td>
<td>ALL</td>
</tr>
</tbody>
</table>
```

**Alter External Table Examples**

The following example sets the numRows table property for the SPECTRUM.SALES external table to 170,000 rows.

```sql
alter table spectrum.sales
set table properties ('numRows'='170000');
```

The following example changes the location for the SPECTRUM.SALES external table.

```sql
alter table spectrum.sales
set location 's3://awssampledbuswest2/ticket/spectrum/sales/';
```
The following example changes the format for the SPECTRUM.SALES external table to Parquet.

```sql
ALTER TABLE spectrum.sales
SET FILE FORMAT parquet;
```

The following example adds one partition for the table SPECTRUM.SALES_PART.

```sql
ALTER TABLE spectrum.sales_part
ADD IF NOT EXISTS PARTITION(saledate='2008-01-01')
LOCATION 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/';
```

The following example adds three partitions for the table SPECTRUM.SALES_PART.

```sql
ALTER TABLE spectrum.sales_part
ADD IF NOT EXISTS
PARTITION(saledate='2008-01-01')
LOCATION 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/';
PARTITION(saledate='2008-02-01')
LOCATION 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-02/';
PARTITION(saledate='2008-03-01')
LOCATION 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-03/';
```

The following example alters SPECTRUM.SALES_PART to drop the partition with saledate='2008-01-01'.

```sql
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'.

```sql
ALTER TABLE spectrum.sales_part
PARTITION(saledate='2008-01-01')
SET LOCATION 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/';
```

The following example changes the name of sales_date to transaction_date.

```sql
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.

```sql
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.

```sql
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 USERS table:

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>delta</td>
<td>true</td>
<td>1</td>
</tr>
<tr>
<td>username</td>
<td>character(8)</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>firstname</td>
<td>character varying(30)</td>
<td>text32k</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>lastname</td>
<td>character varying(30)</td>
<td>text32k</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>city</td>
<td>character varying(30)</td>
<td>text32k</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>state</td>
<td>character(2)</td>
<td>bytedict</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>email</td>
<td>character varying(100)</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>phone</td>
<td>character(14)</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likesports</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>liketheatre</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likeconcerts</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likejazz</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likeclassical</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likeopera</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likerock</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likevegas</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likebroadway</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
<tr>
<td>likemusicals</td>
<td>boolean</td>
<td>none</td>
<td>false</td>
<td>0</td>
</tr>
</tbody>
</table>

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
------------
(5 rows)
```

Drop the column to reinstate the original DDL:

```
alter table users drop column feedback_score;
```

DROPPING a Column with a Dependent Object

This 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** (p. 550) or **INSERT** (p. 592) 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** (p. 663) 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** (p. 433).

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** (p. 433).

Both the source table and the target table must be permanent tables. Both tables must use the same distribution style and distribution key, if one was defined. If the tables are sorted, both tables 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** (p. 151).

**Syntax**

```
ALTER TABLE target_table_name APPEND FROM source_table_name
[  IGNOREEXTRA | FILLTARGET  ]
```
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.

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 (p. 539) 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 tables 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 (p. 539).

You can append a default identity column with the ALTER TABLE APPEND statement. For more information, see CREATE TABLE (p. 537).

**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.

```sql
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 (p. 1094) system catalog table to verify that both tables have the same columns with identical column attributes.

```sql
select trim(tablename) as table, "column", trim(type) as type,
  encoding, distkey, sortkey, "notnull"
from pg_table_def where tablename like 'sales%';
```

<table>
<thead>
<tr>
<th>table</th>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
<th>notnull</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales</td>
<td>salesid</td>
<td>integer</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>listid</td>
<td>integer</td>
<td>none</td>
<td>true</td>
<td>1</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>sellerid</td>
<td>integer</td>
<td>none</td>
<td>false</td>
<td>2</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>buyerid</td>
<td>integer</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>eventid</td>
<td>integer</td>
<td>mostly16</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>dateid</td>
<td>smallint</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>qtysold</td>
<td>smallint</td>
<td>mostly8</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>sales</td>
<td>pricepaid</td>
<td>numeric(8,2)</td>
<td>delta32k</td>
<td>false</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>sales</td>
<td>commission</td>
<td>numeric(8,2)</td>
<td>delta32k</td>
<td>false</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>sales</td>
<td>saletime</td>
<td>timestamp without time zone</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>salesmonth</td>
<td>salesid</td>
<td>integer</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>salesmonth</td>
<td>listid</td>
<td>integer</td>
<td>none</td>
<td>true</td>
<td>1</td>
<td>true</td>
</tr>
<tr>
<td>salesmonth</td>
<td>sellerid</td>
<td>integer</td>
<td>none</td>
<td>false</td>
<td>2</td>
<td>true</td>
</tr>
<tr>
<td>salesmonth</td>
<td>buyerid</td>
<td>integer</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>salesmonth</td>
<td>eventid</td>
<td>integer</td>
<td>mostly16</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
<tr>
<td>salesmonth</td>
<td>dateid</td>
<td>smallint</td>
<td>lzo</td>
<td>false</td>
<td>0</td>
<td>true</td>
</tr>
</tbody>
</table>
Next, look at the size of each table.

```sql
select count(*) from sales_monthly;
```

```
<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
</tr>
</tbody>
</table>
```

```sql
(1 row)
```

```sql
select count(*) from sales;
```

```
<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>412214</td>
</tr>
</tbody>
</table>
```

```sql
(1 row)
```

Now execute the following ALTER TABLE APPEND command.

```sql
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.

```sql
select count(*) from sales_monthly;
```

```
<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>
```

```sql
(1 row)
```

```sql
select count(*) from sales;
```

```
<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>414214</td>
</tr>
</tbody>
</table>
```

```sql
(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.

```sql
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.

```sql
alter table sales_report append from sales_month filltarget;
```

**ALTER USER**

Changes a database user account. If you are the current user, you can change your own password. For all other options, you must be a database superuser to execute this command.
Syntax

ALTER USER username [ WITH ] option [, ... ]

where option is

CREATEDB | NOCREATEDB
| CREATEUSER | NOCREATEUSER
| SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }
| PASSWORD { 'password' | 'md5hash' | DISABLE }
| [ VALID UNTIL 'expiration_date' ]
| RENAME TO new_name |
| CONNECTION LIMIT { limit | UNLIMITED } |
| SET parameter { TO | = } { value | DEFAULT } |
| RESET parameter |

Parameters

username

Name of the user account.

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 (p. 355).

SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }

A clause that specifies the level of access that the user has to the Amazon Redshift system tables and views.

If RESTRICTED is specified, the user can see only the rows generated by that user in user-visible system tables and views. The default is RESTRICTED.

If UNRESTRICTED is specified, the user 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 STV_RECENTS and SVV_TRANSACTIONS are visible to all users.

For more information, see Visibility of Data in System Tables and Views (p. 915).

PASSWORD { 'password' | 'md5hash' | 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
ALTER USER

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 or as an MD5 hash string.

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 quote), " (double quote), \, /, 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 ALTER 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 (p. 853) and the concatenation operator ( || ) to return a 32-character MD5-hash string.

   ```sql
   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.

   ```sql
   create user user1 password 'md5153c434b4b77c89e6b94f12c5393af5b';
   ```

4. Log on to the database using the user name and password.
   For this example, log on as user1 with password ez.

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.

RENAME TO

 Renames the user account.

new_name

New name of the user. For more information about valid names, see Names and Identifiers (p. 367).
Important
When you rename a user, you must also change the user’s 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 super users. 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 (p. 509)`. The default is UNLIMITED. To view current connections, query the `STV_SESSIONS (p. 1011)` 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.

**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.

**Usage Notes**

When using IAM (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.

```
alter user iam_superuser password 'mdA51234567890123456780123456789012';
```

When you set the `search_path (p. 1106)` 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 for the current user and session, use a SET command.

**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:
The following example renames the user ADMIN to SYSADMIN:

```
alter user admin rename to sysadmin;
```

## ANALYZE

Updates table statistics for use by the query planner.

### 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 (p. 440).

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 indicates 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. For more information about predicate columns, see Analyzing Tables (p. 137).
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, execute 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 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 current 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.

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

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. The suggested encoding can be applied by recreating the table, or creating a new
table with the same schema. Recreating an uncompressed table with appropriate encoding schemes can significantly reduce its on-disk footprint, saving disk space and improving query performance for I/O-bound workloads.

ANALYZE COMPRESSION doesn't consider Runlength Encoding (p. 49) encoding on any column that is designated as a SORTKEY because range-restricted scans might perform poorly when SORTKEY columns are compressed much more highly than other columns.

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.

Examples

The following example shows the encoding and estimated percent reduction for the columns in the LISTING table only:

```
analyze compression listing;
```

<table>
<thead>
<tr>
<th>Table</th>
<th>Column</th>
<th>Encoding</th>
<th>Est_reduction_pct</th>
</tr>
</thead>
<tbody>
<tr>
<td>listing</td>
<td>listid</td>
<td>delta</td>
<td>75.00</td>
</tr>
<tr>
<td>listing</td>
<td>sellerid</td>
<td>delta32k</td>
<td>38.14</td>
</tr>
<tr>
<td>listing</td>
<td>eventid</td>
<td>delta32k</td>
<td>5.88</td>
</tr>
<tr>
<td>listing</td>
<td>dateid</td>
<td>zstd</td>
<td>31.73</td>
</tr>
<tr>
<td>listing</td>
<td>numtickets</td>
<td>zstd</td>
<td>36.41</td>
</tr>
<tr>
<td>listing</td>
<td>priceperticket</td>
<td>zstd</td>
<td>59.48</td>
</tr>
<tr>
<td>listing</td>
<td>totalprice</td>
<td>zstd</td>
<td>37.90</td>
</tr>
<tr>
<td>listing</td>
<td>listtime</td>
<td>zstd</td>
<td>13.39</td>
</tr>
</tbody>
</table>

The following example analyzes the QTYSOLD, COMMISSION, and SALETIME columns in the SALES table.

```
analyze compression sales(qtysold, commission, saletime);
```

<table>
<thead>
<tr>
<th>Table</th>
<th>Column</th>
<th>Encoding</th>
<th>Est_reduction_pct</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales</td>
<td>salesid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>listid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>sellerid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>buyerid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>eventid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>dateid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>qtysold</td>
<td>zstd</td>
<td>67.14</td>
</tr>
<tr>
<td>sales</td>
<td>pricepaid</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>sales</td>
<td>commission</td>
<td>zstd</td>
<td>13.94</td>
</tr>
<tr>
<td>sales</td>
<td>saletime</td>
<td>zstd</td>
<td>13.38</td>
</tr>
</tbody>
</table>

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 execute 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** (p. 450) or **END** (p. 578) statement. If necessary, you can use a **ROLLBACK** (p. 606) statement to abort a transaction that is in progress. An exception to this behavior is the **TRUNCATE** (p. 641) 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.

## 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. See Managing Concurrent Write Operations (p. 151). 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-executes 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. 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 (p. 444)
- Driver Support (p. 445)

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 (p. 1074).`
The following example shows passing variables to a nested procedure call through INOUT arguments.

```sql
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;
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>
(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](https://docs.aws.amazon.com/redshift/latest/gsg-connecting-to-redshift-cluster-using-sql-client-tools) in the Amazon Redshift Cluster Management Guide.

**Important**

Currently, you can't use a refcursor data type in a stored procedure using a JDBC or ODBC driver.

The following examples show how to use different API operations of the JDBC driver for stored procedure calls.

```java
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.executeUpdate();
}
```
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_sp1.

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_sp2.

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 of the running query and displays a confirmation message to verify that the query was cancelled.

Syntax

```
CANCEL process_id [ 'message' ]
```

Parameters

`process_id`

Process ID corresponding 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). 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 (p. 895)` 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 STV_LOCKS (p. 1003) system table to view currently held locks.

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 (p. 968) 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, 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';
```

<table>
<thead>
<tr>
<th>pid</th>
<th>starttime</th>
<th>duration</th>
<th>user</th>
<th>querytxt</th>
</tr>
</thead>
<tbody>
<tr>
<td>802</td>
<td>2008-10-14 09:19:03.550885</td>
<td>132</td>
<td>dwuser</td>
<td>select venuename from venue where venuestate='FL', where venuecity not in ('Miami', 'Orlando');</td>
</tr>
<tr>
<td>834</td>
<td>2008-10-14 08:33:49.473585</td>
<td>1250414</td>
<td>dwuser</td>
<td>select * from listing;</td>
</tr>
<tr>
<td>964</td>
<td>2008-10-14 08:30:43.290527</td>
<td>326179</td>
<td>dwuser</td>
<td>select sellerid from sales where qtysold in (8, 10);</td>
</tr>
</tbody>
</table>

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:
CLOSE

(Optional) Closes all of the free resources that are associated with an open cursor. COMMIT (p. 450), END (p. 578), and ROLLBACK (p. 606) automatically close the cursor, so it isn’t necessary to use the CLOSE command to explicitly close the cursor.

For more information, see DECLARE (p. 564), FETCH (p. 584).

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'
```

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
IS 'text"

The text of the comment that you want to apply to the specified object. Enclose the comment in single quotation marks.

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.

arg1_type, arg2_type, ...

Data types of the arguments for a function. Parameter of FUNCTION.

Usage Notes

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.

Example

The following example adds a descriptive comment to the EVENT table:

```sql
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.

```sql
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')
  );

<table>
<thead>
<tr>
<th>objoid</th>
<th>classoid</th>
<th>objsubid</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>116658</td>
<td>1259</td>
<td>0</td>
<td>Contains listings of individual events.</td>
</tr>
</tbody>
</table>
```

The following example uses the psql \dd command to view the comments. Amazon Redshift doesn't support psql directly. You must execute psql commands from the PostgreSQL psql client.

**Note**

The \dd command returns comments only with the psql 8.x versions.
### 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](p. 196).

#### Examples

Each of the following examples commits the current transaction to the database:

```
commit;
```

```
commit work;
```

```
commit transaction;
```

### COPY

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 new input data to any existing rows in the table.

The maximum size of a single input row from any source is 4 MB.

**Note**

To use the COPY command, you must have INSERT ([p. 586](#)) privilege for the Amazon Redshift table.
COPY Syntax

COPY table-name
[ column-list ]
FROM data_source
authorization
[ [ FORMAT ] [ AS ] data_format ]
[ parameter [ argument ] [, ... ] ]

COPY Syntax Overview

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.

This section presents the required COPY command parameters and groups the optional parameters by
function. Subsequent topics describe each parameter and explain how various options work together. You
can also go directly to a parameter description by using the alphabetical parameter list.

Required Parameters

The COPY command requires three elements:

- Table Name (p. 452)
- Data Source (p. 452)
- Authorization (p. 452)

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 awssampledbuswest2. 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 execute it.

copy catdemo
from 's3://awssampledbuswest2/tickit/category_pipe.txt'
iam_role 'arn:aws:iam::<aws-account-id>:role/<role-name>'
region 'us-west-2';

For steps to create an IAM role, see Step 2: Create an IAM Role in the Amazon Redshift Getting Started. For complete instructions on how to use COPY commands to load sample data, including instructions for loading data from other AWS regions, see Step 6: Load Sample Data from Amazon S3 in the Amazon Redshift Getting Started.

**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 (p. 455)
- COPY from Amazon EMR (p. 458)
- COPY from Remote Host (SSH) (p. 460)
- COPY from Amazon DynamoDB (p. 463)

**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 (p. 465)
- Role-Based Access Control (p. 485)
- Key-Based Access Control (p. 486)

**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 (p. 467)
• Data Format Parameters (p. 453)
• Data Conversion Parameters (p. 453)
• Data Load Operations (p. 454)

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 (p. 467)
• JSONPaths File (p. 468)

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 (p. 468)
• CSV (p. 468)
• DELIMITER (p. 469)
• FIXEDWIDTH (p. 469)
• AVRO (p. 469)
• JSON (p. 471)
• ENCRYPTED (p. 457)
• BZIP2 (p. 476)
• GZIP (p. 476)
• LZOP (p. 477)
• PARQUET (p. 476)
• ORC (p. 476)
• ZSTD (p. 477)

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 (p. 477)
• ACCEPTINVCHARS (p. 477)
• BLANKSASNULL (p. 478)
• DATEFORMAT (p. 478)
• EMPTYASNULL (p. 478)
• ENCODING (p. 478)
• ESCAPE (p. 479)
• EXPLICIT_IDS (p. 480)
• FILLRECORD (p. 480)
• IGNOREBLANKLINES (p. 480)
• IGNOREHEADER (p. 480)
• NULL AS (p. 480)
• REMOVEQUOTES (p. 481)
• ROUNDEC (p. 481)
• TIMEFORMAT (p. 481)
• TRIMBLANKS (p. 482)
• TRUNCATECOLUMNS (p. 482)

Data Load Operations

Manage the default behavior of the load operation for troubleshooting or to reduce load times by specifying the following parameters.

• COMPROWS (p. 482)
• COMPUPDATE (p. 482)
• MAXERROR (p. 483)
• NOLOAD (p. 483)
• STATUPDATE (p. 483)

Using the COPY Command

For more information about how to use the COPY command, see the following topics:

• COPY Examples (p. 495)
• Usage Notes (p. 485)
• Tutorial: Loading Data from Amazon S3 (p. 156)
• Amazon Redshift Best Practices for Loading Data (p. 24)
• Using a COPY Command to Load Data (p. 98)
  • Loading Data from Amazon S3 (p. 101)
  • Loading Data from Amazon EMR (p. 110)
  • Loading Data from Remote Hosts (p. 114)
  • Loading Data from an Amazon DynamoDB Table (p. 120)
• Troubleshooting Data Loads (p. 125)

COPY Parameter Reference

Topics

• Data Sources (p. 455)
• Authorization Parameters (p. 465)
• Column Mapping Options (p. 467)
• Data Format Parameters (p. 468)
• Data Load Operations (p. 482)
• Alphabetical Parameter List (p. 484)
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 (p. 642) command.

Topics
- COPY from Amazon S3 (p. 455)
- COPY from Amazon EMR (p. 458)
- COPY from Remote Host (SSH) (p. 460)
- COPY from Amazon DynamoDB (p. 463)

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.

**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 (p. 458) parameter to specify the Region in which the data is located.

Topics
- Syntax (p. 455)
- Examples (p. 455)
- Optional Parameters (p. 458)
- Unsupported Parameters (p. 458)

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://mybucket/customer'
im_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

The following example uses a manifest file to load data from Amazon S3.

```
copy customer
from 's3://mybucket/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 (p. 477).

's3://copy_from_s3_objectpath'

Specifies the path to the Amazon S3 objects that contain the data—for example, 's3://mybucket/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://mybucket/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 (p. 456), 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 (p. 458) parameter to specify the Region in which the data is located.

For more information, see Loading Data from Amazon S3 (p. 101).

'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://mybucket/manifest.txt'. It cannot 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.

```json
{
    "entries": [
        {
            "url": "s3://mybucket-alpha/custdata.1","mandatory":true},
        {
            "url": "s3://mybucket-alpha/custdata.2","mandatory":true},
        {
            "url": "s3://mybucket-beta/custdata.1","mandatory":false}
    ]
}
```

The double quote characters are required, and must be simple quotation marks (0x22), not slanted or "smart" quotes. 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.

```json
{
```
"entries": [
  {
    "url": "s3://mybucket-alpha/orc/2013-10-04-custdata",
    "mandatory": true,
    "meta": {
      "content_length": 99
    }
  },
  {
    "url": "s3://mybucket-beta/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 (p. 101).

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 an IAM user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization Parameters (p. 465).

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 (p. 107).

ENCRYPTED

A clause that specifies that the input files on Amazon S3 are encrypted using client-side encryption with customer-managed symmetric keys (CSE-CMK). For more information, see Loading Encrypted Data Files from Amazon S3 (p. 109). 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 (p. 457) parameter or include the master_symmetric_key value in the CREDENTIALS (p. 466) 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 'master_key'

The master symmetric key that was used to encrypt data files on Amazon S3. If MASTER_SYMMETRIC_KEY is specified, the ENCRYPTED (p. 457) 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 (p. 109).

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 a 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 (p. 467)
- Data Format Parameters (p. 468)
- Data Conversion Parameters (p. 477)
- Data Load Operations (p. 482)

**Unsupported Parameters**

You cannot 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 (p. 459)
- Example (p. 459)
- Parameters (p. 459)
- Supported Parameters (p. 459)
- Unsupported Parameters (p. 460)
Syntax

```
FROM 'emr://emr_cluster_id/hdfs_file_path'
authorization
[ optional_parameters ]
```

Example

The following example loads data from as 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](p. 110).

**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 an IAM user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see [Authorization Parameters](p. 465).

**Supported Parameters**

You can optionally specify the following parameters with COPY from Amazon EMR:

- Column Mapping Options (p. 467)
- Data Format Parameters (p. 468)
- Data Conversion Parameters (p. 477)
Unsupported Parameters

You cannot 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 as Amazon Elastic Compute Cloud (Amazon EC2) instances or other computers. COPY connects to the remote hosts using Secure Shell (SSH) and executes 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 execute the remote commands.

Topics

- Syntax (p. 460)
- Examples (p. 460)
- Parameters (p. 461)
- Optional Parameters (p. 462)
- Unsupported Parameters (p. 463)

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://mybucket/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 executes 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 execute the remote commands.

The s3://copy_from_ssh_manifest_file argument must explicitly reference a single file; it cannot be a key prefix. The following shows an example:

's3://mybucket/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 executed 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:

```json
{
    "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 quote characters are required as shown, both for the field names and the values. The quote characters must be simple quotation marks (0x22), not slanted or "smart" quotation marks. The only value that doesn't need double quote 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 executed 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 (p. 100).
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 execute 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 (p. 114).

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 execute 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 (p. 123).

For detailed procedures for using COPY from SSH, see Loading Data from Remote Hosts (p. 114).

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 an IAM user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization Parameters (p. 465).

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 (p. 461) 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 (p. 467)
- Data Format Parameters (p. 468)
Unsupported Parameters

You cannot 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

- Syntax (p. 463)
- Examples (p. 463)
- Optional Parameters (p. 464)
- Unsupported Parameters (p. 464)

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 (p. 120).

A DynamoDB table name is unique to an AWS account, which is identified by the AWS access credentials.
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 an IAM user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. For more information, see Authorization Parameters (p. 465).

**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 cannot 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 (p. 467)
- The following data conversion parameters are supported:
  - ACCEPTANYDATE (p. 477)
  - BLANKSASNULL (p. 478)
  - DATEFORMAT (p. 478)
  - EMPTYASNULL (p. 478)
  - ROUNDECD (p. 481)
  - TIMEFORMAT (p. 481)
  - TRIMBLANKS (p. 482)
  - TRUNCATECOLUMNS (p. 482)
- Data Load Operations (p. 482)

**Unsupported Parameters**

You cannot use the following parameters with COPY from DynamoDB:

- All data format parameters
- ESCAPE
- FILLRECORD
- IGNOREBLANKLINES
- IGNOREHEADER
- NULL
- REMOVEQUOTES
- ACCEPTINVCHARS
- MANIFEST
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) or by providing the access credentials for an IAM user (key-based access control). For increased security and flexibility, we recommend using IAM role-based access control. COPY can also use temporary credentials to limit access to your load data, and 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 (p. 488)
- Role-Based Access Control (p. 485)
- Key-Based Access Control (p. 486)

Use one of the following to provide authorization for the COPY command:

- IAM_ROLE (p. 465) parameter
- ACCESS_KEY_ID and SECRET_ACCESS_KEY (p. 465) parameters
- CREDENTIALS (p. 466) clause

IAM_ROLE 'iam-role-arn'

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

For more information, see Role-Based Access Control (p. 485).

ACCESS_KEY_ID 'access-key-id' SECRET_ACCESS_KEY 'secret-access-key'

The access key ID and secret access key for an IAM user that is authorized to access the AWS resources that contain the data. ACCESS_KEY_ID and SECRET_ACCESS_KEY must be used together. Optionally, you can provide temporary access credentials and also specify the SESSION_TOKEN (p. 466) parameter.

The following shows the syntax for the ACCESS_KEY_ID and SECRET_ACCESS_KEY parameters.

```
ACCESS_KEY_ID '<access-key-id>'
SECRET_ACCESS_KEY '<secret-access-key>'
```

For more information, see Key-Based Access Control (p. 486).

If you specify ACCESS_KEY_ID and SECRET_ACCESS_KEY, you can't use IAM_ROLE or CREDENTIALS.

**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 (p. 485).
SESSION_TOKEN 'temporary-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 (p. 487) 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 (p. 485).

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>';
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;token=<temporary-token>'

For more information, see Temporary Security Credentials (p. 487).

If the ENCRYPTED (p. 457) parameter is used, the credentials-args string is in the following format, where <master-key> is the value of the master key that was used to encrypt the files.

CREDENTIALS
  '<credentials-args>;master_symmetric_key=<master-key>'

For example, the following COPY command uses role-based access control with an encryption key.

copy customer from 's3://mybucket/mydata'
credentials
  'aws_iam_role=arn:aws:iam::<account-id>:role/<role-name>;master_symmetric_key=<master-key>'

The following COPY command shows key-based access control with an encryption key.

copy customer from 's3://mybucket/mydata'
credentials
  'aws_access_key_id=<access-key-id>;aws_secret_access_key=<secret-access-key>;master_symmetric_key=<master-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 (p. 467)
- JSONPaths File (p. 468)

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 (p. 120)

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 (p. 539) 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 \texttt{IDENTITY} (p. 539) column is included in the column list, then \texttt{EXPLICIT_IDS} (p. 480) must also be specified; if an IDENTITY column is omitted, then \texttt{EXPLICIT_IDS} cannot 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 \texttt{EXPLICIT_IDS} was also not specified.

If a column is defined with \texttt{GENERATED BY DEFAULT AS IDENTITY}, then it can be copied. Values are generated or updated with values that you supply. The \texttt{EXPLICIT_IDS} option isn't required. \texttt{COPY} doesn't update the identity high watermark. For more information, see \texttt{GENERATED BY DEFAULT AS IDENTITY} (p. 540).

\textbf{JSONPaths File}

When loading from data files in JSON or Avro format, \texttt{COPY} automatically maps the data elements in the JSON or Avro source data to the columns in the target table by matching field names in the Avro schema to column names in the target table or column list.

If your column names and field names 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.

For more information, see \texttt{JSONPaths file} (p. 473).

\textbf{Data Format Parameters}

By default, the \texttt{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:

\begin{itemize}
  \item \texttt{FORMAT} (p. 468)
  \item \texttt{CSV} (p. 468)
  \item \texttt{DELIMITER} (p. 469)
  \item \texttt{FIXEDWIDTH} (p. 469)
  \item \texttt{AVRO} (p. 469)
  \item \texttt{JSON} (p. 471)
  \item \texttt{PARQUET} (p. 476)
  \item \texttt{ORC} (p. 476)
\end{itemize}

In addition to the standard data formats, \texttt{COPY} supports the following columnar data formats for \texttt{COPY} from Amazon S3:

\begin{itemize}
  \item \texttt{ORC} (p. 476)
  \item \texttt{PARQUET} (p. 476)
\end{itemize}

\texttt{COPY} from columnar format is supported with certain restriction. For more information, see \texttt{COPY from Columnar Data Formats} (p. 492).

\textbf{Data Format Parameters}

\texttt{FORMAT [AS]}

(Optional) Identifies data format keywords. The \texttt{FORMAT} arguments are described following.

\texttt{CSV [ QUOTE [AS] \texttt{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 \texttt{QUOTE} parameter. The default quote character is a double quotation mark ( ” ). When the quote character is used within a field, escape the character with an additional quote character. For example, if the quote 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 quotes, white space between the delimiters and the quote characters is ignored. If the delimiter is a white space character, such as a tab, the delimiter isn't treated as white space.

CSV cannot be used with FIXEDWIDTH, REMOVEQUOTES, or ESCAPE.

QUOTE [AS] 'quote_character'

Optional. Specifies the character to be used as the quote character when using the CSV parameter. The default is a double quotation mark ("."). If you use the QUOTE parameter to define a quote 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 the single ASCII character that is used to separate fields in the input file, such as a pipe character (|), a comma (,), or a tab (\t). Non-printing ASCII characters are supported. ASCII characters can also be represented in octal, using 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 cannot 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 cannot 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 (p. 378).

The format for fixedwidth_spec is shown following:

'colLabel1:colWidth1,colLabel:colWidth2, ...'

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 creating 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'
• 's3://jsonpaths_file'

The default is 'auto'.

'auto'

COPY automatically maps the data elements in the Avro source data to the columns in the target table by matching field names in the Avro schema to column names in the target table. The matching is case-sensitive. 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 a JSONPaths file (p. 473) to explicitly map column names to Avro field names. With the default 'auto' argument, COPY recognizes only the first level of fields, or *outer fields*, in the structure.

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, then COPY loads the target column's DEFAULT (p. 539) expression. If the target column doesn't have a default, then 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, then 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.

's3://jsonpaths_file'

To explicitly map Avro data elements to columns, you can use an JSONPaths file. For more information about using a JSONPaths file to map Avro data, see JSONPaths file (p. 473).

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.

```json
{
    "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. 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 (p. 473).
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, where 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 (p. 489).

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'
- 's3://jsonpaths_file'

The default is 'auto'.

'auto'

COPY maps the data elements in the JSON source data to the columns in the target table by matching object keys, or names, in the source name/value pairs to the names of columns in the target table. The 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. If the JSON field name keys aren't all lowercase, you can use a JSONPaths file (p. 473) to explicitly map column names to JSON field name keys.

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 a column in the target table is omitted from the column list, then COPY loads the target column's DEFAULT (p. 539) expression. If the target column doesn't have a default, then 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, then 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.

's3://jsonpaths_file'

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, such as `s3://mybucket/jsonpaths.txt`; it can't be a key prefix. For more information about using a JSONPaths file, see the section called "JSONPaths file" (p. 473).
Note
If the file specified by jsonpaths_file has the same prefix as the path specified by copy_from_s3_objectpath for the data files, COPY reads the JSONPaths file as a data file and returns errors. For example, if your data files use the object path s3://mybucket/my_data.json and your JSONPaths file is s3://mybucket/my_data.jsonpaths, COPY attempts to load my_data.jsonpaths as a data file.

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” (p. 473) 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.

```json
{
  "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.

```json
["value1", value2]
```

The JSON must be well-formed. For example, the objects or arrays cannot be separated by commas or any other characters except white space. Strings must be enclosed in double quote 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 (p. 489). 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 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 (p. 474).

To use a JSONPaths file, add the JSON or AVRO keyword to the COPY command and specify the S3 bucket name and object path of the JSONPaths file, using the following format.

```sql
COPY tablename
FROM 'data_source'
CREDENTIALS 'credentials-args'
FORMAT AS { AVRO | JSON } 's3://jsonpaths_file';
```

The `s3://jsonpaths_file` argument must be an Amazon S3 object key that explicitly references a single file, such as `s3://mybucket/jsonpaths.txt`; it cannot be a key prefix.

**Note**

If you are loading from Amazon S3 and the file specified by `jsonpaths_file` has the same prefix as the path specified by `copy_from_s3_objectpath` for the data files, COPY reads the JSONPaths file as a data file and returns errors. For example, if your data files use the object path `s3://mybucket/my_data.json` and your JSONPaths file is `s3://mybucket/my_data.jsonpaths`, COPY attempts to load `my_data.jsonpaths` as a data file.
**Note**

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 (p. 457) option is specified.

For more information, see COPY from JSON Format (p. 489).

**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 quote characters are required as shown, both for the field names and the values. The quote 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 cannot mix notations. The following example shows JSONPath expressions using bracket notation.

```json
{
  "jsonpaths": [
    "$.venuename",
    "$.venuecity",
    "$.venuestate",
    "$.venueseats"
  ]
}
```

The following example shows JSONPath expressions using dot notation.

```json
{
  "jsonpaths": [
    "$venuename",
    "$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 (p. 489).

Using JSONPaths with Avro Data

The following example shows an Avro schema with multiple levels.

```json
{
    "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.

```json
{
    "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 (p. 492).

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. For more information, see ZSTD (p. 50).

**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.

- ACCEPTANYDATE (p. 477)
- ACCEPTINVCHARS (p. 477)
- BLANKASNULL (p. 478)
- DATEFORMAT (p. 478)
- EMPTYASNULL (p. 478)
- ENCODING (p. 478)
- ESCAPE (p. 479)
- EXPLICIT_IDS (p. 480)
- FILLRECORD (p. 480)
- IGNOREBLANKLINES (p. 480)
- IGNOREHEADER (p. 480)
- NULL AS (p. 480)
- REMOVEQUOTES (p. 481)
- ROUNDEC (p. 481)
- TIMEFORMAT (p. 481)
- TRIMBLANKS (p. 482)
- TRUNCATECOLUMNS (p. 482)

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 (p. 128).

COPY returns the number of rows that contained invalid UTF-8 characters, and it adds an entry to the STL_REPLACEMENTS (p. 967) 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 (p. 494).

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 (p. 493).

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

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.

**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) cannot 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 cannot use the ESCAPE parameter for FIXEDWIDTH loads, and you cannot 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:

<table>
<thead>
<tr>
<th></th>
<th>The quick brown fox[newline] jumped over the lazy dog.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>A | \B | C</td>
</tr>
<tr>
<td>3</td>
<td>A | B | C</td>
</tr>
<tr>
<td>4</td>
<td>'A Midsummer Night's Dream'</td>
</tr>
</tbody>
</table>

The data loaded into column 2 looks like this:

The quick brown fox
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_ID

Use EXPLICIT_ID 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_ID values must match the IDENTITY format specified by the CREATE TABLE definition.

After you run a COPY command against a table with the EXPLICIT_ID option, Amazon Redshift no longer checks 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_ID option isn't required. COPY doesn't update the identity high watermark.

FILLRECORD

Allows data files to be loaded when contiguous columns are missing at the end of some of the records. The missing columns are filled with either zero-length strings or NULLs, as appropriate for the data types of the columns in question. If the EMPTYASNULL parameter is present in the COPY command and the missing column is a VARCHAR column, NULLs are loaded; if EMPTYASNULL isn't present and the column is a VARCHAR, zero-length strings are loaded. 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 an
end of record (EOR) and terminates the record. 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 quotes and
the resulting loaded values.

<table>
<thead>
<tr>
<th>Input String</th>
<th>Loaded Value with REMOVEQUOTES Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;The delimiter is a pipe (</td>
<td>) character&quot;</td>
</tr>
<tr>
<td>'Black'</td>
<td>Black</td>
</tr>
<tr>
<td>&quot;White&quot;</td>
<td>White</td>
</tr>
<tr>
<td>Blue'</td>
<td>Blue</td>
</tr>
<tr>
<td>'Blue'</td>
<td>Value not loaded: error condition</td>
</tr>
<tr>
<td>&quot;Blue&quot;</td>
<td>Value not loaded: error condition</td>
</tr>
<tr>
<td>&quot;'Black' &quot;</td>
<td>'Black'</td>
</tr>
<tr>
<td>&quot;&quot;</td>
<td>&lt;white space&gt;</td>
</tr>
</tbody>
</table>

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 (p. 494). For more information about timeformat_string, see
DATEFORMAT and TIMEFORMAT Strings (p. 493).

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 (p. 494).
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 (p. 482)
- COMPUPDATE (p. 482)
- MAXERROR (p. 483)
- NOLOAD (p. 483)
- STATUPDATE (p. 483)

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 (p. 123).

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 (p. 922).

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 (p. 439) 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 (p. 137).
Alphabetical Parameter List

The following list provides links to each COPY command parameter description, sorted alphabetically.

- ACCEPTANYDATE (p. 477)
- ACCEPTINVCHARS (p. 477)
- ACCESS_KEY_ID and SECRET_ACCESS_KEY (p. 465)
- AVRO (p. 469)
- BLANKSASNULL (p. 478)
- BZIP2 (p. 476)
- COMPROWS (p. 482)
- COMPUUPDATE (p. 482)
- CREDENTIALS (p. 466)
- CSV (p. 468)
- DATEFORMAT (p. 478)
- DELIMITER (p. 469)
- EMPTYASNULL (p. 478)
- ENCODING (p. 478)
- ENCRYPTED (p. 457)
- ESCAPE (p. 479)
- EXPLICIT_IDS (p. 480)
- FILLRECORD (p. 480)
- FIXEDWIDTH (p. 469)
- FORMAT (p. 468)
- IAM_ROLE (p. 465)
- FROM (p. 456)
- GZIP (p. 476)
- IGNOREBLANKLINES (p. 480)
- IGNOREHEADER (p. 480)
- JSON (p. 471)
- LZOP (p. 477)
- MANIFEST (p. 457)
- MASTER_SYMMETRIC_KEY (p. 457)
- MAXERROR (p. 483)
- NOLOAD (p. 483)
- NULL AS (p. 480)
- READRATIO (p. 464)
- REGION (p. 458)
- REMOVEQUOTES (p. 481)
- ROUNDEDEC (p. 481)
- SSH (p. 462)
- STATUPDATE (p. 483)
- TIMEFORMAT (p. 481)
- SESSION_TOKEN (p. 466)
- TRIMBLANKS (p. 482)
- TRUNCATECOLUMNS (p. 482)
- ZSTD (p. 477)
Usage Notes

Topics

- Permissions to Access Other AWS Resources (p. 485)
- Loading Multibyte Data from Amazon S3 (p. 488)
- Loading a Column of the GEOMETRY Data Type (p. 489)
- Errors When Reading Multiple Files (p. 489)
- COPY from JSON Format (p. 489)
- COPY from Columnar Data Formats (p. 492)
- DATEFORMAT and TIMEFORMAT Strings (p. 493)
- Using Automatic Recognition with DATEFORMAT and TIMEFORMAT (p. 494)

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 (p. 488).

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 (p. 485)** – 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 (p. 486)** – For key-based access control, you provide the AWS access credentials (access key ID and secret access key) for an IAM 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.

An IAM role is similar to an IAM user, in that it is an AWS identity with permissions policies that determine what the identity can and cannot 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 (p. 488). 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 Cluster 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 Cluster 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 IAM_ROLE (p. 465) parameter or the CREDENTIALS (p. 466) 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://mybucket/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://mybucket/mydata' credentials 'aws_iam_role=arn:aws:iam::0123456789012:role/MyRedshiftRole';
```

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 ACCESS_KEY_ID and SECRET_ACCESS_KEY (p. 465) parameters together or the CREDENTIALS (p. 466) parameter.

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>'
```

**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.
The IAM user must have, at a minimum, the permissions listed in IAM Permissions for COPY, UNLOAD, and CREATE LIBRARY (p. 488).

**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 (p. 485) 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 cannot be reused after they expire. The access key ID and secret access key generated with the token cannot 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 ACCESS_KEY_ID and SECRET_ACCESS_KEY (p. 465) parameters together with the SESSION_TOKEN (p. 466) parameter or the CREDENTIALS (p. 466) 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 `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>;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>'
token '<temporary-token>';
```

The following example loads the LISTING table with temporary credentials and file encryption.

```
copy listing
from 's3://mybucket/data/listings_pipe.txt'
access_key_id '<temporary-access-key-id>'
secret_access_key '<temporary-secret-access-key>'
```
token '<temporary-token>'
master_symmetric_key '<master-key>'
encrypted;

The following example loads the LISTING table using the CREDENTIALS parameter with temporary credentials and file encryption.

copy listing
from 's3://mybucket/data/listings_pipe.txt'
credentials
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;token=<temporary-token>;master_symmetric_key=<master-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 IAM 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 your IAM user, or to the group to which your IAM 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.

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, see Multibyte Characters (p. 370).
Loading a Column of the GEOMETRY Data Type

You can only COPY to GEOMETRY columns from data in text or CSV format. The data must be in the hexadecimal form of the extended well-known binary (EWKB) format and fit within the maximum size of a single input row to the COPY command. For more information, see COPY (p. 450).

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 (p. 1107)) or if data cannot be downloaded 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 aborted and all changes are rolled back. For more information about handling load errors, see Troubleshooting Data Loads (p. 125).

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 (p. 442).

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 quote characters must be simple quotation marks (0x22), not slanted or "smart" quotes.

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.

```json
{
    "id": 1006410,
    "title": "Amazon Redshift Database Developer Guide"
}
{
    "id": 100540,
    "name": "Amazon Simple Storage Service Developer Guide"
}
```

The following shows the same data as two JSON arrays.

```json
[  1006410,
    "Amazon Redshift Database Developer Guide"
]
[
    100540,
    "Amazon Simple Storage Service Developer Guide"
]
```

You can let COPY automatically load fields from the JSON file by specifying the 'auto' option, or you can specify a JSONPaths file that COPY uses 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.

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.

```json
{
    "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 indices must be positive integers (greater than or equal to zero).

The following example shows the previous JSONPaths file using dot notation.

```json
{
    "jsonpaths": [
        ".id",
        ".store.book.title",
        ".location[0]"
    ]
}
```

You cannot 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 must not 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 your JSON data contains the following object.

```json
{
    "id": 0,
    "guid": "84512477-efa9-456b-b407-581d0d851c3c",
    "isActive": true,
    "tags": [
        "nisi",
        "culpa",
        "ad",
        "amet",
        "voluptate",
        "reprehenderit",
        "veniam"
    ]
}
```
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 (p. 503).

**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://mybucket/json/.

```json
{
"backslash": "This is a backslash: \\",
"newline": "This sentence\n is on two lines.",
"tab": "This sentence \t contains a tab."
}
```

Execute the following commands to create the ESCAPES table and load the JSON.

```sql
create table escapes (backslash varchar(25), newline varchar(35), tab varchar(35));
copy escapes from 's3://mybucket/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.
```

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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 (p. 481)` 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

COPY supports columnar formatted data with the following restrictions:

- The cluster must be in one of 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)
  - 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 (Tokyo) Region (ap-northeast-1)
  - Canada (Central) Region (ca-central-1)
  - Europe (Frankfurt) Region (eu-central-1)
  - Europe (Ireland) Region (eu-west-1)
  - Europe (London) Region (eu-west-2)
  - South America (São Paulo) Region (sa-east-1)
- The Amazon S3 bucket must be in the same AWS Region as the Amazon Redshift cluster.
- COPY command credentials must be supplied using an AWS Identity and Access Management (IAM) role as an argument for the `IAM_ROLE (p. 465)` parameter or the `CREDENTIALS (p. 466)` parameter.
- 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 Cluster Management Guide.
- COPY doesn't automatically apply compression encodings.
- Only the following COPY parameters are supported:
  - `FROM (p. 456)`
  - `IAM_ROLE (p. 465)`
  - `CREDENTIALS (p. 466)`
• **STATUPDATE** (p. 483)
• **MANIFEST** (p. 457)

If COPY encounters an error while loading, the command fails. ACCEPTANYDATE, ACCEPTINVCHARS, and MAXERROR aren't supported for columnar data types.

Error messages are sent only to the SQL client. Errors aren't logged in STL_LOAD_ERRORS.

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

**DATEFORMAT and TIMEFORMAT Strings**

The DATEFORMAT and TIMEFORMAT options in the COPY command take format strings. These strings can contain datetime separators (such as ‘-’, ‘/’, or ‘:’) and the following "dateparts" and "timeparts".

**Note**

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 TIMEFORMAT parameter. The 'auto' argument recognizes several formats that aren't supported when using a DATEFORMAT and TIMEFORMAT string.

<table>
<thead>
<tr>
<th>Datepart or Timepart</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>YY</td>
<td>Year without century</td>
</tr>
<tr>
<td>YYYY</td>
<td>Year with century</td>
</tr>
<tr>
<td>MM</td>
<td>Month as a number</td>
</tr>
<tr>
<td>MON</td>
<td>Month as a name (abbreviated name or full name)</td>
</tr>
<tr>
<td>DD</td>
<td>Day of month as a number</td>
</tr>
<tr>
<td>HH or HH24</td>
<td>Hour (24-hour clock)</td>
</tr>
<tr>
<td>HH12</td>
<td>Hour (12-hour clock)</td>
</tr>
<tr>
<td>MI</td>
<td>Minutes</td>
</tr>
<tr>
<td>SS</td>
<td>Seconds</td>
</tr>
<tr>
<td>AM or PM</td>
<td>Meridian indicator (for 12-hour clock)</td>
</tr>
</tbody>
</table>

**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.

The default date format is YYYY-MM-DD. The default time stamp without time zone (TIMESTAMP) format is YYYY-MM-DD HH:MI:SS. The default time stamp 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'. For more information, see Using Automatic Recognition with DATEFORMAT and TIMEFORMAT (p. 494).

For example, the following DATEFORMAT and TIMEFORMAT strings are valid.

<table>
<thead>
<tr>
<th>COPY Syntax</th>
<th>Example of Valid Input String</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATEFORMAT AS 'MM/DD/YYYY'</td>
<td>03/31/2003</td>
</tr>
<tr>
<td>DATEFORMAT AS 'MON DD, YYYY'</td>
<td>March 31, 2003</td>
</tr>
<tr>
<td>TIMEFORMAT AS 'MM.DD.YYYY HH:MI:SS'</td>
<td>03.31.2003 18:45:05</td>
</tr>
<tr>
<td></td>
<td>03.31.2003 18:45:05.123456</td>
</tr>
</tbody>
</table>

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.

```sql
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 (p. 493). In addition, the 'auto' argument recognizes the following formats that aren't supported when using a DATEFORMAT and TIMEFORMAT string.

<table>
<thead>
<tr>
<th>Format</th>
<th>Example of Valid Input String</th>
</tr>
</thead>
<tbody>
<tr>
<td>Julian</td>
<td>J2451187</td>
</tr>
<tr>
<td>BC</td>
<td>Jan-08-95 BC</td>
</tr>
<tr>
<td>YYYYMMDD HHMISS</td>
<td>19960108 040809</td>
</tr>
<tr>
<td>YYYYMMDD HHMISS</td>
<td>960108 040809</td>
</tr>
<tr>
<td>YYYY.DDD</td>
<td>1996.008</td>
</tr>
<tr>
<td>YYYY-MM-DD HH:MI:SS.SSS</td>
<td>1996-01-08 04:05:06.789</td>
</tr>
<tr>
<td>DD Mon HH:MI:SS YYYY TZ</td>
<td>17 Dec 07:37:16 1997 PST</td>
</tr>
<tr>
<td>MM/DD/YYYY HH:MI:SS.SS TZ</td>
<td>12/17/1997 07:37:16.00 PST</td>
</tr>
<tr>
<td>YYYY-MM-DD HH:MI:SS+-TZ</td>
<td>1997-12-17 07:37:16-08</td>
</tr>
<tr>
<td>DD.MM.YYYY HH:MI:SS TZ</td>
<td>12.17.1997 07:37:16.00 PST</td>
</tr>
</tbody>
</table>
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':

```sql
create table formattest (test char(16));
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;
```

<table>
<thead>
<tr>
<th>test</th>
<th>timestamp</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>J2345678 04:05:06.789</td>
<td>1710-02-23 04:05:06</td>
<td>1710-02-23</td>
</tr>
</tbody>
</table>

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 (p. 495)
- Load LISTING from an Amazon S3 Bucket (p. 496)
- Load LISTING from an Amazon EMR Cluster (p. 496)
- Using a Manifest to Specify Data Files (p. 496)
- Load LISTING from a Pipe-Delimited File (Default Delimiter) (p. 498)
- Load LISTING Using Columnar Data in Parquet Format (p. 498)
- Load LISTING Using Temporary Credentials (p. 498)
- Load EVENT with Options (p. 498)
- Load VENUE from a Fixed-Width Data File (p. 499)
- Load CATEGORY from a CSV File (p. 499)
- Load VENUE with Explicit Values for an IDENTITY Column (p. 500)
- Load TIME from a Pipe-Delimited GZIP File (p. 500)
- Load a Timestamp or Datestamp (p. 500)
- Load Data from a File with Default Values (p. 501)
- COPY Data with the ESCAPE Option (p. 503)
- Copy from JSON Examples (p. 503)
- Copy from Avro Examples (p. 506)
- Preparing Files for COPY with the ESCAPE Option (p. 508)

### 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.

```sql
copy favoritemovies from 'dynamodb://Movies'
```
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://mybucket/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://mybucket/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 mybucket that begin with custdata by specifying a prefix:

```
copy category
from 's3://mybucket/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 finish 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":
      
```
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.

```json
{
  "entries": [
    {
      "url": "s3://mybucket/alpha/orc/2013-10-04-custdata",
      "mandatory": true,
      "meta": {
        "content_length": 99
      }
    },
    {
      "url": "s3://mybucket/beta/orc/2013-10-05-custdata",
      "mandatory": true,
      "meta": {
        "content_length": 99
      }
    }
  ]
}
```

The following example uses a manifest named `cust.manifest`.

```sql
copy customer
from 's3://mybucket/cust.manifest'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
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.

```json
{
  "entries": [
    {
      "url": "s3://mybucket/2013-10-04-custdata.txt", "mandatory": true},
    {
      "url": "s3://mybucket/2013-10-05-custdata.txt", "mandatory": true},
    {
      "url": "s3://mybucket/2013-10-06-custdata.txt", "mandatory": true},
    {
      "url": "s3://mybucket/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.

```json
{
    "entries": [
        {
            "url": "s3://mybucket-alpha/custdata1.txt","mandatory":false},
        {
            "url": "s3://mybucket-beta/custdata1.txt","mandatory":false},
        {
            "url": "s3://mybucket-beta/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 ('|').

```sql
copy listing
from 's3://mybucket/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.

```sql
copy listing
from 's3://mybucket/data/listings/parquet/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as parquet;
```

**Load LISTING Using Temporary Credentials**

The following example uses the SESSION_TOKEN parameter to specify temporary session credentials:

```sql
copy listing
from 's3://mybucket/data/listings_pipe.txt'
access_key_id '<access-key-id>'
secret_access_key '<secret-access-key>'
session_token '<temporary-token>';;
```

**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.

```sql
copy event
from 's3://mybucket/data/allevents_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
removequotes
emptyasnull
```
**Load VENUE from a Fixed-Width Data File**

copy venue
from 's3://mybucket/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:

<table>
<thead>
<tr>
<th></th>
<th>Toyota Park</th>
<th>Bridgeview</th>
<th>IL0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Columbus Crew Stadium</td>
<td>Columbus</td>
<td>OH0</td>
</tr>
<tr>
<td>3</td>
<td>RFK Stadium</td>
<td>Washington</td>
<td>DC0</td>
</tr>
<tr>
<td>4</td>
<td>CommunityAmerica Ballpark</td>
<td>Kansas City</td>
<td>KS0</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Foxborough</td>
<td>MA68756</td>
</tr>
</tbody>
</table>

**Load CATEGORY from a CSV File**

Suppose you want to load the CATEGORY with the values shown in the following table.

<table>
<thead>
<tr>
<th></th>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Shows</td>
<td>Musicals</td>
<td>Musical theatre</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Shows</td>
<td>Plays</td>
<td>All &quot;non-musical&quot; theatre</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Shows</td>
<td>Opera</td>
<td>All opera, light, and &quot;rock&quot; opera</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Concerts</td>
<td>Classical</td>
<td>All symphony, concerto, and choir concerts</td>
<td></td>
</tr>
</tbody>
</table>

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 quote characters. If the quote character appears within a quoted string, you need to escape it by doubling the quote character. The default quote 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:

```sql
COPY category
FROM 's3://mybucket/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 quote character by using the `QUOTE AS` parameter. For example, the following version of `category.csv.txt` uses `%` as the quote 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`:

```sql
COPY category
FROM 's3://mybucket/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.

```sql
COPY venue
FROM 's3://mybucket/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:

```sql
COPY time
FROM 's3://mybucket/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.

```sql
COPY timestamp1
FROM 's3://mybucket/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://mybucket/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
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:

<table>
<thead>
<tr>
<th></th>
<th>Bridgeview</th>
<th>IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Columbus</td>
<td>OH</td>
</tr>
<tr>
<td>3</td>
<td>Washington</td>
<td>DC</td>
</tr>
<tr>
<td>4</td>
<td>Kansas City</td>
<td>KS</td>
</tr>
<tr>
<td>5</td>
<td>Foxborough</td>
<td>MA</td>
</tr>
<tr>
<td>6</td>
<td>East Rutherford</td>
<td>NJ</td>
</tr>
<tr>
<td>7</td>
<td>Toronto</td>
<td>ON</td>
</tr>
<tr>
<td>8</td>
<td>Carson</td>
<td>CA</td>
</tr>
<tr>
<td>9</td>
<td>Commerce City</td>
<td>CO</td>
</tr>
<tr>
<td>10</td>
<td>Frisco</td>
<td>TX</td>
</tr>
</tbody>
</table>

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:

```sql
copy venue(venueid, venuename, venuecity, venuestate) from 's3://mybucket/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:

```sql
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:

```sql
copy venue(venueid, venuename, venuecity, venuestate) from 's3://mybucket/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:

```sql
copy venue(venuename, venuecity, venuestate) from 's3://mybucket/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:

```sql
copy venue(venueid, venuename, venuecity, venuestate) from 's3://mybucket/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://mybucket/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.

<table>
<thead>
<tr>
<th>CATID</th>
<th>CATGROUP</th>
<th>CATNAME</th>
<th>CATDESC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sports</td>
<td>MLB</td>
<td>Major League Baseball</td>
</tr>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Concerts</td>
<td>Classical</td>
<td>All symphony, concerto, and choir concerts</td>
</tr>
</tbody>
</table>

Topics

- Load from JSON Data Using the 'auto' Option (p. 503)
- Load from JSON Data Using a JSONPaths file (p. 504)
- Load from JSON Arrays Using a JSONPaths file (p. 505)

Load from JSON Data Using the 'auto' Option

To load from JSON data using the 'auto' argument, the JSON data must consist of a set of objects. The key names must match the column names, but in this case, order doesn't matter. The following shows the contents of a file named category_object_auto.json.
To load from the JSON data file in the previous example, execute the following COPY command.

```sql
COPY category
FROM 's3://mybucket/category_object_auto.json'
IAM_ROLE 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
JSON 'auto';
```

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. Again, 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`.

```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"
}
```
The following JSONPaths file, named category_jsonpath.json, maps the source data to the table columns.

```json
{
  "jsonpaths": [
    "$['one']",
    "$['two']",
    "$['three']",
    "$['four']"
  ]
}
```

To load from the JSON data file in the previous example, execute the following COPY command.

```sql
copy category
from 's3://mybucket/category_object_paths.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 's3://mybucket/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.

```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.

```json
{
  "jsonpaths": [
    "$[0]",
    "$[1]",
    "$[2]",
    "$[3]"
  ]
}
```

To load from the JSON data file in the previous example, execute the following COPY command.

```sql
copy category
from 's3://mybucket/category_array_paths.json'
iarn:aws:iam::0123456789012:role/MyRedshiftRole'
json 's3://mybucket/category_array_jsonpath.json';
```
copy category
from 's3://mybucket/category_array_data.json'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
json 's3://mybucket/category_array_jsonpath.json';

Copy from Avro Examples

In the following examples, you load the CATEGORY table with the following data.

<table>
<thead>
<tr>
<th>CATID</th>
<th>CATGROUP</th>
<th>CATNAME</th>
<th>CATDESC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sports</td>
<td>MLB</td>
<td>Major League Baseball</td>
</tr>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Concerts</td>
<td>Classical</td>
<td>All symphony, concerto, and choir concerts</td>
</tr>
</tbody>
</table>

Topics

- Load from Avro Data Using the 'auto' Option (p. 506)
- Load from Avro Data Using a JSONPaths File (p. 507)

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. However, when using the 'auto' argument, order doesn't matter. The following shows the schema for a file named category_auto.avro.

```json
{
    "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.

```json
{
    "catid": 1,
    "catdesc": "Major League Baseball",
    "catname": "MLB",
    "catgroup": "Sports"
}
{
    "catid": 2,
    "catdesc": "National Hockey League",
    "catname": "NHL",
    "catgroup": "Sports"
}
```
To load from the Avro data file in the previous example, execute the following COPY command.

copy category
from 's3://mybucket/category_auto.avro'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format as avro 'auto';

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, execute the following COPY command.

copy category
from 's3://mybucket/category_object_paths.avro'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
format avro 's3://mybucket/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 good thing about a file or table containing embedded newlines characters is that it provides a relatively easy pattern to match. Each embedded newline character most likely always follows an opening angle brackets (>) character with potentially some white space characters (\s 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;\#a;\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.

```
copy t2 from 's3://mybucket/data/nlTest2.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
escape
delimiter as '|';
select * from t2 order by 2;
c1 | c2
-------------------
```

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).
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.

### CREATE DATABASE

**Creates a new database.**

You can't run CREATE DATABASE within a transaction block (BEGIN ... END). For more information about transactions, see [Serializable Isolation](p. 151).

**Syntax**

```
CREATE DATABASE database_name [ WITH ]
[ OWNER [=] db_owner ]
[ CONNECTION LIMIT { limit | UNLIMITED } ]
```

**Parameters**

- **database_name**
  
  Name of the new database. For more information about valid names, see [Names and Identifiers](p. 367).

- **WITH**
  
  Optional keyword.

- **OWNER**
  
  Specifies a database owner.

- **=**
  
  Optional character.

- **db_owner**
  
  Username for the 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 super users. 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 (p. 557)`. The default is UNLIMITED. To view current connections, query the `STV_SESSIONS (p. 1011)` 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.

### 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.
- Cannot be a reserved word.

### Examples

The following example creates a database named TICKIT and gives ownership to the user DWUSER:

```sql
create database tickit
with owner dwuser;
```

Query the `PG_DATABASE_INFO` catalog table to view details about databases.

```
select datname, datdba, datconnlimit
from pg_database_info
where datdba > 1;
```

<table>
<thead>
<tr>
<th>datname</th>
<th>datdba</th>
<th>datconnlimit</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin</td>
<td>100</td>
<td>UNLIMITED</td>
</tr>
<tr>
<td>reports</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>tickit</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

### CREATE EXTERNAL SCHEMA

Creates a new external schema in the current database. The owner of this schema is the issuer of the CREATE EXTERNAL SCHEMA command. To transfer ownership of an external schema, use `ALTER SCHEMA (p. 420)` to change the owner. Use the `GRANT (p. 585)` command to grant access to the schema to other users or groups.

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.

An Amazon Redshift external schema references a database in an external Data Catalog in AWS Glue or in Amazon Athena or a database in an Apache Hive metastore, such as Amazon EMR.

**Note**
If you currently have Redshift Spectrum external tables in the 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.

All external tables must be created in an external schema. You can't create local tables in external schemas. For more information, see `CREATE EXTERNAL TABLE (p. 513)`.
External schemas don't support search paths.

To view details for external schemas, query the SVV_EXTERNAL_SCHEMAS (p. 1037) system view.

Syntax

```
CREATE EXTERNAL SCHEMA [IF NOT EXISTS] schema_name
FROM { [ DATA CATALOG ] | HIVE METASTORE }
DATABASE 'database_name'
[ REGION 'aws-region' ]
[ URI 'hive_metastore_uri' [ PORT port_number ] ]
IAM_ROLE 'iam-role-arn-string'
[ CATALOG_ROLE 'catalog-role-arn-string' ]
[ CREATE EXTERNAL DATABASE IF NOT EXISTS ]
```

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.

**schema_name**

The name of the new external schema. For more information about valid names, see Names and Identifiers (p. 367).

**FROM [ DATA CATALOG ] | HIVE METASTORE**

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 a Hive metastore. If HIVE METASTORE is specified, URI is required.

**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 ]**

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.

**IAM_ROLE 'iam-role-arn-string'**

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. If the external database is defined in an Amazon Athena data catalog or the AWS Glue Data Catalog, the IAM role must have permission to access Athena unless CATALOG_ROLE is specified. For more information, see IAM Policies for Amazon Redshift Spectrum (p. 243). 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 (p. 246).

**Note**
The list of chained roles must not include spaces.

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>'

CATALOG_ROLE 'catalog-role-arn-string'

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 (p. 243). 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 (p. 246).

**Note**
The list of chained roles must not include spaces.

The following shows the syntax for chaining three roles.


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.

**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.
Examples

The following example creates an external schema using a database in an Athena data catalog named `sampledb` in the US West (Oregon) Region.

```sql
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`.

```sql
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`.

```sql
create external schema hive_schema
from hive metastore
database 'hive_db'
url '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 (p. 246).

```sql
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;
```

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 (p. 510).

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 (p. 585) or REVOKE (p. 600) permissions on an external table. Instead, grant or revoke USAGE on the 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 Amazon Athena data catalog or a Hive metastore. Use the CREATE EXTERNAL SCHEMA (p. 510) command to register an external database defined in an AWS Glue or Athena data catalog or Hive metastore and make the external tables available for use in Amazon Redshift. If the external table exists in an AWS Glue or Athena data 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 (p. 1038) system view.

You can query an external table using the same SELECT syntax you use with other Amazon Redshift tables. External tables are read-only. You can't write to an external table.

To create a view with an external table, include the WITH NO SCHEMA BINDING clause in the CREATE VIEW (p. 561) statement.

You can't run CREATE EXTERNAL TABLE inside a transaction (BEGIN … END). For more information about transactions, see Serializable Isolation (p. 151).

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' [, ... ] ) ]
```

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 (p. 510).

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 textfile
LOCATION 's3://mybucket/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`, and `padb_harvest`.

The table name must be a unique name for the specified schema.

For more information about valid names, see Names and Identifiers (p. 367).

`(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 (p. 367).
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 (p. 519).

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.

Note
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 (p. 544).

data_type
The following Data Types (p. 369) are supported:

- SMALLINT (INT2)
- INTEGER (INT, INT4)
- BIGINT (INT8)
- DECIMAL (NUMERIC)
- REAL (FLOAT4)
- DOUBLE PRECISION (FLOAT8)
- BOOLEAN (BOOL)
- CHAR (CHARACTER)
- VARCHAR (CHARACTER VARYING)
- DATE (DATE data type can be used only with text, Parquet, or ORC data files, or as a partition
column)
- TIMESTAMP

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 (p. 378)

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 (p. 854) 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 (p. 421) … ADD PARTITION
statement to add partitions. When you add a partition, you define the location of the subfolder on
Amazon S3 that contains the partition data. You can add only one partition in each ALTER TABLE statement.

For example, if the table spectrum.lineitem_part is defined with PARTITIONED BY (l_shipdate date), execute the following ALTER TABLE command to add a partition.

```
ALTER TABLE spectrum.lineitem_part ADD PARTITION (l_shipdate='1992-01-29')
```

To view partitions, query the `SVV_EXTERNAL_PARTITIONS` system view.

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. The following are supported:
- `org.apache.hadoop.hive.serde2.RegexSerDe`
- `com.amazonaws.glue.serde.GrokSerDe`
- `org.apache.hadoop.hive.serde2.OpenCSVSerde`
- `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.
- The following SerDe property is supported for the 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.

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
- ORC
- AVRO
- INPUTFORMAT 'input_format_classname' OUTPUTFORMAT 'output_format_classname'

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 Considerations (p. 235).

If the path specifies a bucket or folder, for example, 's3://mybucket/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://mybucket/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.

```json
{
  "entries": [
    {
      "url": "s3://mybucket-alpha/custdata.1", "meta": { "content_length": 5956875 }
    },
    {
      "url": "s3://mybucket-alpha/custdata.2", "meta": { "content_length": 5997091 }
    },
    {
      "url": "s3://mybucket-beta/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.

```json
{
  "entries": [
    {
      "url": "s3://mybucket-alpha/custdata.1", "mandatory": true, "meta": { "content_length": 5956875 }
    },
    {
      "url": "s3://mybucket-alpha/custdata.2", "mandatory": false, "meta": { "content_length": 5997091 }
    },
    {
      "url": "s3://mybucket-beta/custdata.1", "meta": { "content_length": 5978675 }
    }
  ]
}
```
To reference files created using UNLOAD, you can use the manifest created using UNLOAD (p. 642) with the MANIFEST parameter. The manifest file is compatible with a manifest file for COPY from Amazon S3 (p. 455), 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

'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 (p. 266)

**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.

**Usage Notes**

You can't view details for Amazon Redshift Spectrum tables using the same resources you use for standard Amazon Redshift tables, such as PG_TABLE_DEF (p. 1094), STV_TBL_PERM (p. 1013), 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` (p. 1038) and `SVV_EXTERNAL_COLUMNS` (p. 1036).

Permissions to Create and Query External Tables

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` (p. 420). 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 on Amazon S3 to determine the size of the result set. For more information, see Amazon Redshift Pricing.

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.

```
create external table spectrum.sales(
    salesid integer,
    listid integer,
```
The following example creates a table that uses the JsonSerDe to reference data in JSON format.

```sql
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://mybucket/json/cloudtrail';

For a list of existing databases in the external data catalog, query the
SVV_EXTERNAL_DATABASES (p. 1036) system view.

```sql
select eskind,databasename,esoptions from svv_external_databases order by databasename;
```
The following example queries the SVV_EXTERNAL_COLUMNS view.

```sql
select * from svv_external_columns where schemaname like 'spectrum%' and tablename = 'sales';
```

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>columnname</th>
<th>external_type</th>
<th>columnnum</th>
<th>part_key</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>salesid</td>
<td>int</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>listid</td>
<td>int</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>sellerid</td>
<td>int</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>buyerid</td>
<td>int</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>eventid</td>
<td>int</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>saledate</td>
<td>date</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>qtysold</td>
<td>smallint</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>pricepaid</td>
<td>decimal(8,2)</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>commission</td>
<td>decimal(8,2)</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales</td>
<td>saletime</td>
<td>timestamp</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

To view table partitions, use the following query.

```sql
select schemaname, tablename, values, location
from svv_external_partitions
where tablename = 'sales_part';
```

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>values</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
["2008-01-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-01 |
| spectrum   | sales_part | 
["2008-02-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-02 |
| spectrum   | sales_part | 
["2008-03-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-03 |
| spectrum   | sales_part | 
["2008-04-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-04 |
| spectrum   | sales_part | 
["2008-05-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-05 |
| spectrum   | sales_part | 
["2008-06-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-06 |
| spectrum   | sales_part | 
["2008-07-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-07 |
| spectrum   | sales_part | 
["2008-08-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-08 |
| spectrum   | sales_part | 
["2008-09-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-09 |
| spectrum   | sales_part | 
["2008-10-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-10 |
| spectrum   | sales_part | 
| spectrum   | sales_part | 
["2008-12-01"] | s3://awssampledbuswest2/tickit/spectrum/sales_partition/saledate=2008-12 |

The following example returns the total size of related data files for an external table.

```sql
select distinct "$path", "$size"
from spectrum.sales_part;
```
Partitioning Examples

To create an external table partitioned by date, run the following command.

```sql
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://awssampledbuswest2/ticket/spectrum/sales_partition/

drop table spectrum.sales_part;
```

To add the partitions, run the following ALTER TABLE commands.

```sql
alter table spectrum.sales_part
add if not exists partition (saledate='2008-01-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-02-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-02/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-03-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-03/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-04-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-04/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-05-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-05/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-06-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-06/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-07-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-07/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-08-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-08/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-09-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-09/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-10-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-10/';
alter table spectrum.sales_part
add if not exists partition (saledate='2008-11-01')
location 's3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-11/';
```

---

<table>
<thead>
<tr>
<th>$path</th>
<th>$size</th>
</tr>
</thead>
<tbody>
<tr>
<td>s3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-01/</td>
<td>1616</td>
</tr>
<tr>
<td>s3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-02/</td>
<td>1444</td>
</tr>
<tr>
<td>s3://awssampledbuswest2/ticket/spectrum/sales_partition/saledate=2008-03/</td>
<td>1444</td>
</tr>
</tbody>
</table>

---

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ALTER TABLE spectrum.sales_part
ADD IF NOT EXISTS PARTITION (saledate='2008-12-01')
LOCATION 's3://awssampledbuswest2/ticket/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;

<table>
<thead>
<tr>
<th>eventid</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>914</td>
<td>36173.00</td>
</tr>
<tr>
<td>5478</td>
<td>27303.00</td>
</tr>
<tr>
<td>5061</td>
<td>26383.00</td>
</tr>
<tr>
<td>4406</td>
<td>26252.00</td>
</tr>
<tr>
<td>5324</td>
<td>24015.00</td>
</tr>
<tr>
<td>1829</td>
<td>23911.00</td>
</tr>
<tr>
<td>3601</td>
<td>23616.00</td>
</tr>
<tr>
<td>3665</td>
<td>23214.00</td>
</tr>
<tr>
<td>6069</td>
<td>22869.00</td>
</tr>
<tr>
<td>5638</td>
<td>22551.00</td>
</tr>
</tbody>
</table>

To view external table partitions, query the SVV_EXTERNAL_PARTITIONS (p. 1037) system view.

SELECT schemaname, tablename, values, location FROM svv_external_partitions
WHERE tablename = 'sales_part';

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>values</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-01-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-02-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-03-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-04-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-05-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-06-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-07-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-08-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-09-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-10-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-11-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
<tr>
<td>spectrum</td>
<td>sales_part</td>
<td>[&quot;2008-12-01&quot;]</td>
<td>s3://awssampledbuswest2/ticket/spectrum/</td>
</tr>
</tbody>
</table>
Row Format Examples

The following shows an example of specifying the ROW FORMAT SERDE parameters for data files stored in AVRO format.

```sql
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": "bytes", "logicalType": "decimal", 
\'precision\': 8, \'scale\': 2}], 
{"name": "comment","type": "string"}}') 
STORED AS AVRO 
location 's3://mybucket/avro/sales' ;
```

The following shows an example of specifying the ROW FORMAT SERDE parameters using RegEx.

```sql
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://mybucket/regex/types';
```

The following shows an example of specifying the ROW FORMAT SERDE parameters using Grok.

```sql
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://mybucket/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.

```sql
CREATE EXTERNAL TABLE IF NOT EXISTS spectrum.mybucket_s3_logs( 
 bucketowner varchar(255), 
 bucket varchar(255), 
 requestdatetime varchar(2000), 
 remoteip varchar(255), 
 requester varchar(255), 
 requested varchar(255), 
)
```
CREATE FUNCTION

operation varchar(255),
key varchar(255),
requesturi_operation varchar(255),
requesturi_key varchar(255),
requesturi_httpprotoversion varchar(255),
httpstatus varchar(255),
errorcode varchar(255),
bytesent bigint,
objectsize bigint,
totaltime varchar(255),
turnarountime 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]*) \[(.*?)\] (\[^ \s]*) (\[^ \s]*) (\[^ \s]*) (\[^ \s]*)
\(([^ ^\s]*)\) \s*(\[^ \s]*)\s*\(([^ ^\s]*)\) (\[^ ^\s]*)\s*(\[^ ^\s]*)\s*(\[^ ^\s]*)\s*(\[^ ^\s]*)\s*(\[^ ^\s]*)\s*(\[^ ^\s]*)$'),
LOCATION 's3://mybucket/s3logs';

CREATE FUNCTION

Creates a new scalar user-defined function (UDF) using either a SQL SELECT clause or a Python program.

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 (p. 189).

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 (p. 367).

We recommend that you prefix all UDF names with $$. Amazon Redshift reserves the $$. prefix for UDF names, so by using the $$. 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 Naming UDFs (p. 188).
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 (p. 189).

\[ \text{py_arg_name py_arg_data_type | sql_arg_data type} \]

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 will 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 (p. 184) and Data Types (p. 369).

You can specify a maximum of 32 arguments.

\[ \text{RETURNS data_type} \]

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 (p. 184).

\[ \text{VOLATILE | STABLE | IMMUTABLE} \]

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

\[ \text{VOLATILE} \]

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.

\[ \text{STABLE} \]

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.

\[ \text{IMMUTABLE} \]

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 executed. 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 execute, 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 (p. 185).

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 Privileges (p. 182).

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
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 execute 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 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 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 (p. 585) and REVOKE (p. 600).

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 GROUP

Defines a new user group. Only a superuser can create a group.

Syntax

```sql
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 (p. 367).

- **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.

```sql
create group admin_group with user admin1, admin2;
```

CREATE LIBRARY

Installs a Python library, which is available for users to incorporate when creating a user-defined function (UDF) with the CREATE FUNCTION (p. 525) 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 (p. 151).
Amazon Redshift supports Python version 2.7. For more information, go to www.python.org.

For more information, see Importing Custom Python Library Modules (p. 186).

**Syntax**

```sql
CREATE [ OR REPLACE ] LIBRARY library_name LANGUAGE plpythonu
FROM
{ 'https://file_url'
| 's3://bucketname/file_name'
authorization
 [ REGION [AS] 'aws_region']
}
```

**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 (p. 185).

**LANGUAGE plpythonu**

The language to use. Python (plpythonu) is the only supported language. Amazon Redshift supports Python version 2.7. For more information, go to 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, go to 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://bucketname/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://mybucket/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 (p. 458) 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 (p. 465).

To specify an AWS Identity and Access Management (IAM) role, replace <account-id> and <role-name> with the account ID and role name in the CREDENTIALS credentials-args string. An example is shown following.

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

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.

To specify key-based access control, provide the credentials-args in the following format.

```
'aws_access_key_id=<access-key-id>;aws_secret_access_key=<secret-access-key>'
```

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.

```
WITH CREDENTIALS AS
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;token=<temporary-token>'
```

For more information, see Temporary Security Credentials (p. 487)

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 (p. 458) 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
```
The following example installs a library named `f_urlparse` from a library file on a website.

```sql
create library f_urlparse
language plpythonu
from 'https://example.com/packages/urlparse3-1.0.3.zip';
```

**CREATE MATERIALIZED VIEW**

Creates a materialized view.

For more information about materialized views, see Creating Materialized Views in Amazon Redshift (p. 218).

**Syntax**

```sql
CREATE MATERIALIZED VIEW mv_name
[ BACKUP { YES | NO } ]
[ table_attributes ]
AS query
```

**Parameters**

**BACKUP**

A clause that specifies whether the materialized view is included in automated and manual cluster snapshots, which are stored in Amazon S3.

The default value for BACKUP is YES.

You can specify BACKUP NO to save processing time when creating snapshots and restoring from snapshots, and to reduce the amount of storage required in Amazon S3.

**Note**

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 a node failure.

**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 AUTO. For more information, see Distribution Styles (p. 56).
- The distribution key for the materialized view, in the format `DISTKEY ( distkey_identifier )`. For more information, see Designating Distribution Styles (p. 58).
- The sort key for the materialized view, in the format `SORTKEY ( column_name [, ...] )`. For more information, see Choosing Sort Keys (p. 66).

**AS query**

A valid SELECT statement, subject to limitations. For more information about limitations, see Limitations and Usage Notes for Materialized Views (p. 219). The result set from the query defines the columns and rows of the materialized view.
Usage Notes

Create a materialized view, you must have CREATE privileges for a schema.

Example

The following example creates a materialized view. Each row represents a category, along with the number of tickets sold or unsold for that category.

```
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;
```

CREATE PROCEDURE

Creates a new stored procedure or replaces an existing procedure for the current database.

Syntax

```
CREATE [ OR REPLACE ] PROCEDURE sp_procedure_name
    ( [ [ argname ] [ argmode ] argtype [, ...] ] )
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. You must be a superuser or the owner to replace a procedure.

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 (p. 193).

`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 (p. 367).

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 (p. 193).

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 (p. 193)
CREATE PROCEDURE

[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 (p. 215).

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 executed. 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 (p. 202).

```
LANGUAGE plpgsql
```

A language value. Specify plpgsql. You must have permission for usage on language to use plpgsql. For more information, see GRANT (p. 585).
SECURITY INVOKER | SECURITY DEFINER

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 is run using the database privileges as the procedure's owner. 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 }

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.

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 (p. 191).

The following example creates a procedure with two input parameters.

```sql
CREATE OR REPLACE PROCEDURE test_sp1(f1 int, f2 varchar(20))
AS $$
DECLARE
    min_val int;
BEGIN
    DROP TABLE IF EXISTS tmp_tbl;
    CREATE TEMP TABLE tmp_tbl(id int);
    INSERT INTO tmp_tbl values (f1),(10001),(10002);
    SELECT INTO min_val MIN(id) FROM tmp_tbl;
    RAISE INFO 'min_val = %, f2 = %', min_val, f2;
END;
$$ LANGUAGE plpgsql;
```

The following example creates a procedure with one IN parameter, one OUT parameter, and one INOUT parameter.

```sql
CREATE OR REPLACE PROCEDURE test_sp2(f1 IN int, f2 INOUT varchar(256), out_var OUT varchar(256))
AS $$
DECLARE
    loop_var int;
BEGIN
    IF f1 is null OR f2 is null THEN
        RAISE EXCEPTION 'input cannot be null';
    END IF;
    DROP TABLE if exists my_etl;
    CREATE TEMP TABLE my_etl(a int, b varchar);
    FOR loop_var IN 1..f1 LOOP
        insert into my_etl values (loop_var, f2);
        f2 := f2 || '+' || f2;
    END LOOP;
    SELECT out_var INTO out_var FROM my_etl;
END;
$$ LANGUAGE plpgsql;
```

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CREATE SCHEMA

Defines a new schema for the current database.

Syntax

CREATE SCHEMA [ IF NOT EXISTS ] schema_name [ AUTHORIZATION username ] [ schema_element [ ... ] ]

CREATE SCHEMA AUTHORIZATION username [ 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 (p. 367).

Note

The list of schemas in the search_path (p. 1106) 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.

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;
CREATE TABLE

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

Topics
- Syntax (p. 537)
- Parameters (p. 538)
- Usage Notes (p. 544)
- Examples (p. 545)

Creates a new table in the current database. The owner of this table is the issuer of the CREATE TABLE command.

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_attribute]

where column_attributes are:
  [ DEFAULT default_expr ]
  [ IDENTITY ( seed, step ) ]
  [ GENERATED BY DEFAULT AS IDENTITY ( seed, step ) ]
  [ ENCODE encoding ]
  [ DISTKEY ]
  [ SORTKEY ]

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:

- \[ \text{DISTSTYLE} \{ \text{AUTO} | \text{EVEN} | \text{KEY} | \text{ALL} \} \]
- \[ \text{DISTKEY} (\text{column\_name}) \]
- \[ [\text{COMPUND} | \text{INTERLEAVED}] \text{SORTKEY} (\text{column\_name}, [...]) \]  

### 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 will take 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 (p. 1106)`.

**Note**

By default, 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 terminating with an error. Note that the existing table might be nothing like the one that would have been created; only the table name is used for comparison.

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);
```

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 20,000 tables per cluster, 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`, and `padb_harvest`.

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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 (p. 367).

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 (p. 367).

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 (p. 544).

data_type

The 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.

The following Data Types (p. 369) are supported:

- SMALLINT (INT2)
- INTEGER (INT, INT4)
- BIGINT (INT8)
- DECIMAL (NUMERIC)
- REAL (FLOAT4)
- DOUBLE PRECISION (FLOAT8)
- BOOLEAN (BOOL)
- CHAR (CHARACTER)
- VARCHAR (CHARACTER VARYING)
- DATE
- TIMESTAMP
- TIMESTAMPTZ
- GEOMETRY

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** (p. 539).

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**

Compression encoding for a column. If no compression is selected, Amazon Redshift automatically assigns 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, or GEOMETRY data type 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.

**Note**

If you don't want a column to be compressed, explicitly specify RAW encoding.

The following compression encodings (p. 44) 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.

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.

If you don't specify any sort keys, the table isn't sorted. You can define a maximum of 400 SORTKEY columns per table.

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.

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 don't apply 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 effect on automatic replication of data to other nodes within the cluster, so tables with BACKUP NO specified are restored in a node failure. The default is BACKUP YES.

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 Choosing a Data Distribution Style (p. 55). 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 ALL distribution to a small table, then changes the table to EVEN distribution when the table grows larger. The change in distribution occurs in the background, in a few seconds. Amazon Redshift never changes the distribution style from EVEN to ALL. To view the distribution style applied to a table, query the PG_CLASS system catalog table. For more information, see Viewing Distribution Styles (p. 57).

• 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 colocated on the compute nodes. When data is colocated, 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.
CREATE TABLE

[ [ 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 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. The default is COMPOUND. For more information, see Choosing Sort Keys (p. 66).

If you don't specify any sort keys, the table isn't sorted by default. You can define a maximum of 400 COMPOUND SORTKEY columns or 8 INTERLEAVED SORTKEY columns per table.

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.

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(s) of some row of the referenced table. If refcolumn is omitted, the primary key of reftable is used. The
CREATE TABLE 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**

**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 Cluster 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.

**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

The following examples demonstrate various column and table attributes in Amazon Redshift CREATE TABLE statements.

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.

```sql
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,
qtrysold 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 result is as follows:

```
schemaname | tablename | column     | type                        | encoding | distkey | sortkey | notnull
-----------+-----------+------------+-----------------------------+----------+---------+--------+-------
public     | sales     | salesid    | integer                     | lzo      | false   | 0 | true
public     | sales     | listid     | integer                     | none     | true    | 1 | true
```
### 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,  
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

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';

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>eventid</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>eventname</td>
<td>character varying(200)</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>eventcity</td>
<td>character varying(30)</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

(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';

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>eventid</td>
<td>integer</td>
<td>none</td>
<td>t</td>
<td>1</td>
</tr>
<tr>
<td>venueid</td>
<td>smallint</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>catid</td>
<td>smallint</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>dateid</td>
<td>smallint</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>eventname</td>
<td>character varying(200)</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp without time zone</td>
<td>bytedict</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

(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;
```

<table>
<thead>
<tr>
<th>hist_id</th>
<th>base_id</th>
<th>business_key</th>
<th>some_field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>A</td>
<td>MM</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>hist_id</th>
<th>base_id</th>
<th>business_key</th>
<th>some_field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>A</td>
<td>MM</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>B</td>
<td>MNOP</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>hist_id</th>
<th>base_id</th>
<th>business_key</th>
<th>some_field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>A</td>
<td>MM</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>B</td>
<td>MNOP</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>B</td>
<td>MNNN</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Special</td>
<td>Other</td>
<td>Special events</td>
</tr>
</tbody>
</table>
(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:

```sql
create table t1(col1 int distkey, col2 int) diststyle key;
```

The result is as follows:

```sql
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't1';
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>col1</td>
<td>integer</td>
<td>lzo</td>
<td>t</td>
<td>0</td>
</tr>
<tr>
<td>col2</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

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.

```sql
create table t2(col1 int distkey sortkey, col2 int);
```

The result is as follows:

```sql
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't2';
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>col1</td>
<td>integer</td>
<td>none</td>
<td>t</td>
<td>1</td>
</tr>
<tr>
<td>col2</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

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:

```sql
create table t3(col1 int, col2 int sortkey) diststyle all;
```

The result is as follows:

```sql
select "column", type, encoding, distkey, sortkey
from pg_table_def where tablename = 't3';
```

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Encoding</th>
<th>DistKey</th>
<th>SortKey</th>
</tr>
</thead>
<tbody>
<tr>
<td>col1</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>col2</td>
<td>integer</td>
<td>none</td>
<td>f</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

```sql
create table t4(col1 int, col2 int) diststyle even;
```

The result is as follows:
CREATE TABLE AS

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>col1</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>col2</td>
<td>integer</td>
<td>lzo</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

CREATE TABLE AS

Topics
- Syntax (p. 550)
- Parameters (p. 550)
- CTAS Usage Notes (p. 552)
- CTAS Examples (p. 555)

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 { 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 maximum limit of 9,900 permanent tables per cluster. The table name can be qualified with the database and schema name, as the following table shows.

```sql
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.

`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 won'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`.

`DISTSTYLE { EVEN | KEY | ALL }`

Defines the data distribution style for the whole table. Amazon Redshift distributes the rows of a table to the compute nodes according the distribution style specified for the table.

The distribution style that you select for tables affects the overall performance of your database. For more information, see Choosing a Data Distribution Style (p. 55).

- **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.
CREATE TABLE AS

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 (p. 552).

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.

```sql
[ { 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 Choosing Sort Keys (p. 66).

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 (p. 552).

<table>
<thead>
<tr>
<th>COMPOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERLEAVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specifies that the data is sorted using an interleaved sort key. A maximum of eight columns can be specified for an interleaved sort key.</td>
</tr>
</tbody>
</table>

| 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 maximum limit of 9,900 permanent tables.

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, or GEOMETRY data type 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.

For more information, see Compression Encodings (p. 44) and Data Types (p. 369).

To explicitly assign column encodings, use CREATE TABLE (p. 537)

CTAS determines distribution style and sort key for the new table based on the query plan for the SELECT clause.

If the SELECT clause is a simple select operation from a single table, without a limit clause, order by clause, or group by clause, then CTAS uses the source table's distribution style and sort key.

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 data sets or complex queries, we recommend testing using typical data sets.

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.

```sql
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)
```

```sql
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)
```

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CREATE TABLE AS

(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 sortkey for each table, query the PG_TABLE_DEF system catalog table, as shown following.

select * from pg_table_def where tablename like 'sales%';

<table>
<thead>
<tr>
<th>tablename</th>
<th>column</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales</td>
<td>salesid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>listid</td>
<td>t</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>sellerid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>buyerid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>eventid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>dateid</td>
<td>f</td>
<td>1</td>
</tr>
<tr>
<td>sales</td>
<td>qtysold</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>pricepaid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>commission</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>saletime</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales1_simple</td>
<td>listid</td>
<td>t</td>
<td>0</td>
</tr>
<tr>
<td>sales1_simple</td>
<td>dateid</td>
<td>f</td>
<td>1</td>
</tr>
<tr>
<td>sales1_simple</td>
<td>qtysold</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales2_limit</td>
<td>listid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales2_limit</td>
<td>dateid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales2_limit</td>
<td>qtysold</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales3_orderbylistid</td>
<td>listid</td>
<td>t</td>
<td>1</td>
</tr>
<tr>
<td>sales3_orderbylistid</td>
<td>dateid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales3_orderbylistid</td>
<td>qtysold</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales4_orderbyqty</td>
<td>listid</td>
<td>t</td>
<td>0</td>
</tr>
<tr>
<td>sales4_orderbyqty</td>
<td>dateid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales4_orderbyqty</td>
<td>qtysold</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales5_groupby</td>
<td>listid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales5_groupby</td>
<td>dateid</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>sales5_groupby</td>
<td>sum</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>
The following table summarizes the results. For simplicity, we omit cost, rows, and width details from the explain plan.

<table>
<thead>
<tr>
<th>Table</th>
<th>CTAS Select Statement</th>
<th>Explain Plan Top Node</th>
<th>Dist Key</th>
<th>Sort Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1_SIMPLE</td>
<td>select listid, dateid, qtysold from sales</td>
<td>XN Seq Scan on sales ...</td>
<td>LISTID</td>
<td>DATEID</td>
</tr>
<tr>
<td>S2_LIMIT</td>
<td>select listid, dateid, qtysold from sales</td>
<td>XN Limit ...</td>
<td>None (EVEN)</td>
<td>None</td>
</tr>
<tr>
<td>S3_ORDER_BY_LISTID</td>
<td>select listid, dateid, qtysold from sales</td>
<td>XN Sort ...</td>
<td>LISTID</td>
<td>LISTID</td>
</tr>
<tr>
<td>S4_ORDER_BY_QTYSOLD</td>
<td>select listid, dateid, qtysold from sales</td>
<td>XN Sort ...</td>
<td>LISTID</td>
<td>QTYSOLD</td>
</tr>
<tr>
<td>S5_GROUP_BY</td>
<td>select listid, dateid, sum(qtysold) from sales group by listid, dateid</td>
<td>XN HashAggregate ...</td>
<td>None (EVEN)</td>
<td>None</td>
</tr>
</tbody>
</table>

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.

```sql
create table sales_disteven
diststyle even
sortkey (salesid)
as
select eventid, venueid, dateid, eventname
from event;
```

**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:

```sql
create table event_backup as select * from event;
```

The resulting table inherits the distribution and sort keys from the EVENT table.
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:

```sql
create table eventdistsort
distkey (1)
sortkey (1,3)
as
select eventid, venueid, dateid, eventname
from event;
```

The result is as follows:

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

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>eventid</td>
<td>integer</td>
<td>none</td>
<td>t</td>
<td>1</td>
</tr>
<tr>
<td>venueid</td>
<td>smallint</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>dateid</td>
<td>smallint</td>
<td>none</td>
<td>f</td>
<td>2</td>
</tr>
<tr>
<td>eventname</td>
<td>character varying(200)</td>
<td>none</td>
<td>f</td>
<td>0</td>
</tr>
</tbody>
</table>

You could create exactly the same table by using column names for the distribution and sort keys. For example:

```sql
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.

```sql
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.

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

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';
```

## CREATE USER

**Syntax**

```
CREATE USER name [ WITH ]
PASSWORD {'password' | 'md5hash' | DISABLE }
[ option [ ... ] ]
```

where option can be:
CREATE USER

The name of the user account to create. The user name can't be PUBLIC. For more information about valid names, see Names and Identifiers (p. 367).

WITH

Optional keyword. WITH is ignored by Amazon Redshift

PASSWORD { 'password' | 'md5hash' | 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 (p. 435) and specify a password.

You can specify the password in clear text or as an MD5 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 master database user. You can change the password later by using ALTER USER (p. 435).

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 quote), " (double quote), \, /, 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 (p. 853) and the concatenation operator ( || ) to return a 32-character MD5-hash string.
3. Concatenate 'md5' in front of the MD5 hash string and provide the concatenated string as the md5hash argument.

```sql
create user user1 password 'md5153c434b4b77c89e6b94f12c5393af5b';
```

4. Log on to the database using the user name and password.

For this example, log on as user1 with password ez.

CREATEDB | NOCREATEDB

The CREATEDB option allows the new user account 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 (p. 355).

SYSLOG ACCESS { RESTRICTED | UNRESTRICTED }

A clause that specifies the level of access the user has to the Amazon Redshift system tables and views.

If RESTRICTED is specified, the user can see only the rows generated by that user in user-visible system tables and views. The default is RESTRICTED.

If UNRESTRICTED is specified, the user 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 STV_RECENTS and SVV_TRANSACTIONS are visible to all users.

For more information, see Visibility of Data in System Tables and Views (p. 915).

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 account 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 super users. 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 (p. 509). The default is UNLIMITED. To view current connections, query the STV_SESSIONS (p. 1011) 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.

**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.

```sql
create user iam_superuser password 'md5A1234567890123456780123456789012' createuser;
```

**Examples**

The following command creates a user account named dbuser, with the password "abcD1234", database creation privileges, and a connection limit of 30.

```sql
create user dbuser with password 'abcD1234' createdb connection limit 30;
```

Query the PG_USER_INFO catalog table to view details about a database user.

```sql
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.

```sql
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.

```sql
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.

```sql
select md5('\'||'slashpass');
```

```
md5----------------------------------------
0c983d1a624280812631c5389e60d48c
```

```sql
create user slashpass password 'md50c983d1a624280812631c5389e60d48c';
```
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. To query a standard view, you need select privileges for the view itself, but you don't need select privileges for the underlying tables. To query a late binding view, you need select privileges for the late binding view itself. You should also make sure the owner of the late binding view has select privileges to the referenced objects (tables, views, or user-defined functions). For more information about Late Binding Views, see Usage Notes (p. 562).

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.

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 (p. 367). You can't create tables or views in the system databases template0, template1, and padb_harvest.

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. To view details about late binding views, run the PG_GET_LATE_BINDING_VIEW_COLS (p. 905) 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

create view myevent as select eventname from event
with no schema binding;

The following statement executes 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;

<table>
<thead>
<tr>
<th>eventid</th>
<th>venueid</th>
<th>catid</th>
<th>dateid</th>
<th>eventname</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>306</td>
<td>8</td>
<td>2114</td>
<td>Boris Godunov</td>
<td>2008-10-15 20:00:00</td>
</tr>
</tbody>
</table>

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;

<table>
<thead>
<tr>
<th>eventid</th>
<th>venueid</th>
<th>catid</th>
<th>dateid</th>
<th>title</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>306</td>
<td>8</td>
<td>2114</td>
<td>Boris Godunov</td>
<td>2008-10-15 20:00:00</td>
</tr>
</tbody>
</table>

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 (p. 642) 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
For more information about creating Redshift Spectrum external tables, including the `SPECTRUM.SALES` table, see Getting Started with Amazon Redshift Spectrum (p. 236).

**Examples**

The following command creates a view called `myevent` from a table called `EVENT`.

```sql
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`.

```sql
create view myuser as select lastname from users;
```

The following command creates or replaces a view called `myuser` from a table called `USERS`.

```sql
create or replace view myuser as select lastname from users;
```

The following example creates a view with no schema binding.

```sql
create view myevent as select eventname from public.event
with no schema binding;
```

**DEALLOCATE**

Deallocates a prepared statement.

**Syntax**

```sql
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 (p. 597).

**See Also**

EXECUTE (p. 579), PREPARE (p. 597)
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 (p. 565).

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 (p. 584), CLOSE (p. 448).

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 (p. 565).

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 (p. 564).

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
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.

<table>
<thead>
<tr>
<th>Node type</th>
<th>Maximum result set per cluster (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS1 or DS2 XL single node</td>
<td>64000</td>
</tr>
<tr>
<td>DS1 or DS2 XL multiple nodes</td>
<td>1800000</td>
</tr>
<tr>
<td>DS1 or DS2 8XL multiple nodes</td>
<td>14400000</td>
</tr>
<tr>
<td>RA3 16XL multiple nodes</td>
<td>14400000</td>
</tr>
<tr>
<td>DC1 Large single node</td>
<td>16000</td>
</tr>
<tr>
<td>DC1 Large multiple nodes</td>
<td>384000</td>
</tr>
<tr>
<td>DC1 8XL multiple nodes</td>
<td>3000000</td>
</tr>
<tr>
<td>DC2 Large single node</td>
<td>8000</td>
</tr>
<tr>
<td>DC2 Large multiple nodes</td>
<td>192000</td>
</tr>
<tr>
<td>DC2 8XL multiple nodes</td>
<td>3200000</td>
</tr>
</tbody>
</table>

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 (p. 642) 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 (p. 176).
- 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 (p. 308).

**DECLARE CURSOR 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:

```sql
-- 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;

<table>
<thead>
<tr>
<th>eventname</th>
<th>starttime</th>
<th>costperticket</th>
<th>qtysold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lollapalooza</td>
<td>2008-05-01 19:00:00</td>
<td>92.00000000</td>
<td>3</td>
</tr>
<tr>
<td>Lollapalooza</td>
<td>2008-11-15 15:00:00</td>
<td>222.00000000</td>
<td>2</td>
</tr>
<tr>
<td>Lollapalooza</td>
<td>2008-04-17 15:00:00</td>
<td>239.00000000</td>
<td>3</td>
</tr>
<tr>
<td>Lollapalooza</td>
<td>2008-04-17 15:00:00</td>
<td>239.00000000</td>
<td>4</td>
</tr>
<tr>
<td>Lollapalooza</td>
<td>2008-04-17 15:00:00</td>
<td>239.00000000</td>
<td>1</td>
</tr>
</tbody>
</table>
(5 rows)

-- Fetch the next row:

fetch next from lollapalooza;

<table>
<thead>
<tr>
<th>eventname</th>
<th>starttime</th>
<th>costperticket</th>
<th>qtysold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lollapalooza</td>
<td>2008-10-06 14:00:00</td>
<td>114.00000000</td>
<td>2</td>
</tr>
</tbody>
</table>

-- Close the cursor and end the transaction:

close lollapalooza;
commit;

DELETE

Deletes rows from tables.

Note
The maximum size for a single SQL statement is 16 MB.

Syntax

```
DELETE [ FROM ] table_name
[ {USING } table_name, ... ]
[ WHERE condition ]
```

Parameters

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 (p. 641) 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.
**DELETE**

`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 (p. 641).

**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.

**USING**

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:

```sql
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:

```sql
DELETE FROM t1
WHERE col1 IN(SELECT col2 FROM t2);
```

If no condition is specified, all of the rows in the table are deleted.

**Examples**

Delete all of the rows from the CATEGORY table:

```sql
DELETE FROM category;
```

Delete rows with CATID values between 0 and 9 from the CATEGORY table:

```sql
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:

```sql
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:
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 (p. 151).

Syntax

```
DROP DATABASE  database_name
```

Parameters

database_name

Name of the database to be dropped. You can't drop the dev, padb_harvest, template0, or template1 databases, and you can't drop the current database.

To drop an external database, drop the external schema. For more information, see DROP SCHEMA (p. 572).

Examples

The following example drops a database named TICKIT_TEST:

```
drop database tickit_test;
```

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.

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 (p. 561).

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:

\[\text{drop function f_sqrt(int);}\]

To remove a function that has dependencies, use the CASCADE option, as shown in the following example:

\[\text{drop function f_sqrt(int)cascade;}\]

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

\[\text{DROP GROUP name}\]

Parameter

name

Name of the user group to delete.
Example

The following example deletes the GUEST user group:

```sql
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.

```plaintext
ERROR: group "guest" can't be dropped because the group has a privilege on some object
```

If the group has privileges for an object, first revoke the privileges before dropping the group. The following example revokes all privileges on all tables in the `public` schema from the GUEST user group, and then drops the group.

```sql
revoke all on all tables in schema public from group guest;
drop group guests;
```

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 (p. 151).

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 (p. 529).

Syntax

```sql
DROP LIBRARY library_name
```

Parameters

`library_name`

The name of the library.

DROP MATERIALIZED VIEW

Removes a materialized view.

For more information about materialized views, see Creating Materialized Views in Amazon Redshift (p. 218).

Syntax

```sql
DROP MATERIALIZED VIEW [ IF EXISTS ] mv_name
```
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.

Usage Notes

Only the owner of a materialized view can use DROP MATERIALIZED VIEW on that view.

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.

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 (p. 369).
Examples

The following example drops a stored procedure named `quarterly_revenue`.

```sql
DROP PROCEDURE quarterly_revenue(volume INOUT bigint, at_price IN numeric,result OUT int);
```

**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.

**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.

**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. Only the owner of the table, the schema owner, or a superuser can drop a table.

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 (p. 151).

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 a table referenced by the view, include the WITH NO SCHEMA BINDING clause in the view definition. For more information, see CREATE VIEW (p. 561).

**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:

```sql
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:

```sql
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:

```sql
create table feedback(a int);
```

Next, use the CREATE VIEW command to create a view called FEEDBACK_VIEW that relies on the table FEEDBACK:

```sql
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**

You can create a view that holds the dependency information for all of the tables in a database. Before dropping a given table, query this view to determine if the table has dependencies.

Type the following command to create a `FIND_DEPEND` view, which joins dependencies with object references:

```sql
create view find_depend as
select distinct c_p.oid as tbloid,
n_p.nspname as schemaname, c_p.relname as name,
n_c.nspname as refbyschemaname, c_c.relname as refbyname,
c_c.oid as viewoid
from pg_catalog.pg_class c_p
join pg_catalog.pg_depend d_p
on c_p.relfilenode = d_p.refobjid
join pg_catalog.pg_depend d_c
on d_p.objid = d_c.objid
join pg_catalog.pg_class c_c
on d_c.refobjid = c_c.relfilenode
left outer join pg_namespace n_p
on c_p.relnamespace = n_p.oid
left outer join pg_namespace n_c
on c_c.relnamespace = n_c.oid
where d_c.deptype = 'i'::"char"
and c_c.relkind = 'v'::"char";
```

Now create a `SALES_VIEW` from the `SALES` table:

```
create view sales_view as select * from sales;
```

Now query the `FIND_DEPEND` view to view dependencies in the database. Limit the scope of the query to the `PUBLIC` schema, as shown in the following code:

```
select * from find_depend
where refbyschemaname='public'
order by name;
```

This query returns the following dependencies, showing that the `SALES_VIEW` view is also dropped by using the `CASCADE` option when dropping the `SALES` table:

<table>
<thead>
<tr>
<th>tbloid</th>
<th>schemaname</th>
<th>name</th>
<th>viewoid</th>
<th>refbyschemaname</th>
<th>refbyname</th>
</tr>
</thead>
<tbody>
<tr>
<td>100241</td>
<td>public</td>
<td>find_depend</td>
<td>100241</td>
<td>public</td>
<td>find_depend</td>
</tr>
<tr>
<td>100203</td>
<td>public</td>
<td>sales</td>
<td>100245</td>
<td>public</td>
<td>sales_view</td>
</tr>
<tr>
<td>100245</td>
<td>public</td>
<td>sales_view</td>
<td>100245</td>
<td>public</td>
<td>sales_view</td>
</tr>
</tbody>
</table>

(3 rows)

**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 to execute this command.

Syntax

```
DROP USER [ IF EXISTS ] name [, ... ]
```

Parameters

**IF EXISTS**

Clause that indicates that if the specified user account doesn't exist, the command should make no changes and return a message that the user account 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 account.

**name**

Name of the user account to remove. You can specify multiple user accounts, with a comma separating each account name from the next.

Usage Notes

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.

<table>
<thead>
<tr>
<th>Error</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERROR: user &quot;username&quot; can't be dropped because the user owns some object</td>
<td>[SQL State=55006]</td>
</tr>
<tr>
<td>ERROR: user &quot;username&quot; can't be dropped because the user has a privilege on some object</td>
<td>[SQL State=55006]</td>
</tr>
</tbody>
</table>

**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 account called danny:
DROP VIEW

Removes a view from the database. Multiple views can be dropped with a single DROP VIEW command. This command isn’t reversible.

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 (p. 561).

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 the 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, execute 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 (p. 450) 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:

```sql
end;
end work;
end transaction;
```

After any of these commands, Amazon Redshift ends the transaction block and commits the changes.

EXECUTE

Executes a previously prepared statement.

Syntax

```sql
EXECUTE plan_name [ (parameter [, ...]) ]
```

Parameters

`plan_name`

Name of the prepared statement to be executed.

`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 execute a previously prepared statement. Since prepared statements only exist for the duration of a session, the prepared statement must have been created by a PREPARE statement executed 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 executing 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 (p. 580) command.

For examples and more information on the creation and usage of prepared statements, see PREPARE (p. 597).

See Also

DEALLOCATE (p. 563), PREPARE (p. 597)

EXPLAIN

Displays the execution plan for a query statement without running the query.

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.

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. 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.

<table>
<thead>
<tr>
<th>EXPLAIN Operators</th>
<th>Query Execution Steps</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCAN:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequential Scan</td>
<td>scan</td>
<td>Amazon Redshift relation scan or table scan operator or step. Scans whole table sequentially 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.</td>
</tr>
<tr>
<td><strong>JOINS:</strong> 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nested Loop</td>
<td>nloop</td>
<td>Least optimal join; mainly used for cross-joins (Cartesian products; without a join condition) and some inequality joins.</td>
</tr>
<tr>
<td>Hash Join</td>
<td>hjoin</td>
<td>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.)</td>
</tr>
<tr>
<td>Merge Join</td>
<td>mjoin</td>
<td>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.</td>
</tr>
<tr>
<td><strong>AGGREGATION:</strong> Operators and steps used for queries that involve aggregate functions and GROUP BY operations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>aggr</td>
<td>Operator/step for scalar aggregate functions.</td>
</tr>
<tr>
<td>HashAggregate</td>
<td>aggr</td>
<td>Operator/step for grouped aggregate functions. Can operate from disk by virtue of hash table spilling to disk.</td>
</tr>
<tr>
<td>GroupAggregate</td>
<td>aggr</td>
<td>Operator sometimes chosen for grouped aggregate queries if the Amazon Redshift configuration setting for force_hash_grouping setting is off.</td>
</tr>
<tr>
<td><strong>SORT:</strong> Operators and steps used when queries have to sort or merge result sets.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sort</td>
<td>sort</td>
<td>Sort performs the sorting specified by the ORDER BY clause as well as other operations such as UNIONS and joins. Can operate from disk.</td>
</tr>
<tr>
<td>Merge</td>
<td>merge</td>
<td>Produces final sorted results of a query based on intermediate sorted results derived from operations performed in parallel.</td>
</tr>
<tr>
<td>EXPLAIN Operators</td>
<td>Query Execution Steps</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>EXCEPT, INTERSECT, and UNION operations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SetOp Except [Distinct]</td>
<td>hjoin</td>
<td>Used for EXCEPT queries. Can operate from disk based on virtue of fact that input hash can be disk-based.</td>
</tr>
<tr>
<td>Hash Intersect [Distinct]</td>
<td>hjoin</td>
<td>Used for INTERSECT queries. Can operate from disk based on virtue of fact that input hash can be disk-based.</td>
</tr>
<tr>
<td>Append [All [Distinct]]</td>
<td>save</td>
<td>Append used with Subquery Scan to implement UNION and UNION ALL queries. Can operate from disk based on virtue of &quot;save&quot;.</td>
</tr>
<tr>
<td>Miscellaneous/Other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hash</td>
<td>hash</td>
<td>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.)</td>
</tr>
<tr>
<td>Limit</td>
<td>limit</td>
<td>Evaluates the LIMIT clause.</td>
</tr>
<tr>
<td>Materialize</td>
<td>save</td>
<td>Materialize rows for input to nested loop joins and some merge joins. Can operate from disk.</td>
</tr>
<tr>
<td>--</td>
<td>parse</td>
<td>Used to parse textual input data during a load.</td>
</tr>
<tr>
<td>--</td>
<td>project</td>
<td>Used to rearrange columns and compute expressions, that is, project data.</td>
</tr>
<tr>
<td>Result</td>
<td>--</td>
<td>Run scalar functions that don't involve any table access.</td>
</tr>
<tr>
<td>--</td>
<td>return</td>
<td>Return rows to the leader or client.</td>
</tr>
<tr>
<td>Subplan</td>
<td>--</td>
<td>Used for certain subqueries.</td>
</tr>
<tr>
<td>Unique</td>
<td>unique</td>
<td>Eliminates duplicates from SELECT DISTINCT and UNION queries.</td>
</tr>
<tr>
<td>Window</td>
<td>window</td>
<td>Compute aggregate and ranking window functions. Can operate from disk.</td>
</tr>
<tr>
<td>Network Operations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network (Broadcast)</td>
<td>bcast</td>
<td>Broadcast is also an attribute of Join Explain operators and steps.</td>
</tr>
<tr>
<td>Network (Distribute)</td>
<td>dist</td>
<td>Distribute rows to compute nodes for parallel processing by data warehouse cluster.</td>
</tr>
<tr>
<td>Network (Send to Leader)</td>
<td>return</td>
<td>Sends results back to the leader for further processing.</td>
</tr>
</tbody>
</table>

**DML Operations (operators that modify data):**
### EXPLAIN Operators

<table>
<thead>
<tr>
<th>EXPLAIN Operators</th>
<th>Query Execution Steps</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert (using Result)</td>
<td>insert</td>
<td>Inserts data.</td>
</tr>
<tr>
<td>Delete (Scan + Filter)</td>
<td>delete</td>
<td>Deletes data. Can operate from disk.</td>
</tr>
<tr>
<td>Update (Scan + Filter)</td>
<td>delete, insert</td>
<td>Implemented as delete and Insert.</td>
</tr>
</tbody>
</table>

### 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:

```sql
explain
select eventid, eventname, event.venueid, venuename
from event, venue
where event.venueid = venue.venueid;
```

**QUERY PLAN**

<table>
<thead>
<tr>
<th>XN Hash Join DS_DIST_OUTER (cost=2.52..58653620.93 rows=8712 width=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hash Cond: (&quot;outer&quot;.venueid = &quot;inner&quot;.venueid)</td>
</tr>
<tr>
<td>-&gt; XN Seq Scan on event (cost=0.00..87.98 rows=8798 width=23)</td>
</tr>
<tr>
<td>-&gt; XN Hash (cost=2.02..2.02 rows=202 width=22)</td>
</tr>
<tr>
<td>-&gt; XN Seq Scan on venue (cost=0.00..2.02 rows=202 width=22)</td>
</tr>
<tr>
<td>(5 rows)</td>
</tr>
</tbody>
</table>

The following example returns the query plan for the same query with verbose output:

```sql
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) |
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 (p. 564).

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 (p. 565).

For more information, see DECLARE (p. 564), CLOSE (p. 448).

**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.
The following example declares a cursor named LOLLIPOP to select sales information for the Lollapalooza event, and then fetches rows from the result set using the cursor:

```sql
-- 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 privileges for a user or user group.

Privileges include access options such as being able to read data in tables and views, write data, and create tables. Use this command to give specific privileges for a table, database, schema, function, procedure, language, or column. To revoke privileges from a database object, use the REVOKE (p. 600) command.

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 privileges to an AWS Identity and Access Management (IAM) role. For the list of privileges, see the syntax.

For stored procedures, the only privilege 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 (p. 151).
Syntax

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | REFERENCES } [,...] | ALL [ PRIVILEGES ] }
   ON { [ TABLE ] table_name [,...] | ALL TABLES IN SCHEMA schema_name [,...] }
   TO { username [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [,...]

GRANT { { CREATE | TEMPORARY | TEMP } [,...] | ALL [ PRIVILEGES ] }
   ON DATABASE db_name [,...]
   TO { username [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [,...]

GRANT { { CREATE | USAGE } [,...] | ALL [ PRIVILEGES ] }
   ON SCHEMA schema_name [,...]
   TO { username [ WITH GRANT OPTION ] | 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 ] | 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 ] | GROUP group_name | PUBLIC } [,...]

GRANT USAGE
   ON LANGUAGE language_name [,...]
   TO { username [ WITH GRANT OPTION ] | GROUP group_name | PUBLIC } [,...]
```

The following is the syntax for column-level privileges on Amazon Redshift tables and views.

```
GRANT { { SELECT | UPDATE } ( column_name [, ...] ) [,...] | ALL [ PRIVILEGES ]
   ( column_name [,...] ) }
   ON { [ TABLE ] table_name [,...] }
   TO { username | GROUP group_name | PUBLIC } [,...]
```

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 ]
```

Parameters

SELECT

Grants privilege to select data from a table or view using a SELECT statement. The SELECT privilege is also required to reference existing column values for UPDATE or DELETE operations.

INSERT

Grants privilege to load data into a table using an INSERT statement or a COPY statement.
UPDATE

Grants privilege to update a table column using an UPDATE statement. UPDATE operations also require the SELECT privilege, because they must reference table columns to determine which rows to update, or to compute new values for columns.

DELETE

Grants privilege to delete a data row from a table. DELETE operations also require the SELECT privilege, because they must reference table columns to determine which rows to delete.

REFERENCES

Grants privilege to create a foreign key constraint. You need to grant this privilege on both the referenced table and the referencing table; otherwise, the user can't create the constraint.

ALL [ PRIVILEGES ]

Grants all available privileges at once to the specified user or user group. The PRIVILEGES keyword is optional.

GRANT ALL ON SCHEMA doesn't grant CREATE privileges for external schemas.

You can grant ALL privilege to a table in an AWS Glue Data Catalog that is enabled for Lake Formation. In this case, individual privileges (such as SELECT, ALTER, and so on) are recorded in the Data Catalog.

ALTER

Grants privilege to alter a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This privilege only applies when using Lake Formation.

DROP

Grants privilege to drop a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This privilege only applies when using Lake Formation.

ON [ TABLE ] table_name

Grants the specified privileges 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 privileges on all tables and views in the referenced schema.

( column_name [,...] ) ON TABLE table_name

Grants the specified privileges 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 privileges 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 privileges to an IAM role on the specified Lake Formation tables in the referenced schema.

ON EXTERNAL SCHEMA schema_name

Grants the specified privileges to an IAM role on the referenced schema.

TO username

Indicates the user receiving the privileges.
TO IAM_ROLE `iam_role`

Indicates the IAM role receiving the privileges.

WITH GRANT OPTION

Indicates that the user receiving the privileges can in turn grant the same privileges to others. WITH GRANT OPTION cannot be granted to a group or to PUBLIC.

GROUP `group_name`

Grants the privileges to a user group.

PUBLIC

Grants the specified privileges to all users, including users created later. PUBLIC represents a group that always includes all users. An individual user’s privileges consist of the sum of privileges granted to PUBLIC, privileges granted to any groups that the user belongs to, and any privileges granted to the user individually.

Granting PUBLIC to a Lake Formation EXTERNAL TABLE results in granting the privilege to the Lake Formation `everyone` group.

CREATE

Depending on the database object, grants the following privileges 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 privilege 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 (p. 420) to change the owner.

TEMPORARY | TEMP

Grants the privilege 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 privilege 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 privileges on a database.

USAGE

Grants USAGE privilege 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 privileges on tables). By default, all users have CREATE and USAGE privileges on the PUBLIC schema.

ON SCHEMA `schema_name`

Grants the specified privileges on a schema.

GRANT CREATE ON SCHEMA and the CREATE privilege 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 (p. 420) to change the owner.
GRANT

EXECUTE ON FUNCTION `function_name`

Grants the EXECUTE privilege on a specific function. Because function names can be overloaded, you must include the argument list for the function. For more information, see Naming UDFs (p. 188).

EXECUTE ON ALL FUNCTIONS IN SCHEMA `schema_name`

Grants the specified privileges on all functions in the referenced schema.

EXECUTE ON PROCEDURE `procedure_name`

Grants the EXECUTE privilege 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 (p. 193).

EXECUTE ON ALL PROCEDURES IN SCHEMA `schema_name`

Grants the specified privileges on all stored procedures in the referenced schema.

USAGE ON LANGUAGE `language_name`

Grants the USAGE privilege on a language.

The USAGE ON LANGUAGE privilege is required to create user-defined functions (UDFs) by running the CREATE FUNCTION (p. 525) command. For more information, see UDF Security and Privileges (p. 182).

The USAGE ON LANGUAGE privilege is required to create stored procedures by running the CREATE PROCEDURE (p. 533) command. For more information, see Security and Privileges for Stored Procedures (p. 194).

For Python UDFs, use `plpythonu`. For SQL UDFs, use `sql`. For stored procedures, use `plpgsql`.

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.

```sql
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.

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`.

```sql
create external schema mySchema
from data catalog
```
GRANT

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 Privileges

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 SELECT privilege on all columns in a table, performing a SELECT operation for all columns (`SELECT *`) fails.

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 look up grants of column-level privileges, use the `PG_ATTRIBUTE_INFO (p. 1088)` view.
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 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;

INSERT

Topics

- Syntax (p. 593)
- Parameters (p. 593)
- Usage Notes (p. 594)
- INSERT Examples (p. 594)

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 (p. 450) 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 (p. 550) to improve performance. For more information about using the COPY command to load tables, see Loading Data (p. 98).

**Note**
The maximum size for a single SQL statement is 16 MB.

**Syntax**

```sql
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**
Amazon Redshift Spectrum external tables are read-only. You can't INSERT to an 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:

```sql
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 (p. 450) 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 (p. 550) to improve performance. For more information about using the COPY command to load tables, see Loading Data (p. 98).

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 (p. 540).

**INSERT Examples**

The CATEGORY table in the TICKIT database contains the following rows:

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>594</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Create a CATEGORY_STAGE table with a similar schema to the CATEGORY table but define default values for the columns:

```sql
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.

```sql
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:

```sql
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:

```sql
insert into category_stage values
(13, 'Concerts', 'Other', default);
```

Run the following query to return the inserted rows:

```sql
select * from category_stage
where catid in(12,13) order by 1;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Concerts</td>
<td>Comedy</td>
<td>All stand-up comedy performances</td>
</tr>
<tr>
<td>13</td>
<td>Concerts</td>
<td>Other</td>
<td>General</td>
</tr>
</tbody>
</table>

(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.

```sql
insert into category_stage values
(14, default, default, default),
```
The next example inserts three rows with various combinations of specific and default values:

```sql
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;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>General</td>
<td>General</td>
<td>General</td>
</tr>
<tr>
<td>20</td>
<td>General</td>
<td>Country</td>
<td>General</td>
</tr>
<tr>
<td>21</td>
<td>Concerts</td>
<td>Rock</td>
<td>General</td>
</tr>
</tbody>
</table>

(3 rows)

The first set of VALUES in this example produce 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:

```sql
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;

select catgroup,catname,catdesc from category_ident;
```

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:

```sql
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

### 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 abort if they violate serializable isolation rules.) See Managing Concurrent Write
Operations (p. 151).

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 aborted. Every time a lock
conflict occurs, Amazon Redshift writes an entry to the STL_TR_CONFLICT (p. 980) 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

```sql
BEGIN;
LOCK event, sales;
...
```

**PREPARE**

Prepare a statement for execution.

PREPARE creates a prepared statement. When the PREPARE statement is executed, 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 executing 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 execute 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.

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 executed. 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, ... When executing the statement, specify the actual values for these parameters in the EXECUTE statement. See EXECUTE (p. 579) for more details.

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 execute 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 (p. 580) command.

For more information on query planning and the statistics collected by Amazon Redshift for query optimization, see the ANALYZE (p. 439) command.

Examples

Create a temporary table, prepare INSERT statement and then execute it:

```sql
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 execute it:

```sql
PREPARE prep_select_plan (int) AS select * from prep1 where c1 = $1;
EXECUTE prep_select_plan (2);
EXECUTE prep_select_plan (3);
```
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 the 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.

`REFRESH MATERIALIZED VIEW` attempts to perform an incremental refresh. However, if the underlying SQL query for the materialized view can't be incrementally refreshed, then Amazon Redshift refreshes by full recomputation of the materialized view. For information about which SQL elements can't support incremental refreshes, see Limitations and Usage Notes for Materialized Views (p. 219).

For more information about materialized views, see Creating Materialized Views in Amazon Redshift (p. 218).

Syntax

```
REFRESH MATERIALIZED VIEW mv_name
```

Parameters

`mv_name`

The name of the materialized view to be refreshed.

Usage Notes

Only the owner of a materialized view can perform a `REFRESH MATERIALIZED VIEW` operation on that view. If the owner no longer has SELECT privilege on the underlying base tables, `REFRESH MATERIALIZED VIEW` doesn't run.

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.

Furthermore, take a case where a transaction B follows a transaction A. In such a case, `REFRESH MATERIALIZED VIEW` doesn't see some committed base table rows that are updated by transaction B while the older transaction A is in progress. These omitted rows are updated by subsequent refresh operations.

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.

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.
An operation can force a full refresh even when the materialized view only uses the SQL features that lend themselves to incremental refresh. For more information, see Limitations and Usage Notes for Materialized Views (p. 219).

**Examples**

The following example refreshes the `tickets_mv` materialized view.

```
REFRESH MATERIALIZED VIEW tickets_mv;
```

**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 (p. 636) command. To display the current value of a parameter, use the SHOW (p. 639) command.

**Syntax**

```
RESET { parameter_name | ALL }
```

**Parameters**

`parameter_name`

Name of the parameter to reset. See Modifying the Server Configuration (p. 1101) for more documentation about parameters.

`ALL`

Resets all runtime parameters.

**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;
```

**REVOKE**

Removes access privileges, such as privileges to create or update tables, from a user or user group.

You can only GRANT or REVOKE USAGE permissions on an external schema to database users and user groups using the ON SCHEMA syntax. When using ON EXTERNAL SCHEMA with AWS Lake Formation, you can only GRANT and REVOKE privileges to an AWS Identity and Access Management (IAM) role. For the list of privileges, 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 privileges that you want to remove. To give privileges, use the GRANT (p. 585) command.

### Syntax

| REVOKE [ GRANT OPTION FOR ] | ( { SELECT | INSERT | UPDATE | DELETE | REFERENCES } [,...] | ALL [ PRIVILEGES ] ) |
|------------------------------|------------------------------------------------------------------------------------------------|
| ON { [ TABLE ] table_name [, ...] | ALL TABLES IN SCHEMA schema_name [, ...] } |
| FROM { username | GROUP group_name | PUBLIC } [, ...] |
| [ CASCADE | RESTRICT ] |

| REVOKE [ GRANT OPTION FOR ] | ( { CREATE | TEMPORARY | TEMP } [,...] | ALL [ PRIVILEGES ] ) |
|------------------------------|------------------------------------------------------------------------------------------------|
| ON DATABASE db_name [, ...] |
| FROM { username | GROUP group_name | PUBLIC } [, ...] |
| [ CASCADE | RESTRICT ] |

| REVOKE [ GRANT OPTION FOR ] | ( { CREATE | USAGE } [,...] | ALL [ PRIVILEGES ] ) |
|------------------------------|------------------------------------------------------------------------------------------------|
| ON SCHEMA schema_name [, ...] |
| FROM { username | GROUP group_name | PUBLIC } [, ...] |
| [ CASCADE | RESTRICT ] |

<table>
<thead>
<tr>
<th>REVOKE [ GRANT OPTION FOR ]</th>
<th>EXECUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON FUNCTION function_name ( { [ argname ] argtype [, ...] } [, ...] )</td>
<td></td>
</tr>
<tr>
<td>FROM { username</td>
<td>GROUP group_name</td>
</tr>
<tr>
<td>[ CASCADE</td>
<td>RESTRICT ]</td>
</tr>
</tbody>
</table>

| REVOKE [ GRANT OPTION FOR ] | ( { EXECUTE } [,...] | ALL [ PRIVILEGES ] ) |
|------------------------------|------------------------------------------------------------------------------------------------|
| ON PROCEDURE procedure_name ( { [ argname ] argtype [, ...] } [, ...] ) |
| FROM { username | GROUP group_name | PUBLIC } [, ...] |
| [ CASCADE | RESTRICT ] |

<table>
<thead>
<tr>
<th>REVOKE [ GRANT OPTION FOR ]</th>
<th>USAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON LANGUAGE language_name [, ...]</td>
<td></td>
</tr>
<tr>
<td>FROM { username</td>
<td>GROUP group_name</td>
</tr>
<tr>
<td>[ CASCADE</td>
<td>RESTRICT ]</td>
</tr>
</tbody>
</table>

The following is the syntax for column-level privileges on Amazon Redshift tables and views.

| REVOKE { { SELECT | UPDATE } ( column_name [, ...] ) [, ...] | ALL [ PRIVILEGES ] | ( column_name [, ...] ) } |
|---------------------------------------------|------------------------------------------------------------------------------------------------|
| ON { [ TABLE ] table_name [, ...] } |
| FROM { username | GROUP group_name | PUBLIC } [, ...] |
| [ CASCADE | RESTRICT ] |

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 ] |
REVOKE

{ { CREATE | ALTER | DROP } [, ...] | ALL [ PRIVILEGES ] } 
ON EXTERNAL SCHEMA schema_name [, ...]
FROM { IAM_ROLE iam_role } [, ...]

Parameters

GRANT OPTION FOR

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.

SELECT

Revokes the privilege to select data from a table or a view using a SELECT statement.

INSERT

Revokes the privilege to load data into a table using an INSERT statement or a COPY statement.

UPDATE

Revokes the privilege to update a table column using an UPDATE statement.

DELETE

Revokes the privilege to delete a data row from a table.

REFERENCES

Revokes the privilege to create a foreign key constraint. You should revoke this privilege on both the referenced table and the referencing table.

ALL [ PRIVILEGES ]

Revokes all available privileges at once from the specified user or group. The PRIVILEGES keyword is optional.

ALTER

Revokes privilege to alter a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This privilege only applies when using Lake Formation.

DROP

Revokes privilege to drop a table in an AWS Glue Data Catalog that is enabled for Lake Formation. This privilege only applies when using Lake Formation.

ON [ TABLE ] table_name

Revokes the specified privileges on a table or a view. The TABLE keyword is optional.

ON ALL TABLES IN SCHEMA schema_name

Revokes the specified privileges on all tables in the referenced schema.

( column_name [, ...] ) ON TABLE table_name

Revokes the specified privileges 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 privileges 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 privileges from an IAM role on the specified Lake Formation tables in the referenced schema.
ON EXTERNAL SCHEMA schema_name

Revokes the specified privileges from an IAM role on the referenced schema.
FROM IAM_ROLE iam_role

Indicates the IAM role losing the privileges.
GROUP group_name

Revokes the privileges from the specified user group.
PUBLIC

Revokes the specified privileges from all users. PUBLIC represents a group that always includes all users. An individual user’s privileges consist of the sum of privileges granted to PUBLIC, privileges granted to any groups that the user belongs to, and any privileges granted to the user individually.

Revoking PUBLIC from a Lake Formation external table results in revoking the privilege from the Lake Formation everyone group.
CREATE

Depending on the database object, revokes the following privileges 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 privilege and own the object to be renamed.

Note
By default, all users have CREATE and USAGE privileges on the PUBLIC schema.
TEMPORARY | TEMP

Revokes the privilege 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 privilege 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 privileges on the specified database.
USAGE

Revokes USAGE privileges 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 privilege on functions).

Note
By default, all users have CREATE and USAGE privileges on the PUBLIC schema.
ON SCHEMA schema_name

Revokes the privileges on the specified schema. You can use schema privileges to control the creation of tables; the CREATE privilege for a database only controls the creation of schemas.
CASCADE

If a user holds a privilege with grant option and has granted the privilege to other users, the privileges held by those other users are dependent privileges. If the privilege or the grant option held
by the first user is being revoked and dependent privileges exist, those dependent privileges are also revoked if CASCADE is specified; otherwise, the revoke action fails.

For example, if user A has granted a privilege with grant option to user B, and user B has granted the privilege to user C, user A can revoke the grant option from user B and use the CASCADE option to in turn revoke the privilege from user C.

RESTRICT

Revokes only those privileges that the user directly granted. This behavior is the default.

EXECUTE ON FUNCTION function_name

Revokes the EXECUTE privilege on a specific function. Because function names can be overloaded, you must include the argument list for the function. For more information, see Naming UDFs (p. 188).

EXECUTE ON PROCEDURE procedure_name

Revokes the EXECUTE privilege 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 (p. 193).

EXECUTE ON ALL PROCEDURES IN SCHEMA procedure_name

Revokes the specified privileges on all procedures in the referenced schema.

USAGE ON LANGUAGE language_name

Revokes the USAGE privilege 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.

```sql
revoke usage on language sql from PUBLIC;
grant usage on language sql to group udf_devs;
```

For more information, see UDF Security and Privileges (p. 182).

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 (p. 194).

**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.

```sql
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.

**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`.

```sql
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.

```sql
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.

```sql
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.

```sql
revoke select(cust_name) on cust_profile_vw from user2;
```

### ROLLBACK

Aborts the current transaction and discards all updates made by that transaction.

This command performs the same function as the `ABORT (p. 413)` command.

#### Syntax

```sql
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 (p. 196).

#### 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:

<table>
<thead>
<tr>
<th>name</th>
<th>gross</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raiders of the Lost Ark</td>
<td>23400000</td>
</tr>
<tr>
<td>Star Wars</td>
<td>10000000</td>
</tr>
</tbody>
</table>

(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;

<table>
<thead>
<tr>
<th>name</th>
<th>gross</th>
</tr>
</thead>
</table>

(0 rows)

**SELECT**

**Topics**

- Syntax (p. 608)
- WITH Clause (p. 608)
- SELECT List (p. 611)
- FROM Clause (p. 614)
- WHERE Clause (p. 615)
- GROUP BY Clause (p. 620)
- HAVING Clause (p. 621)
- UNION, INTERSECT, and EXCEPT (p. 622)
- ORDER BY Clause (p. 629)
- Join Examples (p. 632)
- Subquery Examples (p. 632)
- Correlated Subqueries (p. 633)

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 ] [, ... ]
[ FROM table_reference [, ...] ]
[ WHERE condition ]
[ GROUP BY expression [, ...] ]
[ HAVING condition ]
[ { UNION | ALL | INTERSECT | EXCEPT | MINUS } query ]
[ ORDER BY expression
[ ASC | DESC ]
[ LIMIT { number | ALL } ]
[ OFFSET start ]
```

WITH Clause

A WITH clause is an optional clause that precedes the SELECT list in a query. The WITH clause defines one or more subqueries. Each subquery defines a temporary table, similar to a view definition. These temporary tables can be referenced in the FROM clause and are used only during the execution of the query to which they belong. Each subquery 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).

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 with_subquery [, ...] ]
```

where `with_subquery` is:

```
with_subquery_table_name [ { column_name [, ...] } ] AS ( query )
```

Parameters

`with_subquery_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 (p. 614).

`column_name`

An optional 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.

`query`

Any SELECT query that Amazon Redshift supports. See SELECT (p. 607).
Usage Notes

You can use a WITH clause in the following SQL statements:

- SELECT (including subqueries within SELECT statements)
- SELECT INTO
- CREATE TABLE AS
- CREATE VIEW
- DECLARE
- EXPLAIN
- INSERT INTO...SELECT
- PREPARE
- UPDATE (within a WHERE clause subquery)

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 executes 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:

```sql
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.

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.

```sql
with venuecopy as (select * from venue)
select * from venuecopy order by 1 limit 10;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toyota Park</td>
<td>Bridgeview</td>
<td>IL</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Columbus Crew Stadium</td>
<td>Columbus</td>
<td>OH</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>RFK Stadium</td>
<td>Washington</td>
<td>DC</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>CommunityAmerica Ballpark</td>
<td>Kansas City</td>
<td>KS</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Foxborough</td>
<td>MA</td>
<td>68756</td>
</tr>
<tr>
<td>6</td>
<td>New York Giants Stadium</td>
<td>East Rutherford</td>
<td>NJ</td>
<td>80242</td>
</tr>
<tr>
<td>7</td>
<td>BMO Field</td>
<td>Toronto</td>
<td>ON</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>The Home Depot Center</td>
<td>Carson</td>
<td>CA</td>
<td>0</td>
</tr>
</tbody>
</table>
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.

```sql
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;
```

<table>
<thead>
<tr>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venue_qty</th>
<th>venue_sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>August Wilson Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>3187</td>
<td>1032156.00</td>
</tr>
<tr>
<td>Biltmore Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2629</td>
<td>828981.00</td>
</tr>
<tr>
<td>Charles Playhouse</td>
<td>Boston</td>
<td>MA</td>
<td>2502</td>
<td>857031.00</td>
</tr>
<tr>
<td>Ethel Barrymore Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2828</td>
<td>891172.00</td>
</tr>
<tr>
<td>Eugene O'Neill Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2488</td>
<td>828950.00</td>
</tr>
<tr>
<td>Greek Theatre</td>
<td>Los Angeles</td>
<td>CA</td>
<td>2445</td>
<td>838918.00</td>
</tr>
<tr>
<td>Helen Hayes Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2948</td>
<td>978765.00</td>
</tr>
<tr>
<td>Hilton Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2999</td>
<td>885686.00</td>
</tr>
<tr>
<td>Imperial Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2802</td>
<td>877993.00</td>
</tr>
<tr>
<td>Lunt-Fontanne Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>3326</td>
<td>1115182.00</td>
</tr>
<tr>
<td>Majestic Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2549</td>
<td>894275.00</td>
</tr>
<tr>
<td>Nederlander Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2934</td>
<td>936312.00</td>
</tr>
<tr>
<td>Pasadena Playhouse</td>
<td>Pasadena</td>
<td>CA</td>
<td>2739</td>
<td>820435.00</td>
</tr>
<tr>
<td>Winter Garden Theatre</td>
<td>New York City</td>
<td>NY</td>
<td>2838</td>
<td>939257.00</td>
</tr>
</tbody>
</table>

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:

```sql
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;
```
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.

```sql
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
```

### SELECT List

**Topics**

- Syntax (p. 611)
- Parameters (p. 611)
- Usage Notes (p. 612)
- Examples with TOP (p. 612)
- SELECT DISTINCT Examples (p. 613)

The SELECT list names the columns, functions, and expressions that you want the query to return. The list represents the output of the query.

#### 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.
SELECT

* (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, salestime))
```

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, salestime)) 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 with TOP

Return any 10 rows from the SALES table. Because no ORDER BY clause is specified, the set of rows that this query returns is unpredictable.

```
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;
```

Return the first 10 rows from the SALES table, 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)

Return 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)

SELECT DISTINCT Examples

Return a list of different category groups from the CATEGORY table:

select distinct catgroup from category
order by 1;

catgroup
-------
Concerts
Shows
Sports
(3 rows)

Return the distinct set of week numbers for December 2008:

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)
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).

Syntax

```sql
FROM table_reference [, ...]
```

where `table_reference` is one of the following:

```sql
with_subquery_table_name [ AS alias [ ( column_alias [, ...] ) ] ]
table_name [ * ] [ AS alias [ ( column_alias [, ...] ) ] ]
( subquery ) [ AS alias [ ( column_alias [, ...] ) ] ]
table_reference [ NATURAL ] join_type table_reference
[ ON join_condition | USING ( join_column [, ...] ) ]
```

Parameters

`with_subquery_table_name`
A table defined by a subquery in the WITH Clause (p. 608).

`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:

```sql
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

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)
```

Join Types

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.

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 (p. 608).

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
```
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 TABLE2 that have no matching rows in TABLE1, 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

```sql
[ WHERE {
[ table1.column1 = table2.column1(+) ]
[ table1.column1(+) = table2.column1 ]
}
```

The first condition is equivalent to:

```sql
from table1 left outer join table2
on table1.column1=table2.column1
```

The second condition is equivalent to:

```sql
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:

```sql
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:

```sql
event.eventid*10(+)=category.catid
```

However, the following join condition is valid:

```sql
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 executes 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:

```sql
select count(*)
from event a, event b
where a.eventid(+)=b.catid;
```

```sql
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:

```sql
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.

```sql
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:

```sql
select count(*)
from sales, listing
where sales.listid = listing.listid(+);
```
The following equivalent query produces the same result but uses FROM clause join syntax:

```sql
select count(*)
from sales left outer join listing on sales.listid = listing.listid;
```

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.

```sql
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      |  76.00 |  11.40 |
| 4      | 525.00 |  78.75 |

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:

```sql
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:

```sql
select catname, catgroup, eventid
from category, event
where category.catid=event.catid(+)
```
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:

```sql
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`).

```sql
select catname, catgroup, eventid
from category, event
where category.catid=event.catid(+) and eventid=796;
```

<table>
<thead>
<tr>
<th>catname</th>
<th>catgroup</th>
<th>eventid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musicals</td>
<td>Shows</td>
<td>796</td>
</tr>
<tr>
<td>(1 row)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GROUP BY Clause**

The GROUP BY clause identifies the grouping columns for the query. 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 (p. 669).

**GROUP BY expression [, ...]**

**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:

```sql
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;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>eventid</th>
<th>revenue</th>
<th>numtix</th>
</tr>
</thead>
<tbody>
<tr>
<td>89397</td>
<td>47</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>106590</td>
<td>76</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>124683</td>
<td>393</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>103037</td>
<td>403</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>147685</td>
<td>429</td>
<td>20.00</td>
<td>1</td>
</tr>
</tbody>
</table>

620
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:

```sql
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;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>eventid</th>
<th>revenue</th>
<th>numtix</th>
</tr>
</thead>
<tbody>
<tr>
<td>89397</td>
<td>47</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>106590</td>
<td>76</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>124683</td>
<td>393</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>103037</td>
<td>403</td>
<td>20.00</td>
<td>1</td>
</tr>
<tr>
<td>147685</td>
<td>429</td>
<td>20.00</td>
<td>1</td>
</tr>
</tbody>
</table>

**HAVING Clause**

The HAVING clause applies a condition to the intermediate grouped result set that a query returns.

**Syntax**

```sql
[ HAVING condition ]
```

For example, you can restrict the results of a SUM function:

```sql
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 alias that was defined in the select list. You must repeat the original, unaliased expression.
  - 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)`.
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;
```

<table>
<thead>
<tr>
<th>eventname</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamma Mia!</td>
<td>1135454.00</td>
</tr>
<tr>
<td>Spring Awakening</td>
<td>972855.00</td>
</tr>
<tr>
<td>The Country Girl</td>
<td>910563.00</td>
</tr>
<tr>
<td>Macbeth</td>
<td>862580.00</td>
</tr>
<tr>
<td>Jersey Boys</td>
<td>811877.00</td>
</tr>
<tr>
<td>Legally Blonde</td>
<td>804583.00</td>
</tr>
<tr>
<td>Chicago</td>
<td>790993.00</td>
</tr>
<tr>
<td>Spamalot</td>
<td>714307.00</td>
</tr>
</tbody>
</table>

(8 rows)

UNION, INTERSECT, and EXCEPT

Topics
- Syntax (p. 623)
- Parameters (p. 623)
- Order of Evaluation for Set Operators (p. 623)
- Usage Notes (p. 624)
- Example UNION Queries (p. 625)
- Example UNION ALL Query (p. 626)
- Example INTERSECT Queries (p. 627)
- Example EXCEPT Query (p. 628)

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 (p. 388).

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
```
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:

```sql
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.

```sql
(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.

- The LIMIT and OFFSET clauses aren't supported as a means of restricting the number of rows returned by an intermediate result of a set operation. For example, the following query returns an error:

```sql
(select listid from listing
limit 10)
intersect
select listid from sales;
```

**ERROR**: LIMIT may not be used within input to set operations.

- 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):

```sql
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.

```sql
select listid, sellerid, eventid from listing
union select listid, sellerid, eventid from sales
order by listid, sellerid, eventid desc limit 5;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>sellerid</th>
<th>eventid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36861</td>
<td>7872</td>
</tr>
<tr>
<td>2</td>
<td>16002</td>
<td>4806</td>
</tr>
<tr>
<td>3</td>
<td>21461</td>
<td>4256</td>
</tr>
<tr>
<td>4</td>
<td>8117</td>
<td>4337</td>
</tr>
<tr>
<td>5</td>
<td>1616</td>
<td>8647</td>
</tr>
</tbody>
</table>

(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.

```sql
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;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>lastname</th>
<th>firstname</th>
<th>username</th>
<th>price</th>
<th>buyorsell</th>
</tr>
</thead>
<tbody>
<tr>
<td>209658</td>
<td>Lamb</td>
<td>Colette</td>
<td>VOR15LYI</td>
<td>10000.00</td>
<td>B</td>
</tr>
<tr>
<td>209658</td>
<td>West</td>
<td>Rato</td>
<td>ELU81XAA</td>
<td>10000.00</td>
<td>S</td>
</tr>
<tr>
<td>212395</td>
<td>Greer</td>
<td>Harlan</td>
<td>GX071KOC</td>
<td>12624.00</td>
<td>S</td>
</tr>
<tr>
<td>212395</td>
<td>Perry</td>
<td>Cora</td>
<td>YWR73YNZ</td>
<td>12624.00</td>
<td>B</td>
</tr>
<tr>
<td>215156</td>
<td>Banks</td>
<td>Patrick</td>
<td>ZNQ969CLT</td>
<td>10000.00</td>
<td>S</td>
</tr>
<tr>
<td>215156</td>
<td>Hayden</td>
<td>Malachi</td>
<td>BBG56AKU</td>
<td>10000.00</td>
<td>B</td>
</tr>
</tbody>
</table>

(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').

```sql
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;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>listid</th>
<th>salesrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7787</td>
<td>500</td>
<td>No</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>6473</td>
<td>501</td>
<td>No</td>
</tr>
<tr>
<td>5108</td>
<td>502</td>
<td>No</td>
</tr>
</tbody>
</table>

(6 rows)

If you run the same query without the ALL keyword, the result retains only one of the sales transactions.

```sql
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;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>listid</th>
<th>salesrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7787</td>
<td>500</td>
<td>No</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>6473</td>
<td>501</td>
<td>No</td>
</tr>
<tr>
<td>5108</td>
<td>502</td>
<td>No</td>
</tr>
</tbody>
</table>

(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;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>listid</th>
<th>salesrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7787</td>
<td>500</td>
<td>No</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>6473</td>
<td>501</td>
<td>No</td>
</tr>
<tr>
<td>5108</td>
<td>502</td>
<td>No</td>
</tr>
</tbody>
</table>

(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;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>listid</th>
<th>salesrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7787</td>
<td>500</td>
<td>No</td>
</tr>
<tr>
<td>7787</td>
<td>500</td>
<td>Yes</td>
</tr>
<tr>
<td>6473</td>
<td>501</td>
<td>No</td>
</tr>
<tr>
<td>5108</td>
<td>502</td>
<td>No</td>
</tr>
</tbody>
</table>

(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:

```
select listid, sellerid, eventid from listing
intersect
select listid, sellerid, eventid from sales
```

This is the only row in the limited result of 5 rows that was found in both tables.
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.

```sql
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;
```

<table>
<thead>
<tr>
<th>eventname</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Streetcar Named Desire</td>
</tr>
<tr>
<td>Dirty Dancing</td>
</tr>
<tr>
<td>Electra</td>
</tr>
<tr>
<td>Running with Annalise</td>
</tr>
<tr>
<td>Hairspray</td>
</tr>
<tr>
<td>Mary Poppins</td>
</tr>
<tr>
<td>November</td>
</tr>
<tr>
<td>Oliver!</td>
</tr>
<tr>
<td>Return To Forever</td>
</tr>
<tr>
<td>Rhinoceros</td>
</tr>
<tr>
<td>South Pacific</td>
</tr>
<tr>
<td>The 39 Steps</td>
</tr>
<tr>
<td>The Bacchae</td>
</tr>
<tr>
<td>The Caucasian Chalk Circle</td>
</tr>
<tr>
<td>The Country Girl</td>
</tr>
<tr>
<td>Wicked</td>
</tr>
<tr>
<td>Woyzeck</td>
</tr>
</tbody>
</table>

(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         |
```
Assume that a CATEGORY_STAGE table (a staging table) contains one additional row:

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Concerts</td>
<td>Comedy</td>
<td>All stand up comedy performances</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Concerts</td>
<td>Comedy</td>
<td>All stand up comedy performances</td>
</tr>
</tbody>
</table>

The following equivalent query uses the synonym MINUS.

```
select * from category_stage
minus
select * from category;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Concerts</td>
<td>Comedy</td>
<td>All stand up comedy performances</td>
</tr>
</tbody>
</table>

If you reverse the order of the SELECT expressions, the query returns no rows.

**ORDER BY Clause**

**Topics**
- Syntax (p. 629)
- Parameters (p. 630)
- Usage Notes (p. 630)
- Examples with ORDER BY (p. 631)

The ORDER BY clause sorts the result set of a query.

**Syntax**

```
[ ORDER BY expression
```
### 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 executed 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.

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 | 2008-06-07 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;
Join Examples

The following query is an 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 LISTING (the left table) and SALES (the right table). The results show that listings 2, 3, and 5 did not result in any sales.

```sql
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      |        |       |
| 3      |        |       |
| 4      | 76.00  | 11.40 |
| 5      | 525.00 | 78.75 |

(5 rows)

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):

```sql
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 |

(2 rows)

These FROM clause subqueries are *table* subqueries; they can return multiple columns and rows.

Subquery Examples

The following examples show different ways in which subqueries fit into SELECT queries. See Join Examples (p. 632) 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;
```

<table>
<thead>
<tr>
<th>qtr</th>
<th>qtrsales</th>
<th>q1sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>30560050.00</td>
<td>24742065.00</td>
</tr>
<tr>
<td>3</td>
<td>31170237.00</td>
<td>24742065.00</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>firstname</th>
<th>lastname</th>
<th>city</th>
<th>maxsold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noah</td>
<td>Guerrero</td>
<td>Worcester</td>
<td>8</td>
</tr>
<tr>
<td>Isadora</td>
<td>Moss</td>
<td>Winooski</td>
<td>8</td>
</tr>
<tr>
<td>Kieran</td>
<td>Harrison</td>
<td>Westminster</td>
<td>8</td>
</tr>
<tr>
<td>Heidi</td>
<td>Davis</td>
<td>Warwick</td>
<td>8</td>
</tr>
<tr>
<td>Sara</td>
<td>Anthony</td>
<td>Waco</td>
<td>8</td>
</tr>
<tr>
<td>Bree</td>
<td>Buck</td>
<td>Valdez</td>
<td>8</td>
</tr>
<tr>
<td>Evangeline</td>
<td>Sampson</td>
<td>Trenton</td>
<td>8</td>
</tr>
<tr>
<td>Kendall</td>
<td>Keith</td>
<td>Stillwater</td>
<td>8</td>
</tr>
<tr>
<td>Bertha</td>
<td>Bishop</td>
<td>Stevens Point</td>
<td>8</td>
</tr>
<tr>
<td>Patricia</td>
<td>Anderson</td>
<td>South Portland</td>
<td>8</td>
</tr>
</tbody>
</table>

WITH Clause Subqueries

See WITH Clause (p. 608).

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 executed to qualify or disqualify the row.

<table>
<thead>
<tr>
<th>salesid</th>
<th>listid</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>28</td>
<td>111.00</td>
</tr>
<tr>
<td>81</td>
<td>103</td>
<td>181.00</td>
</tr>
<tr>
<td>142</td>
<td>149</td>
<td>240.00</td>
</tr>
<tr>
<td>146</td>
<td>152</td>
<td>231.00</td>
</tr>
<tr>
<td>194</td>
<td>210</td>
<td>144.00</td>
</tr>
</tbody>
</table>

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:

```sql
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 join:

```sql
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:

```sql
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 = opowner);
```

- Correlation references from within a subquery that contains a window function.

```sql
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 ] [, ...]
INTO [ TEMPORARY | TEMP ] [ TABLE ] new_table
[ FROM table_reference [, ...] ]
[ WHERE condition ]
[ GROUP BY expression [, ...] ]
[ HAVING condition [, ...] ]
[ { UNION | INTERSECT | { EXCEPT | MINUS } } [ ALL ] query ]
[ ORDER BY expression
[ ASC | DESC ]
[ LIMIT { number | ALL } ]
[ OFFSET start ]
```

For details about the parameters of this command, see SELECT (p. 607).

### 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
```
### SET

Sets the value of a server configuration parameter.

Use the `RESET` (p. 600) command to return a parameter to its default value. See Modifying the Server Configuration (p. 1101) for more information about parameters.

#### Syntax

```
SET { [ SESSION | LOCAL ]
( SEED | parameter_name ) { TO | = }
( value | 'value' | DEFAULT ) |
SEED TO value }
```

#### Parameters

**SESSION**

Specifies that the setting is valid for the current session. Default value.

**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 (p. 829) 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 (p. 1101) 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.

```sql
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;
```

See Implementing Workload Management (p. 309)

### Setting a Label for a Group of Queries

The QUERY_GROUP parameter defines a label for one or more queries that are executed in the same session after a SET command. In turn, this label is logged when queries are executed and can be used to constrain results returned from the STL_QUERY and STV_INFLIGHT system tables and the SVL_QLOG view.

```sql
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:
SET

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)
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.

Syntax

```
SET [ SESSION | LOCAL ] SESSION AUTHORIZATION { user_name | DEFAULT }
```

Parameters

SESSION

Specifies that the setting is valid for the current session. Default value.

LOCAL

Specifies that the setting is valid for the current transaction.

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 (p. 1101).
Syntax

SHOW { parameter_name | ALL }

Parameters

parameter_name

Displays the current value of the specified parameter.

ALL

Displays the current values of all of the parameters.

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
```

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_sp2.

```
show procedure test_sp2(int, varchar);
```

```
CREATE OR REPLACE PROCEDURE public.test_sp2(f1 integer, INOUT f2 character varying, OUT character varying)
LANGUAGE plpgsql
AS $$_$
DECLARE
  out_var alias for $3;
  loop_var int;
BEGIN
  IF f1 is null OR f2 is null THEN
    RAISE EXCEPTION 'input cannot be null';
  END IF;
  CREATE TEMP TABLE etl(a int, b varchar);
  FOR loop_var IN 1..f1 LOOP
    insert into etl values (loop_var, f2);
    f2 := f2 || '+' || f2;
  END LOOP;
  SELECT INTO out_var count(*) from etl;
END;
$$$_
```

START TRANSACTION

Synonym of the BEGIN function.

See BEGIN (p. 442).

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 execute a TRUNCATE command, you must be the owner of the table or a superuser.

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
```

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.

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.

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.

UNLOAD

Unloads the result of a query to one or more text 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) or client-side encryption with a customer-managed key (CSE-CMK).

You can manage the size of files on Amazon S3, and by extension the number of files, by setting the MAXFILESIZE parameter.

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.

Syntax

```
UNLOAD ('select-statement')
TO 's3://object-path/name-prefix'
authorization
[ option [ ... ] ]
where option is
```
UNLOAD

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.

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 Management Console or API. For more information, go to Protecting Data Using Server-Side Encryption.

To use Amazon S3 client-side encryption, specify the ENCRYPTED option.
Important
REGION is required when the Amazon S3 bucket isn't in the same AWS Region as the Amazon Redshift cluster.

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 (p. 465) in the COPY command syntax reference.

[ FORMAT [AS] ] CSV | PARQUET

When CSV, unloads to a text file in CSV format using a comma (,) character as the delimiter. If a field contains commas, 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 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.

The FORMAT and AS keywords are optional. You can't use CSV with DELIMITER or FIXEDWIDTH. 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).

PARTITION BY (column_name [, ... ])

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://my_bucket_name/my_prefix/year=2019/month=September/000.parquet.

The value for column_name must be a column in the query results being unloaded.

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://mybucket/venue_', the manifest file location is 's3://mybucket/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. HEADER can't be used with FIXEDWIDTH.
DELIMITER AS 'delimiter_character'

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 is a pipe character. The AS keyword is optional. DELIMITER can't be used 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, ...'

FIXEDWIDTH can't be used with DELIMITER or HEADER.

ENCRYPTED

A clause that specifies that the output files on Amazon S3 are encrypted using Amazon S3 server-side encryption or client-side encryption. If MANIFEST is specified, the manifest file is also encrypted. For more information, see Unloading Encrypted Data Files (p. 179). 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).

To unload to Amazon S3 using server-side encryption with an AWS KMS key (SSE-KMS), use the KMS_KEY_ID (p. 645) parameter to provide the key ID. You can't use the CREDENTIALS (p. 466) parameter with the KMS_KEY_ID parameter. If you UNLOAD data using KMS_KEY_ID, you can then COPY the same data without specifying a key.

To unload to Amazon S3 using client-side encryption with a customer-supplied symmetric key (CSE-CMK), provide the key using the MASTER_SYMMETRIC_KEY (p. 645) parameter or the master_symmetric_key portion of a CREDENTIALS (p. 466) credential string. If you unload data using a master symmetric key, you must supply the same key when you COPY the encrypted data.

UNLOAD doesn't support Amazon S3 server-side encryption with a customer-supplied key (SSE-C).

To compress encrypted unload files, add the BZIP2, GZIP, or ZSTD parameter.

KMS_KEY_ID 'key-id'

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 (p. 645) parameter also. If you specify KMS_KEY_ID, you can't authenticate using the CREDENTIALS parameter. Instead, use either IAM_ROLE (p. 465) or ACCESS_KEY_ID and SECRET_ACCESS_KEY (p. 465).

MASTER_SYMMETRIC_KEY 'master_key'

The master symmetric key to be used to encrypt data files on Amazon S3. If you specify MASTER_SYMMETRIC_KEY, you must specify the ENCRYPTED (p. 645) parameter also. MASTER_SYMMETRIC_KEY can't be used with the CREDENTIALS parameter. For more information, see Loading Encrypted Data Files from Amazon S3 (p. 109).

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.

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

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.
**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://mybucket/key000    6.2 GB
s3://mybucket/key001    6.2 GB
s3://mybucket/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 ]**

The maximum size of files 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.

**REGION [AS] 'aws-region'**

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 cluster.

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 cluster.

**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')
```
Instead, use a nested LIMIT clause, as in the following example.

```sql
UNLOAD ('select * from venue where venueid in 
(select venueid from venue order by venueid desc limit 10)')
to 's3://mybucket/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.

### 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.
- The MANIFEST keyword isn't supported.
- The column data types that you can use as the partition key are SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, BOOLEAN, CHAR, VARCHAR, DATE, and TIMESTAMP.
UNLOAD Examples

Unload VENUE to a Pipe-Delimited File (Default Delimiter)

Note
These examples contain line breaks for readability. Do not include line breaks or spaces in your credentials-args string.

The following example unloads the VENUE table and writes the data to s3://mybucket/unload/:

```sql
unload ('select * from venue')
to 's3://mybucket/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 mybucket:

```
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://mybucket/venue_pipe_:

```sql
unload ('select * from venue')
to 's3://mybucket/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.

```sql
unload ('select * from lineitem')
to 's3://mybucket/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://mybucket/lineitem/l_shipdate=1992-01-02/0000_part_00.parquet
0001_part_00.parquet
0002_part_00.parquet
0003_part_00.parquet
s3://mybucket/lineitem/l_shipdate=1992-01-03/0000_part_00.parquet
0001_part_00.parquet
0002_part_00.parquet
0003_part_00.parquet
```
Unload VENUE to a CSV file

The following example unloads the VENUE table and writes the data in CSV format to s3://mybucket/unload/.

```sql
unload ('select * from venue')
to 's3://mybucket/unload/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
CSV;
```

Suppose the VENUE table contains the following rows.

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pinewood Racetrack</td>
<td>Akron</td>
<td>OH</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Columbus &quot;Crew&quot; Stadium</td>
<td>Columbus</td>
<td>OH</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Community, Ballpark, Arena</td>
<td>Kansas City</td>
<td>KS</td>
<td>0</td>
</tr>
</tbody>
</table>

The unload file would look 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 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://mybucket/venue_pipe:_

```sql
unload ('select * from venue')
to 's3://mybucket/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest;
```

The result is these five files:

- `s3://mybucket/venue_pipe_0000_part_00`
- `s3://mybucket/venue_pipe_0001_part_00`
- `s3://mybucket/venue_pipe_0002_part_00`
- `s3://mybucket/venue_pipe_0003_part_00`
- `s3://mybucket/venue_pipe_manifest`

The following shows the contents of the manifest file.

```json
{
  "entries": [
    {"url":"s3://mybucket/ticket/venue_0000_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.

```sql
unload ('select * from venue')
to 's3://mybucket/unload_venue_folder/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest verbose;
```

The following shows the contents of the manifest file.

```json
{
  "entries": [
    {"url":"s3://mybucket/venue_pipe_0000_part_00", "meta": { "content_length": 32295,
      "record_count": 10 }},
    {"url":"s3://mybucket/venue_pipe_0001_part_00", "meta": { "content_length": 32771,
      "record_count": 20 }},
    {"url":"s3://mybucket/venue_pipe_0002_part_00", "meta": { "content_length": 32302,
      "record_count": 10 }},
    {"url":"s3://mybucket/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": "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.

```sql
unload ('select * from venue where venueseats > 75000')
to 's3://mybucket/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.

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New York Giants Stadium</td>
<td>East Rutherford</td>
<td>NJ</td>
<td>80242</td>
</tr>
<tr>
<td>78</td>
<td>INVESCO Field</td>
<td>Denver</td>
<td>CO</td>
<td>76125</td>
</tr>
<tr>
<td>83</td>
<td>FedEx Field</td>
<td>Landover</td>
<td>MD</td>
<td>91704</td>
</tr>
<tr>
<td>79</td>
<td>Arrowhead Stadium</td>
<td>Kansas City</td>
<td>MO</td>
<td>79451</td>
</tr>
</tbody>
</table>

### 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://mybucket/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://mybucket/unload/`.

```
unload ('select * from venue')
to 's3://mybucket/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://mybucket/unload/`.

```
unload ('select * from lineorder')
to 's3://mybucket/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://mybucket/venue_pipe_`.
The result is these four files in the `unload` folder, again assuming four slices.

<table>
<thead>
<tr>
<th>File Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>venue_pipe_0000_part_00</code></td>
</tr>
<tr>
<td><code>venue_pipe_0001_part_00</code></td>
</tr>
<tr>
<td><code>venue_pipe_0002_part_00</code></td>
</tr>
<tr>
<td><code>venue_pipe_0003_part_00</code></td>
</tr>
</tbody>
</table>

### 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.

```sql
create table loadvenue (like venue);
COPY loadvenue FROM 's3://mybucket/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.

```sql
COPY loadvenue FROM 's3://mybucket/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 a 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 (p. 179).

```sql
UNLOAD ('select * from venue')
to 's3://mybucket/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 master symmetric key.

```sql
UNLOAD ('select * from venue')
to 's3://mybucket/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 master 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.

```sql
create table loadvenue (like venue);

copy loadvenue
from 's3://mybucket/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

```sql
unload ('select venueid, venuename, venueseats from venue')
to 's3://mybucket/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 Using Temporary Credentials

You can limit the access users have to your data by using temporary security credentials. Temporary security credentials provide enhanced security because they have short life spans and can't be reused after they expire. A user who has these temporary security credentials can access your resources only until the credentials expire. For more information, see Temporary Security Credentials (p. 487) in the usage notes for the COPY command.

The following example unloads the LISTING table using temporary credentials:

```sql
unload ('select venueid, venuename, venueseats from venue')
to 's3://mybucket/venue_tab' credentials
'aws_access_key_id=<temporary-access-key-id>;aws_secret_access_key=<temporary-secret-access-key>;token=<temporary-token>'
delimiter as '\t';
```

Important

The temporary security credentials must be valid for the entire duration of the UNLOAD statement. If the temporary security credentials expire during the load process, the UNLOAD fails and the transaction is rolled back. For example, if temporary security credentials expire after 15 minutes and the UNLOAD requires one hour, the UNLOAD fails before it completes.

Unload VENUE to a Fixed-Width Data File

```sql
unload ('select * from venue')
to 's3://mybucket/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.
Unload VENUE to a Set of Tab-Delimited GZIP-Compressed Files

unload ('select * from venue')
to 's3://mybucket/venue_tab_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimeter as '\t'
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://mybucket/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 event on sales.dateid=date.dateid
       join venue on event.venueid=venue.venueid
       order by 1,2')
to 's3://mybucket/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
... 
```
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.

```sql
update venue set venuestate = NULL
where venuecity = 'Cleveland';
```

Select from VENUE where VENUESTATE is null to verify that the columns contain NULL.

```sql
select * from venue where venuestate is null;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Quicken Loans Arena</td>
<td>Cleveland</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>101</td>
<td>Progressive Field</td>
<td>Cleveland</td>
<td></td>
<td>43345</td>
</tr>
<tr>
<td>72</td>
<td>Cleveland Browns Stadium</td>
<td>Cleveland</td>
<td></td>
<td>73200</td>
</tr>
</tbody>
</table>

(3 rows)

Now, UNLOAD the VENUE table using the NULL AS option to replace null values with the character string 'fred'.

```sql
unload ('select * from venue')
to 's3://mybucket/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.

<table>
<thead>
<tr>
<th></th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>248</td>
<td>Charles Playhouse</td>
<td>Boston</td>
<td>MA</td>
<td>0</td>
</tr>
<tr>
<td>251</td>
<td>Paris Hotel</td>
<td>Las Vegas</td>
<td>NV</td>
<td>fred</td>
</tr>
<tr>
<td>258</td>
<td>Tropicana Hotel</td>
<td>Las Vegas</td>
<td>NV</td>
<td>fred</td>
</tr>
<tr>
<td>300</td>
<td>Kennedy Center Opera House</td>
<td>Washington</td>
<td>DC</td>
<td>0</td>
</tr>
<tr>
<td>306</td>
<td>Lyric Opera House</td>
<td>Baltimore</td>
<td>MD</td>
<td>0</td>
</tr>
<tr>
<td>308</td>
<td>Metropolitan Opera</td>
<td>New York City</td>
<td>NY</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Foxborough</td>
<td>MA</td>
<td>5</td>
</tr>
<tr>
<td>22</td>
<td>Quicken Loans Arena</td>
<td>Cleveland</td>
<td>fred</td>
<td>43345</td>
</tr>
<tr>
<td>101</td>
<td>Progressive Field</td>
<td>Cleveland</td>
<td>fred</td>
<td>43345</td>
</tr>
</tbody>
</table>

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.

```sql
create table loadvenuenulls (like venue);
```
copy loadvenuenulls from 's3://mybucket/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.

```sql
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.

```sql
unload ('select * from venue')
to 's3://mybucket/nulls/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' allowoverwrite;
truncate loadvenuenulls;
copy loadvenuenulls from 's3://mybucket/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.

```sql
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.

```sql
unload ('select * from venue')
to 's3://mybucket/nulls/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' allowoverwrite;
truncate loadvenuenulls;
copy loadvenuenulls from 's3://mybucket/nulls/
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole' EMPTYASNULL;
```
To verify that the columns contain NULL, not just whitespace or empty, select from LOADVENUENULLS and filter for null.

```sql
select * from loadvenuenulls where venuestate is null or venueseats is null;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>Cleveland Browns Stadium</td>
<td>Cleveland</td>
<td></td>
<td>73200</td>
</tr>
<tr>
<td>253</td>
<td>Mirage Hotel</td>
<td>Las Vegas</td>
<td>NV</td>
<td></td>
</tr>
<tr>
<td>255</td>
<td>Venetian Hotel</td>
<td>Las Vegas</td>
<td>NV</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Quicken Loans Arena</td>
<td>Cleveland</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>101</td>
<td>Progressive Field</td>
<td>Cleveland</td>
<td></td>
<td>43345</td>
</tr>
<tr>
<td>251</td>
<td>Paris Hotel</td>
<td>Las Vegas</td>
<td>NV</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ALLOWOVERWRITE Example**

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.

```sql
unload ('select * from venue')
to 's3://mybucket/venue_pipe_'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
manifest allowoverwrite;
```

**UPDATE**

**Topics**
- Syntax (p. 658)
- Parameters (p. 658)
- Usage Notes (p. 659)
- Examples of UPDATE Statements (p. 659)

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**

```sql
UPDATE table_name SET column = { expression | DEFAULT } [,...] 
[ FROM fromlist ]
[ WHERE condition ]
```

**Parameters**

`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.

**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.

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 |
|-------+----------+---------+---------|
| 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)

Updating a Table Based on a Range of Values

Update the CATGROUP column based on a range of values in the CATID column.

```sql
update category
set catgroup='Theatre'
where catid between 6 and 8;
```

```sql
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 |

(3 rows)

Updating a Table Based on a Current Value

Update the CATNAME and CATDESC columns based on their current CATGROUP value:

```sql
update category
set catdesc=default, catname='Shows'
where catgroup='Theatre';
```

```sql
select * from category
where catname='Shows';
```

| catid | catgroup | catname | catdesc |
|-------+----------+---------+---------|
| 6     | Theatre  | Shows   |         |
| 7     | Theatre  | Shows   |         |
| 8     | Theatre  | Shows   |         |

(3 rows)

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:

```sql
truncate category;
```
copy category from 's3://mybucket/data/category_pipe.txt'
iam_role 'arn:aws:iam::0123456789012:role/MyRedshiftRole'
delimiter '|';

### 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:

```sql
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:

```sql
select * from category order by 1;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sports</td>
<td>MLB</td>
<td>Major League Baseball</td>
</tr>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Sports</td>
<td>MLS</td>
<td>Major League Soccer</td>
</tr>
<tr>
<td>6</td>
<td>Shows</td>
<td>Musicals</td>
<td>Broadway Musical</td>
</tr>
<tr>
<td>7</td>
<td>Shows</td>
<td>Plays</td>
<td>All non-musical theatre</td>
</tr>
<tr>
<td>8</td>
<td>Shows</td>
<td>Opera</td>
<td>All opera and light opera</td>
</tr>
<tr>
<td>9</td>
<td>Concerts</td>
<td>Pop</td>
<td>All rock and pop music concerts</td>
</tr>
<tr>
<td>10</td>
<td>Concerts</td>
<td>Jazz</td>
<td>All jazz singers and bands</td>
</tr>
<tr>
<td>11</td>
<td>Concerts</td>
<td>Classical</td>
<td>All symphony, concerto, and choir concerts</td>
</tr>
<tr>
<td></td>
<td>Shows</td>
<td>Musicals</td>
<td>Musical theatre</td>
</tr>
<tr>
<td></td>
<td>Plays</td>
<td></td>
<td>All non-musical theatre</td>
</tr>
</tbody>
</table>

(11 rows)

### 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:

```sql
update category set catid=100
from event
where event.catid=category.catid;
```

View the updated table:

```sql
select * from category order by 1;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>catname</th>
<th>catdesc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sports</td>
<td>MLB</td>
<td>Major League Baseball</td>
</tr>
<tr>
<td>2</td>
<td>Sports</td>
<td>NHL</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>Sports</td>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>Sports</td>
<td>NBA</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Sports</td>
<td>MLS</td>
<td>Major League Soccer</td>
</tr>
<tr>
<td>10</td>
<td>Concerts</td>
<td>Jazz</td>
<td>All jazz singers and bands</td>
</tr>
<tr>
<td>11</td>
<td>Concerts</td>
<td>Classical</td>
<td>All symphony, concerto, and choir concerts</td>
</tr>
<tr>
<td>100</td>
<td>Shows</td>
<td>Opera</td>
<td>All opera and light opera</td>
</tr>
<tr>
<td>100</td>
<td>Concerts</td>
<td>Pop</td>
<td>All rock and pop music concerts</td>
</tr>
<tr>
<td>100</td>
<td>Shows</td>
<td>Plays</td>
<td>All non-musical theatre</td>
</tr>
</tbody>
</table>

(11 rows)
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:

```sql
select distinct catid from event;
ccatid
-------
9
8
6
7
(4 rows)
```

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).

```sql
update category set catid=100
from event
where event.catid=category.catid
and catgroup='Concerts';
```

```sql
select * from category where catid=100;
ccatid | catgroup | catname | catdesc
-------+----------+---------+----------------------------------
100 | Concerts | Pop     | All rock and pop music concerts
(1 row)
```

An alternative way to write this example is as follows:

```sql
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:

```sql
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:

```sql
update category set catid=100
from
(select event.catid from event left join category cat on event.catid=cat.catid
where category.catid=eventcat.catid
and catgroup='Concerts');
```
VACUUM

Re-sorts rows and reclaims space in either a specified table or all tables in the current database.

**Note**
Only the table owner or a superuser can effectively vacuum a table. If VACUUM is run without the necessary table privileges, the operation completes successfully but has no effect.

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 (p. 142).

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 execute 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 (p. 142).

**Syntax**

```
VACUUM [ FULL | SORT ONLY | DELETE ONLY | REINDEX ]
[ [ 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 (p. 664) 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` tablename**

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.

**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, VACUUM 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.

The TO threshold PERCENT parameter can’t be used 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 (p. 142).

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 (p. 151).
- You can run only one VACUUM command on a cluster at any given time. If you attempt to run multiple vacuum operations concurrently, Amazon Redshift returns an error.
- 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 user triggers VACUUM on any table in the cluster (only one VACUUM can run at a time).
- A period of high cluster load.

**Examples**

Reclaim space and database and re-sort rows in all tables based on the default 95 percent vacuum threshold.

```sql
vacuum;
```

Reclaim space and re-sort rows in the SALES table based on the default 95 percent threshold.

```sql
vacuum sales;
```

Always reclaim space and re-sort rows in the SALES table.

```sql
vacuum sales to 100 percent;
```

Re-sort rows in the SALES table only if fewer than 75 percent of rows are already sorted.

```sql
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.

```sql
vacuum delete only sales to 75 percent;
```

Reindex and then vacuum the LISTING table.

```sql
vacuum reindex listing;
```

The following command returns an error.
SQL Functions Reference

Topics
- Leader Node–Only Functions (p. 667)
- Compute Node–Only Functions (p. 668)
- Aggregate Functions (p. 669)
- Bit-Wise Aggregate Functions (p. 684)
- Window Functions (p. 689)
- Conditional Expressions (p. 733)
- Date and Time Functions (p. 742)
- Spatial Functions (p. 779)
- Math Functions (p. 813)
- String Functions (p. 837)
- JSON Functions (p. 874)
- Data Type Formatting Functions (p. 880)
- System Administration Functions (p. 890)
- System Information Functions (p. 897)

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 8.0.2. 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 (p. 361).

Leader Node–Only Functions

Some Amazon Redshift queries are distributed and executed on the compute nodes; other queries execute 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 execute 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 (p. 360).

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

The following leader-node only functions are deprecated:

Date functions

- AGE
- CURRENT_TIME
- CURRENT_TIMESTAMP
- LOCALTIME
- ISFINITE
- NOW

String functions

- ASCII
- GET_BIT
- GET_BYTE
- SET_BIT
- SET_BYTE
- TO_ASCII

**Compute Node–Only Functions**

Some Amazon Redshift queries must execute 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.

The documentation for each compute-node only function includes a note stating that the function will return an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

The following SQL functions are compute-node only functions:

- LISTAGG
- MEDIAN
- PERCENTILE_CONT
Aggregate Functions

Topics

- APPROXIMATE PERCENTILE_DISC Function (p. 669)
- AVG Function (p. 670)
- COUNT Function (p. 672)
- LISTAGG Function (p. 673)
- MAX Function (p. 676)
- MEDIAN Function (p. 676)
- MIN Function (p. 678)
- PERCENTILE_CONT Function (p. 679)
- STDDEV_SAMP and STDDEV_POP Functions (p. 681)
- SUM Function (p. 682)
- VAR_SAMP and VAR_POP Functions (p. 683)

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. See the COUNT (p. 672) function description for an example of these additional clauses.

Aggregate functions don't accept nested aggregate functions or window functions as arguments.

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 execute 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.

APPROXIMATE PERCENTILE_DISC is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

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 (p. 679).

**Examples**

The following example returns the number of sales, total sales, and fiftieth percentile value for the top 10 dates.:

```sql
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;
```

<table>
<thead>
<tr>
<th>caldate</th>
<th>count</th>
<th>sum</th>
<th>percentile_disc</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-01-07</td>
<td>658</td>
<td>2081400.00</td>
<td>2020.00</td>
</tr>
<tr>
<td>2008-01-02</td>
<td>614</td>
<td>2064840.00</td>
<td>2178.00</td>
</tr>
<tr>
<td>2008-07-22</td>
<td>593</td>
<td>1994256.00</td>
<td>2214.00</td>
</tr>
<tr>
<td>2008-01-26</td>
<td>595</td>
<td>1993188.00</td>
<td>2272.00</td>
</tr>
<tr>
<td>2008-02-24</td>
<td>655</td>
<td>1975345.00</td>
<td>2070.00</td>
</tr>
<tr>
<td>2008-02-04</td>
<td>616</td>
<td>1972491.00</td>
<td>1995.00</td>
</tr>
<tr>
<td>2008-02-14</td>
<td>628</td>
<td>1971759.00</td>
<td>2184.00</td>
</tr>
<tr>
<td>2008-09-01</td>
<td>600</td>
<td>1944976.00</td>
<td>2100.00</td>
</tr>
<tr>
<td>2008-07-29</td>
<td>597</td>
<td>1944888.00</td>
<td>2106.00</td>
</tr>
<tr>
<td>2008-07-23</td>
<td>592</td>
<td>1943265.00</td>
<td>1974.00</td>
</tr>
</tbody>
</table>

**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

\[
\text{AVG ( [ DISTINCT | ALL ] expression )}
\]

Arguments

\[
\text{expression}
\]

The target column or expression that the function operates on.

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, and DOUBLE PRECISION.

The return types supported by the AVG function are:

- NUMERIC for any integer type argument
- DOUBLE PRECISION for a floating point argument

The default precision for an AVG function result with a 64-bit NUMERIC or DECIMAL argument is 19. The default precision for a result with a 128-bit 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(19,2) data type.

Examples

Find the average quantity sold per transaction from the SALES table:

```sql
select avg(qtysold) from sales;
```

avg
---
2
(1 row)

Find the average total price listed for all listings:

```sql
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:

```sql
select avg(pricepaid) as avg_price, month
from sales, date
where sales.dateid = date.dateid
```
COUNT Function

The COUNT function counts the rows defined by the expression.

The COUNT function has three 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.

Syntax

```
[ APPROXIMATE ] COUNT ( [ DISTINCT | ALL ] * | expression )
```

Arguments

*expression*

The target column or expression that the function operates on.

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 expression ) 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 execute 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 ).

Data Types

The COUNT function supports all argument data types.

The COUNT function returns BIGINT.
### Examples

Count all of the users from the state of Florida:

```sql
select count(*) from users where state='FL';
```

```
count
-------
510
(1 row)
```

Count all of the unique venue IDs from the EVENT table:

```sql
select count (distinct venueid) as venues from event;
```

```
venues
-------
204
(1 row)
```

Count the number of times each seller listed batches of more than four tickets for sale. Group the results by seller ID:

```sql
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.

```sql
select count(distinct pricepaid) from sales;
```

```
count
-------
4528
(1 row)
```

Time: 48.048 ms

```sql
select approximate count(distinct pricepaid) from sales;
```

```
count
-------
4541
(1 row)
```

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.
LISTAGG is a compute-node only function. The function returns an error if the query doesn’t reference a user-defined table or Amazon Redshift system table.

Syntax

```sql
LISTAGG( [DISTINCT] aggregate_expression [, 'delimiter' ] )
[ WITHIN GROUP (ORDER BY order_list) ]
```

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 (p. 379).

**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 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.

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
```

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 will return an error.

```sql
select listagg(sellerid)
within group (order by dateid) as sellers,
listagg(dateid)
within group (order by sellerid) as dates
from winsales;
```

The following statements will execute successfully.

```sql
select listagg(sellerid)
within group (order by dateid) as sellers,
listagg(dateid)
within group (order by dateid) as dates
from winsales;
select listagg(sellerid)
```
within group (order by dateid) as sellers,
listagg(dateid) as dates
from winsales;

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 winsales;
listagg
-------------
31141242333
```

The following example returns a pipe-separated list of sales dates for buyer B.

```
select listagg(dateid,'|')
within group (order by sellerid desc,salesid asc)
from winsales
where buyerid  = 'b';
listagg
---------------------------------------
```

The following example returns a comma-separated list of sales IDs for each buyer ID.

```
select buyerid,
listagg(salesid,',')
within group (order by salesid) as sales_id
from winsales
group by buyerid
order by buyerid;
buyerid | sales_id
----------------------------------------
a |10005,40001,40005
b |20001,30001,30004,30003
```
MAX Function

The MAX function returns the maximum value in a set of rows. DISTINCT or ALL may 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.

`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

Accepts any data type except Boolean as input. Returns the same data type as `expression`. The Boolean equivalent of the MIN function is the BOOL_AND Function (p. 686), and the Boolean equivalent of MAX is the BOOL_OR Function (p. 687).

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 (p. 679)(.5).
MEDIAN is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

**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.

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Return Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT2, INT4, INT8, NUMERIC, DECIMAL</td>
<td>DECIMAL</td>
</tr>
<tr>
<td>FLOAT, DOUBLE</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>TIMESTAMPTZ</td>
<td>TIMESTAMPTZ</td>
</tr>
</tbody>
</table>

**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.

```sql
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:

```sql
select top 10 salesid, sum(pricepaid),
percentile_cont(0.6) within group (order by salesid),
median (pricepaid)
from sales group by salesid, pricepai...
```
ERROR: within group ORDER BY clauses for aggregate functions must be the same

The following statement executes successfully.

```sql
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 example shows that MEDIAN produces the same results as PERCENTILE_CONT(0.5).

```sql
select top 10  distinct sellerid, qtysold,
percentile_cont(0.5) within group (order by qtysold),
median (qtysold)
from sales
group by sellerid, qtysold;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qtysold</th>
<th>percentile_cont</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>25</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**MIN Function**

The MIN function returns the minimum value in a set of rows. DISTINCT or ALL may be used but do not affect the result.

**Syntax**

```sql
MIN ( [ DISTINCT | ALL ] expression )
```

**Arguments**

- **expression**
  
  The target column or expression that the function operates on.

  **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**

Accepts any data type except Boolean as input. Returns the same data type as expression. The Boolean equivalent of the MIN function is BOOL_AND Function (p. 686), and the Boolean equivalent of MAX is BOOL_OR Function (p. 687).
Examples

Find the lowest price paid from all sales:

```sql
select min(pricepaid) from sales;
```

```
max
-------
20.00
(1 row)
```

Find the lowest price paid per ticket from all sales:

```sql
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).

PERCENTILE_CONT is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

Syntax

```sql
PERCENTILE_CONT ( 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)

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.

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Return Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT2, INT4, INT8, NUMERIC, DECIMAL</td>
<td>DECIMAL</td>
</tr>
<tr>
<td>FLOAT, DOUBLE</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>TIMESTAMPTZ</td>
<td>TIMESTAMPTZ</td>
</tr>
</tbody>
</table>

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 executes 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 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;

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qtysold</th>
<th>percentile_cont</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>25</td>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

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 avg(commission),
cast(stddev_samp(commission) as dec(14,2)) stddevsamp,
cast(stddev_pop(commission) as dec(14,2)) stddevpop
from sales;
```

```
avg  | stddevsamp | stddevpop
-------|------------|-----------
681   |  78.4776   |  77.7320
(1 row)
```
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.

```sql
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.

```sql
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**

```sql
SUM ( [ DISTINCT | ALL ] expression )
```

**Arguments**

- **expression**
  
  The target column or expression that the function operates on.

- 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, and DOUBLE PRECISION.

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

The default precision for a SUM function result with a 64-bit NUMERIC or DECIMAL argument is 19. The
default precision for a result with a 128-bit 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(19,2)
data type.

Examples

Find the sum of all commissions paid from the SALES table:

```sql
select sum(commission) from sales;
```
```
sum
------------
16614814.65
(1 row)
```

Find the number of seats in all venues in the state of Florida:

```sql
select sum(venueseats) from venue
where venuestate = 'FL';
```
```
sum
-------
250411
(1 row)
```

Find the number of seats sold in May:

```sql
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**

<table>
<thead>
<tr>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR_SAMP</td>
</tr>
<tr>
<td>VAR_POP  ( [ DISTINCT</td>
</tr>
</tbody>
</table>

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.

```sql
select avg(numtickets),
round(var_samp(numtickets)) varsamp,
round(var_pop(numtickets)) varpop
from listing;
```

<table>
<thead>
<tr>
<th>avg</th>
<th>varsamp</th>
<th>varpop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>54</td>
<td>54</td>
</tr>
</tbody>
</table>

The following query runs the same calculations but casts the results to decimal values.

```sql
select avg(numtickets),
cast(var_samp(numtickets) as dec(10,4)) varsamp,
cast(var_pop(numtickets) as dec(10,4)) varpop
from listing;
```

<table>
<thead>
<tr>
<th>avg</th>
<th>varsamp</th>
<th>varpop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>53.6291</td>
<td>53.6288</td>
</tr>
</tbody>
</table>

Bit-Wise Aggregate Functions

Topics
- BIT_AND and BIT_OR (p. 685)
- BOOL_AND and BOOL_OR (p. 685)
- NULLs in Bit-Wise Aggregations (p. 685)
- DISTINCT Support for Bit-Wise Aggregations (p. 686)
- BIT_AND Function (p. 686)
- BIT_OR Function (p. 686)
- BOOL_AND Function (p. 686)
- BOOL_OR Function (p. 687)
- Bit-Wise Function Examples (p. 687)

Amazon Redshift supports the following bit-wise aggregate functions:

- BIT_AND
- BIT_OR
- BOOL_AND
• **BOOL_OR**

**BIT_AND and BIT_OR**

The BIT_AND and BIT_OR functions run bit-wise AND and OR operations on all of the values in a single integer column or expression. These functions aggregate 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 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:

<table>
<thead>
<tr>
<th>Integer</th>
<th>Binary value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>111</td>
</tr>
<tr>
<td>10</td>
<td>1010</td>
</tr>
<tr>
<td>22</td>
<td>10110</td>
</tr>
</tbody>
</table>

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.

If you apply the BIT_OR function to the same 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).

**BOOL_AND and BOOL_OR**

The BOOL_AND and BOOL_OR functions operate on a single Boolean or integer column or expression. These functions apply similar logic to the BIT_AND and BIT_OR functions. For these functions, 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).
- If any value in a set is true, the BOOL_OR function returns true (t). If no value in a set is true, the function returns false (f).

**NULLs in Bit-Wise Aggregations**

When a bit-wise function is applied 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. For example:

```sql
select sum(venueseats), bit_and(venueseats) from venue
where venueseats is null;
```

<table>
<thead>
<tr>
<th>sum</th>
<th>bit_and</th>
</tr>
</thead>
<tbody>
<tr>
<td>685</td>
<td></td>
</tr>
</tbody>
</table>
### DISTINCT Support for Bit-Wise Aggregations

Like other aggregate functions, 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 bitwise AND or OR operations, and 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, do not use DISTINCT with these functions.

#### BIT_AND Function

**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. See DISTINCT Support for Bit-Wise Aggregations (p. 686).

#### BIT_OR Function

**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. See DISTINCT Support for Bit-Wise Aggregations (p. 686).

#### BOOL_AND Function

**Syntax**

```
BOOL_AND ( [DISTINCT | ALL] expression )
```

---

null | null
(1 row)
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 (p. 686).

BOOL_OR Function

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 (p. 686).

Bit-Wise Function Examples

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. For example:

```sql
select userid, username, lastname, city, state,
likesports, liketheatre
from users limit 10;
```

<table>
<thead>
<tr>
<th>userid</th>
<th>username</th>
<th>lastname</th>
<th>city</th>
<th>state</th>
<th>likesports</th>
<th>liketheatre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JSG99FHE</td>
<td>Taylor</td>
<td>Kent</td>
<td>WA</td>
<td>t</td>
<td>t</td>
</tr>
<tr>
<td>9</td>
<td>MSD36KVR</td>
<td>Watkins</td>
<td>Port Orford</td>
<td>MD</td>
<td>t</td>
<td>f</td>
</tr>
</tbody>
</table>

Assume that a new version of the USERS table is built in a different way, with 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, and 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 does not like any of these events has all eight bits set to 0 (see second row). A user who likes only sports and jazz is represented in the third row:

<table>
<thead>
<tr>
<th>SPORTS</th>
<th>THEATRE</th>
<th>JAZZ</th>
<th>OPERA</th>
<th>ROCK</th>
<th>VEGAS</th>
<th>BROADWAY</th>
<th>CLASSICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
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 could be stored in a single LIKES column as integers:

<table>
<thead>
<tr>
<th>User</th>
<th>Binary value</th>
<th>Stored value (integer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>11111111</td>
<td>255</td>
</tr>
<tr>
<td>User 2</td>
<td>00000000</td>
<td>0</td>
</tr>
<tr>
<td>User 3</td>
<td>10100000</td>
<td>160</td>
</tr>
</tbody>
</table>

**BIT_AND and BIT_OR 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;
```

<table>
<thead>
<tr>
<th>city</th>
<th>bit_and</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>0</td>
</tr>
<tr>
<td>Sacramento</td>
<td>0</td>
</tr>
<tr>
<td>San Francisco</td>
<td>0</td>
</tr>
<tr>
<td>San Jose</td>
<td>64</td>
</tr>
<tr>
<td>Santa Barbara</td>
<td>192</td>
</tr>
</tbody>
</table>

(5 rows)

These results can be interpreted 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.

If you apply the BIT_OR function to the same data, the results are as follows:

```
select city, bit_or(likes) from userlikes group by city
order by city;
```

<table>
<thead>
<tr>
<th>city</th>
<th>bit_or</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>127</td>
</tr>
<tr>
<td>Sacramento</td>
<td>255</td>
</tr>
<tr>
<td>San Francisco</td>
<td>255</td>
</tr>
<tr>
<td>San Jose</td>
<td>255</td>
</tr>
<tr>
<td>Santa Barbara</td>
<td>255</td>
</tr>
</tbody>
</table>

(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 and BOOL_OR Examples

You can use the Boolean functions against either Boolean expressions or integer expressions. For example, the following query returns 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. The BOOL_AND function returns false for all five rows. Not all users in each of those states likes sports.

```sql
select state, bool_or(likesports), bool_and(likesports) from users
group by state order by state limit 5;
```

<table>
<thead>
<tr>
<th>state</th>
<th>bool_or</th>
<th>bool_and</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>AK</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>AL</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>AZ</td>
<td>t</td>
<td>f</td>
</tr>
<tr>
<td>BC</td>
<td>t</td>
<td>f</td>
</tr>
</tbody>
</table>

(5 rows)

Window Functions

Topics

- Window Function Syntax Summary (p. 691)
- AVG Window Function (p. 693)
- COUNT Window Function (p. 694)
- CUME_DIST Window Function (p. 695)
- DENSE_RANK Window Function (p. 696)
- FIRST_VALUE and LAST_VALUE Window Functions (p. 697)
- LAG Window Function (p. 698)
- LEAD Window Function (p. 699)
- LISTAGG Window Function (p. 700)
- MAX Window Function (p. 701)
- MEDIAN Window Function (p. 702)
- MIN Window Function (p. 703)
- NTH_VALUE Window Function (p. 704)
- NTILE Window Function (p. 705)
- PERCENT_RANK Window Function (p. 706)
- PERCENTILE_CONT Window Function (p. 707)
- PERCENTILE_DISC Window Function (p. 708)
- RANK Window Function (p. 709)
- RATIO_TO_REPORT Window Function (p. 710)
- ROW_NUMBER Window Function (p. 711)
- STDDEV_SAMP and STDDEV_POP Window Functions (p. 712)
- SUM Window Function (p. 713)
- VAR_SAMP and VAR_POP Window Functions (p. 714)
- Window Function Examples (p. 715)
Window functions provide application developers the ability to 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, nonwindowed functions perform their calculations with respect to every row in the result set. Unlike group functions that aggregate result rows, all rows in the table expression are retained.

The values returned are calculated by utilizing values from the sets of rows in that window. The window defines, for each row in the table, 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. Multiple window functions can be used within a single query with different frame clauses. Window functions may be present in other scalar expressions, such as CASE.

Amazon Redshift supports two types of window functions: aggregate and ranking.

These are the supported aggregate functions:

- AVG
- COUNT
- CUME_DIST
- FIRST_VALUE
- LAG
- LAST_VALUE
- LEAD
- MAX
- MEDIAN
- MIN
- NTH_VALUE
- PERCENTILE_CONT
- PERCENTILE_DISC
- RATIO_TO_REPORT
- STDDEV_POP
- STDDEV_SAMP (synonym for STDDEV)
- SUM
- VAR_POP
- VAR_SAMP (synonym for VARIANCE)

These are the supported ranking functions:

- DENSE_RANK
- NTILE
- PERCENT_RANK
- RANK
• ROW_NUMBER

Window Function Syntax Summary

Standard window function syntax is as follows:

```
function (expression) OVER {
[ PARTITION BY expr_list ]
[ ORDER BY order_list [ frame_clause ] ]
}
```

where `function` is one of the functions described in this section and `expr_list` is:

```
expression | column_name [, expr_list ]
```

and `order_list` is:

```
expression | column_name [ ASC | DESC ]
[ NULLS FIRST | NULLS LAST ]
[, order_list ]
```

and `frame_clause` is:

```
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 } }
```

Note

STDDEV_SAMP and VAR_SAMP are synonyms for STDDEV and VARIANCE, respectively.

Arguments

`function`

For details, see the individual function descriptions.

`OVER`

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 execute 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 executed
serially on a single slice, which can have a significant negative impact on performance, especially for large clusters.

**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 an ORDER BY clause in a nonwindow function (outside of the OVER clause). The ORDER BY clause can be used without the PARTITION BY clause.

For the 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 (p. 689).

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.

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 does not 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 (p. 733).

**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 provides the ability 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 does not apply to ranking functions and is not 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:

\[\text{BETWEEN} \]
\{UNBOUNDED PRECEDING | offset \{ PRECEDING | FOLLOWING \} | CURRENT ROW\}
\[\text{AND} \]
\{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 will end the frame 5 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, and ROWS UNBOUNDED FOLLOWING is equal to ROWS BETWEEN CURRENT ROW AND UNBOUNDED FOLLOWING.

**Note**
You cannot specify a frame in which the starting boundary is greater than the ending boundary. For example, you cannot specify any of these frames:

- between 5 following and 5 preceding
- between current row and 2 preceding
- between 3 following and current row

**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 (p. 691).

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

See AVG Window Function Examples (p. 716).

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
```
Window Functions

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 (p. 691).

Data Types
The COUNT function supports all argument data types.

The return type supported by the COUNT function is BIGINT.

Examples
See COUNT Window Function Examples (p. 717).

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:

\[
\frac{\text{count of rows with values } \leq x}{\text{count of rows in the window or partition}}
\]

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:

<table>
<thead>
<tr>
<th>Row#</th>
<th>Value</th>
<th>Calculation</th>
<th>CUME_DIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500</td>
<td>(1)/(5)</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>2600</td>
<td>(2)/(5)</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>2800</td>
<td>(3)/(5)</td>
<td>0.6</td>
</tr>
</tbody>
</table>
The return value range is >0 to 1, inclusive.

Syntax

```sql
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 does not produce a unique ordering, the order of the rows is nondeterministic. For more information, see Unique Ordering of Data for Window Functions (p. 733).

Return Type

FLOAT8

Example

See CUME_DIST Window Function Examples (p. 717).

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

```sql
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 does not produce a unique ordering, the order of the rows is nondeterministic. For more 
information, see Unique Ordering of Data for Window Functions (p. 733).

Return Type

INTEGER

Examples

See DENSE_RANK Window Function Examples (p. 718).

FIRST_VALUE and LAST_VALUE Window Functions

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. The LAST_VALUE function returns the value of the expression with 
respect to the last row in the frame.

Syntax

FIRST_VALUE | 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

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). When this option is used with LAST_VALUE, 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 of the FIRST_VALUE and LAST_VALUE functions 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 (p. 691).

Data Types

These functions support expressions that use any of the Amazon Redshift data types. The return type is the same as the type of the expression.

Examples

See FIRST_VALUE and LAST_VALUE Window Function Examples (p. 719).

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 Expression (p. 738).

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

See LAG Window Function Examples (p. 721).

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 Expression (p. 738).

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
See LEAD Window Function Examples (p. 721).

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.

LISTAGG is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

Syntax

```sql
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 (p. 379).

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

See LISTAGG Window Function Examples (p. 722).

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 (p. 691).

Data Types

Accepts any data type as input. Returns the same data type as expression.

Examples

See MAX Window Function Examples (p. 723).

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.

MEDIAN is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

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.

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Return Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT2, INT4, INT8, NUMERIC, DECIMAL</td>
<td>DECIMAL</td>
</tr>
<tr>
<td>FLOAT, DOUBLE</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
</tbody>
</table>
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).

```sql
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.

```sql
select salesid, sum(pricepaid), median(sum(pricepaid)::decimal(30,2))
over() from sales where salesid < 10 group by salesid;
```

Examples

See MEDIAN Window Function Examples (p. 724).

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

```sql
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 (p. 691).

Data Types

Accepts any data type as input. Returns the same data type as expression.

Examples

See MIN Window Function Examples (p. 724).

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 (p. 691).

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

See NTH_VALUE Window Function Examples (p. 725).

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 (p. 733).

### Return Type

BIGINT

### Examples

See NTILE Window Function Examples (p. 726).

#### PERCENT_RANK Window Function

Calculates the percent rank of a given row. The percent rank is determined using this formula:

\[
\frac{x - 1}{(\text{the number of rows in the window or partition} - 1)}
\]

where \( x \) is the rank of the current row. The following dataset illustrates use of this formula:

<table>
<thead>
<tr>
<th>Row#</th>
<th>Value</th>
<th>Rank</th>
<th>Calculation</th>
<th>PERCENT_RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>1</td>
<td>(1-1)/(7-1)</td>
<td>0.0000</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>2</td>
<td>(2-1)/(7-1)</td>
<td>0.1666</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>2</td>
<td>(2-1)/(7-1)</td>
<td>0.1666</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>2</td>
<td>(2-1)/(7-1)</td>
<td>0.1666</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>5</td>
<td>(5-1)/(7-1)</td>
<td>0.6666</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>5</td>
<td>(5-1)/(7-1)</td>
<td>0.6666</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>7</td>
<td>(7-1)/(7-1)</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

The return value range is 0 to 1, inclusive. The first row in any set has a PERCENT_RANK of 0.

#### Syntax

```sql
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 (p. 733).

Return Type

FLOAT8

Examples

See PERCENT_RANK Window Function Examples (p. 726).

**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 
\[
RN = 1 + \left( P \times (N-1) \right).
\]

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 \( \text{value of expression from row at RN} \)

Otherwise the result is as follows:

\[
(CRN - RN) \times (\text{value of expression for row at FRN}) + (RN - FRN) \times (\text{value of expression for row at CRN}).
\]

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.

PERCENTILE_CONT is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

**Syntax**

\[
\text{PERCENTILE_CONT ( percentil e }) \\
\text{WITHIN GROUP (ORDER BY expr))} \\
\text{OVER ( [ PARTITION BY expr_list ] )}
\]

**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.

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Return Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT2, INT4, INT8, NUMERIC, DECIMAL</td>
<td>DECIMAL</td>
</tr>
<tr>
<td>FLOAT, DOUBLE</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TIMESTAMP</td>
</tr>
</tbody>
</table>

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).

```sql
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.

```sql
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

See PERCENTILE_CONT Window Function Examples (p. 727).

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.

PERCENTILE_DISC is a compute-node only function. The function returns an error if the query doesn't reference a user-defined table or Amazon Redshift system table.

Syntax

```sql
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

See PERCENTILE_DISC Window Function Examples (p. 728).

**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 (p. 696) 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

```sql
RANK () OVER
```
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 (p. 733).

Return Type

INTEGER

Examples

See RANK Window Function Examples (p. 728).

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:

\[
\text{value of ratio_expression argument for the current row} \div \text{sum of ratio_expression argument for the window or partition}
\]

The following dataset illustrates use of this formula:

<table>
<thead>
<tr>
<th>Row#</th>
<th>Value</th>
<th>Calculation</th>
<th>RATIO_TO_REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500</td>
<td>(2500)/(13900)</td>
<td>0.1798</td>
</tr>
<tr>
<td>2</td>
<td>2600</td>
<td>(2600)/(13900)</td>
<td>0.1870</td>
</tr>
<tr>
<td>3</td>
<td>2800</td>
<td>(2800)/(13900)</td>
<td>0.2014</td>
</tr>
<tr>
<td>4</td>
<td>2900</td>
<td>(2900)/(13900)</td>
<td>0.2086</td>
</tr>
<tr>
<td>5</td>
<td>3100</td>
<td>(3100)/(13900)</td>
<td>0.2230</td>
</tr>
</tbody>
</table>

The return value range is 0 to 1, inclusive. If ratio_expression is NULL, then the return value is NULL.

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

See RATIO_TO_REPORT Window Function Examples (p. 730).

**ROW_NUMBER Window Function**

Determines the 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

```sql
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 clauses for the ROW_NUMBER function.

PARTITION BY *expr_list*

Optional. One or more expressions that define the ROW_NUMBER function.

ORDER BY *order_list*

Optional. The expression that defines the columns on which the row numbers are based. 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 (p. 733).

Return Type

BIGINT

Examples

See ROW_NUMBER Window Function Example (p. 730).

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 (p. 681).

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 (p. 691).
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

See STDDEV_POP and VAR_POP Window Function Examples (p. 731).

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 (p. 691).

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**

See SUM Window Function Examples (p. 731).

**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 (p. 683).

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 (p. 691).
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.

Window Function Examples

Topics

- AVG Window Function Examples (p. 716)
- COUNT Window Function Examples (p. 717)
- CUME_DIST Window Function Examples (p. 717)
- DENSE_RANK Window Function Examples (p. 718)
- FIRST_VALUE and LAST_VALUE Window Function Examples (p. 719)
- LAG Window Function Examples (p. 721)
- LEAD Window Function Examples (p. 721)
- LISTAGG Window Function Examples (p. 722)
- MAX Window Function Examples (p. 723)
- MEDIAN Window Function Examples (p. 724)
- MIN Window Function Examples (p. 724)
- NTH_VALUE Window Function Examples (p. 725)
- NTILE Window Function Examples (p. 726)
- PERCENT_RANK Window Function Examples (p. 726)
- PERCENTILE_CONT Window Function Examples (p. 727)
- PERCENTILE_DISC Window Function Examples (p. 728)
- RANK Window Function Examples (p. 728)
- RATIO_TO_REPORT Window Function Examples (p. 730)
- ROW_NUMBER Window Function Example (p. 730)
- STDDEV_POP and VAR_POP Window Function Examples (p. 731)
- SUM Window Function Examples (p. 731)
- Unique Ordering of Data for Window Functions (p. 733)

This section provides examples for using the window functions.

Some of the window function examples in this section use a table named WINSALES, which contains 11 rows:

<table>
<thead>
<tr>
<th>SALESID</th>
<th>DATEID</th>
<th>SELLERID</th>
<th>BUYERID</th>
<th>QTY</th>
<th>QTY_SHIPPED</th>
</tr>
</thead>
<tbody>
<tr>
<td>30001</td>
<td>8/2/2003</td>
<td>3</td>
<td>B</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10001</td>
<td>12/24/2003</td>
<td>1</td>
<td>C</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10005</td>
<td>12/24/2003</td>
<td>1</td>
<td>A</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>40001</td>
<td>1/9/2004</td>
<td>4</td>
<td>A</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>10006</td>
<td>1/18/2004</td>
<td>1</td>
<td>C</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
### Window Functions

#### AVG Window Function Examples

The following script creates and populates the sample WINSALES table.

```sql
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);
```

Computing a rolling average of quantities sold by date; order the results by date ID and sales ID:

```sql
select salesid, dateid, sellerid, qty,
avg(qty) over
(order by dateid, salesid rows unbounded preceding) as avg
from winsales
order by 2,1;
```

<table>
<thead>
<tr>
<th>SALESID</th>
<th>DATEID</th>
<th>SELLERID</th>
<th>BUYERID</th>
<th>QTY</th>
<th>QTY_SHIPPED</th>
</tr>
</thead>
<tbody>
<tr>
<td>20001</td>
<td>2/12/2004</td>
<td>2</td>
<td>B</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>40005</td>
<td>2/12/2004</td>
<td>4</td>
<td>A</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>20002</td>
<td>2/16/2004</td>
<td>2</td>
<td>C</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>30003</td>
<td>4/18/2004</td>
<td>3</td>
<td>B</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>30004</td>
<td>4/18/2004</td>
<td>3</td>
<td>B</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>30007</td>
<td>9/7/2004</td>
<td>3</td>
<td>C</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

(11 rows)
For a description of the WINSALES table, see Window Function Examples (p. 715).

**COUNT Window Function Examples**

Show the sales ID, quantity, and count of all rows from the beginning of the data window:

```sql
select salesid, qty,
count(*) over (order by salesid rows unbounded preceding) as count
from winsales
order by salesid;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>10006</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>20001</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>20002</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>30001</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>30003</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>30004</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>30007</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>40001</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>40005</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

(11 rows)

For a description of the WINSALES table, see Window Function Examples (p. 715).

Show 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.)

```sql
select salesid, qty, qty_shipped,
count(qty_shipped)
over (order by salesid rows unbounded preceding) as count
from winsales
order by salesid;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>qty_shipped</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10006</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20001</td>
<td>20</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>20002</td>
<td>20</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>30001</td>
<td>10</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>30003</td>
<td>15</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>30004</td>
<td>20</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>30007</td>
<td>30</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>40001</td>
<td>40</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>40005</td>
<td>10</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

(11 rows)

**CUME_DIST Window Function Examples**

The following example calculates the cumulative distribution of the quantity for each seller:

```sql
select sellerid, qty, cume_dist()
over (partition by sellerid order by qty)
from winsales;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qty</th>
<th>cume_dist</th>
</tr>
</thead>
<tbody>
<tr>
<td>717</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(11 rows)
1. For a description of the WINSALES table, see Window Function Examples (p. 715).

**DENSE_RANK Window Function Examples**

**Dense Ranking with ORDER BY**

Order the table by the quantity sold (in descending order), and assign both a dense rank and a regular rank to each row. The results are sorted after the window function results are applied.

```sql
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
(11 rows)
```

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. For a description of the WINSALES table, see Window Function Examples (p. 715).

**Dense Ranking with PARTITION BY and ORDER BY**

Partition the table by SELLERID and order each partition by the quantity (in descending order) and assign a dense rank to each row. The results are sorted after the window function results are applied.

```sql
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
30001 |        1 |  10 |     2
40005 |        1 |  10 |     2
30003 |        1 |  15 |     4
20001 |        2 |  20 |     3
20002 |        2 |  20 |     3
30004 |        2 |  20 |     3
10005 |        3 |  30 |     2
30007 |        3 |  30 |     2
40001 |        4 |  40 |     1
(11 rows)
```

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. For a description of the WINSALES table, see Window Function Examples (p. 715).
For a description of the WINSALES table, see Window Function Examples (p. 715).

**FIRST_VALUE and LAST_VALUE Window Function Examples**

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.

```sql
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;
```

<table>
<thead>
<tr>
<th>venuestate</th>
<th>venueseats</th>
<th>venuename</th>
<th>first_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>70561</td>
<td>Qualcomm Stadium</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>69843</td>
<td>Monster Park</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>63026</td>
<td>McAfee Coliseum</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>56000</td>
<td>Dodger Stadium</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>45050</td>
<td>Angel Stadium of Anaheim</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>42445</td>
<td>PETCO Park</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>41503</td>
<td>AT&amp;T Park</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CA</td>
<td>22000</td>
<td>Shoreline Amphitheatre</td>
<td>Qualcomm Stadium</td>
</tr>
<tr>
<td>CO</td>
<td>76125</td>
<td>INVECO Field</td>
<td>INVECO Field</td>
</tr>
<tr>
<td>CO</td>
<td>50445</td>
<td>Coors Field</td>
<td>INVECO Field</td>
</tr>
<tr>
<td>DC</td>
<td>41888</td>
<td>Nationals Park</td>
<td>Nationals Park</td>
</tr>
<tr>
<td>FL</td>
<td>74916</td>
<td>Dolphin Stadium</td>
<td>Dolphin Stadium</td>
</tr>
<tr>
<td>FL</td>
<td>73800</td>
<td>Jacksonville Municipal Stadium</td>
<td>Dolphin Stadium</td>
</tr>
<tr>
<td>FL</td>
<td>65647</td>
<td>Raymond James Stadium</td>
<td>Dolphin Stadium</td>
</tr>
<tr>
<td>FL</td>
<td>36048</td>
<td>Tropicana Field</td>
<td>Dolphin Stadium</td>
</tr>
</tbody>
</table>

The next example uses the LAST_VALUE function instead of FIRST_VALUE; otherwise, the query is the same as the previous example. For California, Shoreline Amphitheatre is returned for every row in the partition because it has the lowest number of seats (22000).

```sql
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);
```
The following example shows the use of the IGNORE NULLS option and relies on the addition of a new row to the VENUE table:

```sql
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:

```sql
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;
```

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:

```sql
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;
```
LAG Window Function 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:

```sql
select buyerid, saletime, qtysold,
       lag(qtysold, 1) over (order by buyerid, saletime) as prev_qtysold
from sales where buyerid = 3 order by buyerid, saletime;
```

<table>
<thead>
<tr>
<th>buyerid</th>
<th>saletime</th>
<th>qtysold</th>
<th>prev_qtysold</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2008-01-16 01:06:09</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2008-01-28 02:10:01</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-03-12 10:39:53</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-03-13 02:56:07</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-03-29 08:21:39</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-04-27 02:39:01</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2008-08-16 07:04:37</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-08-22 11:45:26</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2008-09-12 09:11:25</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2008-10-01 06:22:37</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-10-20 01:55:51</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-10-28 01:30:40</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

(12 rows)

LEAD Window Function 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.

```sql
select eventid, commission, saletime,
       lead(commission, 1) over (order by saletime) as next_comm
from sales where saletime between '2008-01-01 00:00:00' and '2008-01-02 12:59:59'
order by saletime;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>commission</th>
<th>saletime</th>
<th>next_comm</th>
</tr>
</thead>
<tbody>
<tr>
<td>6213</td>
<td>52.05</td>
<td>2008-01-01 01:00:19</td>
<td>106.20</td>
</tr>
<tr>
<td>7003</td>
<td>106.20</td>
<td>2008-01-01 02:30:52</td>
<td>103.20</td>
</tr>
<tr>
<td>8762</td>
<td>103.20</td>
<td>2008-01-01 03:50:02</td>
<td>70.80</td>
</tr>
<tr>
<td>1150</td>
<td>70.80</td>
<td>2008-01-01 06:06:57</td>
<td>50.55</td>
</tr>
<tr>
<td>1749</td>
<td>50.55</td>
<td>2008-01-01 07:05:02</td>
<td>125.40</td>
</tr>
<tr>
<td>8649</td>
<td>125.40</td>
<td>2008-01-01 07:26:20</td>
<td>35.10</td>
</tr>
<tr>
<td>2903</td>
<td>35.10</td>
<td>2008-01-01 09:41:06</td>
<td>259.50</td>
</tr>
<tr>
<td>6605</td>
<td>259.50</td>
<td>2008-01-01 12:50:55</td>
<td>628.80</td>
</tr>
<tr>
<td>6870</td>
<td>628.80</td>
<td>2008-01-01 12:59:34</td>
<td>74.10</td>
</tr>
<tr>
<td>6977</td>
<td>74.10</td>
<td>2008-01-02 01:11:16</td>
<td>13.50</td>
</tr>
<tr>
<td>4650</td>
<td>13.50</td>
<td>2008-01-02 01:40:59</td>
<td>26.55</td>
</tr>
<tr>
<td>4515</td>
<td>26.55</td>
<td>2008-01-02 01:52:35</td>
<td>22.80</td>
</tr>
<tr>
<td>5465</td>
<td>22.80</td>
<td>2008-01-02 02:28:01</td>
<td>45.60</td>
</tr>
<tr>
<td>5465</td>
<td>45.60</td>
<td>2008-01-02 02:28:02</td>
<td>53.10</td>
</tr>
<tr>
<td>7003</td>
<td>53.10</td>
<td>2008-01-02 02:31:12</td>
<td>70.35</td>
</tr>
<tr>
<td>4124</td>
<td>70.35</td>
<td>2008-01-02 03:12:50</td>
<td>36.15</td>
</tr>
<tr>
<td>1673</td>
<td>36.15</td>
<td>2008-01-02 03:15:00</td>
<td>1300.80</td>
</tr>
</tbody>
</table>

... (39 rows)
LISTAGG Window Function Examples

The following examples uses the WINSALES table. For a description of the WINSALES table, see Window Function Examples (p. 715).

The following example returns a list of seller IDs, ordered by seller ID.

```sql
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.

```sql
select listagg(sellerid)
within group (order by dateid)
over () as seller
from winsales
where buyerid = 'b' ;

seller
--------
3233
3233
3233
3233
(4 rows)
```

The following example returns a comma-separated list of sales dates for buyer B.

```sql
select listagg(dateid,',')
within group (order by sellerid desc,salesid asc)
over () as dates
from winsales
where buyerid  = 'b';

dates
-------------------------------------------
(4 rows)
```

The following example uses DISTINCT to return a list of unique sales dates for buyer B.

```sql
select listagg(distinct dateid,',')
within group (order by sellerid desc,salesid asc)
over () as dates
from winsales
```
where buyerid = 'b';


<table>
<thead>
<tr>
<th>dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-08-02,2004-04-18,2004-02-12</td>
</tr>
<tr>
<td>2003-08-02,2004-04-18,2004-02-12</td>
</tr>
<tr>
<td>2003-08-02,2004-04-18,2004-02-12</td>
</tr>
<tr>
<td>2003-08-02,2004-04-18,2004-02-12</td>
</tr>
<tr>
<td>(4 rows)</td>
</tr>
</tbody>
</table>

The following example returns a comma-separated list of sales IDs for each buyer ID.

```sql
select buyerid,
listagg(salesid,',')
within group (order by salesid)
over (partition by buyerid) as sales_id
from winsales
order by buyerid;
```

<table>
<thead>
<tr>
<th>buyerid</th>
<th>sales_id</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>10005,40001,40005</td>
</tr>
<tr>
<td>a</td>
<td>10005,40001,40005</td>
</tr>
<tr>
<td>a</td>
<td>10005,40001,40005</td>
</tr>
<tr>
<td>b</td>
<td>20001,30001,30004,30003</td>
</tr>
<tr>
<td>b</td>
<td>20001,30001,30004,30003</td>
</tr>
<tr>
<td>b</td>
<td>20001,30001,30004,30003</td>
</tr>
<tr>
<td>c</td>
<td>10001,20002,30007,10006</td>
</tr>
<tr>
<td>c</td>
<td>10001,20002,30007,10006</td>
</tr>
<tr>
<td>c</td>
<td>10001,20002,30007,10006</td>
</tr>
<tr>
<td>(11 rows)</td>
<td></td>
</tr>
</tbody>
</table>

**MAX Window Function Examples**

Show the sales ID, quantity, and maximum quantity from the beginning of the data window:

```sql
select salesid, qty,
max(qty) over (order by salesid rows unbounded preceding) as max
from winsales
order by salesid;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>10006</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>20001</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>20002</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>30001</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>30003</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>30004</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>30007</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>40001</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>40005</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>(11 rows)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For a description of the WINSALES table, see Window Function Examples (p. 715).

Show 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;

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>10006</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>20001</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>20002</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>30001</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>30003</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>30004</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>30007</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>40001</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>40005</td>
<td>10</td>
<td>40</td>
</tr>
</tbody>
</table>

(11 rows)

**MEDIAN Window Function 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;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qty</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10.0</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10.0</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20.0</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20.0</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>17.5</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>17.5</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>17.5</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>17.5</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>25.0</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>25.0</td>
</tr>
</tbody>
</table>

For a description of the WINSALES table, see Window Function Examples (p. 715).

**MIN Window Function Examples**

Show 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;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>min</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>10006</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

(3 rows)
For a description of the WINSALES table, see Window Function Examples (p. 715).

Show the sales ID, quantity, and minimum quantity in a restricted frame:

```sql
select salesid, qty, 
    min(qty) over 
    (order by salesid rows between 2 preceding and 1 preceding) as min 
from winsales 
order by salesid;
```

```plaintext
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
```

NTH_VALUE Window Function 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:

```sql
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                 |      63026 |            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 |
### NTILE Window Function 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:

```sql
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;
```

<table>
<thead>
<tr>
<th>eventname</th>
<th>caldate</th>
<th>pricepaid</th>
<th>ntile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>1883.00</td>
<td>1</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>1065.00</td>
<td>1</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>589.00</td>
<td>1</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>530.00</td>
<td>1</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>472.00</td>
<td>1</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>460.00</td>
<td>2</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>355.00</td>
<td>2</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>334.00</td>
<td>2</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>296.00</td>
<td>2</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>230.00</td>
<td>3</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>216.00</td>
<td>3</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>212.00</td>
<td>3</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>106.00</td>
<td>3</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>100.00</td>
<td>4</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>94.00</td>
<td>4</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>53.00</td>
<td>4</td>
</tr>
<tr>
<td>Hamlet</td>
<td>2008-08-26</td>
<td>25.00</td>
<td>4</td>
</tr>
</tbody>
</table>

(17 rows)

### PERCENT_RANK Window Function Examples

The following example calculates the percent rank of the sales quantities for each seller:

```sql
select sellerid, qty, percent_rank()
over (partition by sellerid order by qty)
from winsales;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qty</th>
<th>percent_rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.00</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>10.64</td>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
<td>30.37</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>10.04</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>15.15</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>20.75</td>
<td>0.67</td>
</tr>
<tr>
<td>3</td>
<td>30.55</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>20.09</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>20.12</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>10.12</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>40.23</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For a description of the WINSALES table, see Window Function Examples (p. 715).
PERCENTILE_CONT Window Function Examples

The following examples uses the WINSALES table. For a description of the WINSALES table, see Window Function Examples (p. 715).

```
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         
```

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PERCENTILE_DISC Window Function Examples

The following examples uses the WINSALES table. For a description of the WINSALES table, see Window Function Examples (p. 715).

```sql
select sellerid, qty, percentile_disc(0.5) within group (order by qty) over() as median from winsales;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qty</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

(11 rows)

```sql
select sellerid, qty, percentile_disc(0.5) within group (order by qty) over(partition by sellerid) as median from winsales;
```

<table>
<thead>
<tr>
<th>sellerid</th>
<th>qty</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>

(11 rows)

RANK Window Function Examples

Ranking with ORDER BY

Order 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:

```sql
select salesid, qty, rank() over (order by qty) as rnk from winsales order by 2,1;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>qty</th>
<th>rnk</th>
</tr>
</thead>
<tbody>
<tr>
<td>728</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Ranking with ORDER BY and PARTITION BY

Partition 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;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>sellerid</th>
<th>qty</th>
<th>rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>10006</td>
<td>1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>30001</td>
<td>1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>40005</td>
<td>1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>30003</td>
<td>15</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>20001</td>
<td>20</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>20002</td>
<td>20</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>30004</td>
<td>20</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>10005</td>
<td>30</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>30007</td>
<td>30</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>40001</td>
<td>40</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

(11 rows)

For a description of the WINSALES table, see Window Function Examples (p. 715).
Window Functions

RATIO_TO_REPORT Window Function Examples

The following example calculates the ratios of the sales quantities for each seller:

```sql
select sellerid, qty, ratio_to_report(qty)
over (partition by sellerid)
from winsales;
```

```
sellerid  qty  ratio_to_report
-----------+-----+-------------------
        2  20.12312341   0.5
        2  20.08630000   0.5
        4  10.12414400   0.2
        4  40.23000000   0.8
        1  30.37262000   0.6
        1  10.64000000   0.21
        1  10.00000000   0.2
        3  10.03500000   0.13
        3  15.14660000   0.2
        3  30.54790000   0.4
        3  20.74630000   0.27
```

For a description of the WINSALES table, see Window Function Examples (p. 715).

ROW_NUMBER Window Function Example

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.

```sql
select salesid, sellerid, qty,
row_number() over (partition by sellerid
    order by qty asc) as row
from winsales
order by 2,4;
```

```
salesid | sellerid | qty | row
--------+----------+-----+-----
  10006 |        1 |  10 |   1
  10001 |        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
(11 rows)
```

For a description of the WINSALES table, see Window Function Examples (p. 715).
STDDEV_POP and VAR_POP Window Function 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.

```sql
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;
```

The sample standard deviation and variance functions can be used in the same way.

SUM Window Function Examples

Cumulative Sums (Running Totals)

Create a cumulative (rolling) sum of sales quantities ordered by date and sales ID:

```sql
select salesid, dateid, sellerid, qty,
    sum(qty) over (order by dateid, salesid rows unbounded preceding) as sum
from winsales
order by 2,1;
```

For a description of the WINSALES table, see Window Function Examples (p. 715).

Create 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:

```sql
select salesid, dateid, sellerid, qty,
    sum(qty) over (order by dateid, salesid rows unbounded preceding) as sum
from winsales
order by 2,1;
```
### Window Functions

#### Example 1: Sum of Sales by Seller and Date

```sql
sum(qty) over (partition by sellerid
  order by dateid, salesid rows unbounded preceding) as sum
from winsales
order by 2,1;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>dateid</th>
<th>sellerid</th>
<th>qty</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>30001</td>
<td>2003-08-02</td>
<td>3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10001</td>
<td>2003-12-24</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>10005</td>
<td>2003-12-24</td>
<td>1</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>40001</td>
<td>2004-01-09</td>
<td>4</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>10006</td>
<td>2004-01-18</td>
<td>1</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>20001</td>
<td>2004-02-12</td>
<td>2</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>40005</td>
<td>2004-02-12</td>
<td>4</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>20002</td>
<td>2004-02-16</td>
<td>2</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>30003</td>
<td>2004-04-18</td>
<td>3</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>30004</td>
<td>2004-04-18</td>
<td>3</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>30007</td>
<td>2004-09-07</td>
<td>3</td>
<td>30</td>
<td>75</td>
</tr>
</tbody>
</table>
```

#### Example 2: Number Rows Sequentially

Number all of the rows in the result set, ordered by the SELLERID and SALESID columns:

```sql
select salesid, sellerid, qty,
  sum(1) over (order by sellerid, salesid rows unbounded preceding) as rownum
from winsales
order by 2,1;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>sellerid</th>
<th>qty</th>
<th>rownum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>10005</td>
<td>1</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>10006</td>
<td>1</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>20001</td>
<td>2</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>20002</td>
<td>2</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>30001</td>
<td>3</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>30003</td>
<td>3</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>30004</td>
<td>3</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>30007</td>
<td>3</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>40001</td>
<td>4</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>40005</td>
<td>4</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>
```

For a description of the WINSALES table, see Window Function Examples (p. 715).

#### Example 3: Number Rows by Seller ID

Number all rows in the result set, partition the results by SELLERID, and order the results by SELLERID and SALESID within the partition:

```sql
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;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>sellerid</th>
<th>qty</th>
<th>rownum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>10005</td>
<td>1</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>10006</td>
<td>1</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>20001</td>
<td>2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>20002</td>
<td>2</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>30001</td>
<td>3</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
```

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Unique Ordering of Data for Window Functions

If an ORDER BY clause for a window function does not 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 may vary in multiple runs and window functions may return unexpected or inconsistent results.

For example, the following query returns different results over multiple runs because `order by dateid` does not 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;
```

<table>
<thead>
<tr>
<th>dateid</th>
<th>pricepaid</th>
<th>sumpaid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1827</td>
<td>1730.00</td>
<td>1730.00</td>
</tr>
<tr>
<td>1827</td>
<td>708.00</td>
<td>2438.00</td>
</tr>
<tr>
<td>1827</td>
<td>234.00</td>
<td>2672.00</td>
</tr>
</tbody>
</table>

... 

In this case, adding a second ORDER BY column to the window function may solve the problem:

```
select dateid, pricepaid,
    sum(pricepaid) over(order by dateid, pricepaid rows unbounded preceding) as sumpaid
from sales
group by dateid, pricepaid;
```

<table>
<thead>
<tr>
<th>dateid</th>
<th>pricepaid</th>
<th>sumpaid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1827</td>
<td>234.00</td>
<td>234.00</td>
</tr>
<tr>
<td>1827</td>
<td>472.00</td>
<td>706.00</td>
</tr>
<tr>
<td>1827</td>
<td>347.00</td>
<td>1053.00</td>
</tr>
</tbody>
</table>

... 

Conditional Expressions

Topics

- **CASE Expression** (p. 734)
- **COALESCE** (p. 735)
Amazon Redshift supports some conditional expressions that are extensions to the SQL standard.

**CASE Expression**

**Syntax**

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.

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 matching CASEs are found among the WHEN clauses, the action in the ELSE clause is returned.

**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 boolean 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.

- **Boolean condition**
  
  A Boolean condition is valid or true when the value is equal to the constant. When true, the result specified following the THEN clause is returned. If a condition is false, the result following the ELSE clause is returned. If the ELSE clause is omitted and no condition matches, the result is null.
Examples

Use a simple CASE expression is used to replace New York City with Big Apple in a query against the VENUE table. Replace all other city names with other.

```sql
select venuecity,
case venuecity
when 'New York City'
then 'Big Apple'
else 'other'
end from venue
order by venueid desc;
```

<table>
<thead>
<tr>
<th>venuecity</th>
<th>case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>other</td>
</tr>
<tr>
<td>New York City</td>
<td>Big Apple</td>
</tr>
<tr>
<td>San Francisco</td>
<td>other</td>
</tr>
<tr>
<td>Baltimore</td>
<td>other</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>(202 rows)</td>
<td></td>
</tr>
</tbody>
</table>

Use a searched CASE expression to assign group numbers based on the PRICEPAID value for individual ticket sales:

```sql
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;
```

<table>
<thead>
<tr>
<th>pricepaid</th>
<th>case</th>
</tr>
</thead>
<tbody>
<tr>
<td>12624.00</td>
<td>group 2</td>
</tr>
<tr>
<td>10000.00</td>
<td>group 3</td>
</tr>
<tr>
<td>10000.00</td>
<td>group 3</td>
</tr>
<tr>
<td>9996.00</td>
<td>group 1</td>
</tr>
<tr>
<td>9988.00</td>
<td>group 1</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>(172456 rows)</td>
<td></td>
</tr>
</tbody>
</table>

COALESCE

Synonym of the NVL expression.

See NVL Expression (p. 738).

DECODE Expression

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

```sql
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 Expression (p. 739), 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 START_DATE column of DATETABLE, the following example replaces it with June 1st, 2008. The example replaces all other START_DATE values with NULL.

```
select decode(caldate, '2008-06-01', 'June 1st, 2008')
from date
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',
               Unknown)
from category;
```
'NFL', 'National Football League',
'NBA', 'National Basketball Association',
'Unknown')
from category
order by catid;
ccatid | 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

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 data type of the expressions.

Example

The following example returns the highest value alphabetically for firstname or lastname.

```sql
select firstname, lastname, greatest(firstname, lastname) from users
where userid < 10
order by 3;
```

<table>
<thead>
<tr>
<th>firstname</th>
<th>lastname</th>
<th>greatest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lars</td>
<td>Ratliff</td>
<td>Ratliff</td>
</tr>
<tr>
<td>Reagan</td>
<td>Hodge</td>
<td>Reagan</td>
</tr>
<tr>
<td>Colton</td>
<td>Roy</td>
<td>Roy</td>
</tr>
<tr>
<td>Barry</td>
<td>Roy</td>
<td>Roy</td>
</tr>
<tr>
<td>Tamekah</td>
<td>Juarez</td>
<td>Tamekah</td>
</tr>
<tr>
<td>Rafael</td>
<td>Taylor</td>
<td>Taylor</td>
</tr>
<tr>
<td>Victor</td>
<td>Hernandez</td>
<td>Victor</td>
</tr>
<tr>
<td>Vladimir</td>
<td>Humphrey</td>
<td>Vladimir</td>
</tr>
<tr>
<td>Mufutau</td>
<td>Watkins</td>
<td>Watkins</td>
</tr>
</tbody>
</table>

(9 rows)

NVL Expression

An NVL expression is identical to a COALESCE expression. NVL and COALESCE are synonyms.

Syntax

```
NVL | COALESCE ( expression, expression, ... )
```

An NVL or COALESCE expression returns the value of the first expression in the list that is not null. If all expressions are null, the result is null. When a non-null value is found, the remaining expressions in the list are not evaluated.

This type of expression is useful when you want to return a backup value for something when the preferred value is missing or null. For example, a query might return one of three phone numbers (cell, home, or work, in that order), whichever is found first in the table (not null).

Examples

Create a table with START_DATE and END_DATE columns, insert some rows that include null values, then apply an NVL expression to the two columns.

```sql
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;
```
The default column name for an NVL expression is COALESCE. The following query would return the same results:

```sql
select coalesce(start_date, end_date)
from datetable
order by 1;
```

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 0.0:

```sql
select nvl(sum(sales), 0.0) as sumresult, ...
```

### NVL2 Expression

Returns one of two values based on whether a specified expression evaluates to NULL or NOT NULL.

#### Syntax

```sql
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 Expression (p. 735)** 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.

```sql
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:

```sql
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;
```

<table>
<thead>
<tr>
<th>name</th>
<th>contact_info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphrodite Acevedo</td>
<td>(906) 632-4407</td>
</tr>
<tr>
<td>Caldwell Acevedo</td>
<td><a href="mailto:Nunc.sollicitudin@Duisac.ca">Nunc.sollicitudin@Duisac.ca</a></td>
</tr>
<tr>
<td>Quinn Adams</td>
<td><a href="mailto:vel@adipiscingligulaAenean.com">vel@adipiscingligulaAenean.com</a></td>
</tr>
<tr>
<td>Kamal Aguilar</td>
<td><a href="mailto:quis@vulpumatetrisusa.com">quis@vulpumatetrisusa.com</a></td>
</tr>
<tr>
<td>Samson Alexander</td>
<td><a href="mailto:hendrerit.neque@indolorFusce.ca">hendrerit.neque@indolorFusce.ca</a></td>
</tr>
<tr>
<td>Hall Alford</td>
<td><a href="mailto:ac.mattis@vitaediamProin.edu">ac.mattis@vitaediamProin.edu</a></td>
</tr>
<tr>
<td>Lane Allen</td>
<td><a href="mailto:et.netus@risusDonec.org">et.netus@risusDonec.org</a></td>
</tr>
<tr>
<td>Xander Allisson</td>
<td><a href="mailto:ac.facilisis.facilisis@Infaucibus.com">ac.facilisis.facilisis@Infaucibus.com</a></td>
</tr>
<tr>
<td>Amaya Alvarado</td>
<td><a href="mailto:dui.nec.tempus@eudui.edu">dui.nec.tempus@eudui.edu</a></td>
</tr>
<tr>
<td>Vera Alvarez</td>
<td><a href="mailto:at.arcu.Vestibulum@pellentesque.edu">at.arcu.Vestibulum@pellentesque.edu</a></td>
</tr>
<tr>
<td>Yetta Anthony</td>
<td><a href="mailto:enim.site@risus.org">enim.site@risus.org</a></td>
</tr>
<tr>
<td>Violet Arnold</td>
<td><a href="mailto:ad.litora@at.com">ad.litora@at.com</a></td>
</tr>
<tr>
<td>August Ashley</td>
<td><a href="mailto:consectetuer.euismod@Phasellus.com">consectetuer.euismod@Phasellus.com</a></td>
</tr>
<tr>
<td>Karyn Austin</td>
<td><a href="mailto:ipsum.primis.in@Maurisblanditimenim.org">ipsum.primis.in@Maurisblanditimenim.org</a></td>
</tr>
<tr>
<td>Lucas Ayers</td>
<td><a href="mailto:at@elitpretiumet.com">at@elitpretiumet.com</a></td>
</tr>
</tbody>
</table>

740
NULLIF Expression

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 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';
```

<table>
<thead>
<tr>
<th>catgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>null</td>
</tr>
</tbody>
</table>

(1 row)

NULLIF ignores trailing spaces. If a string is not empty but contains spaces, NULLIF still returns null:

```
create table nulliftest(c1 char(2), c2 char(2));
insert into nulliftest values ('a','a ');
```
Date and Time Functions

In this section, you can find information about the date and time scalar functions that Amazon Redshift supports.

Topics

- Summary of Date and Time Functions (p. 743)
- Summary of Date and Time Functions (p. 746)
- Date and Time Functions in Transactions (p. 749)
- Deprecated Leader Node-Only Functions (p. 749)
- ADD_MONTHS Function (p. 749)
- AT TIME ZONE Function (p. 750)
- CONVERT_TIMEZONE Function (p. 751)
- CURRENT_DATE Function (p. 754)
- DATE_CMP Function (p. 754)
- DATE_CMP_TIMESTAMP Function (p. 755)
- DATE_CMP_TIMESTAMPZ Function (p. 756)
- DATE_PART_YEAR Function (p. 756)
- DATEADD Function (p. 757)
- DATEDIFF Function (p. 759)
- DATE_DIFF Function (p. 761)
- DATE_TRUNC Function (p. 762)
- EXTRACT Function (p. 762)
- GETDATE Function (p. 763)
- INTERVAL_CMP Function (p. 764)
- LAST_DAY Function (p. 765)
- MONTHS_BETWEEN Function (p. 766)
- NEXT_DAY Function (p. 767)
- SYSDATE Function (p. 768)
- TIMEOFDAY Function (p. 769)
- TIMESTAMP_CMP Function (p. 769)
- TIMESTAMP_CMP_DATE Function (p. 771)
- TIMESTAMP_CMP_TIMESTAMP Function (p. 772)
- TIMESTAMP_CMP_TIMESTAMPZ Function (p. 772)
- TIMESTAMPTZ_CMP Function (p. 772)
- TIMESTAMPTZ_CMP_DATE Function (p. 772)
- TIMESTAMPTZ_CMP_TIMESTAMP Function (p. 773)
### Summary of Date and Time Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Syntax</th>
<th>Returns</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADD_MONTHS</strong> (p. 749)</td>
<td><code>ADD_MONTHS (date[timestamp], integer)</code></td>
<td>TIMESTAMP</td>
<td>Adds the specified number of months to a date or time stamp.</td>
</tr>
<tr>
<td><strong>AT TIME ZONE</strong> (p. 750)</td>
<td><code>AT TIME ZONE 'timezone'</code></td>
<td>TIMESTAMP</td>
<td>Specifies which time zone to use with a TIMESTAMP or TIMESTAMPTZ expression.</td>
</tr>
<tr>
<td><strong>CONVERT_TIMEZONE</strong> (p. 751)</td>
<td><code>CONVERT_TIMEZONE (['timezone'], 'timezone', timestamp)</code></td>
<td>TIMESTAMP</td>
<td>Converts a time stamp from one time zone to another.</td>
</tr>
<tr>
<td><strong>CURRENT_DATE</strong> (p. 754)</td>
<td><code>CURRENT_DATE</code></td>
<td>DATE</td>
<td>Returns a date in the current session time zone (UTC by default) for the start of the current transaction.</td>
</tr>
<tr>
<td><strong>DATE_CMP</strong> (p. 754)</td>
<td><code>DATE_CMP (date1, date2)</code></td>
<td>INTEGER</td>
<td>Compares two dates and returns 0 if the dates are identical, 1 if <code>date1</code> is greater, and −1 if <code>date2</code> is greater.</td>
</tr>
<tr>
<td><strong>DATE_CMP_TIMESTAMP</strong> (p. 755)</td>
<td><code>DATE_CMP_TIMESTAMP (date, timestamp)</code></td>
<td>INTEGER</td>
<td>Compares a date to a time and returns 0 if the values are identical, 1 if <code>date</code> is greater and −1 if <code>timestamp</code> is greater.</td>
</tr>
<tr>
<td><strong>DATE_CMP_TIMESTAMPTZ</strong> (p. 756)</td>
<td><code>DATE_CMP_TIMESTAMPTZ (date, timestamp)</code></td>
<td>INTEGER</td>
<td>Compares a date and a time stamp with time zone and returns 0 if the values are identical, 1 if <code>date</code> is greater and −1 if <code>timestamp</code> is greater.</td>
</tr>
<tr>
<td><strong>DATE_PART_YEAR</strong> (p. 756)</td>
<td><code>DATE_PART_YEAR (date)</code></td>
<td>INTEGER</td>
<td>Extracts the year from a date.</td>
</tr>
<tr>
<td><strong>DATEADD</strong> (p. 757)</td>
<td>`DATEADD (datepart, interval, {date</td>
<td>timestamp})`</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>Function</td>
<td>Syntax</td>
<td>Returns</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DATEDIFF (p. 759)</td>
<td>DATEDIFF (datepart, {date</td>
<td>time}, {date</td>
<td>timestamp})</td>
</tr>
<tr>
<td>DATE_PART (p. 761)</td>
<td>DATE_PART (datepart, {date</td>
<td>time})</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>DATE_TRUNC (p. 762)</td>
<td>DATE_TRUNC ('datepart', timestamp)</td>
<td>TIMESTAMP</td>
<td>Truncates a timestamp based on a date part.</td>
</tr>
<tr>
<td>EXTRACT (p. 762)</td>
<td>EXTRACT (datepart FROM {TIMESTAMP 'literal'</td>
<td>timestamp))</td>
<td>DOUBLE</td>
</tr>
<tr>
<td>GETDATE (p. 763)</td>
<td>GETDATE()</td>
<td>TIMESTAMP</td>
<td>Returns the current date and time in the current session time zone (UTC by default). The parentheses are required.</td>
</tr>
<tr>
<td>INTERVAL_CMP (p. 764)</td>
<td>INTERVAL_CMP (interval1, interval2)</td>
<td>INTEGER</td>
<td>Compares two intervals and returns 0 if the intervals are equal, 1 if interval1 is greater, and -1 if interval2 is greater.</td>
</tr>
<tr>
<td>LAST_DAY (p. 765)</td>
<td>LAST_DAY(date)</td>
<td>DATE</td>
<td>Returns the date of the last day of the month that contains date.</td>
</tr>
<tr>
<td>MONTHS_BETWEEN (p. 766)</td>
<td>MONTHS_BETWEEN (date, date)</td>
<td>FLOAT8</td>
<td>Returns the number of months between two dates.</td>
</tr>
<tr>
<td>NEXT_DAY (p. 767)</td>
<td>NEXT_DAY (date, day)</td>
<td>DATE</td>
<td>Returns the date of the first instance of day that is later than date.</td>
</tr>
<tr>
<td>SYSDATE (p. 768)</td>
<td>SYSDATE</td>
<td>TIMESTAMP</td>
<td>Returns the date and time in the current session time zone (UTC by default) for the start of the current transaction.</td>
</tr>
<tr>
<td>TIMEOFDAY (p. 769)</td>
<td>TIMEOFDAY()</td>
<td>VARCHAR</td>
<td>Returns the current weekday, date, and time in the current session time zone (UTC by default) as a string value.</td>
</tr>
<tr>
<td>Function</td>
<td>Syntax</td>
<td>Returns</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>TIMESTAMP_CMP (p. 769)</td>
<td><code>TIMESTAMP_CMP (timestamp1, timestamp2)</code></td>
<td>INTEGER</td>
<td>Compares two timestamps and returns 0 if the timestamps are equal, 1 if <code>timestamp1</code> is greater, and -1 if <code>timestamp2</code> is greater.</td>
</tr>
<tr>
<td>TIMESTAMP_CMP_DATE (p. 770)</td>
<td><code>TIMESTAMP_CMP_DATE (timestamp, date)</code></td>
<td>INTEGER</td>
<td>Compares a timestamp to a date and returns 0 if the values are equal, 1 if <code>timestamp</code> is greater, and -1 if <code>date</code> is greater.</td>
</tr>
<tr>
<td>TIMESTAMP_CMP_TIMESTAMP (p. 772)</td>
<td><code>TIMESTAMP_CMP_TIMESTAMP (timestamp, timestamptz)</code></td>
<td>INTEGER</td>
<td>Compares a timestamp with a time stamp with time zone and returns 0 if the values are equal, 1 if <code>timestamp</code> is greater, and -1 if <code>timestamptz</code> is greater.</td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP (p. 772)</td>
<td><code>TIMESTAMPTZ_CMP (timestamptz1, timestamptz2)</code></td>
<td>INTEGER</td>
<td>Compares two timestamp with time zone values and returns 0 if the values are equal, 1 if <code>timestamptz1</code> is greater, and -1 if <code>timestamptz2</code> is greater.</td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP_DATE (p. 772)</td>
<td><code>TIMESTAMPTZ_CMP_DATE (timestamptz, date)</code></td>
<td>INTEGER</td>
<td>Compares the value of a timestamp with time zone and a date and returns 0 if the values are equal, 1 if <code>timestamptz</code> is greater, and -1 if <code>date</code> is greater.</td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP_TIMESTAMP (p. 773)</td>
<td><code>TIMESTAMPTZ_CMP_TIMESTAMP (timestamptz, timestamp)</code></td>
<td>INTEGER</td>
<td>Compares a timestamp with time zone with a time stamp and returns 0 if the values are equal, 1 if <code>timestamptz</code> is greater, and -1 if <code>timestamp</code> is greater.</td>
</tr>
<tr>
<td>TIMEZONE (p. 773)</td>
<td>`TIMEZONE ('timezone', { timestamp</td>
<td>timestamptz })`</td>
<td>TIMESTAMP or TIMESTAMPTZ</td>
</tr>
<tr>
<td>Function</td>
<td>Syntax</td>
<td>Returns</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>TO_TIMESTAMP (p. 774)</td>
<td>TO_TIMESTAMP ('timestamp', 'format')</td>
<td>TIMESTAMPTZ</td>
<td>Returns a time stamp with time zone for the specified time stamp and time zone format.</td>
</tr>
<tr>
<td>TRUNC (p. 775)</td>
<td>TRUNC(timestamp)</td>
<td>DATE</td>
<td>Truncates a time stamp and returns a date.</td>
</tr>
</tbody>
</table>

**Note**

Leap seconds are not considered in elapsed-time calculations.

## Summary of Date and Time Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Syntax</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD_MONTHS (p. 749)</td>
<td>ADD_MONTHS ((date</td>
<td>timestamp), integer)</td>
</tr>
<tr>
<td>Adds the specified number of months to a date or time stamp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT TIME ZONE (p. 750)</td>
<td>AT TIME ZONE 'timezone'</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>Specifies which time zone to use with a TIMESTAMP or TIMESTAMPTZ expression.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONVERT_TIMEZONE (p. 751)</td>
<td>CONVERT_TIMEZONE ([timezone], 'timezone', timestamp)</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>Converts a time stamp from one time zone to another.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CURRENT_DATE (p. 754)</td>
<td>CURRENT_DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>Returns a date in the current session time zone (UTC by default) for the start of the current transaction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATE_CMP (p. 754)</td>
<td>DATE_CMP (date1, date2)</td>
<td>INTEGER</td>
</tr>
<tr>
<td>Compares two dates and returns 0 if the dates are identical, 1 if date1 is greater, and -1 if date2 is greater.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATE_CMP_TIMESTAMP (p. 755)</td>
<td>DATE_CMP_TIMESTAMP (date, timestamp)</td>
<td>INTEGER</td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATE_CMP_TIMESTAMPTZ (p. 756)</td>
<td>DATE_CMP_TIMESTAMPTZ (date, timestamp)</td>
<td>INTEGER</td>
</tr>
<tr>
<td>Compares a date and a time stamp with time zone and returns 0 if the values are identical, 1 if date is greater and -1 if timestamp is greater.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATE_PART_YEAR (p. 756)</td>
<td>DATE_PART_YEAR (date)</td>
<td>INTEGER</td>
</tr>
<tr>
<td>Function</td>
<td>Syntax</td>
<td>Returns</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------</td>
<td>----------</td>
</tr>
</tbody>
</table>
| **Extracts the year from a date.** | **DATEADD (p. 757)**
  Increments a date or time by a specified interval. | **DATEADD (datepart, interval, {date|timestamp})** | **TIMESTAMP** |
<p>| <strong>DATEDIFF (p. 759)</strong> | Returns the difference between two dates or times for a given date part, such as a day or month. | <strong>DATEDIFF (datepart, {date|timestamp}, {date|time})</strong> | <strong>INTEGER</strong> |
| <strong>DATE_PART (p. 761)</strong> | <strong>DATE_PART (datepart, {date|timestamp})</strong> | <strong>DOUBLE</strong> |
| <strong>DATE_TRUNC (p. 762)</strong> | <strong>DATE_TRUNC (datepart, timestamp)</strong> | <strong>TIMESTAMP</strong> |
| <strong>EXTRACT (p. 762)</strong> | <strong>EXTRACT (datepart FROM {TIMESTAMP 'literal' | timestamp})</strong> | <strong>INTEGER or DOUBLE</strong> |
| <strong>GETDATE (p. 763)</strong>  | Returns the current date and time in the current session time zone (UTC by default). The parentheses are required. | <strong>GETDATE()</strong> | <strong>TIMESTAMP</strong> |
| <strong>INTERVAL_CMP (p. 764)</strong> | <strong>INTERVAL_CMP (interval1, interval2)</strong> | <strong>INTEGER</strong> |
| <strong>LAST_DAY (p. 765)</strong> | Returns the date of the last day of the month that contains date. | <strong>LAST_DAY(date)</strong> | <strong>DATE</strong> |
| <strong>MONTHS_BETWEEN (p. 766)</strong> | <strong>MONTHS_BETWEEN (date, date)</strong> | <strong>FLOAT8</strong> |
| <strong>NEXT_DAY (p. 767)</strong> | Returns the date of the first instance of day that is later than date. | <strong>NEXT_DAY (date, day)</strong> | <strong>DATE</strong> |
| <strong>SYSDATE (p. 768)</strong>  | Returns the date and time in UTC for the start of the current transaction. | <strong>SYSDATE</strong> | <strong>TIMESTAMP</strong> |</p>
<table>
<thead>
<tr>
<th>Function</th>
<th>Syntax</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMEOFDAY (p. 769)</td>
<td>TIMEOFDAY()</td>
<td>VARCHAR</td>
</tr>
<tr>
<td></td>
<td>Returns the current weekday, date, and time in the current session time zone (UTC by default) as a string value.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMP_CMP (p. 769)</td>
<td>TIMESTAMP_CMP (timestamp1, timestamp2)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Compares two timestamps and returns 0 if the timestamps are equal, 1 if interval1 is greater, and −1 if interval2 is greater.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMP_CMP_DATE (p. 771)</td>
<td>TIMESTAMP_CMP_DATE (timestamp, date)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMP_CMP_TIMESTAMPTZ (p. 772)</td>
<td>TIMESTAMP_CMP_TIMESTAMPTZ (timestamp, timestamp)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Compares a timestamp with a time stamp with time zone and returns 0 if the values are equal, 1 if timestamp is greater, and −1 if timestamp is greater.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP (p. 772)</td>
<td>TIMESTAMPTZ_CMP (timestamp1, timestamp2)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Compares two timestamp with time zone values and returns 0 if the values are equal, 1 if timestamp1 is greater, and −1 if timestamp2 is greater.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP_DATE (p. 772)</td>
<td>TIMESTAMPTZ_CMP_DATE (timestamp, date)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Compares the value of a time stamp with time zone and a date and returns 0 if the values are equal, 1 if timestamp is greater, and −1 if date is greater.</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMPTZ_CMP_TIMESTAMP (p. 773)</td>
<td>TIMESTAMPTZ_CMP_TIMESTAMP (timestamp, timestamp)</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Compares a timestamp with time zone with a time stamp and returns 0 if the values are equal, 1 if timestamp is greater, and −1 if timestamp is greater.</td>
<td></td>
</tr>
<tr>
<td>TIMEZONE (p. 773)</td>
<td>TIMEZONE (timezone' { timestamp</td>
<td>timestampz } )</td>
</tr>
<tr>
<td></td>
<td>Returns a time stamp for the specified time zone and time stamp value.</td>
<td></td>
</tr>
<tr>
<td>TO_TIMESTAMP (p. 774)</td>
<td>TO_TIMESTAMP (timestamp' , 'format')</td>
<td>INTEGER</td>
</tr>
<tr>
<td></td>
<td>Returns a time stamp with time zone for the specified time stamp and time zone format.</td>
<td></td>
</tr>
</tbody>
</table>
Date and Time Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Syntax</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUNC (p. 775)</td>
<td>TRUNC(timestamp)</td>
<td>DATE</td>
</tr>
</tbody>
</table>

Truncates a time stamp and returns a date.

**Note**
Leap seconds are not considered in elapsed-time calculations.

Date and Time Functions in Transactions

When you execute 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 execute only on the leader node. For more information, see Leader Node-Only Functions (p. 667).

- AGE. Use DATEDIFF Function (p. 759) instead.
- CURRENT_TIME. Use GETDATE Function (p. 763) or SYSDATE (p. 768) instead.
- CURRENT_TIMESTAMP. Use GETDATE Function (p. 763) or SYSDATE (p. 768) instead.
- LOCALTIME. Use GETDATE Function (p. 763) or SYSDATE (p. 768) instead.
- LOCALTIMESTAMP. Use GETDATE Function (p. 763) or SYSDATE (p. 768) instead.
- ISFINITE
- NOW. Use GETDATE Function (p. 763) or SYSDATE (p. 768) instead.

ADD_MONTHS Function

ADD_MONTHS adds the specified number of months to a date or time stamp value or expression. The DATEADD (p. 757) function provides similar functionality.

**Syntax**

```
ADD_MONTHS( {date | timestamp}, integer)
```
Arguments

date | timestamp

A date or timestamp column or an expression that implicitly converts to a date or time stamp. 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 positive or negative integer. Use a negative number to subtract months from dates.

Return Type

TIMESTAMP

Example

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.

```
select distinct trunc(add_months(caldate, 12)) as calplus12, 
        trunc(caldate) as cal 
from date 
order by 1 asc;
```

<table>
<thead>
<tr>
<th>calplus12</th>
<th>cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-01-01</td>
<td>2008-01-01</td>
</tr>
<tr>
<td>2009-01-02</td>
<td>2008-01-02</td>
</tr>
<tr>
<td>2009-01-03</td>
<td>2008-01-03</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>(365 rows)</td>
<td></td>
</tr>
</tbody>
</table>

The following examples demonstrate the behavior when the ADD_MONTHS function operates on dates with months that have different numbers of days.

```
select add_months('2008-03-31',1);
```

```
add_months
---------------------
2008-04-30 00:00:00
(1 row)
```

```
select add_months('2008-04-30',1);
```

```
add_months
---------------------
2008-05-31 00:00:00
(1 row)
```

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 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, execute the following command.

`select pg_timezone_names();`

To view a list of supported time zone abbreviations, execute the following command.

`select pg_timezone_abbrevs();`

For more information and examples, see Time Zone Usage Notes (p. 752).

Return Type

TIMESTAMP when used with a TIMESTAMP expression. TIMESTAMPTZ when used with a TIMESTAMPTZ expression.

Examples

The following example converts a time stamp value without time zone and interprets it as MST time (UTC–7), which is then converted to PST (UTC–8) for display.

```sql
SELECT TIMESTAMP '2001-02-16 20:38:40' AT TIME ZONE 'MST';
```

<table>
<thead>
<tr>
<th>timestamptz</th>
<th>------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td>'2001-02-16 19:38:40-08'</td>
<td></td>
</tr>
</tbody>
</table>

The following example takes an input time stamp with a time zone value where the specified time zone is UTC-5 (EST) and converts it to MST (UTC-7).

```sql
SELECT TIMESTAMP WITH TIME ZONE '2001-02-16 20:38:40-05' AT TIME ZONE 'MST';
```

<table>
<thead>
<tr>
<th>timestamp</th>
<th>------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td>'2001-02-16 18:38:40'</td>
<td></td>
</tr>
</tbody>
</table>

**CONVERT_TIMEZONE Function**

CONVERT_TIMEZONE converts a time stamp from one time zone to another.

Syntax

```sql
CONVERT_TIMEZONE ( ['source_timezone',] 'target_timezone', 'timestamp')
```
Arguments

*source_timezone*

(Optional) The time zone of the current time stamp. The default is UTC. For more information, see Time Zone Usage Notes (p. 752).

*target_timezone*

The time zone for the new time stamp. For more information, see Time Zone Usage Notes (p. 752).

*timestamp*

A timestamp column or an expression that implicitly converts to a time stamp.

Return Type

TIMESTAMP

Time Zone Usage Notes

Either *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').

**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.

To view a list of supported time zone names, execute the following command.

```sql
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, execute the following command.

```sql
select pg_timezone_abbrevs();
```

Using a Time Zone Name

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 UTC+1 in the summer.

Using a Time Zone Abbreviation

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 does not adjust for any local seasonal protocol. For example, ADT (Atlantic Daylight Time) always represents UTC-03, even in winter.

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-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.

```sql
set timezone to 'xxx36';
```

**Examples**

The following example converts the time stamp value in the LISTTIME column from the default UTC time zone to PST. Even though the time stamp is within the daylight time period, it is converted to standard time because the target time zone is specified as an abbreviation (PST).

```sql
select listtime, convert_timezone('PST', listtime) from listing
where listid = 16;
```

<table>
<thead>
<tr>
<th>listtime</th>
<th>convert_timezone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-08-24 09:36:12</td>
<td>2008-08-24 01:36:12</td>
</tr>
</tbody>
</table>

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 time stamp is within the daylight time period, so the function returns the daylight time.

```sql
select listtime, convert_timezone('US/Pacific', listtime) from listing
where listid = 16;
```

<table>
<thead>
<tr>
<th>listtime</th>
<th>convert_timezone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-08-24 09:36:12</td>
<td>2008-08-24 02:36:12</td>
</tr>
</tbody>
</table>

The following example converts a time stamp string from EST to PST:

```sql
select convert_timezone('EST', 'PST', '20080305 12:25:29');
```

```
convert_timezone
-------------------
2008-03-05 09:25:29
```

The following example converts a time stamp to US Eastern Standard Time because the target time zone uses a time zone name (America/New_York) and the time stamp is within the standard time period.

```sql
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 time stamp to US Eastern Daylight Time because the target time zone uses a time zone name (America/New_York) and the time stamp is within the daylight time period.

```sql
select convert_timezone('America/New_York', '2013-06-01 08:00:00');
```

<table>
<thead>
<tr>
<th>convert_timezone</th>
<th>---------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-06-01 04:00:00</td>
<td>(1 row)</td>
</tr>
</tbody>
</table>

The following example demonstrates the use of offsets.

```sql
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;
```

<table>
<thead>
<tr>
<th>newzone_plus_2</th>
<th>newzone_minus_2_15</th>
<th>la_plus_2</th>
<th>gmt_plus_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-05-17 10:00:00</td>
<td>2014-05-17 14:15:00</td>
<td>2014-05-17 10:00:00</td>
<td>2014-05-17 10:00:00</td>
</tr>
</tbody>
</table>

(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.

**Syntax**

```sql
CURRENT_DATE
```

**Return Type**

DATE

**Examples**

Return the current date:

```sql
select current_date;
```

<table>
<thead>
<tr>
<th>date</th>
<th>------------</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-10-01</td>
<td>(1 row)</td>
</tr>
</tbody>
</table>

### 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**

```sql
DATE_CMP(date1, date2)
```
Arguments

date1

A date column or an expression that implicitly converts to a date.
date2

A date column or an expression that implicitly converts to a date.

Return Type

INTEGER

Example

The following query compares 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;
```

<table>
<thead>
<tr>
<th>caldate</th>
<th>?column?</th>
<th>date_cmp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-01-01</td>
<td>2008-01-04</td>
<td>-1</td>
</tr>
<tr>
<td>2008-01-02</td>
<td>2008-01-04</td>
<td>-1</td>
</tr>
<tr>
<td>2008-01-03</td>
<td>2008-01-04</td>
<td>-1</td>
</tr>
<tr>
<td>2008-01-04</td>
<td>2008-01-04</td>
<td>0</td>
</tr>
<tr>
<td>2008-01-05</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
<tr>
<td>2008-01-06</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
<tr>
<td>2008-01-07</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
<tr>
<td>2008-01-08</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
<tr>
<td>2008-01-09</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
<tr>
<td>2008-01-10</td>
<td>2008-01-04</td>
<td>1</td>
</tr>
</tbody>
</table>

(10 rows)

DATE_CMP_TIMESTAMP Function

Compares a date to a time stamp and returns 0 if the values are identical, 1 if date is greater alphabetically and -1 if timestamp is greater.

Syntax

```
DATE_CMP_TIMESTAMP(date, timestamp)
```

Arguments

date

A date column or an expression that implicitly converts to a date.
timestamp

A timestamp column or an expression that implicitly converts to a time stamp.
### 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.

```sql
select listid, '2008-06-18', listtime, 
date_cmp_timestamp('2008-06-18', listtime) 
from listing 
order by 1, 2, 3, 4 
limit 10;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>?column?</th>
<th>listtime</th>
<th>date_cmp_timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008-06-18</td>
<td>2008-01-24 06:43:29</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2008-06-18</td>
<td>2008-03-05 12:25:29</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2008-06-18</td>
<td>2008-11-01 07:35:33</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>2008-06-18</td>
<td>2008-05-24 01:18:37</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2008-06-18</td>
<td>2008-05-17 02:29:11</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>2008-06-18</td>
<td>2008-08-15 02:08:13</td>
<td>-1</td>
</tr>
<tr>
<td>7</td>
<td>2008-06-18</td>
<td>2008-11-15 09:38:15</td>
<td>-1</td>
</tr>
<tr>
<td>8</td>
<td>2008-06-18</td>
<td>2008-11-09 05:07:30</td>
<td>-1</td>
</tr>
<tr>
<td>9</td>
<td>2008-06-18</td>
<td>2008-09-09 08:03:36</td>
<td>-1</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-18</td>
<td>2008-06-17 09:44:54</td>
<td>1</td>
</tr>
</tbody>
</table>

(10 rows)

### DATE_CMP_TIMESTAMPTZ Function

DATE_CMP_TIMESTAMPTZ compares a date to a time stamp with time zone. If the date and time stamp values are identical, the function returns 0. If the date is greater alphabetically, the function returns 1. If the time stamp is greater, the function returns -1.

#### Syntax

```sql
DATE_CMP_TIMESTAMPTZ(date, timestamptz)
```

#### Arguments

- **date**

  A DATE column or an expression that implicitly converts to a date.

- **timestamptz**

  A TIMESTAMPTZ column or an expression that implicitly converts to a time stamp with a time zone.

#### Return Type

**INTEGER**

### DATE_PART_YEAR Function

The DATE_PART_YEAR function extracts the year from a date.
Date and Time Functions

Syntax

DATE_PART_YEAR(date)

Argument

date

A date column or an expression that implicitly converts to a date.

Return Type

INTEGER

Examples

The following example extracts the year from the CALDATE column:

```
select caldate, date_part_year(caldate)
from date
order by
dateid limit 10;
```

<table>
<thead>
<tr>
<th>caldate</th>
<th>date_part_year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-01-01</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-02</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-03</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-04</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-05</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-06</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-07</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-08</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-09</td>
<td>2008</td>
</tr>
<tr>
<td>2008-01-10</td>
<td>2008</td>
</tr>
</tbody>
</table>

DATEADD Function

Increments a date or time stamp value by a specified interval.

Syntax

DATEADD( datepart, interval, {date|timestamp} )

This function returns a time stamp data type.

Arguments

datepart

The date part (year, month, or day, for example) that the function operates on. See Dateparts for Date or Time Stamp Functions (p. 776).

interval

An integer that specified the interval (number of days, for example) to add to the target expression. A negative integer subtracts the interval.
A date or timestamp column or an expression that implicitly converts to a date or time stamp. The date or time stamp expression must contain the specified date part.

**Return Type**
TIMESTAMP

**Examples**

Add 30 days to each date in November that exists in the DATE table:

```sql
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)
```

Add 18 months to a literal date value:

```sql
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 time stamp for a date value is 00:00:00.

Add 30 minutes to a date value that does not specify a time stamp:

```sql
SELECT dateadd(m, 30, '2008-02-28');
```

```
date_add
---------------------
2008-02-28 00:30:00
(1 row)
```

You can name dateparts in full or abbreviate them; in this case, \( m \) stands for minutes, not months.

**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 30th + 1 month is May 31st:
DATEADD: If there are fewer days in the date you are adding to than in the result month, the result will be the corresponding day of the result month, not the last day of that month. For example, April 30th + 1 month is May 30th:

```
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|timestamp}, {date|timestamp} )
```

**Arguments**

`datepart`

The specific part of the date value (year, month, or day, for example) that the function operates on. For more information, see Dateparts for Date or Time Stamp Functions (p. 776).

Specifically, DATEDIFF determines the number of datepart boundaries that are crossed between two expressions. For example, if you are calculating the difference in years between two dates, 12-31-2008 and 01-01-2009, 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 time stamps, 01-01-2009 8:30:00 and 01-01-2009 10:00:00, the result is 2 hours.

`timestamp`

A date or timestamp columns or expressions that implicitly convert to a date or time stamp. The expressions must both contain the specified date 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**

Find the difference, in number of weeks, between two literal date values:

```sql
select datediff(week, '2009-01-01', '2009-12-31') as numweeks;
```

```sql
numweeks
--------
52
```

Find the difference, in number of quarters, between a literal value in the past and today's date. This
either assumes that the current date is June 5, 2008. You can name dateparts in full or abbreviate
them. The default column name for the DATEDIFF function is DATE_DIFF.

```sql
select datediff(qtr, '1998-07-01', current_date);
```

```sql
date_diff
--------
40
```

This 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).

```sql
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;
```

```sql
<table>
<thead>
<tr>
<th>priceperticket</th>
<th>wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.00</td>
<td>15</td>
</tr>
<tr>
<td>123.00</td>
<td>11</td>
</tr>
<tr>
<td>131.00</td>
<td>9</td>
</tr>
<tr>
<td>123.00</td>
<td>6</td>
</tr>
<tr>
<td>129.00</td>
<td>4</td>
</tr>
<tr>
<td>96.00</td>
<td>4</td>
</tr>
<tr>
<td>96.00</td>
<td>0</td>
</tr>
</tbody>
</table>
```

This example calculates the average number of hours sellers waited for all ticket sales.

```sql
select avg(datediff(hours, listtime, saletime)) as avgwait
from sales, listing
where sales.listid = listing.listid;
```

```sql
avgwait
-------
465
```
DATE_PART Function

DATE_PART extracts datepart values from an expression. DATE_PART is a synonym of the PGDATE_PART function.

Syntax

```
DATE_PART ( datepart, {date|timestamp} )
```

Arguments

datepart

The specific part of the date value (year, month, or day, for example) that the function operates on. For more information, see Dateparts for Date or Time Stamp Functions (p. 776).

{date|timestamp}

A date or timestamp column or an expression that implicitly converts to a date or time stamp. The expression must be a date or time stamp expression that contains the specified datepart.

Return Type

DOUBLE

Examples

Apply the DATE_PART function to a column in a table:

```
select date_part(w, listtime) as weeks, listtime
from listing where listid=10;
```

<table>
<thead>
<tr>
<th>weeks</th>
<th>listtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>2008-06-17 09:44:54</td>
</tr>
</tbody>
</table>

(1 row)

You can name dateparts in full or abbreviate them; in this case, w stands for weeks.

The day of week datepart 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;
```

<table>
<thead>
<tr>
<th>dow</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2008-01-05 14:00:00</td>
</tr>
<tr>
<td>6</td>
<td>2008-01-05 14:00:00</td>
</tr>
<tr>
<td>6</td>
<td>2008-01-05 14:00:00</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

(1147 rows)
Apply the DATE_PART function to a literal date value:

```sql
select date_part(minute, '2009-01-01 02:08:01');
```

```
pgdate_part
-------------
8
```

(1 row)

The default column name for the DATE_PART function is PGDATE_PART.

### DATE_TRUNC Function

The DATE_TRUNC function truncates a time stamp expression or literal based on the date part that you specify, such as hour, week, or month. DATE_TRUNC returns the first day of the specified year, the first day of the specified month, or the Monday of the specified week.

#### Syntax

```
DATE_TRUNC('datepart', timestamp)
```

#### Arguments

- **datepart**
  
  The date part to which to truncate the time stamp value. See Dateparts for Date or Time Stamp Functions (p. 776) for valid formats.

- **timestamp**
  
  A timestamp column or an expression that implicitly converts to a time stamp.

#### Return Type

TIMESTAMP

#### Example

In the following example, the DATE_TRUNC function uses the 'week' datepart to return the date for the Monday of each week.

```sql
select date_trunc('week', saletime), sum(pricepaid) from sales where saletime like '2008-09%' group by date_trunc('week', saletime) order by 1;
```

<table>
<thead>
<tr>
<th>date_trunc</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-09-01</td>
<td>2474899.00</td>
</tr>
<tr>
<td>2008-09-08</td>
<td>2412354.00</td>
</tr>
<tr>
<td>2008-09-15</td>
<td>2364707.00</td>
</tr>
<tr>
<td>2008-09-22</td>
<td>2359351.00</td>
</tr>
<tr>
<td>2008-09-29</td>
<td>705249.00</td>
</tr>
</tbody>
</table>

(5 rows)

### EXTRACT Function

The EXTRACT function returns a date part, such as a day, month, or year, from a time stamp value or expression.
Syntax

```sql
EXTRACT ( datepart FROM { TIMESTAMP 'literal' | timestamp } )
```

Arguments

datepart

For possible values, see [Dateparts for Date or Time Stamp Functions](p. 776).

literal

A time stamp value, enclosed in single quotation marks and preceded by the TIMESTAMP keyword.

timestamp

A TIMESTAMP or TIMESTAMPTZ column, or an expression that implicitly converts to a time stamp or time stamp with time zone.

Return Type

INTEGER if the argument is TIMESTAMP

DOUBLE PRECISION if the argument is TIMESTAMPTZ

Examples

Determine the week numbers for sales in which the price paid was $10,000 or more.

```sql
select salesid, extract(week from saletime) as weeknum
from sales where pricepaid > 9999 order by 2;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>weeknum</th>
</tr>
</thead>
<tbody>
<tr>
<td>159073</td>
<td>6</td>
</tr>
<tr>
<td>160318</td>
<td>8</td>
</tr>
<tr>
<td>161723</td>
<td>26</td>
</tr>
</tbody>
</table>

(3 rows)

Return the minute value from a literal time stamp value.

```sql
select extract(minute from timestamp '2009-09-09 12:08:43');
```

<table>
<thead>
<tr>
<th>date_part</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
</tr>
</tbody>
</table>

(1 row)

GETDATE Function

GETDATE returns the current date and time in the current session time zone (UTC by default).

Syntax

```sql
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:

```sql
select getdate();
```

```
timestamp
--------------------
2008-12-04 16:10:43
(1 row)
```

The following example uses the GETDATE() function inside the TRUNC function to return the current date without the time:

```sql
select trunc(getdate());
```

```
trunc
-------
2008-12-04
(1 row)
```

**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 Interval Literals (p. 384).

Syntax

```sql
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":

```sql
select interval_cmp('3 days','1 year');
```

764
```
interval_cmp
---------------
-1
```
This example compares the value "7 days" to "1 week":
```
select interval_cmp('7 days','1 week');
interval_cmp
---------------
0
(1 row)
```

### LAST_DAY Function

LAST_DAY returns the date of the last day of the month that contains \textit{date}. The return type is always DATE, regardless of the data type of the \textit{date} argument.

### Syntax

```
LAST_DAY ( { date | timestamp } )
```

### Arguments

\textit{date} | \textit{timestamp}
---
A date or timestamp column or an expression that implicitly converts to a date or time stamp.

### 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
(1 row)
```

The following example returns the number of tickets sold for each of the last 7 days of the month:
```
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;

<table>
<thead>
<tr>
<th>days remaining</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10140</td>
</tr>
<tr>
<td>1</td>
<td>11187</td>
</tr>
<tr>
<td>2</td>
<td>11515</td>
</tr>
</tbody>
</table>
```
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

An expression, such as a column name, that evaluates to a valid date or time stamp value.

date2

An expression, such as a column name, that evaluates to a valid date or time stamp value.

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:

```sql
select months_between('1969-01-18', '1969-03-18') as months;
months
----------
-2
```

The following example returns the months between the first and last showings of an event:

```sql
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;

<table>
<thead>
<tr>
<th>eventname</th>
<th>first_show</th>
<th>last_show</th>
<th>month_diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>.38 Special</td>
<td>2008-01-21 19:30:00.0</td>
<td>2008-12-25 15:00:00.0</td>
<td>11.12</td>
</tr>
<tr>
<td>3 Doors Down</td>
<td>2008-01-03 15:00:00.0</td>
<td>2008-12-01 19:30:00.0</td>
<td>10.94</td>
</tr>
<tr>
<td>70s Soul Jam</td>
<td>2008-01-16 19:30:00.0</td>
<td>2008-12-07 14:00:00.0</td>
<td>10.7</td>
</tr>
<tr>
<td>A Bronx Tale</td>
<td>2008-01-21 19:00:00.0</td>
<td>2008-12-15 15:00:00.0</td>
<td>10.8</td>
</tr>
<tr>
<td>A Catered Affair</td>
<td>2008-01-08 19:30:00.0</td>
<td>2008-12-19 19:00:00.0</td>
<td>11.35</td>
</tr>
</tbody>
</table>

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 given_date, the next occurrence of that day is returned.

Syntax

NEXT_DAY ( { date | timestamp }, day )

Arguments

date | timestamp

A date or timestamp column or an expression that implicitly converts to a date or time stamp.

day

A string containing the name of any day. Capitalization does not matter.

Valid values are as follows.

<table>
<thead>
<tr>
<th>Day</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>Su, Sun, Sunday</td>
</tr>
<tr>
<td>Monday</td>
<td>M, Mo, Mon, Monday</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Tu, Tue, Tues, Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
<td>W, We, Wed, Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
<td>Th, Thu, Thurs, Thursday</td>
</tr>
<tr>
<td>Friday</td>
<td>F, Fr, Fri, Friday</td>
</tr>
<tr>
<td>Saturday</td>
<td>Sa, Sat, Saturday</td>
</tr>
</tbody>
</table>

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 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
CKT700IE Hadassah Adkins Ana Gabriel              2008-07-06 2008-07-07
VVG07000 Nathan Abbott Armando Manzanero          2008-07-04 2008-07-07
GEW77SII Scarlet Avila August: Osage County        2008-07-06 2008-07-07
ECW71CVS Caryn Adkins Ben Folds                    2008-07-03 2008-07-07
KUN82CYU Kaden Aguilar Bette Midler                2008-07-01 2008-07-07
WZE78DIZ Kay Avila                                 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 time stamp for the current date:

```
select sysdate;
```

```
timestamp
```
The following example uses the SYSDATE function inside the TRUNC function to return the current date without the time:

```sql
select trunc(sysdate);
```

```
trunc
------------
2008-12-04
(1 row)
```

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:

```sql
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.

**Syntax**

```
TIMEOFDAY()
```

**Return Type**

VARCHAR

**Examples**

Return the current date and time by using the TIMEOFDAY function:

```sql
select timeofday();
timeofday
------------
Thu Sep 19 22:53:50.333525 2013 UTC
(1 row)
```

**TIMESTAMP_CMP Function**

Compares the value of two time stamps and returns an integer. If the time stamps are identical, the function returns 0. If the first time stamp is greater alphabetically, the function returns 1. If the second time stamp is greater, the function returns −1.
Syntax

```plaintext
TIMESTAMP_CMP(timestamp1, timestamp2)
```

Arguments

`timestamp1`

A TIMESTAMP column or an expression that implicitly converts to a time stamp.

`timestamp2`

A TIMESTAMP column or an expression that implicitly converts to a time stamp.

Return Type

INTEGER

Examples

The following example compares the LISTTIME and SALETIME for a listing. Note that the value for TIMESTAMP_CMP is -1 for all listings because the time stamp for the sale is after the time stamp for the listing:

```sql
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;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>listtime</th>
<th>saletime</th>
<th>timestamp_cmp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008-01-24 06:43:29</td>
<td>2008-02-18 02:36:48</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>2008-05-24 01:18:37</td>
<td>2008-06-06 05:00:16</td>
<td>-1</td>
</tr>
<tr>
<td>5</td>
<td>2008-05-17 02:29:11</td>
<td>2008-06-06 08:26:17</td>
<td>-1</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-17 09:44:54</td>
<td>2008-08-04 03:06:36</td>
<td>-1</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-17 09:44:54</td>
<td>2008-08-04 03:06:36</td>
<td>-1</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-17 09:44:54</td>
<td>2008-08-04 03:06:36</td>
<td>-1</td>
</tr>
</tbody>
</table>

This example shows that TIMESTAMP_CMP returns a 0 for identical time stamps:

```sql
select listid, timestamp_cmp(listtime, listtime)
from listing
order by 1, 2
limit 10;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>timestamp_cmp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
**TIMESTAMP_CMP_DATE Function**

TIMESTAMP_CMP_DATE compares the value of a time stamp and a date. If the time stamp and date values are identical, the function returns 0. If the time stamp is greater alphabetically, the function returns 1. If the date is greater, the function returns −1.

**Syntax**

```sql
TIMESTAMP_CMP_DATE(timestamp, date)
```

**Arguments**

- `timestamp`:
  A timestamp column or an expression that implicitly converts to a time stamp.

- `date`:
  A date column or an expression that implicitly converts to a date.

**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.

```sql
select listid, listtime, timestamp_cmp_date(listtime, '2008-06-18')
from listing
order by 1, 2, 3
limit 10;
```

<table>
<thead>
<tr>
<th>listid</th>
<th>listtime</th>
<th>timestamp_cmp_date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008-01-24 06:43:29</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>2008-03-05 12:25:29</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>2008-11-01 07:35:33</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2008-05-24 01:18:37</td>
<td>-1</td>
</tr>
<tr>
<td>5</td>
<td>2008-05-17 02:29:11</td>
<td>-1</td>
</tr>
<tr>
<td>6</td>
<td>2008-08-15 02:08:13</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2008-11-15 09:38:15</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2008-11-09 05:07:30</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>2008-09-09 08:03:36</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-17 09:44:54</td>
<td>-1</td>
</tr>
</tbody>
</table>

(10 rows)
TIMESTAMP_CMP_TIMESTAMPTZ Function

TIMESTAMP_CMP_TIMESTAMPTZ compares the value of a time stamp expression with a time stamp with time zone expression. If the time stamp and time stamp with time zone values are identical, the function returns 0. If the time stamp is greater alphabetically, the function returns 1. If the time stamp with time zone is greater, the function returns –1.

Syntax

```
TIMESTAMP_CMP_TIMESTAMPTZ(timestamp, timestamptz)
```

Arguments

timestamp

- A TIMESTAMP column or an expression that implicitly converts to a time stamp.

timestamptz

- A TIMESTAMP column or an expression that implicitly converts to a time stamp with a time zone.

Return Type

INTEGER

TIMESTAMPTZ_CMP Function

TIMESTAMPTZ_CMP compares the value of two time stamp with time zone values and returns an integer. If the time stamps are identical, the function returns 0. If the first time stamp is greater alphabetically, the function returns 1. If the second time stamp is greater, the function returns –1.

Syntax

```
TIMESTAMPTZ_CMP(timestamptz1, timestamptz2)
```

Arguments

timestamptz1

- A TIMESTAMPTZ column or an expression that implicitly converts to a time stamp with time zone.

timestamptz2

- A TIMESTAMPTZ column or an expression that implicitly converts to a time stamp with time zone.

Return Type

INTEGER

TIMESTAMPTZ_CMP_DATE Function

TIMESTAMPTZ_CMP_DATE compares the value of a time stamp and a date. If the time stamp and date values are identical, the function returns 0. If the time stamp is greater alphabetically, the function returns 1. If the date is greater, the function returns –1.
Syntax

TIMESTAMPTZ_CMP_DATE(timestamptz, date)

Arguments

timestamptz
A TIMESTAMPTZ column or an expression that implicitly converts to a time stamp with a time zone.
date
A date column or an expression that implicitly converts to a date.

Return Type

INTEGER

TIMESTAMPTZ_CMP_TIMESTAMP Function

TIMESTAMPTZ_CMP_TIMESTAMP compares the value of a time stamp with time zone expression with a time stamp expression. If the time stamp with time zone and time stamp values are identical, the function returns 0. If the time stamp with time zone is greater alphabetically, the function returns 1. If the time stamp is greater, the function returns −1.

Syntax

TIMESTAMPTZ_CMP_TIMESTAMP(timestamptz, timestamp)

Arguments

timestamptz
A TIMESTAMPTZ column or an expression that implicitly converts to a time stamp with a time zone.
timestamp
A TIMESTAMP column or an expression that implicitly converts to a time stamp.

Return Type

INTEGER

TIMEZONE Function

TIMEZONE returns a time stamp for the specified time zone and time stamp value.

For information and examples about how to set time zone, see timezone (p. 1108).
For information and examples about how to convert time zone, see CONVERT_TIMEZONE (p. 751).

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, execute the following command.

```sql
select pg_timezone_names();
```

To view a list of supported time zone abbreviations, execute the following command.

```sql
select pg_timezone_abbrevs();
```

For more information and examples, see Time Zone Usage Notes (p. 752).

timestamp

An expression that results in a TIMESTAMP type, or a value that can implicitly be coerced to a time stamp.

timestamptz

An expression that results in a TIMESTAMPTZ type, or a value that can implicitly be coerced to a time stamp with time zone.

Return Type

TIMESTAMPTZ when used with a TIMESTAMP expression.

TIMESTAMP when used with a TIMESTAMPTZ expression.

TO_TIMESTAMP Function

TO_TIMESTAMP converts a TIMESTAMP string to TIMESTAMPTZ.

Syntax

```sql
to_timestamp ('timestamp', 'format')
```

Arguments

timestamp

A string that represents a time stamp value in the format specified by format.

format

The format for the timestamp value. Formats that include a time zone (TZ, tz, or OF) are not supported as input. For valid time stamp formats, see Datetime Format Strings (p. 888).

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, 'HH24:MI:SS') as seconds;
```

<table>
<thead>
<tr>
<th>timestamp</th>
<th>seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018-05-17 23:54:51</td>
<td>0001-03-24 18:05:17.0</td>
</tr>
</tbody>
</table>

TRUNC Date Function

Truncates a time stamp and returns a date.

Syntax

```
TRUNC(timestamp)
```

Arguments

\(timestamp\)

A timestamp column or an expression that implicitly converts to a time stamp.

To return a time stamp value with \(00:00:00\) as the time, cast the function result to a TIMESTAMP.

Return Type

DATE

Examples

Return the date portion from the result of the SYSDATE function (which returns a time stamp):

```
select sysdate;
```

<table>
<thead>
<tr>
<th>timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-07-21 10:32:38.248109</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>

```
select trunc(sysdate);
```

<table>
<thead>
<tr>
<th>trunc</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-07-21</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>

Apply the TRUNC function to a TIMESTAMP column. The return type is a date.

```
select trunc(starttime) from event 
  order by eventid limit 1;
```
Dateparts for Date or Time Stamp Functions

The following table identifies the datepart and timepart names and abbreviations that are accepted as arguments to the following functions:

- DATEADD
- DATEDIFF
- DATE_PART
- DATE_TRUNC
- EXTRACT

<table>
<thead>
<tr>
<th>Datepart or Timepart</th>
<th>Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>millennium, millennia</td>
<td>mil, mils</td>
</tr>
<tr>
<td>century, centuries</td>
<td>c, cent, cents</td>
</tr>
<tr>
<td>decade, decades</td>
<td>dec, decs</td>
</tr>
<tr>
<td>epoch</td>
<td>epoch (supported by the DATE_PART (p. 761) and the EXTRACT (p. 762))</td>
</tr>
<tr>
<td>year, years</td>
<td>y, yr, yrs</td>
</tr>
<tr>
<td>quarter, quarters</td>
<td>qtr, qtrs</td>
</tr>
<tr>
<td>month, months</td>
<td>mon, mons</td>
</tr>
<tr>
<td>week, weeks</td>
<td>w</td>
</tr>
<tr>
<td></td>
<td>When used with the DATE_TRUNC (p. 762), returns the date for the most recent Monday.</td>
</tr>
<tr>
<td>day of week</td>
<td>dayofweek, dow, dw, weekday (supported by the DATE_PART (p. 761) and the EXTRACT Function (p. 762))</td>
</tr>
<tr>
<td></td>
<td>Returns an integer from 0–6, starting with Sunday.</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong> The DOW datepart 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 (p. 888).</td>
</tr>
<tr>
<td>day of year</td>
<td>dayofyear, doy, dy, yearday (supported by the DATE_PART (p. 761) and the EXTRACT (p. 762))</td>
</tr>
<tr>
<td>day, days</td>
<td>d</td>
</tr>
<tr>
<td>hour, hours</td>
<td>h, hr, hrs</td>
</tr>
<tr>
<td>minute, minutes</td>
<td>m, min, mins</td>
</tr>
</tbody>
</table>
### Datepart or Timepart

<table>
<thead>
<tr>
<th>Datepart or Timepart</th>
<th>Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>second, seconds</td>
<td>s, sec, secs</td>
</tr>
<tr>
<td>millisecond, milliseconds</td>
<td>ms, msec, msecs, msecond, mseconds, millisec, millisecon</td>
</tr>
<tr>
<td>microsecond, microseconds</td>
<td>microsec, microsecs, microsecond, usecond, useconds, us, usec, usecs</td>
</tr>
<tr>
<td>timezone, timezone_hour,</td>
<td>Supported by the DATE_TRUNC (p. 762) function and the</td>
</tr>
<tr>
<td>timezone_minute</td>
<td>EXTRACT (p. 762) for time stamp with time zone (TIMESTAMPTZ) only.</td>
</tr>
</tbody>
</table>

### Variations in Results with Seconds, Milliseconds, and Microseconds

Minor differences in query results occur when different date functions specify seconds, milliseconds, or microseconds as dateparts:

- The EXTRACT function return integers for the specified datepart only, ignoring higher- and lower-level dateparts. If the specified datepart is seconds, milliseconds and microseconds are not included in the result. If the specified datepart is milliseconds, seconds and microseconds are not included. If the specified datepart is microseconds, seconds and milliseconds are not included.
- The DATE_PART function returns the complete seconds portion of the time stamp, regardless of the specified datepart, returning either a decimal value or an integer as required.

For example, compare the results of the following queries:

```sql
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
(1 row)

select date_part(sec, micro) from seconds;
pdate_part
-------------
3.189717
(1 row)
```

### CENTURY, EPOCH, DECADE, and MIL Notes

**CENTURY or CENTURIES**

Amazon Redshift interprets a CENTURY to start with year ###1 and end with year ###0:

```sql
select extract (century from timestamp '2000-12-16 12:21:13');
date_part
----------
20
(1 row)

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.

```sql
create table event_example
as select eventname, starttime, date_part(epoch, starttime) from event;
```

```sql
select "column", type from pg_table_def where tablename='event_example';
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>eventname</td>
<td>character varying(200)</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp without time zone</td>
</tr>
<tr>
<td>pgdate_part</td>
<td>double precision</td>
</tr>
</tbody>
</table>

```sql
select eventname, starttime, pgdate_part from event_example;
```

```sql
select eventname, starttime, timestamp with time zone 'epoch' + pgdate_part * interval '1 second' AS converted_timestamp from event_example;
```

---

(1 row)
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:

```sql
select extract(decade from timestamp '1999-02-16 20:38:40');
date_part
-----------
200
(1 row)

select extract(decade from timestamp '2000-02-16 20:38:40');
date_part
-----------
201
(1 row)

select extract(decade from timestamp '2010-02-16 20:38:40');
date_part
-----------
202
(1 row)
```

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:

```sql
select extract (mil from timestamp '2000-12-16 12:21:13');
date_part
---------
2
(1 row)

select extract (mil from timestamp '2001-12-16 12:21:13');
date_part
---------
3
(1 row)
```

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.

Amazon Redshift supports the following spatial functions.

Topics

- GeometryType (p. 780)
- ST_AsBinary (p. 781)
- ST_AsEWKB (p. 782)
- ST_AsEWKT (p. 783)
- ST_AsGeoJSON (p. 784)
- ST_AsText (p. 785)
- ST_Azimuth (p. 786)
- ST_Contains (p. 786)
- ST_CoveredBy (p. 787)
- ST_Covers (p. 788)
- ST_Dimension (p. 789)
- ST_Disjoint (p. 790)
- ST_Distance (p. 791)
- ST_DistanceSphere (p. 791)
- ST_DWithin (p. 792)
- ST_Equals (p. 793)
- ST_GeometryType (p. 794)
- ST_GeomFromEWKB (p. 795)
- ST_GeomFromText (p. 796)
- ST_GeomFromWKB (p. 797)
- ST_Intersects (p. 798)
- ST_IsClosed (p. 798)
- ST_IsCollection (p. 799)
- ST_IsEmpty (p. 800)
- ST_MakeLine (p. 800)
- ST_MakePoint (p. 801)
- ST_MakePolygon (p. 802)
- ST_NPoints (p. 802)
- ST_NRings (p. 803)
- ST_NumGeometries (p. 804)
- ST_NumInteriorRings (p. 804)
- ST_NumPoints (p. 805)
- ST_Point (p. 806)
- ST_Polygon (p. 806)
- ST_SetSRID (p. 807)
- ST_SRID (p. 808)
- ST_Within (p. 809)
- ST_X (p. 809)
- ST_XMax (p. 810)
- ST_XMin (p. 811)
- ST_Y (p. 811)
- ST_YMax (p. 812)
- ST_YMin (p. 812)

**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.

<table>
<thead>
<tr>
<th>Returned String Value</th>
<th>Geometry Subtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>POINT</td>
<td>Returned if <code>geom</code> is a POINT subtype</td>
</tr>
<tr>
<td>LINestring</td>
<td>Returned if <code>geom</code> is a LINestring subtype</td>
</tr>
<tr>
<td>POLYGON</td>
<td>Returned if <code>geom</code> is a POLYGON subtype</td>
</tr>
<tr>
<td>MULTIPOINT</td>
<td>Returned if <code>geom</code> is a MULTIPOINT subtype</td>
</tr>
<tr>
<td>MULTILINESTRING</td>
<td>Returned if <code>geom</code> is a MULTILINESTRING subtype</td>
</tr>
<tr>
<td>MULTIPOLYGON</td>
<td>Returned if <code>geom</code> is a MULTIPOLYGON subtype</td>
</tr>
<tr>
<td>GEOMETRYCOLLECTION</td>
<td>Returned if <code>geom</code> is a GEOMETRYCOLLECTION subtype</td>
</tr>
</tbody>
</table>

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
```

ST_AsBinary

ST_AsBinary returns the hexadecimal well-known binary (WKB) representation of an input geometry using ASCII hexadecimal characters (0–9, A–F).

Syntax

```
ST_AsBinary(geom)
```
Arguments

*geom*

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return Type

VARCHAR

If *geom* 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.

```sql
SELECT ST_AsBinary(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```


ST_AsEWKB

ST_AsEWKB returns the extended well-known binary (EWKB) representation of an input geometry using ASCII hexadecimal characters (0–9, A–F).

Syntax

```
ST_AsEWKB(geom)
```

Arguments

*geom*

A value of data type `GEOMETRY` or an expression that evaluates to a `GEOMETRY` type.

Return Type

VARCHAR

If *geom* 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.

```sql
SELECT ST_AsEWKB(ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326));
```
ST_AsEWKT

ST_AsEWKT returns the extended well-known text (EWKT) representation of an input geometry.

**Syntax**

```
ST_AsEWKT(geom)
```

```
ST_AsEWKT(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 coordinates of `geom` are displayed using the specified precision 1–20. If `precision` is not specified, the default is 15.

**Return Type**

`VARCHAR`

If `geom` 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_asewkb
------------------
0103000020E6100000100000050000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

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));
```

```
st_asewkt
------------------
SRID=4326;LINESTRING(3.141592653589793 -6.283185307179586,2.718281828459045 -1.414213562373095)
```

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));
```
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st_asewkt
-------------------------------SRID=4326;LINESTRING(3.14159 -6.28319,2.71828 -1.41421)

ST_AsGeoJSON
ST_AsGeoJSON returns the GeoJSON representation of an input geometry. For more information about
GeoJSON, see GeoJSON in Wikipedia.

Syntax
ST_AsGeoJSON(geom)
ST_AsGeoJSON(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 coordinates of geom are displayed using the speciﬁed precision
1–20. If precision is not speciﬁed, the default is 15.

Return Type
VARCHAR
If geom 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);

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ST_AsText

ST_AsText returns the well-known text (WKT) representation of an input geometry.

Syntax

```
ST_AsText(geom)
```

```
ST_AsText(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 coordinates of `geom` are displayed using the specified precision 1–20. If `precision` is not specified, the default is 15.

Return Type

VARCHAR

If `geom` 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_asgeojson
----------------------------------------------------------------------------------------------------------------------------------
{"type":"LineString","coordinates":\[[3.14159,-6.28319],[2.71828,-1.41421]\]}
```

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_asgeojson
----------------------------------------------------------------------------------------------------------------------------------
{"type":"LineString","coordinates":\[[3.141592653589793,-6.283185307179586,2.718281828459045,-1.414213562373095]\]}
```

```
st_asgeojson
----------------------------------------------------------------------------------------------------------------------------------
LINESTRING(3.141592653589793 -6.283185307179586,2.718281828459045 -1.414213562373095)
```

```
```
ST_Azimuth

ST_Azimuth returns the north-based Cartesian azimuth of two input points.

Syntax

\[
\text{ST_Azimuth}(\text{point1}, \text{point2})
\]

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 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 same SRID value, then an error is returned.

Examples

The following SQL returns the azimuth of the input points.

```sql
SELECT ST_Azimuth(ST_Point(1,2), ST_Point(5,6));
```

This returns:

```
0.7853981633974483
```

ST_Contains

ST_Contains returns true if the first input geometry contains 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_CoveredBy**

`ST_CoveredBy` returns true if the first input geometry is covered by 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`.

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.
**ST_Covers**

ST_Covers returns true if the first input geometry covers 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**

```sql
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.

```sql
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))'));
```

```
<table>
<thead>
<tr>
<th>st_covers</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
</tr>
</tbody>
</table>
```

**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.

**Syntax**

```sql
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.

<table>
<thead>
<tr>
<th>Returned Value</th>
<th>Geometry Subtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Returned if <code>geom</code> is a <code>POINT</code> or <code>MULTIPOINT</code> subtype</td>
</tr>
<tr>
<td>1</td>
<td>Returned if <code>geom</code> is a <code>LINESTRING</code> or <code>MULTILINESTRING</code> subtype.</td>
</tr>
<tr>
<td>2</td>
<td>Returned if <code>geom</code> is a <code>POLYGON</code> or <code>MULTIPOLYGON</code> subtype.</td>
</tr>
<tr>
<td>0</td>
<td>Returned if <code>geom</code> is an empty <code>GEOMETRYCOLLECTION</code> subtype</td>
</tr>
<tr>
<td>Returned Value</td>
<td>Geometry Subtype</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Largest dimension of the components of the collection</td>
<td>Returned if <code>geom</code> is a GEOMETRYCOLLECTION subtype</td>
</tr>
</tbody>
</table>

### 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.

```sql
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 two input geometries have no points in common.

#### Syntax

```sql
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.

```sql
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_Distance

ST_Distance returns the Euclidean distance between the two input geometry values.

Syntax

```
ST_Distance(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

DOUBLE PRECISION in the same units as the input geometries.

If **geom1** or **geom2** is null or empty, 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 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
```

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.

`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.

`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 `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 distances in kilometers between three airport locations in Germany: Berlin Tegel (TXL), Munich International (MUC), and Frankfurt International (FRA).

```sql
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;
```

<table>
<thead>
<tr>
<th>airports</th>
<th>distance_in_km</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRA &lt;-&gt; MUC</td>
<td>299</td>
</tr>
<tr>
<td>FRA &lt;-&gt; TXL</td>
<td>432</td>
</tr>
<tr>
<td>MUC &lt;-&gt; TXL</td>
<td>480</td>
</tr>
</tbody>
</table>

`ST_DWithin`

`ST_DWithin` returns true if the Euclidean distance between 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_Equals

`ST_Equals` returns true if 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.

```sql
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))'));
```

<table>
<thead>
<tr>
<th>st_equals</th>
<th>-------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>false</td>
</tr>
</tbody>
</table>

The following SQL checks if the two linestrings are geometrically equal.

```sql
SELECT ST_Equals(ST_GeomFromText('LINESTRING(1 0,10 0)'), ST_GeomFromText('LINESTRING(1 0,5 0,10 0)'));
```

<table>
<thead>
<tr>
<th>st_equals</th>
<th>-------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>true</td>
</tr>
</tbody>
</table>

**ST_GeometryType**

ST_GeometryType returns the subtype of an input geometry as a string.

**Syntax**

```sql
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.

<table>
<thead>
<tr>
<th>Returned String Value</th>
<th>Geometry Subtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST_Point</td>
<td>Returned if <code>geom</code> is a POINT subtype</td>
</tr>
<tr>
<td>ST_LineString</td>
<td>Returned if <code>geom</code> is a LINESTRING subtype</td>
</tr>
<tr>
<td>ST_Polygon</td>
<td>Returned if <code>geom</code> is a POLYGON subtype</td>
</tr>
<tr>
<td>ST_MultiPoint</td>
<td>Returned if <code>geom</code> is a MULTIPOLYGON subtype</td>
</tr>
<tr>
<td>ST_MultiLineString</td>
<td>Returned if <code>geom</code> is a MULTILINESTRING subtype</td>
</tr>
<tr>
<td>ST_MultiPolygon</td>
<td>Returned if <code>geom</code> is a MULTILINESTRING subtype</td>
</tr>
<tr>
<td>ST_GeometryCollection</td>
<td>Returned if <code>geom</code> is a GEOMETRYCOLLECTION subtype</td>
</tr>
</tbody>
</table>

### Examples

The following SQL returns the subtype of the input linestring geometry.

```sql
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.

#### 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.

```sql
SELECT ST_AsEWKT(ST_GeomFromEWKB('0103000020E6100000010000000500000000000000000000000000000000000000000000000000000000000F03F000000000000F03F000000000000F03F000000000000F03F000000000000000000000000000000000000000000000000'))
```

<table>
<thead>
<tr>
<th>st_aowkt</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRID=4326;POLYGON((0,0,1,1,1,0,0))</td>
</tr>
</tbody>
</table>

**ST_GeomFromText**

`ST_GeomFromText` constructs a geometry object from a well-known text (WKT) representation of an input geometry.

**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.

- **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 `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.
Amazon Redshift Database Developer Guide
Spatial Functions

SELECT ST_GeomFromText('POLYGON((0 0,0 1,1 1,1 0,0 0))',4326);

st_geomfromtext
-------------------------------0103000020E61000000100000005000000000000000000000000000000000000000000000000000000000000000000F03F00000

ST_GeomFromWKB
ST_GeomFromWKB constructs a geometry object from a hexadecimal well-known binary (WKB)
representation of an input geometry.

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('0103000000010000000500000000000000000000000000000000000000000000000000000000

st_astext
--------------------------------

797


ST_Intersects

ST_Intersects returns true if 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_IsClosed

ST_IsClosed returns true if 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

\[
\text{ST\_IsClosed}(\text{geom})
\]

Arguments

\textit{geom}

A value of data type \textit{GEOMETRY} or an expression that evaluates to a \textit{GEOMETRY} type.

Return Type

\textbf{BOOLEAN}

If \textit{geom} is null, then null is returned.

Examples

The following SQL checks if the polygon is closed.

```sql
SELECT ST_IsClosed(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

\begin{verbatim}
stisclosed
------------
true
\end{verbatim}

\textbf{ST\_IsCollection}

\textit{ST\_IsCollection} returns true if the input geometry is one of the following subtypes: \textit{GEOMETRYCOLLECTION}, \textit{MULTIPOINT}, \textit{MULTILINSTRING}, or \textit{MULTIPOLYGON}.

Syntax

\[
\text{ST\_IsCollection}(\text{geom})
\]

Arguments

\textit{geom}

A value of data type \textit{GEOMETRY} or an expression that evaluates to a \textit{GEOMETRY} type.

Return Type

\textbf{BOOLEAN}

If \textit{geom} is null, then null is returned.

Examples

The following SQL checks if the polygon is a collection.

```sql
SELECT ST_IsCollection(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```
ST_IsEmpty
ST_IsEmpty returns true if the input geometry is empty. A geometry is empty if it contains no points.

Syntax
```sql
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.
```sql
SELECT ST_IsEmpty(ST_GeomFromText('POLYGON((0 2,1 1,0 -1,0 2))'));
```

ST_MakeLine
ST_MakeLine creates a linestring from the input geometries.

Syntax
```sql
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 MULTIPOLY.

`geom2`
A value of data type GEOMETRY or an expression that evaluates to a GEOMETRY type. The subtype must be POINT, LINESTRING, or MULTIPOLY.
Return Type

GEOMETRY of subtype LINestring.

The spatial reference system identifier (SRID) value of the returned geometry is the SRID value of the input geometries.

If \( \text{geom1} \) or \( \text{geom2} \) is null, then null is returned.

If \( \text{geom1} \) and \( \text{geom2} \) have different SRID values, then an error is returned.

If \( \text{geom1} \) or \( \text{geom2} \) is not a POINT, LINestring, or MULTIPOINT, then an error is returned.

Examples

The following SQL constructs a linestring from two input linestrings.

```sql
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_MakePoint

ST_MakePoint returns a point geometry whose coordinate values are the input values.

Syntax

```sql
ST_MakePoint(x, y)
```

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.

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 returns a GEOMETRY type of subtype POINT with the provided coordinates.

```sql
SELECT ST_AsText(ST_MakePoint(1,3));
```
**ST_MakePolygon**

ST_MakePolygon returns a polygon geometry whose outer ring is the input linestring.

**Syntax**

```
ST_MakePolygon(linestring)
```

**Arguments**

*linestring*

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.

**Return Type**

`GEOMETRY` of subtype `POLYGON`.

The spatial reference system identifier (SRID) of the returned geometry is equal to the SRID of the value input as `linestring`.

If `linestring` 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.

**Examples**

The following SQL returns a polygon from an input linestring.

```sql
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))
```

**ST_NPoints**

ST_NPoints returns the number of points in an input geometry.

**Syntax**

```
ST_NPoints(geom)
```
Arguments

\textit{geom}

A value of data type \texttt{GEOMETRY} or an expression that evaluates to a \texttt{GEOMETRY} type.

Return Type

\texttt{INTEGER}

If \textit{geom} is null, then null is returned.

Examples

The following SQL returns the number of points in a linestring.

\begin{verbatim}
SELECT ST_NPoints(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07)'));
\end{verbatim}

\begin{tabular}{|l|}
\hline
\texttt{st_npoints} \\
\hline
\texttt{---------------} \\
\texttt{4} \\
\hline
\end{tabular}

\textbf{ST_NRings}

ST_NRings returns the number of rings in an input geometry.

Syntax

\begin{verbatim}
ST_NRings(geom)
\end{verbatim}

Arguments

\textit{geom}

A value of data type \texttt{GEOMETRY} or an expression that evaluates to a \texttt{GEOMETRY} type.

Return Type

\texttt{INTEGER}

If \textit{geom} is null, then null is returned.

The values returned are as follows.

\begin{tabular}{|l|l|}
\hline
\textbf{Returned Value} & \textbf{Geometry Subtype} \\
\hline
0 & Returned if \textit{geom} is a \texttt{POINT}, \texttt{LINESTRING}, \texttt{MULTIPOINT}, or \texttt{MULTILINESTRING} subtype \\
\hline
The number of rings. & Returned if \textit{geom} is a \texttt{POLYGON} or \texttt{MULTIPOLYGON} subtype \\
\hline
The number of rings in all components & Returned if \textit{geom} is a \texttt{GEOMETRYCOLLECTION} subtype \\
\hline
\end{tabular}
Examples

The following SQL returns the number of rings in a multipolygon.

```sql
SELECT ST_NRings(ST_GeomFromText('MULTIPOLYGON(((0 0,10 0,0 10,0 0)),((0 0,-10 0,0 -10,0)))'));
```

```
st_nrings
------------
2
```

ST_NumGeometries

ST_NumGeometries returns the number of geometries in an input geometry.

Syntax

```sql
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 GEOMETRYCOLLECTION or a MULTI subtype, then the number of geometries is returned.

If `geom` is a single geometry, then 1 is returned.

If `geom` is null, then null is returned.

Examples

The following SQL returns the number of geometries in the input multilinestring.

```sql
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

```sql
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.

```sql
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.

```sql
SELECT ST_NumPoints(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07)'));
```

```
ST_NumPoints
-------------
805
```
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_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_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).
Syntax

```sql
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.

```sql
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_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

```sql
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_SRID**

ST_SRID returns the spatial reference system identifier (SRID) of an input geometry.

**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.

```
SELECT ST_SRID(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07)'));
```

```
st_srid
----------
808
```
ST_Within

ST_Within returns true if the first input geometry is within 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))'));
```

```
<table>
<thead>
<tr>
<th>st_within</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
</tr>
</tbody>
</table>
```

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 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_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_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 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));
```

```
<table>
<thead>
<tr>
<th>st_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
</tr>
</tbody>
</table>
```

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

\[
\text{ST\_YMin(geom)}
\]

Arguments

\( \text{geom} \)

A value of data type \text{GEOMETRY} or an expression that evaluates to a \text{GEOMETRY} type.

Return Type

\text{DOUBLE PRECISION} value of the minimum second coordinate.

If \text{geom} is empty, then null is returned.

If \text{geom} is null, then null is returned.

Examples

The following SQL returns the smallest second coordinate of a linestring.

```sql
SELECT ST_YMin(ST_GeomFromText('LINESTRING(77.29 29.07,77.42 29.26,77.27 29.31,77.29 29.07)'));
```

<table>
<thead>
<tr>
<th>st_ymin</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.07</td>
</tr>
</tbody>
</table>

Math Functions

Topics

- Mathematical Operator Symbols (p. 814)
- ABS Function (p. 815)
- ACOS Function (p. 816)
- ASIN Function (p. 817)
- ATAN Function (p. 817)
- ATAN2 Function (p. 818)
- CBRT Function (p. 819)
- CEILING (or CEIL) Function (p. 819)
- CHECKSUM Function (p. 820)
- COS Function (p. 821)
- COT Function (p. 821)
- DEGREES Function (p. 822)
- DEXP Function (p. 822)
- DLOG1 Function (p. 823)
- DLOG10 Function (p. 823)
- EXP Function (p. 824)
- FLOOR Function (p. 824)
- LN Function (p. 825)
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**

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Example</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>addition</td>
<td>2 + 3</td>
<td>5</td>
</tr>
<tr>
<td>-</td>
<td>subtraction</td>
<td>2 - 3</td>
<td>-1</td>
</tr>
<tr>
<td>*</td>
<td>multiplication</td>
<td>2 * 3</td>
<td>6</td>
</tr>
<tr>
<td>/</td>
<td>division</td>
<td>4 / 2</td>
<td>2</td>
</tr>
<tr>
<td>%</td>
<td>modulo</td>
<td>5 % 4</td>
<td>1</td>
</tr>
<tr>
<td>^</td>
<td>exponentiation</td>
<td>2.0 ^ 3.0</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>square root</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cube root</td>
</tr>
<tr>
<td>@</td>
<td>absolute value</td>
<td>@ -5.0</td>
<td>5</td>
</tr>
<tr>
<td>&lt;&lt;</td>
<td>bitwise shift left</td>
<td>1 &lt;&lt; 4</td>
<td>16</td>
</tr>
<tr>
<td>&gt;&gt;</td>
<td>bitwise shift right</td>
<td>8 &gt;&gt; 2</td>
<td>2</td>
</tr>
<tr>
<td>&amp;</td>
<td>bitwise and</td>
<td>8 &amp; 2</td>
<td>0</td>
</tr>
</tbody>
</table>

**Examples**

Calculate the commission paid plus a $2.00 handling for a given transaction:

```sql
select commission, (commission + 2.00) as comm
from sales where salesid=10000;
```
Calculate 20 percent of the sales price for a given transaction:

```
select pricepaid, (pricepaid * .20) as twentypct
from sales where salesid=10000;
```

<table>
<thead>
<tr>
<th>pricepaid</th>
<th>twentypct</th>
</tr>
</thead>
<tbody>
<tr>
<td>187.00</td>
<td>37.400</td>
</tr>
</tbody>
</table>

(1 row)

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 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;
```

<table>
<thead>
<tr>
<th>qty10years</th>
</tr>
</thead>
<tbody>
<tr>
<td>587.664019657491</td>
</tr>
</tbody>
</table>

(1 row)

Find the total price paid and commission for sales with a date ID that is greater than or equal to 2000. 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;
```

<table>
<thead>
<tr>
<th>sum_price</th>
<th>dateid</th>
<th>sum_comm</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>364445.00</td>
<td>2044</td>
<td>54666.75</td>
<td>309778.25</td>
</tr>
<tr>
<td>349344.00</td>
<td>2112</td>
<td>52401.60</td>
<td>296942.40</td>
</tr>
<tr>
<td>343756.00</td>
<td>2124</td>
<td>51563.40</td>
<td>292192.60</td>
</tr>
<tr>
<td>378595.00</td>
<td>2116</td>
<td>56789.25</td>
<td>321805.75</td>
</tr>
<tr>
<td>328725.00</td>
<td>2080</td>
<td>49308.75</td>
<td>279416.25</td>
</tr>
<tr>
<td>349554.00</td>
<td>2028</td>
<td>52433.10</td>
<td>297120.90</td>
</tr>
<tr>
<td>249207.00</td>
<td>2164</td>
<td>37381.05</td>
<td>211825.95</td>
</tr>
<tr>
<td>285202.00</td>
<td>2064</td>
<td>42780.30</td>
<td>242421.70</td>
</tr>
<tr>
<td>320945.00</td>
<td>2124</td>
<td>48141.75</td>
<td>272803.25</td>
</tr>
<tr>
<td>321096.00</td>
<td>2016</td>
<td>48164.40</td>
<td>272931.60</td>
</tr>
</tbody>
</table>

(10 rows)

**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**

```sql
ABS (number)
```
**Arguments**

`number`

Number or expression that evaluates to a number.

**Return Type**

ABS returns the same data type as its argument.

**Examples**

Calculate the absolute value of -38:

```
select abs (-38);
abs
-------
 38  
(1 row)
```

Calculate the absolute value of (14-76):

```
select abs (14-76);
abs
-------
 62  
(1 row)
```

**ACOS Function**

ACOS is a trigonometric function that returns the arc cosine of a number. The return value is in radians and is between PI/2 and -PI/2.

**Syntax**

```
ACOS(number)
```

**Arguments**

`number`

The input parameter is a double precision number.

**Return Type**

The ACOS function returns a double precision number.

**Examples**

The following example returns the arc cosine of -1:

```
select acos(-1);
acos
----------
 3.14159265358979
```
The following example converts the arc cosine of .5 to the equivalent number of degrees:

```
select (acos(.5) * 180/(select pi())) as degrees;
degrees
---------
60
```

### 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)
```

#### Argument

*number*

The input parameter is a double precision number.

#### Return Type

The ASIN function returns a double precision number.

#### Examples

The following example returns the arc sine of 1 and multiples it by 2:

```
select asin(1)*2 as pi;
piprint
------------------
3.14159265358979
```

The following example converts the arc sine of .5 to the equivalent number of degrees:

```
select (asin(.5) * 180/(select pi())) as degrees;
degrees
---------
30
```

### 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/2 and -PI/2.

#### Syntax

```
ATAN(number)
```
Argument

*number*

The input parameter is a double precision number.

Return Type

The ATAN function returns a double precision number.

Examples

The following example returns the arc tangent of 1 and multiplies it by 4:

```sql
select atan(1) * 4 as pi;
pi
--------------
3.14159265358979
(1 row)
```

The following example converts the arc tangent of 1 to the equivalent number of degrees:

```sql
select (atan(1) * 180/(select pi())) as degrees;
degrees
-------
45
(1 row)
```

ATAN2 Function

ATAN2 is a trigonometric function that returns the arc tangent of a one number divided by another number. The return value is in radians and is between PI/2 and -PI/2.

Syntax

```sql
ATAN2(number1, number2)
```

Arguments

*number1*

The first input parameter is a double precision number.

*number2*

The second parameter is a double precision number.

Return Type

The ATAN2 function returns a double precision number.

Examples

The following example returns the arc tangent of 2/2 and multiplies it by 4:

```sql
select atan2(2, 2) * 4 as pi;
```
The following example converts the arc tangent of 1/0 (or 0) to the equivalent number of degrees:

```sql
select (atan2(1,0) * 180/(select pi())) as degrees;
```

<table>
<thead>
<tr>
<th>degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
</tr>
</tbody>
</table>

(1 row)

### CBRT Function

The CBRT function is a mathematical function that calculates the cube root of a number.

**Syntax**

```sql
CBRT (number)
```

**Argument**

CBRT takes a DOUBLE PRECISION number as an argument.

**Return Type**

CBRT returns a DOUBLE PRECISION number.

**Examples**

Calculate the cube root of the commission paid for a given transaction:

```sql
select cbrt(commission) from sales where salesid=10000;
```

<table>
<thead>
<tr>
<th>cbrt</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.03839539048843</td>
</tr>
</tbody>
</table>

(1 row)

### CEILING (or CEIL) Function

The CEILING or CEIL function is used to round a number up to the next whole number. (The FLOOR Function (p. 824) rounds a number down to the next whole number.)

**Syntax**

```sql
CEIL | CEILING(number)
```

**Arguments**

`number`

DOUBLE PRECISION number to be rounded.
Return Type

CEILING and CEIL return an integer.

Example

Calculate the ceiling of the commission paid for a given sales transaction:

```sql
select ceiling(commission) from sales
where salesid=10000;
```

<table>
<thead>
<tr>
<th>ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
</tr>
</tbody>
</table>

(1 row)

CHECKSUM Function

Computes a checksum value for building a hash index.

Syntax

```sql
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:

```sql
select checksum(commission)
from sales
order by salesid
limit 10;
```

<table>
<thead>
<tr>
<th>checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10920</td>
</tr>
<tr>
<td>1140</td>
</tr>
<tr>
<td>5250</td>
</tr>
<tr>
<td>2625</td>
</tr>
<tr>
<td>2310</td>
</tr>
<tr>
<td>5910</td>
</tr>
<tr>
<td>11820</td>
</tr>
<tr>
<td>2955</td>
</tr>
<tr>
<td>8865</td>
</tr>
<tr>
<td>975</td>
</tr>
</tbody>
</table>

(10 rows)
COS Function

COS is a trigonometric function that returns the cosine of a number. The return value is in radians and is between PI/2 and -PI/2.

Syntax

COS(double_precision)

Argument

number

The input parameter is a double precision number.

Return Type

The COS function returns a double precision number.

Examples

The following example returns cosine of 0:

```sql
select cos(0);
cos
-----
 1
(1 row)
```

The following example returns the cosine of PI:

```sql
select cos(pi());
cos
-----
-1
(1 row)
```

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

The COT function returns a double precision number.


**Examples**

The following example returns the cotangent of 1:

```
select cot(1);
```

```
cot
-------------------
0.642092615934331
(1 row)
```

**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**

The DEGREES function returns a double precision number.

**Examples**

The following example returns the degree equivalent of .5 radians:

```
select degrees(.5);
```

```
degrees
------------------
28.6478897565412
(1 row)
```

The following example converts PI radians to degrees:

```
select degrees(pi());
```

```
degrees
---------
180
(1 row)
```

**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

The DEXP function returns a double precision number.

Example

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
------------------
695447.483772222
(1 row)
```

DLOG1 Function

The DLOG1 function returns the natural logarithm of the input parameter. Synonym for the LN function.

*Synonym of LN Function (p. 825).*

DLOG10 Function

The DLOG10 returns the base 10 logarithm of the input parameter. Synonym of the LOG function.

*Synonym of LOG Function (p. 826).*

Syntax

```
DLOG10(number)
```

Argument

*number*

The input parameter is a double precision number.

Return Type

The DLOG10 function returns a double precision number.

Example

The following example returns the base 10 logarithm of the number 100:
Math Functions

select dlog10(100);

dlog10
--------
 2
 (1 row)

**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 (p. 825).

**Syntax**

```sql
EXP (expression)
```

**Argument**

*expression*

The expression must be an INTEGER, DECIMAL, or DOUBLE PRECISION data type.

**Return Type**

EXP returns a DOUBLE PRECISION number.

**Example**

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.

```sql
select (select sum(qtysold) from sales, date
where sales.dateid=date.dateid
and year=2008) * exp((7::float/100)*10) qty2018;

qty2018  ------------------
695447.483772222
```

**FLOOR Function**

The FLOOR function rounds a number down to the next whole number.

**Syntax**

```sql
FLOOR (number)
```

**Argument**

*number*

DOUBLE PRECISION number to be rounded down.
Return Type

FLOOR returns an integer.

Example

Calculate the floor of the commission paid for a given sales transaction:

```sql
select floor(commission) from sales
where salesid=10000;

floor
-------
28
(1 row)
```

LN Function

Returns the natural logarithm of the input parameter. Synonym of the DLOG1 function.

Synonym of DLOG1 Function (p. 823).

Syntax

```sql
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 expression.

Example

The following example returns the natural logarithm, or base e logarithm, of the number 2.718281828:

```
select ln(2.718281828);
```

```
ln
-------------------
0.9999999998311267
```

(1 row)

Note that the answer is nearly equal to 1.

This example returns the natural logarithm of the values in the USERID column in the USERS table:

```
select username, ln(userid) from users order by userid limit 10;
```

```
username |        ln
----------+-------------------
JSG99FHE |                 0
PGL08LJI | 0.693147180559945
IFT66TXU | 1.09861228866811
XDG38RDD | 1.38629436111989
AEB55QTM | 1.6094379124341
NDQ15VBM | 1.79175946922805
OWY35QYB | 1.94591014905531
AZG78YIP | 2.07944154167984
MSD36KVR | 2.19722457733622
WKW41AIW | 2.30258509299405
```

(10 rows)

LOG Function

Returns the base 10 logarithm of a number.

Synonym of DLOG10 Function (p. 823).

Syntax

```
LOG(number)
```

Argument

```
number
```

The input parameter is a double precision number.

Return Type

The LOG function returns a double precision number.

Example

The following example returns the base 10 logarithm of the number 100:
MOD Function

The MOD function returns a numeric result that is the remainder of two numeric parameters. The first parameter is divided by the second parameter.

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

Valid return types are DECIMAL, INT, SMALLINT, and BIGINT. 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.

Example

The following example returns information for odd-numbered categories in the CATEGORY table:

```
select catid, catname
from category
where mod(catid,2)=1
order by 1,2;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catname</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MLB</td>
</tr>
<tr>
<td>3</td>
<td>NFL</td>
</tr>
<tr>
<td>5</td>
<td>MLS</td>
</tr>
<tr>
<td>7</td>
<td>Plays</td>
</tr>
<tr>
<td>9</td>
<td>Pop</td>
</tr>
<tr>
<td>11</td>
<td>Classical</td>
</tr>
</tbody>
</table>

(6 rows)

PI Function

The PI function returns the value of PI to 14 decimal places.
Syntax

PI()

Return Type

PI returns a DOUBLE PRECISION number.

Examples

Return the value of pi:

```
select pi();
pi
3.14159265358979
```

POWER Function

Syntax

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.

```
POW | POWER (expression1, expression2)

POW and POWER are synonyms.

Arguments

expression1

Numeric expression to be raised. Must be an integer, decimal, or floating-point data type.

expression2

Power to raise expression1. Must be an integer, decimal, or floating-point data type.

Return Type

POWER returns a DOUBLE PRECISION number.

Examples

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
```
The following example is a variation on the previous example, with the growth rate at 7% per year but the interval 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;
```

<table>
<thead>
<tr>
<th>qty2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>694034.54678046</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>

**RADIANS Function**

Converts an angle in degrees to its equivalent in radians.

**Syntax**

```
RADIANS(number)
```

**Argument**

*string*

The input parameter is a double precision number.

**Return Type**

The RADIANS function returns a double precision number.

**Examples**

The following example returns the radian equivalent of 180 degrees:

```
select radians(180);
```

<table>
<thead>
<tr>
<th>radians</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.14159265358979</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>

**RANDOM Function**

The RANDOM function generates a random value between 0.0 (inclusive) and 1.0 (exclusive).

**Syntax**

```
RANDOM()
```

**Return Type**

RANDOM returns a DOUBLE PRECISION number.
Usage Notes

Call RANDOM after setting a seed value with the SET (p. 636) command to cause RANDOM to generate numbers in a predictable sequence.

Examples

1. Compute a random value between 0 and 99. If the random number is 0 to 1, this query produces a random number from 0 to 100:

   ```sql
   select cast (random() * 100 as int);
   int4
   -------
   24
   (1 row)
   ```

2. Retrieve a uniform random sample of 10 items:

   ```sql
   select * 
   from sales 
   order by random() 
   limit 10;
   ```

   Now retrieve a random sample of 10 items, but choose the items in proportion to their prices. For example, an item that is twice the price of another would be twice as likely to appear in the query results:

   ```sql
   select * 
   from sales 
   order by log(1 - random()) / pricepaid 
   limit 10;
   ```

3. This example uses the SET (p. 636) command to set a SEED value so that RANDOM generates a predictable sequence of numbers.

   First, return three RANDOM integers without setting the SEED value first:

   ```sql
   select cast (random() * 100 as int);
   int4
   -------
   6
   (1 row)
   ```

   ```sql
   select cast (random() * 100 as int);
   int4
   -------
   68
   (1 row)
   ```

   ```sql
   select cast (random() * 100 as int);
   int4
   -------
   56
   (1 row)
   ```

   Now, set the SEED value to .25, and return three more RANDOM numbers:

   ```sql
   set seed to .25;
   ```
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)
```

**ROUND Function**

The ROUND function rounds numbers to the nearest integer or decimal.

The ROUND function can optionally include a second argument: an integer to indicate the number of decimal places for rounding, in either direction. If the second argument is not provided, the function rounds to the nearest whole number; if the second argument \( n \) is specified, the function rounds to the nearest number with \( n \) decimal places of precision.

**Syntax**

```
ROUND (number [ , integer ] )
```

**Argument**

*number*

INTEGER, DECIMAL, and FLOAT data types are supported.
If the first argument is an integer, the parser converts the integer into a decimal data type prior to processing. If the first argument is a decimal number, the parser processes the function without conversion, resulting in better performance.

**Return Type**

ROUND returns the same numeric data type as the input argument(s).

**Examples**

Round the commission paid for a given transaction to the nearest whole number.

```
select commission, round(commission)
from sales where salesid=10000;
```

<table>
<thead>
<tr>
<th>commission</th>
<th>round</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.05</td>
<td>28</td>
</tr>
</tbody>
</table>

(1 row)

Round the commission paid for a given transaction to the first decimal place.

```
select commission, round(commission, 1)
from sales where salesid=10000;
```

<table>
<thead>
<tr>
<th>commission</th>
<th>round</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.05</td>
<td>28.1</td>
</tr>
</tbody>
</table>

(1 row)

For the same query, extend the precision in the opposite direction.

```
select commission, round(commission, -1)
from sales where salesid=10000;
```

<table>
<thead>
<tr>
<th>commission</th>
<th>round</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.05</td>
<td>30</td>
</tr>
</tbody>
</table>

(1 row)

**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**

The SIN function returns a double precision number.
Examples

The following example returns the sine of -\(\pi\):

```sql
select sin(-pi());
```

```
<table>
<thead>
<tr>
<th>sin</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.22464679914735e-16</td>
</tr>
</tbody>
</table>
```

(1 row)

SIGN Function

The SIGN function returns the sign (positive or negative) of a number. The result of the SIGN function is 1, -1, or 0 indicating the sign of the argument.

Syntax

```sql
SIGN (number)
```

Argument

`number`

Number to be evaluated. The data type can be numeric or double precision. Other data types can be converted by Amazon Redshift per the implicit conversion rules.

Return Type

The output type is numeric(1, 0) for a numeric input, and double precision for a double precision input.

Examples

Determine the sign of the commission paid for a given transaction:

```sql
select commission, sign (commission) from sales where salesid=10000;
```

```
<table>
<thead>
<tr>
<th>commission</th>
<th>sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.05</td>
<td>1</td>
</tr>
</tbody>
</table>
```

(1 row)

The following example shows that “t2.d” has double precision as its type since the input is double precision and that “t2.n” has numeric(1,0) as output since the input is numeric.

```sql
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;
```

The output of the “\d” commands is:

```
<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Encoding</th>
<th>DistKey</th>
<th>SortKey</th>
<th>Preload</th>
<th>Encryption</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>-------</em></td>
<td>----------*</td>
<td>---------*</td>
<td>---------*</td>
<td>---------*</td>
<td>---------*</td>
<td>------------*</td>
<td>-----------*</td>
</tr>
</tbody>
</table>
```
Math Functions

SQRT Function

The SQRT function returns the square root of a numeric value.

Syntax

```
SQRT (expression)
```

Argument

`expression`

The expression must have an integer, decimal, or floating-point data type.

Return Type

SQRT returns a DOUBLE PRECISION number.

Examples

The following example returns the square root for some COMMISSION values from the SALES table. The COMMISSION column is a DECIMAL column.

```
select sqrt(commission)
from sales where salesid < 10 order by salesid;
```

```
<table>
<thead>
<tr>
<th>sqrt</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.4498803820905</td>
</tr>
<tr>
<td>3.37638860322683</td>
</tr>
<tr>
<td>7.24568837309472</td>
</tr>
<tr>
<td>5.1234753829798</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>
```

The following query returns the rounded square root for the same set of COMMISSION values.

```
select salesid, commission, round(sqrt(commission))
from sales where salesid < 10 order by salesid;
```

```
<table>
<thead>
<tr>
<th>salesid</th>
<th>commission</th>
<th>round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>109.20</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>11.40</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>52.50</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>26.25</td>
<td>5</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
**TAN Function**

TAN is a trigonometric function that returns the tangent of a number. The input parameter must be a non-zero number (in radians).

**Syntax**

```
TAN(number)
```

**Argument**

`number`

The input parameter is a double precision number.

**Return Type**

The TAN function returns a double precision number.

**Examples**

The following example returns the tangent of 0:

```
select tan(0);
```

```
tan
-----
0
(1 row)
```

**TO_HEX Function**

The TO_HEX function converts a number to its equivalent hexadecimal value.

**Syntax**

```
TO_HEX(string)
```

**Arguments**

`number`

A number to convert to its hexadecimal value.

**Return Type**

The TO_HEX function returns a hexadecimal value.

**Examples**

The following example shows the conversion of a number to its hexadecimal value:

```
select to_hex(2147676847);
```

```
to_hex
-------
8002f2af
(1 row)
```
TRUNC Function

The TRUNC function truncates a number and right-fills it with zeros from the position specified. This function also truncates a time stamp and returns a date.

Syntax

```
TRUNC(number [ , integer ] |
timestamp )
```

Arguments

**number**

Numeric data type to be truncated. SMALLINT, INTEGER, BIGINT, DECIMAL, REAL, and DOUBLE PRECISION data types are supported.

**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.

**timestamp**

The function can also return the date from a time stamp. (To return a time stamp value with 00:00:00 as the time, cast the function result to a time stamp.)

Return Type

TRUNC returns the same numeric data type as the first input argument. For time stamps, TRUNC returns a date.

Examples

Truncate the commission paid for a given sales transaction.

```
select commission, trunc(commission) 
from sales where salesid=784;
```

```
<table>
<thead>
<tr>
<th>commission</th>
<th>trunc</th>
</tr>
</thead>
<tbody>
<tr>
<td>111.15</td>
<td>111</td>
</tr>
</tbody>
</table>
```

(1 row)

Truncate the same commission value to the first decimal place.

```
select commission, trunc(commission,1) 
from sales where salesid=784;
```

```
<table>
<thead>
<tr>
<th>commission</th>
<th>trunc</th>
</tr>
</thead>
<tbody>
<tr>
<td>111.15</td>
<td>111.1</td>
</tr>
</tbody>
</table>
```

(1 row)
Truncate the commission with a negative value for the second argument; 111.15 is rounded down to 110.

```sql
select commission, trunc(commission,-1)
from sales where salesid=784;
```

<table>
<thead>
<tr>
<th>commission</th>
<th>trunc</th>
</tr>
</thead>
<tbody>
<tr>
<td>111.15</td>
<td>110</td>
</tr>
</tbody>
</table>

(1 row)

Return the date portion from the result of the SYSDATE function (which returns a time stamp):

```sql
select sysdate;
```

```
timestamp
2011-07-21 10:32:38.248109
```

(1 row)

```sql
select trunc(sysdate);
```

```
trunc
2011-07-21
```

(1 row)

Apply the TRUNC function to a TIMESTAMP column. The return type is a date.

```sql
select trunc(starttime) from event
order by eventid limit 1;
```

```
trunc
2008-01-25
```

(1 row)

---

### String Functions

**Topics**

- `||` (Concatenation) Operator (p. 838)
- BPCHARCMP Function (p. 840)
- BTRIM Function (p. 841)
- BTTEXT_PATTERN_CMP Function (p. 842)
- CHAR_LENGTH Function (p. 842)
- CHARACTER_LENGTH Function (p. 842)
- CHARINDEX Function (p. 842)
- CHR Function (p. 843)
- CONCAT (p. 844)
- CRC32 Function (p. 845)
- FUNC_SHA1 Function (p. 846)
- INITCAP Function (p. 846)
- LEFT and RIGHT Functions (p. 848)
- LEN Function (p. 849)
• LENGTH Function (p. 850)
• LOWER Function (p. 850)
• LPAD and RPAD Functions (p. 851)
• LTRIM Function (p. 852)
• MD5 Function (p. 853)
• OCTET_LENGTH Function (p. 854)
• POSITION Function (p. 854)
• QUOTE_IDENT Function (p. 855)
• QUOTE_LITERAL Function (p. 856)
• REGEXP_COUNT Function (p. 857)
• REGEXP_INSTR Function (p. 858)
• REGEXP_REPLACE Function (p. 859)
• REGEXP_SUBSTR Function (p. 861)
• REPEAT Function (p. 862)
• REPLACE Function (p. 863)
• REPLICATE Function (p. 864)
• REVERSE Function (p. 864)
• RTRIM Function (p. 865)
• SPLIT_PART Function (p. 866)
• STRPOS Function (p. 867)
• STRTOL Function (p. 868)
• SUBSTRING Function (p. 869)
• TEXTLEN Function (p. 871)
• TRANSLATE Function (p. 871)
• TRIM Function (p. 873)
• UPPER Function (p. 874)

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 quotes. 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 1-based.

Deprecated Leader Node-Only Functions

The following string functions are deprecated because they execute only on the leader node. For more information, see Leader Node–Only Functions (p. 667)

• ASCII
• GET_BIT
• GET_BYTE
• SET_BIT
• SET_BYTE
• TO_ASCII

|| (Concatenation) Operator

Concatenates two strings on either side of the || symbol and returns the concatenated string.
Similar to CONCAT (p. 844).

**Note**
For both the CONCAT function and the concatenation operator, if one or both strings is null, the result of the concatenation is null.

**Syntax**

```
string1 || string2
```

**Arguments**

```
string1, string2
```

Both arguments can be fixed-length or variable-length character strings or expressions.

**Return Type**

The `||` operator returns a string. The type of string is the same as the input arguments.

**Example**

The following example concatenates the FIRSTNAME and LASTNAME fields from the USERS table:

```sql
select firstname || ' ' || lastname
from users
order by 1
limit 10;
```

<table>
<thead>
<tr>
<th>column?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaron Banks</td>
</tr>
<tr>
<td>Aaron Booth</td>
</tr>
<tr>
<td>Aaron Browning</td>
</tr>
<tr>
<td>Aaron Burnett</td>
</tr>
<tr>
<td>Aaron Casey</td>
</tr>
<tr>
<td>Aaron Cash</td>
</tr>
<tr>
<td>Aaron Castro</td>
</tr>
<tr>
<td>Aaron Dickerson</td>
</tr>
<tr>
<td>Aaron Dixon</td>
</tr>
<tr>
<td>Aaron Dotson</td>
</tr>
</tbody>
</table>

(10 rows)

To concatenate columns that might contain nulls, use the NVL Expression (p. 738) expression. The following example uses NVL to return a 0 whenever NULL is encountered.

```sql
select venuename || ' seats ' || nvl(venueseats, 0)
from venue where venuestate = 'NV' or venuestate = 'NC'
order by 1
limit 10;
```

<table>
<thead>
<tr>
<th>seating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballys Hotel seats 0</td>
</tr>
<tr>
<td>Bank of America Stadium seats 73298</td>
</tr>
<tr>
<td>Bellagio Hotel seats 0</td>
</tr>
<tr>
<td>Caesars Palace seats 0</td>
</tr>
<tr>
<td>Harrahs Hotel seats 0</td>
</tr>
<tr>
<td>Hilton Hotel seats 0</td>
</tr>
</tbody>
</table>
BPCHARCMP Function

Compares the value of two strings and returns an integer. If the strings are identical, returns 0. If the first string is "greater" alphabetically, returns 1. If the second string is "greater", returns -1.

For multibyte characters, the comparison is based on the byte encoding.

Synonym of BTTEXT_PATTERN_CMP Function (p. 842).

Syntax

BPCHARCMP(string1, string2)

Arguments

string1

The first input parameter is a CHAR or VARCHAR string.

string2

The second parameter is a CHAR or VARCHAR string.

Return Type

The BPCHARCMP function returns an integer.

Examples

The following example determines whether a user's first name is alphabetically greater than the user's last name for the first ten entries in USERS:

```
select userid, firstname, lastname, bpcharcmp(firstname, lastname)
from users
order by 1, 2, 3, 4
limit 10;
```

This example returns the following sample output:

<table>
<thead>
<tr>
<th>userid</th>
<th>firstname</th>
<th>lastname</th>
<th>bpcharcmp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rafael</td>
<td>Taylor</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>Vladimir</td>
<td>Humphrey</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Lars</td>
<td>Ratliff</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>Barry</td>
<td>Roy</td>
<td>-1</td>
</tr>
<tr>
<td>5</td>
<td>Reagan</td>
<td>Hodge</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Victor</td>
<td>Hernandez</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Tamekah</td>
<td>Juarez</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Colton</td>
<td>Roy</td>
<td>-1</td>
</tr>
<tr>
<td>9</td>
<td>Mufutau</td>
<td>Watkins</td>
<td>-1</td>
</tr>
<tr>
<td>10</td>
<td>Naida</td>
<td>Calderon</td>
<td>1</td>
</tr>
</tbody>
</table>

(10 rows)
You can see that for entries where the string for the FIRSTNAME is later alphabetically than the LASTNAME, BPCHARCMP returns 1. If the LASTNAME is alphabetically later than FIRSTNAME, BPCHARCMP returns -1.

This example returns all entries in the USER table whose FIRSTNAME is identical to their 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
```

(8 rows)

### BTRIM Function

The BTRIM function trims a string by removing leading and trailing blanks or by removing characters that match an optional specified string.

**Syntax**

```
BTRIM(string [, matching_string ] )
```

**Arguments**

- **string**
  
  The first input parameter is a VARCHAR string.

- **matching_string**
  
  The second parameter, if present, is a VARCHAR string.

**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
```

(1 row)

The following example removes the leading and trailing 'xyz' strings from the string 'xyzaxyzbxyzcxyz'

841
select 'xyzaxyzbxyzcxyz' as untrim,
        btrim('xyzaxyzbxyzcxyz', 'xyz') as trim;

| untrim      | trim    |
|-----------------+----------|
| xyzaxyzbxyzcxyz | axyzbxyzc |

(1 row)

Note that the leading and trailing occurrences of 'xyz' were removed, but that occurrences that were internal within the string were not removed.

**BTTEXT_PATTERN_CMP Function**

Synonym for the BPCHARCMP function.

See BPCHARCMP Function (p. 840) for details.

**CHAR_LENGTH Function**

Synonym of the LEN function.

See LEN Function (p. 849)

**CHARACTER_LENGTH Function**

Synonym of the LEN function.

See LEN Function (p. 849)

**CHARINDEX Function**

Returns the location of the specified substring within a string. Synonym of the STRPOS function.

**Syntax**

```
CHARINDEX( substring, string )
```

**Arguments**

*substring*

The substring to search for within the *string*.

*string*

The string or column to be searched.

**Return Type**

The CHARINDEX function returns an integer corresponding to the position of the substring (one-based, not zerobased). The position is based on the number of characters, not bytes, so that multi-byte characters are counted as single characters.

**Usage Notes**

CHARINDEX returns 0 if the substring is not found within the *string*:

```
select charindex('dog', 'fish');
```
Examples

The following example shows the position of the string fish within the word dogfish:

```sql
select charindex('fish', 'dogfish');
```

<table>
<thead>
<tr>
<th>charindex</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

(1 row)

The following example returns the number of sales transactions with a COMMISSION over 999.00 from the SALES table:

```sql
select distinct charindex('.', commission), count (charindex('.', commission))
from sales where charindex('.', commission) > 4 group by charindex('.', commission)
order by 1,2;
```

<table>
<thead>
<tr>
<th>charindex</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>629</td>
</tr>
</tbody>
</table>

(1 row)

See STRPOS Function (p. 867) for details.

CHR Function

The CHR function returns the character that matches the ASCII code point value specified by the input parameter.

Syntax

```sql
CHR(number)
```

Argument

`number`

The input parameter is an integer that represents an ASCII code point value.

Return Type

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.

Example

The following example returns event names that begin with a capital A (ASCII code point 65):

```sql
select distinct eventname from event
where substring(eventname, 1, 1)=chr(65);
```

<table>
<thead>
<tr>
<th>eventname</th>
</tr>
</thead>
<tbody>
<tr>
<td>843</td>
</tr>
</tbody>
</table>

(1 row)
CONCAT

The CONCAT function concatenates two character strings and returns the resulting string. To concatenate more than two strings, use nested CONCAT functions. The concatenation operator (||) between two strings produces the same results as the CONCAT function.

Note

For both the CONCAT function and the concatenation operator, if one or both strings is null, the result of the concatenation is null.

Syntax

```
CONCAT ( string1, string2 )
```

Arguments

string1, string2

Both arguments can be fixed-length or variable-length character strings or expressions.

Return Type

CONCAT returns a string. The data type of the string is the same type as the input arguments.

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';
```

```
-------------------
December 25, 2008
(1 row)
```

The following example uses two CONCAT functions to concatenate three character strings:

```
select concat('Thursday, ', concat('December 25, ', '2008'));
```

```
-------------------
Thursday, December 25, 2008
```

To concatenate columns that might contain nulls, use the NVL Expression (p. 738). 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;
```

<table>
<thead>
<tr>
<th>seating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballys Hotel seats 0</td>
</tr>
<tr>
<td>Bank of America Stadium seats 73298</td>
</tr>
<tr>
<td>Bellagio Hotel seats 0</td>
</tr>
<tr>
<td>Caesars Palace seats 0</td>
</tr>
<tr>
<td>Harrahs Hotel seats 0</td>
</tr>
</tbody>
</table>

The following query concatenates CITY and STATE values from the VENUE table:

```
select concat(venuecity, venuestate)
from venue
where venueseats > 75000
order by venueseats;
```

<table>
<thead>
<tr>
<th>concat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denver, CO</td>
</tr>
<tr>
<td>Kansas City, MO</td>
</tr>
<tr>
<td>East Rutherford, NJ</td>
</tr>
<tr>
<td>Landover, MD</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>concat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denver, CO</td>
</tr>
<tr>
<td>Kansas City, MO</td>
</tr>
<tr>
<td>East Rutherford, NJ</td>
</tr>
<tr>
<td>Landover, MD</td>
</tr>
</tbody>
</table>

## CRC32 Function

CRC32 is an error-detecting function that 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.

### Syntax

```
CRC32(string)
```
Arguments

*string*

A variable-length string.

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.

Example

The following example shows the 32-bit value for the string 'Amazon Redshift':

```sql
select crc32('Amazon Redshift');
crc32
----------------------------------
f2726906
(1 row)
```

**FUNC_SHA1 Function**

The FUNC_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

```
FUNC_SHA1(string)
```

Arguments

*string*

A variable-length string.

Return Type

The FUNC_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':

```sql
select func_sha1('Amazon Redshift');
```

**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

\textit{string}

The input parameter is a CHAR or VARCHAR string.

Return Type

The \texttt{INITCAP} function returns a VARCHAR string.

Usage Notes

The \texttt{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 \textit{word separator} character is any non-alphanumeric character, including punctuation marks, symbols, and control characters. All of the following characters are word separators:

\begin{verbatim}
! " # $ % & ' ( ) * + , - . / ; ; < > ? @ [ \ ] ^ ` { | } ~
\end{verbatim}

Tabs, newline characters, form feeds, line feeds, and carriage returns are also word separators.

Examples

The following example capitalizes the initials of each word in the \texttt{CATDESC} column:

\begin{verbatim}
select catid, catdesc, initcap(catdesc)
from category
order by 1, 2, 3;
\end{verbatim}

\begin{verbatim}
<table>
<thead>
<tr>
<th>catid</th>
<th>catdesc</th>
<th>initcap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Major League Baseball</td>
<td>Major League Baseball</td>
</tr>
<tr>
<td>2</td>
<td>National Hockey League</td>
<td>National Hockey League</td>
</tr>
<tr>
<td>3</td>
<td>National Football League</td>
<td>National Football League</td>
</tr>
<tr>
<td>4</td>
<td>National Basketball Association</td>
<td>National Basketball Association</td>
</tr>
<tr>
<td>5</td>
<td>Major League Soccer</td>
<td>Major League Soccer</td>
</tr>
<tr>
<td>6</td>
<td>Musical theatre</td>
<td>Musical Theatre</td>
</tr>
<tr>
<td>7</td>
<td>All non-musical theatre</td>
<td>All Non-Musical Theatre</td>
</tr>
<tr>
<td>8</td>
<td>All opera and light opera</td>
<td>All Opera And Light Opera</td>
</tr>
<tr>
<td>9</td>
<td>All rock and pop music concerts</td>
<td>All Rock And Pop Music Concerts</td>
</tr>
<tr>
<td>10</td>
<td>All jazz singers and bands</td>
<td>All Jazz Singers And Bands</td>
</tr>
<tr>
<td>11</td>
<td>All symphony, concerto, and choir concerts</td>
<td>All Symphony, Concerto, And Choir Concerts</td>
</tr>
</tbody>
</table>
\end{verbatim}

The following example shows that the \texttt{INITCAP} function does not preserve uppercase characters when they do not begin words. For example, MLB becomes Mlb.

\begin{verbatim}
select initcap(catname)
from category
order by catname;
\end{verbatim}

\begin{verbatim}
initcap
--------
Classical
Jazz
Mlb
\end{verbatim}
The following example shows that non-alphanumeric characters other than spaces function as word separators, causing uppercase characters to be applied to several letters in each string:

```sql
select email, initcap(email)
from users
order by userid desc limit 5;
```

<table>
<thead>
<tr>
<th>email</th>
<th>initcap</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:urna.Ut@egetdictumplacerat.edu">urna.Ut@egetdictumplacerat.edu</a></td>
<td><a href="mailto:Urna.Ut@Egetdictumplacerat.Edu">Urna.Ut@Egetdictumplacerat.Edu</a></td>
</tr>
<tr>
<td><a href="mailto:nibh.enim@egestas.ca">nibh.enim@egestas.ca</a></td>
<td><a href="mailto:Nibh.Enim@Egestas.Ca">Nibh.Enim@Egestas.Ca</a></td>
</tr>
<tr>
<td><a href="mailto:in@Donecat.ca">in@Donecat.ca</a></td>
<td><a href="mailto:In@Donecat.Ca">In@Donecat.Ca</a></td>
</tr>
<tr>
<td><a href="mailto:sodales@blanditviverradonec.ca">sodales@blanditviverradonec.ca</a></td>
<td><a href="mailto:Sodales@Blanditviverradonec.Ca">Sodales@Blanditviverradonec.Ca</a></td>
</tr>
<tr>
<td><a href="mailto:sociis.natoque.penatibus@vitae.org">sociis.natoque.penatibus@vitae.org</a></td>
<td><a href="mailto:Sociis.Natoque.Penatibus@Vitae.Org">Sociis.Natoque.Penatibus@Vitae.Org</a></td>
</tr>
</tbody>
</table>

(5 rows)

**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**

```sql
LEFT ( string, integer )
RIGHT ( string, integer )
```

**Arguments**

- **string**
  - Any character string or any expression that evaluates to a character string.

- **integer**
  - A positive integer.

**Return Type**

LEFT and RIGHT return a VARCHAR string.

**Example**

The following example returns the leftmost 5 and rightmost 5 characters from event names that have IDs between 1000 and 1005:

```sql
select eventid, eventname,
```
<table>
<thead>
<tr>
<th>eventid</th>
<th>eventname</th>
<th>left_5</th>
<th>right_5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>Gypsy</td>
<td>Gypsy</td>
<td>Gypsy</td>
</tr>
<tr>
<td>1001</td>
<td>Chicago</td>
<td>Chica</td>
<td>icago</td>
</tr>
<tr>
<td>1002</td>
<td>The King and I</td>
<td>The K</td>
<td>and I</td>
</tr>
<tr>
<td>1003</td>
<td>Pal Joey</td>
<td>Pal J</td>
<td>Joey</td>
</tr>
<tr>
<td>1004</td>
<td>Grease</td>
<td>Greas</td>
<td>rease</td>
</tr>
<tr>
<td>1005</td>
<td>Chicago</td>
<td>Chica</td>
<td>icago</td>
</tr>
</tbody>
</table>

### LEN Function

Returns the length of the specified string as the number of characters.

**Syntax**

LEN is a synonym of LENGTH Function (p. 850), CHAR_LENGTH Function (p. 842), CHARACTER_LENGTH Function (p. 842), and TEXTLEN Function (p. 871).

```
LEN(expression)
```

**Argument**

*expression*

The input parameter is a CHAR or VARCHAR text string.

**Return Type**

The LEN function returns an integer indicating the number of characters in the input 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 (p. 854) function.

**Usage Notes**

Length calculations do not count trailing spaces for fixed-length character strings but do count them for variable-length strings.

**Example**

The following example returns the number of bytes and the number of characters in the string français.

```
select octet_length('français'),
       len('français');
```

<table>
<thead>
<tr>
<th>octet_length</th>
<th>len</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>
The following example returns the number of characters in the strings `cat` with no trailing spaces and `cat   ` with three trailing spaces:

```
select len('cat'), len('cat   ');
  len | len
-----+-----
    3 |   6
(1 row)
```

The following example returns the ten longest `VENUENAME` entries in the `VENUE` table:

```
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
(10 rows)
```

**LENGTH Function**

Synonym of the `LEN` function.

See LEN Function (p. 849)

**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`

The input parameter is a CHAR or VARCHAR string.

**Return Type**

The LOWER function returns a character string that is the same data type as the input string (CHAR or VARCHAR).
Examples

The following example converts the CATNAME field to lowercase:

```sql
select catname, lower(catname) from category order by 1,2;
```

<table>
<thead>
<tr>
<th>catname</th>
<th>lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>classical</td>
</tr>
<tr>
<td>Jazz</td>
<td>jazz</td>
</tr>
<tr>
<td>MLB</td>
<td>mlb</td>
</tr>
<tr>
<td>MLS</td>
<td>mls</td>
</tr>
<tr>
<td>Musicals</td>
<td>musicals</td>
</tr>
<tr>
<td>NBA</td>
<td>nba</td>
</tr>
<tr>
<td>NFL</td>
<td>nfl</td>
</tr>
<tr>
<td>NHL</td>
<td>nhl</td>
</tr>
<tr>
<td>Opera</td>
<td>opera</td>
</tr>
<tr>
<td>Plays</td>
<td>plays</td>
</tr>
<tr>
<td>Pop</td>
<td>pop</td>
</tr>
</tbody>
</table>

(11 rows)

LPAD and RPAD Functions

These functions prepend or append characters to a string, based on a specified length.

Syntax

```sql
LPAD (string1, length, [ string2 ])
```

```sql
RPAD (string1, length, [ string2 ])
```

Arguments

`string1`

A character string or an expression that evaluates to a character string, such as the name of a character column.

`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 a negative number, the result of the function is an empty string.

`string2`

One or more characters that are prepended or appended to `string1`. This argument is optional; if it is not specified, spaces are used.

Return Type

These functions return a VARCHAR data type.

Examples

Truncate a specified set of event names to 20 characters and prepend the shorter names with spaces:
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
(5 rows)

Truncate the same set of event names to 20 characters but append the shorter names with 0123456789.

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
(5 rows)

### LTRIM Function

The LTRIM function trims a specified set of characters from the beginning of a string.

#### Syntax

```
LTRIM( string, 'trim_chars' )
```

#### Arguments

- **string**
  
  The string column or expression to be trimmed.

- **trim_chars**
  
  A string column or expression representing the characters to be trimmed from the beginning of `string`.

#### Return Type

The LTRIM function returns a character string that is the same data type as the input string (CHAR or VARCHAR).

#### Example

The following example trims the year from LISTTIME:

```
select listid, listtime, ltrim(listtime, '2008-')
from listing
order by 1, 2, 3
limit 10;
```
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`.

```sql
select venueid, venuename, trim(venuename, 'CDG')
from venue
where venuename like '%Park'
order by 2
limit 7;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>btrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>121</td>
<td>ATT Park</td>
<td>ATT Park</td>
</tr>
<tr>
<td>109</td>
<td>Citizens Bank Park</td>
<td>Citizens Bank Park</td>
</tr>
<tr>
<td>102</td>
<td>Comerica Park</td>
<td>Comerica Park</td>
</tr>
<tr>
<td>9</td>
<td>Dick's Sporting Goods Park</td>
<td>Dick's Sporting Goods Park</td>
</tr>
<tr>
<td>97</td>
<td>Fenway Park</td>
<td>Fenway Park</td>
</tr>
<tr>
<td>112</td>
<td>Great American Ball Park</td>
<td>Great American Ball Park</td>
</tr>
<tr>
<td>114</td>
<td>Miller Park</td>
<td>Miller Park</td>
</tr>
</tbody>
</table>

(10 rows)

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**

```sql
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':

<table>
<thead>
<tr>
<th>listid</th>
<th>listtime</th>
<th>ltrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008-01-24 06:43:29</td>
<td>1-24 06:43:29</td>
</tr>
<tr>
<td>3</td>
<td>2008-11-01 07:35:33</td>
<td>11-01 07:35:33</td>
</tr>
<tr>
<td>5</td>
<td>2008-05-17 02:29:11</td>
<td>5-17 02:29:11</td>
</tr>
<tr>
<td>6</td>
<td>2008-08-15 02:08:13</td>
<td>15 02:08:13</td>
</tr>
<tr>
<td>7</td>
<td>2008-11-15 09:38:15</td>
<td>11-15 09:38:15</td>
</tr>
<tr>
<td>8</td>
<td>2008-11-09 05:07:30</td>
<td>11-09 05:07:30</td>
</tr>
<tr>
<td>9</td>
<td>2008-09-09 08:03:36</td>
<td>9-09 08:03:36</td>
</tr>
<tr>
<td>10</td>
<td>2008-06-17 09:44:54</td>
<td>6-17 09:44:54</td>
</tr>
</tbody>
</table>

(10 rows)
**OCTET_LENGTH Function**

Returns the length of the specified string as the number of bytes.

**Syntax**

```
OCTET_LENGTH(expression)
```

**Argument**

`expression`

The input parameter is a CHAR or VARCHAR text string.

**Return Type**

The OCTET_LENGTH function returns an integer indicating the number of bytes in the input string. The `LEN (p. 849)` function returns the actual number of characters in multi-byte strings, not the number of bytes. For example, to store three four-byte Chinese characters, you need a VARCHAR(12) column. The LEN function will return 3 for that same string.

**Usage Notes**

Length calculations do not count trailing spaces for fixed-length character strings but do count them for variable-length strings.

**Example**

The following example returns the number of bytes and the number of characters in the string 'français'.

```
select octet_length('français'),
   len('français');
```

<table>
<thead>
<tr>
<th>octet_length</th>
<th>len</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

(1 row)

**POSITION Function**

Returns the location of the specified substring within a string.

**Synonym of the STRPOS Function (p. 867) function.**

**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.

Usage Notes

POSITION returns 0 if the substring is not found within the string:

```
select position('dog' in 'fish');
position
--------
 0
(1 row)
```

Examples

The following example shows the position of the string fish within the word dogfish:

```
select position('fish' in 'dogfish');
position
--------
  4
(1 row)
```

The following example returns the number of sales transactions with a COMMISSION over 999.00 from the SALES table:

```
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
(1 row)
```

QUOTE_IDENT Function

The QUOTE_IDENT function returns the specified string as a double quoted string so that it can be used as an identifier in a SQL statement. Appropriately doubles any embedded double quotes.

QUOTE_IDENT adds double quotes 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 (p. 856).
String Functions

Syntax

QUOTE_IDENT(string)

Argument

string

The input parameter can be a CHAR or VARCHAR string.

Return Type

The QUOTE_IDENT function returns the same type string as the input parameter.

Example

The following example returns the CATNAME column surrounded by quotes:

```sql
select catid, quote_ident(catname)
from category
order by 1,2;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>quote_ident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;MLB&quot;</td>
</tr>
<tr>
<td>2</td>
<td>&quot;NHL&quot;</td>
</tr>
<tr>
<td>3</td>
<td>&quot;NFL&quot;</td>
</tr>
<tr>
<td>4</td>
<td>&quot;NBA&quot;</td>
</tr>
<tr>
<td>5</td>
<td>&quot;MLS&quot;</td>
</tr>
<tr>
<td>6</td>
<td>&quot;Musicals&quot;</td>
</tr>
<tr>
<td>7</td>
<td>&quot;Plays&quot;</td>
</tr>
<tr>
<td>8</td>
<td>&quot;Opera&quot;</td>
</tr>
<tr>
<td>9</td>
<td>&quot;Pop&quot;</td>
</tr>
<tr>
<td>10</td>
<td>&quot;Jazz&quot;</td>
</tr>
<tr>
<td>11</td>
<td>&quot;Classical&quot;</td>
</tr>
</tbody>
</table>

(11 rows)

QUOTE_LITERAL Function

The QUOTE_LITERAL function returns the specified string as a 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 quotes and backslashes.

Syntax

QUOTE_LITERAL(string)

Argument

string

The input parameter is a CHAR or VARCHAR string.

Return Type

The QUOTE_LITERAL function returns a string that is the same data type as the input string (CHAR or VARCHAR).
Example

The following example returns the CATID column surrounded by quotes. Note that the ordering now treats this column as a string:

```sql
select quote_literal(catid), catname
from category
order by 1,2;
```

<table>
<thead>
<tr>
<th>quote_literal</th>
<th>catname</th>
</tr>
</thead>
<tbody>
<tr>
<td>'1'</td>
<td>MLB</td>
</tr>
<tr>
<td>'10'</td>
<td>Jazz</td>
</tr>
<tr>
<td>'11'</td>
<td>Classical</td>
</tr>
<tr>
<td>'2'</td>
<td>NHL</td>
</tr>
<tr>
<td>'3'</td>
<td>NFL</td>
</tr>
<tr>
<td>'4'</td>
<td>NBA</td>
</tr>
<tr>
<td>'5'</td>
<td>MLS</td>
</tr>
<tr>
<td>'6'</td>
<td>Musicals</td>
</tr>
<tr>
<td>'7'</td>
<td>Plays</td>
</tr>
<tr>
<td>'8'</td>
<td>Opera</td>
</tr>
<tr>
<td>'9'</td>
<td>Pop</td>
</tr>
</tbody>
</table>

(11 rows)

**REGEXP_COUNT Function**

Searches a string for a regular expression pattern and returns an integer that indicates the number of times the pattern occurs in the string. If no match is found, then the function returns 0. For more information about regular expressions, see [POSIX Operators](p. 405).

**Syntax**

```
REGEXP_COUNT ( source_string, pattern [, position ] )
```

**Arguments**

*source_string*

A string expression, such as a column name, to be searched.

*pattern*

A string literal that represents a SQL standard regular expression pattern.

*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 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.

**Return Type**

Integer

**Example**

The following example counts the number of times a three-letter sequence occurs.
select regexp_count('abcdefghijklmnopqrstuvwxyz', '[a-z]{3}');

regexp_count
-------------
8
(1 row)

The following example counts the number of times the top-level domain name is either org or edu.

select email, regexp_count(email, '@[^.]*\.(org|edu)')
from users limit 5;

<table>
<thead>
<tr>
<th>email</th>
<th>regexp_count</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:elementum@semperpretiumneque.ca">elementum@semperpretiumneque.ca</a></td>
<td>0</td>
</tr>
<tr>
<td><a href="mailto:Integer.mollis.Integer@tristiquealiquet.org">Integer.mollis.Integer@tristiquealiquet.org</a></td>
<td>1</td>
</tr>
<tr>
<td><a href="mailto:lorem.ipsum@Vestibulumante.com">lorem.ipsum@Vestibulumante.com</a></td>
<td>0</td>
</tr>
<tr>
<td><a href="mailto:euismod@turpis.org">euismod@turpis.org</a></td>
<td>1</td>
</tr>
<tr>
<td><a href="mailto:non.justo.Proin@ametconsectetuer.edu">non.justo.Proin@ametconsectetuer.edu</a></td>
<td>1</td>
</tr>
</tbody>
</table>

**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 (p. 854) function, but lets you search a string for a regular expression pattern. For more information about regular expressions, see POSIX Operators (p. 405).

**Syntax**


**Arguments**

- **source_string**
  
  A string expression, such as a column name, to be searched.

- **pattern**
  
  A string literal that represents a SQL standard regular expression pattern.

- **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 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**
  
  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**
  
  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

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.

Return Type

Integer

Example

The following example searches for the @ character that begins a domain name and returns the starting position of the first match.

```
select email, regexp_instr(email,'@[^.]*)'
from users
limit 5;
```

<table>
<thead>
<tr>
<th>email</th>
<th>regexp_instr</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:Cum@accumsan.com">Cum@accumsan.com</a></td>
<td>4</td>
</tr>
<tr>
<td><a href="mailto:lorem.ipsum@Vestibulumante.com">lorem.ipsum@Vestibulumante.com</a></td>
<td>12</td>
</tr>
<tr>
<td><a href="mailto:non.justo.Proin@ametconsectetuer.edu">non.justo.Proin@ametconsectetuer.edu</a></td>
<td>16</td>
</tr>
<tr>
<td><a href="mailto:non.ante.bibendum@porttitortellus.org">non.ante.bibendum@porttitortellus.org</a></td>
<td>18</td>
</tr>
<tr>
<td><a href="mailto:eros@blanditatnisi.org">eros@blanditatnisi.org</a></td>
<td>5</td>
</tr>
<tr>
<td>(5 rows)</td>
<td></td>
</tr>
</tbody>
</table>

The following example searches for variants of the word Center and returns the starting position of the first match.

```
select venuename, regexp_instr(venuename,'^[Cc]ent(er|re)$')
from venue
where regexp_instr(venuename,'^[Cc]ent(er|re)$') > 0
limit 5;
```

<table>
<thead>
<tr>
<th>venuename</th>
<th>regexp_instr</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Home Depot Center</td>
<td>16</td>
</tr>
<tr>
<td>Izod Center</td>
<td>6</td>
</tr>
<tr>
<td>Wachovia Center</td>
<td>10</td>
</tr>
<tr>
<td>Air Canada Centre</td>
<td>12</td>
</tr>
<tr>
<td>United Center</td>
<td>8</td>
</tr>
</tbody>
</table>

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 (p. 863), but lets you search a string for a regular expression pattern. For more information about regular expressions, see POSIX Operators (p. 405).
REGEXP_REPLACE is similar to the TRANSLATE Function (p. 871) and the REPLACE Function (p. 863), 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

\[
\text{REGEXP\_REPLACE} \left( \text{source\_string}, \text{pattern} \left[ , \text{replace\_string} \left[ , \text{position} \right] \right] \right)
\]

Arguments

**source\_string**

A string expression, such as a column name, to be searched.

**pattern**

A string literal that represents a SQL standard regular expression pattern.

**replace\_string**

A string expression, such as a column name, that will replace each occurrence of pattern. The default is an empty string ("").

**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 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.

Return Type

VARCHAR

If either pattern or replace\_string is NULL, the return is NULL.

Example

The following example deletes the @ and domain name from email addresses.

```
select email, regexp_replace(email, '@.*\.(org|gov|com)\$')
from users limit 5;
```

<table>
<thead>
<tr>
<th>email</th>
<th>regexp_replace</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:DonecFri@semperpretiumneque.com">DonecFri@semperpretiumneque.com</a></td>
<td>DonecFri</td>
</tr>
<tr>
<td><a href="mailto:mk1wait@UniOfTech.org">mk1wait@UniOfTech.org</a></td>
<td>mk1wait</td>
</tr>
<tr>
<td><a href="mailto:sed@redshiftemails.com">sed@redshiftemails.com</a></td>
<td>sed</td>
</tr>
<tr>
<td><a href="mailto:bunyung@integermath.gov">bunyung@integermath.gov</a></td>
<td>bunyung</td>
</tr>
<tr>
<td><a href="mailto:tomsupporter@galaticmess.org">tomsupporter@galaticmess.org</a></td>
<td>tomsupporter</td>
</tr>
</tbody>
</table>

The following example selects URLs from the fictional WEBSITES table and replaces the domainnames with this value: internal.company.com/

```
select url, regexp_replace(url, '^.*\.[[:alpha:]]{3}/', 'internal.company.com/')
from websites limit 4;
```
### REGEXP_SUBSTR Function

Returns the characters extracted from a string by searching for a regular expression pattern. REGEXP_SUBSTR is similar to the SUBSTRING Function (p. 869) function, but lets you search a string for a regular expression pattern. For more information about regular expressions, see POSIX Operators (p. 405).

#### Syntax

```
REGEXP_SUBSTR ( source_string, pattern [, position [, occurrence [, parameters ] ] ] )
```

#### Arguments

- **source_string**
  
  A string expression, such as a column name, to be searched.

- **pattern**
  
  A string literal that represents a SQL standard regular expression pattern.

- **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 NULL.

- **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. 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.

**Return Type**

VARCHAR

**Example**

The following example returns the portion of an email address between the @ character and the domain extension.

```sql
select email, regexp_substr(email,'@[^.]*')
from users limit 5;
```

<table>
<thead>
<tr>
<th>email</th>
<th>regexp_substr</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:Suspendisse.tristique@nonnisiAenean.edu">Suspendisse.tristique@nonnisiAenean.edu</a></td>
<td>@nonnisiAenean</td>
</tr>
<tr>
<td><a href="mailto:sed@lacusUtne.ca">sed@lacusUtne.ca</a></td>
<td>@lacusUtne</td>
</tr>
<tr>
<td><a href="mailto:elementum@semperpretiumneque.ca">elementum@semperpretiumneque.ca</a></td>
<td>@semperpretiumneque</td>
</tr>
<tr>
<td><a href="mailto:Integer.mollis.Integer@tristiquealiquet.org">Integer.mollis.Integer@tristiquealiquet.org</a></td>
<td>@tristiquealiquet</td>
</tr>
<tr>
<td><a href="mailto:Donec.fringilla@sodalesat.org">Donec.fringilla@sodalesat.org</a></td>
<td>@sodalesat</td>
</tr>
</tbody>
</table>

**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 (p. 864).

**Syntax**

```sql
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**

The REPEAT function returns a string.

**Examples**

The following example repeats the value of the CATID column in the CATEGORY table three times:

```sql
select catid, repeat(catid,3)
from category
```
**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 (p. 871) and the REGEXP_REPLACE Function (p. 859), 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(string1, old_chars, new_chars)
```

**Arguments**

- `string`
  - CHAR or VARCHAR string to be searched
- `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 converts the string `Shows` to `Theatre` in the CATGROUP field:

```
select catid, catgroup,
    replace(catgroup, 'Shows', 'Theatre')
from category
order by 1,2,3;
```

<table>
<thead>
<tr>
<th>catid</th>
<th>catgroup</th>
<th>replace</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>111</td>
<td>111</td>
</tr>
<tr>
<td>2</td>
<td>222</td>
<td>222</td>
</tr>
<tr>
<td>3</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>4</td>
<td>444</td>
<td>444</td>
</tr>
<tr>
<td>5</td>
<td>555</td>
<td>555</td>
</tr>
<tr>
<td>6</td>
<td>666</td>
<td>666</td>
</tr>
<tr>
<td>7</td>
<td>777</td>
<td>777</td>
</tr>
<tr>
<td>8</td>
<td>888</td>
<td>888</td>
</tr>
<tr>
<td>9</td>
<td>999</td>
<td>999</td>
</tr>
<tr>
<td>10</td>
<td>101010</td>
<td>101010</td>
</tr>
<tr>
<td>11</td>
<td>111111</td>
<td>111111</td>
</tr>
</tbody>
</table>

(11 rows)
### REPLICATE Function

Synonym for the REPEAT function.

See [REPEAT Function](p. 862).

### 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, time stamp, or numeric data type that represents the target of the character reversal. All expressions are implicitly converted to variable-length character strings.

  Trailing blanks in fixed-width character strings are ignored.

#### Return Type

REVERSE returns a VARCHAR.

#### Examples

Select five distinct city names and their corresponding reversed names from the USERS table:

```
select distinct city as cityname, reverse(cityname)
from users order by city limit 5;
```

<table>
<thead>
<tr>
<th>cityname</th>
<th>reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aberdeen</td>
<td>needrebA</td>
</tr>
<tr>
<td>Abilene</td>
<td>enelibA</td>
</tr>
<tr>
<td>Ada</td>
<td>adA</td>
</tr>
<tr>
<td>Agat</td>
<td>tagA</td>
</tr>
<tr>
<td>Agawam</td>
<td>mawagA</td>
</tr>
</tbody>
</table>

(5 rows)
Select five sales IDs and their corresponding reversed IDs cast as character strings:

```
select salesid, reverse(salesid)::varchar
from sales order by salesid desc limit 5;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>172456</td>
<td>654271</td>
</tr>
<tr>
<td>172455</td>
<td>554271</td>
</tr>
<tr>
<td>172454</td>
<td>454271</td>
</tr>
<tr>
<td>172453</td>
<td>354271</td>
</tr>
<tr>
<td>172452</td>
<td>254271</td>
</tr>
</tbody>
</table>

(5 rows)

**RTRIM Function**

The RTRIM function trims a specified set of characters from the end of a string.

**Syntax**

```
RTRIM( string, trim_chars )
```

**Arguments**

- `string`
  - The string column or expression to be trimmed.
- `trim_chars`
  - A string column or expression representing the characters to be trimmed from the end of `string`.

**Return Type**

A string that is the same data type as the `string` argument.

**Example**

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;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>rtrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toyota Park</td>
<td>Toyota</td>
</tr>
<tr>
<td>2</td>
<td>Columbus Crew Stadium</td>
<td>Columbus Crew Stadium</td>
</tr>
<tr>
<td>3</td>
<td>RFK Stadium</td>
<td>RFK Stadium</td>
</tr>
<tr>
<td>4</td>
<td>CommunityAmerica Ballpark</td>
<td>CommunityAmerica Ballp</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Gillette Stadium</td>
</tr>
<tr>
<td>6</td>
<td>New York Giants Stadium</td>
<td>New York Giants Stadium</td>
</tr>
<tr>
<td>7</td>
<td>BMO Field</td>
<td>BMO Field</td>
</tr>
<tr>
<td>8</td>
<td>The Home Depot Center</td>
<td>The Home Depot Center</td>
</tr>
<tr>
<td>9</td>
<td>Dick's Sporting Goods Park</td>
<td>Dick's Sporting Goods</td>
</tr>
<tr>
<td>10</td>
<td>Pizza Hut Park</td>
<td>Pizza Hut</td>
</tr>
</tbody>
</table>

(10 rows)
Note that RTRIM removes any of the characters P, a, r, or k when they appear at the end of a VENUE NAME.

**SPLIT_PART Function**

Splits a string on the specified delimiter and returns the part at the specified position.

**Syntax**

```sql
SPLIT_PART(string, delimiter, part)
```

**Arguments**

*string*

The string to be split. The string can be CHAR or VARCHAR.

*delimiter*

The delimiter string.

If *delimiter* is a literal, enclose it in single quotes.

*part*

Position of the portion to return (counting from 1). Must be an integer greater than 0. If *part* 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 the time stamp field LISTTIME into year, month, and day components.

```sql
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;
```

<table>
<thead>
<tr>
<th>listtime</th>
<th>year</th>
<th>month</th>
<th>day</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-03-05 12:25:29</td>
<td>2008</td>
<td>03</td>
<td>05</td>
</tr>
<tr>
<td>2008-09-09 08:03:36</td>
<td>2008</td>
<td>09</td>
<td>09</td>
</tr>
<tr>
<td>2008-09-26 05:43:12</td>
<td>2008</td>
<td>09</td>
<td>26</td>
</tr>
<tr>
<td>2008-10-04 02:00:30</td>
<td>2008</td>
<td>10</td>
<td>04</td>
</tr>
<tr>
<td>2008-01-06 08:33:11</td>
<td>2008</td>
<td>01</td>
<td>06</td>
</tr>
</tbody>
</table>

(5 rows)

The following example selects the LISTTIME time stamp 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:

```sql
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    |

(12 rows)

**STRPOS Function**

Returns the position of a substring within a specified string.

Synonym of [CHARINDEX Function (p. 842)](http://example.com) and [POSITION Function (p. 854)](http://example.com).

**Syntax**

```sql
STRPOS(string, substring)
```

**Arguments**

*string*

The first input parameter is the string to be searched.

*substring*

The second parameter is the substring to search for within the *string*.

**Return Type**

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*:

```sql
select strpos('dogfish', 'fist');
```

```sql
strpos
--------
0
(1 row)
```

**Examples**

The following example shows the position of the string *fish* within the word *dogfish*:

```sql
select strpos('dogfish', 'fish');
```
The following example returns the number of sales transactions with a COMMISSION over 999.00 from the SALES table:

```sql
select distinct strpos(commission, '.'),
count (strpos(commission, '.'))
from sales
where strpos(commission, '.') > 4
  group by strpos(commission, '.')
order by 1, 2;
```

<table>
<thead>
<tr>
<th>strpos</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>629</td>
</tr>
</tbody>
</table>

**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**

```sql
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, returns NULL.

**Examples**

The following examples convert string and base value pairs to integers:

```sql
select strtol('0xf',16);
```

```
<table>
<thead>
<tr>
<th>strtol</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
</tr>
</tbody>
</table>
```

(1 row)
select strtol('abcd1234',16);
strtol
---------
2882343476
(1 row)

select strtol('1234567', 10);
strtol
--------
1234567
(1 row)

select strtol('1234567', 8);
strtol
--------
342391
(1 row)

select strtol('110101', 2);
strtol
--------
53

select strtol('\0', 2);
strtol
--------
0

---

**SUBSTRING Function**

Returns the characters extracted from a string based on the specified character position for a specified number of characters.

The character position and number of characters are based on the number of characters, not bytes, so that multi-byte characters are counted as single characters. You cannot specify a negative length, but you can specify a negative starting position.

**Syntax**

```
SUBSTRING(string FROM start_position [ FOR number_characters ] )
```

```
SUBSTRING(string, start_position, number_characters )
```

**Arguments**

- **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.
### Return Type
VARCHAR

### Usage Notes
The following example returns a four-character string beginning with the sixth character.

```sql
select substring('caterpillar',6,4);
```

```
<table>
<thead>
<tr>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>pill</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>
```

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:

```sql
select substring('caterpillar',6,8);
```

```
<table>
<thead>
<tr>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>pillar</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>
```

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:

```sql
select substring('caterpillar',-2,6);
```

```
<table>
<thead>
<tr>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>
```

If `start_position + number_characters` - 1 is less than or equal to zero, `SUBSTRING` returns an empty string. For example:

```sql
select substring('caterpillar',-5,4);
```

```
| (1 row) |
```

### Examples
The following example returns the month from the `LISTTIME` string in the `LISTING` table:

```sql
select listid, listtime,
       substring(listtime, 6, 2) as month
from listing
order by 1, 2, 3
limit 10;
```

```
P| 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    |
```

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The following example is the same as above, but uses the FROM...FOR option:

```sql
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
```

You cannot 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'.

```sql
select cast('Fourscore and seven' as varchar(5));
```

```
varchar
-------
Fours
```

**TEXTLEN Function**

Synonym of LEN function.

See LEN Function (p. 849).

**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 (p. 863) and the REGEXP_REPLACE Function (p. 859), 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

The following example replaces several characters in a string:

```
select translate('mint tea', 'inea', 'osin');
```

```
translate
-----------
mint tin
```

The following example replaces the at sign (@) with a period for all values in a column:

```
select email, translate(email, '@', '.') as obfuscated_email
from users limit 10;
```

<table>
<thead>
<tr>
<th>email</th>
<th>obfuscated_email</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:Etiam.laoreet.libero@sodalesMaurisblandit.edu">Etiam.laoreet.libero@sodalesMaurisblandit.edu</a></td>
<td>Etiam.laoreet.libero.sodalesMaurisblandit.edu</td>
</tr>
<tr>
<td>Etiam.laoreet.libero.sodalesMaurisblandit.edu</td>
<td><a href="mailto:Etiam.laoreet.libero@sodalesMaurisblandit.edu">Etiam.laoreet.libero@sodalesMaurisblandit.edu</a></td>
</tr>
<tr>
<td><a href="mailto:amet.faucibus.ut@condimentumgetvolutpat.ca">amet.faucibus.ut@condimentumgetvolutpat.ca</a></td>
<td><a href="mailto:amet.faucibus.ut@condimentumgetvolutpat.ca">amet.faucibus.ut@condimentumgetvolutpat.ca</a></td>
</tr>
<tr>
<td><a href="mailto:turpis@accumsanlaoreet.org">turpis@accumsanlaoreet.org</a></td>
<td><a href="mailto:turpis@accumsanlaoreet.org">turpis@accumsanlaoreet.org</a></td>
</tr>
<tr>
<td><a href="mailto:ullamcorper.nisl@Cras.edu">ullamcorper.nisl@Cras.edu</a></td>
<td><a href="mailto:ullamcorper.nisl@Cras.edu">ullamcorper.nisl@Cras.edu</a></td>
</tr>
<tr>
<td><a href="mailto:arcu.Curabitur@senectusetnetus.com">arcu.Curabitur@senectusetnetus.com</a></td>
<td><a href="mailto:arcu.Curabitur@senectusetnetus.com">arcu.Curabitur@senectusetnetus.com</a></td>
</tr>
<tr>
<td><a href="mailto:ac@velit.ca">ac@velit.ca</a></td>
<td><a href="mailto:ac@velit.ca">ac@velit.ca</a></td>
</tr>
<tr>
<td><a href="mailto:Aliquam.vulputate.ullamcorper@amalesuada.org">Aliquam.vulputate.ullamcorper@amalesuada.org</a></td>
<td><a href="mailto:Aliquam.vulputate.ullamcorper@amalesuada.org">Aliquam.vulputate.ullamcorper@amalesuada.org</a></td>
</tr>
<tr>
<td><a href="mailto:vel.est@velitegestas.edu">vel.est@velitegestas.edu</a></td>
<td><a href="mailto:vel.est@velitegestas.edu">vel.est@velitegestas.edu</a></td>
</tr>
<tr>
<td><a href="mailto:dolor.nonummy@ipsumdolorsit.ca">dolor.nonummy@ipsumdolorsit.ca</a></td>
<td><a href="mailto:dolor.nonummy@ipsumdolorsit.ca">dolor.nonummy@ipsumdolorsit.ca</a></td>
</tr>
<tr>
<td><a href="mailto:et@Nunclaoreet.ca">et@Nunclaoreet.ca</a></td>
<td><a href="mailto:et@Nunclaoreet.ca">et@Nunclaoreet.ca</a></td>
</tr>
</tbody>
</table>

The following example replaces spaces with underscores and strips out periods for all values in a column:

```
select city, translate(city, ' ', '.') from users
where city like 'Sain%' or city like 'St%'
group by city
```

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TRIM Function

The TRIM function trims a string by removing leading and trailing blanks or by removing characters that match an optional specified string.

Syntax

```
TRIM([ BOTH ] ['characters' FROM ] string )
```

Arguments

- `characters`
  
  (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 and CONVERT Functions (p. 881) and CONVERT (p. 881) functions for information about explicit conversions.

Example

The following example removes the double quotes that surround the string “dog”:

```
select trim('"' FROM '"dog"');
```
btrim
-------
dog
(1 row)

**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 CHAR or VARCHAR string.

**Return Type**

The UPPER function returns a character string that is the same data type as the input string (CHAR or VARCHAR).

**Examples**

The following example converts the CATNAME field to uppercase:

```
select catname, upper(catname) from category order by 1,2;
```

<table>
<thead>
<tr>
<th>catname</th>
<th>upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>CLASSICAL</td>
</tr>
<tr>
<td>Jazz</td>
<td>JAZZ</td>
</tr>
<tr>
<td>MLB</td>
<td>MLB</td>
</tr>
<tr>
<td>MLS</td>
<td>MLS</td>
</tr>
<tr>
<td>Musicals</td>
<td>MUSICALS</td>
</tr>
<tr>
<td>NBA</td>
<td>NBA</td>
</tr>
<tr>
<td>NFL</td>
<td>NFL</td>
</tr>
<tr>
<td>NHL</td>
<td>NHL</td>
</tr>
<tr>
<td>Opera</td>
<td>OPERA</td>
</tr>
<tr>
<td>Plays</td>
<td>PLAYS</td>
</tr>
<tr>
<td>Pop</td>
<td>POP</td>
</tr>
</tbody>
</table>

(11 rows)

**JSON Functions**

**Topics**

- IS_VALID_JSON Function (p. 875)
- IS_VALID_JSON_ARRAY Function (p. 876)
- JSON_ARRAY_LENGTH Function (p. 877)
- JSON_EXTRACT_ARRAY_ELEMENT_TEXT Function (p. 878)
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 without needing to add columns to a table.

We recommend using JSON sparingly. JSON is not a good choice for storing larger datasets because, by storing disparate data in a single column, JSON does not leverage Amazon Redshift’s column store architecture.

JSON uses UTF-8 encoded text strings, so JSON strings can be stored as CHAR or VARCHAR data types. Use VARCHAR if the strings include multi-byte characters.

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, \texttt{\{"one":1, "two":2\}}
  - A JSON array is an ordered set of comma-separated values enclosed by brackets.
    - An example is the following: \texttt{["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 double quoted string.
  - A JSON value can be any of:
    - JSON object
    - JSON array
    - string (double quoted)
    - number (integer and float)
    - 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 \texttt{COPY from JSON Format (p. 489)}

**IS_VALID_JSON Function**

IS_VALID_JSON validates a JSON string. The function returns Boolean \texttt{true} (\texttt{t}) if the string is properly formed JSON or \texttt{false} (\texttt{f}) if the string is malformed. To validate a JSON array, use \texttt{IS_VALID_JSON_ARRAY Function (p. 876)}

For more information, see \texttt{JSON Functions (p. 874)}. 

---

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Amazon Redshift Database Developer Guide
JSON Functions

Syntax
is_valid_json('json_string')

Arguments
json_string
A string or expression that evaluates to a JSON string.

Return Type
BOOLEAN

Example
The following example creates a table and inserts JSON strings for testing.
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]');

The following example validates the strings in the preceding 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
2 | {"a":{"b":{"c":1}}} | true
4 | {"a": [1,2,"b"]}
| true
6 | {{}}
| false
8 | {1:"a"}
| false
10 | [1,2,3]
| false

IS_VALID_JSON_ARRAY Function
IS_VALID_JSON_ARRAY validates a JSON array. The function returns Boolean true (t) if the array
is properly formed JSON or false (f) if the array is malformed. To validate a JSON string, use
IS_VALID_JSON Function (p. 875)
For more information, see JSON Functions (p. 874).

Syntax
is_valid_json_array('json_array')

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Arguments

\textit{json\_array}

A string or expression that evaluates to a JSON array.

Return Type

\textbf{BOOLEAN}

Example

The following example creates a table and inserts JSON strings for testing.

```
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,');
```

The following example validates the strings in the preceding 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             |

\textbf{JSON\_ARRAY\_LENGTH Function}

\textbf{JSON\_ARRAY\_LENGTH} returns the number of elements in the outer array of a JSON string. If the \textit{null\_if\_invalid} argument is set to \texttt{true} and the JSON string is invalid, the function returns NULL instead of returning an error.

For more information, see \textbf{JSON Functions (p. 874)}.

Syntax

\texttt{json\_array\_length('json\_array' [, null\_if\_invalid ] )}

Arguments

\textit{json\_array}

A properly formatted JSON array.
null_if_invalid

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

Example
The following example returns the number of elements in the array:

```sql
select json_array_length('[11,12,13,{"f1":21,"f2":[25,26]},14']);
```

```
json_array_length
--------------
5
```

The following example returns an error because the JSON is invalid.

```sql
select json_array_length('[11,12,13,{"f1":21,"f2":[25,26]},14');
```

An error occurred when executing the SQL command:

```sql
select json_array_length('[11,12,13,{"f1":21,"f2":[25,26]},14')
```

The following example sets null_if_invalid to true, so the statement the returns NULL instead of returning an error for invalid JSON.

```sql
select json_array_length('[11,12,13,{"f1":21,"f2":[25,26]},14',true);
```

```
json_array_length
--------------
```

JSON_EXTRACT_ARRAY_ELEMENT_TEXT Function

JSON_EXTRACT_ARRAY_ELEMENT_TEXT 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 bound, JSON_EXTRACT_ARRAY_ELEMENT_TEXT returns empty 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 (p. 874).

Syntax

```sql
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
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
A VARCHAR string representing the JSON array element referenced by pos.

Example
The following example returns array element at position 2:

```
select json_extract_array_element_text('[111,112,113]', 2);
```

```
{0}__json_extract_array_element_text
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>113</td>
</tr>
</tbody>
</table>
```

The following example returns an error because the JSON is invalid.

```
select json_extract_array_element_text('"a","b",1,"c",2,3,null,]]\'',1);
```

An error occurred when executing the SQL command:
```
select json_extract_array_element_text('"a","b",1,"c",2,3,null,]]\'',1)
```

The following example sets null_if_invalid to true, so the statement returns NULL instead of returning an error for invalid JSON.

```
select json_extract_array_element_text('"a","b",1,"c",2,3,null,]]\'',1,true);
```

```
{0}__json_extract_array_element_text
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>{0}</td>
</tr>
</tbody>
</table>
```

**JSON_EXTRACT_PATH_TEXT Function**

JSON_EXTRACT_PATH_TEXT 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 an empty 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 (p. 874).

**Syntax**

```
json_extract_path_text('json_string', 'path_elem [,'path_elem'][, ...] [, null_if_invalid ] )
```

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Data Type Formatting Functions

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
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 (p. 491).

Return Type
VARCHAR string representing the JSON value referenced by the path elements.

Example
The following example returns the value for the path 'f4', 'f6':
select json_extract_path_text('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}}','f4', 'f6');
json_extract_path_text
---------------------star

The following example returns an error because the JSON is invalid.
select json_extract_path_text('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}','f4', 'f6');
An error occurred when executing the SQL command:
select json_extract_path_text('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}','f4', 'f6')

The following example sets null_if_invalid to true, so the statement returns NULL for invalid JSON
instead of returning an error.
select json_extract_path_text('{"f2":{"f3":1},"f4":{"f5":99,"f6":"star"}','f4', 'f6',true);
json_extract_path_text
-------------------------------

Data Type Formatting Functions
Topics
• CAST and CONVERT Functions (p. 881)
• TO_CHAR (p. 884)

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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 and CONVERT Functions**

You can do runtime conversions between compatible data types by using the CAST and CONVERT functions.

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 the CAST or CONVERT function. See Type Compatibility and Conversion (p. 388).

**CAST**

You can use two equivalent syntax forms to cast expressions from one data type to another:

```sql
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 (p. 369).

**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 the following DECIMAL conversion that loses precision:

```sql
select 123.456::decimal(2,1);
```

or an INTEGER conversion that causes an overflow:

```sql
select 12345678::smallint;
```

**CONVERT**

You can also use the CONVERT function to convert values from one data type to another:
CONVERT ( type, expression )

**Arguments**

*type*

One of the supported Data Types (p. 369).

*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.

**Examples**

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 query uses the CONVERT function to return the same result:

```
select convert(integer, pricepaid) 
from sales where salesid=100;
```

```
pricepaid
----------
  162
(1 row)
```

In this example, the values in a time stamp column are cast as dates:

```
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
```

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In this example, the values in a date column are cast as time stamps:

```
select cast(caldate as timestamp), dateid 
from date order by dateid limit 10;
```

<table>
<thead>
<tr>
<th>caldate</th>
<th>dateid</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-01-01 00:00:00</td>
<td>1827</td>
</tr>
<tr>
<td>2008-01-02 00:00:00</td>
<td>1828</td>
</tr>
<tr>
<td>2008-01-03 00:00:00</td>
<td>1829</td>
</tr>
<tr>
<td>2008-01-04 00:00:00</td>
<td>1830</td>
</tr>
<tr>
<td>2008-01-05 00:00:00</td>
<td>1831</td>
</tr>
<tr>
<td>2008-01-06 00:00:00</td>
<td>1832</td>
</tr>
<tr>
<td>2008-01-07 00:00:00</td>
<td>1833</td>
</tr>
<tr>
<td>2008-01-08 00:00:00</td>
<td>1834</td>
</tr>
<tr>
<td>2008-01-09 00:00:00</td>
<td>1835</td>
</tr>
<tr>
<td>2008-01-10 00:00:00</td>
<td>1836</td>
</tr>
</tbody>
</table>
```

(10 rows)

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
```

In this example, 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;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7280000000000000000000000.00</td>
</tr>
<tr>
<td>2</td>
<td>7600000000000000000000000.00</td>
</tr>
<tr>
<td>3</td>
<td>3500000000000000000000000.00</td>
</tr>
<tr>
<td>4</td>
<td>1750000000000000000000000.00</td>
</tr>
<tr>
<td>5</td>
<td>1540000000000000000000000.00</td>
</tr>
<tr>
<td>6</td>
<td>3940000000000000000000000.00</td>
</tr>
<tr>
<td>7</td>
<td>7880000000000000000000000.00</td>
</tr>
<tr>
<td>8</td>
<td>1970000000000000000000000.00</td>
</tr>
<tr>
<td>9</td>
<td>5910000000000000000000000.00</td>
</tr>
</tbody>
</table>
```

(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.

```sql
SELECT ST_AsText('01010000000000000000001C400000000000002040');
```

```
st_astext
-------------------
POINT(7 8)
```

You can also explicitly specify the GEOMETRY data type.

```sql
SELECT ST_AsText('010100000000000000000014400000000000001840'::geometry);
```

```
st_astext
-------------------
POINT(5 6)
```

**TO_CHAR**

TO_CHAR converts a time stamp 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 time stamp.

*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 (p. 371). 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 (p. 888) and Numeric Format Strings (p. 890).

**Return Type**

VARCHAR

**Examples**

The following example converts each STARTTIME value in the EVENT table to a string that consists of hours, minutes, and seconds.
The following example converts an entire time stamp value into a different format.

```sql
select starttime, to_char(starttime, 'MON-DD-YYYY HH12:MIPM')
from event where eventid=1;
```

<table>
<thead>
<tr>
<th>starttime</th>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-01-25 14:30:00</td>
<td>JAN-25-2008 02:30PM</td>
</tr>
</tbody>
</table>

(1 row)

The following example converts a time stamp literal to a character string.

```sql
select to_char(timestamp '2009-12-31 23:15:59','HH24:MI:SS');
```

<table>
<thead>
<tr>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>23:15:59</td>
</tr>
</tbody>
</table>

(1 row)

The following example converts a number to a character string.

```sql
select to_char(-125.8, '999D99S');
```

<table>
<thead>
<tr>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>125.80-</td>
</tr>
</tbody>
</table>

(1 row)

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:

```sql
select salesid, pricepaid, commission, (pricepaid - commission) as difference, to_char(pricepaid - commission, 'rn') from sales
order by salesid limit 10;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>pricepaid</th>
<th>commission</th>
<th>difference</th>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>728.00</td>
<td>109.20</td>
<td>618.80</td>
<td>dcxix</td>
</tr>
<tr>
<td>2</td>
<td>76.00</td>
<td>11.40</td>
<td>64.60</td>
<td>lxv</td>
</tr>
<tr>
<td>3</td>
<td>350.00</td>
<td>52.50</td>
<td>297.50</td>
<td>ccxcviii</td>
</tr>
<tr>
<td>4</td>
<td>175.00</td>
<td>26.25</td>
<td>148.75</td>
<td>clix</td>
</tr>
<tr>
<td>5</td>
<td>154.00</td>
<td>23.10</td>
<td>130.90</td>
<td>cxxxi</td>
</tr>
<tr>
<td>6</td>
<td>394.00</td>
<td>59.10</td>
<td>334.90</td>
<td>ccxxxv</td>
</tr>
<tr>
<td>7</td>
<td>788.00</td>
<td>118.20</td>
<td>669.80</td>
<td>dclxx</td>
</tr>
<tr>
<td>8</td>
<td>197.00</td>
<td>29.55</td>
<td>167.45</td>
<td>clxvii</td>
</tr>
<tr>
<td>9</td>
<td>591.00</td>
<td>88.65</td>
<td>502.35</td>
<td>dii</td>
</tr>
<tr>
<td>10</td>
<td>65.00</td>
<td>9.75</td>
<td>55.25</td>
<td>lv</td>
</tr>
</tbody>
</table>

(10 rows)
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
order by salesid limit 10;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>pricepaid</th>
<th>commission</th>
<th>difference</th>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>728.00</td>
<td>109.20</td>
<td>618.80</td>
<td>$ 618.80</td>
</tr>
<tr>
<td>2</td>
<td>76.00</td>
<td>11.40</td>
<td>64.60</td>
<td>$ 64.60</td>
</tr>
<tr>
<td>3</td>
<td>350.00</td>
<td>52.50</td>
<td>297.50</td>
<td>$ 297.50</td>
</tr>
<tr>
<td>4</td>
<td>175.00</td>
<td>26.25</td>
<td>148.75</td>
<td>$ 148.75</td>
</tr>
<tr>
<td>5</td>
<td>154.00</td>
<td>23.10</td>
<td>130.90</td>
<td>$ 130.90</td>
</tr>
<tr>
<td>6</td>
<td>394.00</td>
<td>59.10</td>
<td>334.90</td>
<td>$ 334.90</td>
</tr>
<tr>
<td>7</td>
<td>788.00</td>
<td>118.20</td>
<td>669.80</td>
<td>$ 669.80</td>
</tr>
<tr>
<td>8</td>
<td>197.00</td>
<td>29.55</td>
<td>167.45</td>
<td>$ 167.45</td>
</tr>
<tr>
<td>9</td>
<td>591.00</td>
<td>88.65</td>
<td>502.35</td>
<td>$ 502.35</td>
</tr>
<tr>
<td>10</td>
<td>65.00</td>
<td>9.75</td>
<td>55.25</td>
<td>$ 55.25</td>
</tr>
</tbody>
</table>

(10 rows)

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;
```

<table>
<thead>
<tr>
<th>salesid</th>
<th>saletime</th>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008-02-18 02:36:48</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>2008-06-06 05:00:16</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>2008-06-06 08:26:17</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>2008-06-09 08:38:52</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>2008-08-31 09:17:02</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>2008-07-16 11:59:24</td>
<td>21</td>
</tr>
<tr>
<td>7</td>
<td>2008-06-26 12:56:10</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>2008-07-10 02:12:36</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>2008-07-22 02:23:17</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>2008-08-06 02:51:55</td>
<td>21</td>
</tr>
</tbody>
</table>

(10 rows)

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;
```

<table>
<thead>
<tr>
<th>to_char</th>
</tr>
</thead>
<tbody>
<tr>
<td>02:30:00 UTC</td>
</tr>
<tr>
<td>08:00:00 UTC</td>
</tr>
<tr>
<td>02:30:00 UTC</td>
</tr>
<tr>
<td>02:30:00 UTC</td>
</tr>
<tr>
<td>07:00:00 UTC</td>
</tr>
</tbody>
</table>

(5 rows)

(10 rows)

**TO_DATE**

TO_DATE converts a date represented in a character string to a DATE data type.
The second argument is a format string that indicates how the character string should be parsed to create the date value.

Syntax

```
TO_DATE (string, format)
```

Arguments

`string`

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 formats, see Datetime Format Strings (p. 888).

Return Type

TO_DATE returns a DATE, depending on the `format` value.

Example

The following command converts the date `02 Oct 2001` into the default date format:

```
select to_date ('02 Oct 2001', 'DD Mon YYYY');
```

```
to_date
----------
2001-10-02
(1 row)
```

**TO_NUMBER**

TO_NUMBER converts a string to a numeric (decimal) value.

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 `'99D999'` 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','99D999')` returns `12.345` as a numeric value. For a list of valid formats, see Numeric Format Strings (p. 890).

Return Type

TO_NUMBER returns a DECIMAL number.
**Examples**

The following example converts the string 12,454.8- to a number:

```sql
select to_number('12,454.8-', '99G999D9S');
```

```
to_number
-----------
-12454.8
(1 row)
```

**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".

<table>
<thead>
<tr>
<th>Datepart or Timepart</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC or B.C., AD or A.D., b.c. or bc, ad or a.d.</td>
<td>Upper and lowercase era indicators</td>
</tr>
<tr>
<td>CC</td>
<td>Two-digit century number</td>
</tr>
<tr>
<td>YYYY, YYY, YY, Y</td>
<td>4-digit, 3-digit, 2-digit, 1-digit year number</td>
</tr>
<tr>
<td>Y,YYY</td>
<td>4-digit year number with comma</td>
</tr>
<tr>
<td>IYYY, IYY, IY, I</td>
<td>4-digit, 3-digit, 2-digit, 1-digit International Organization for Standardization (ISO) year number</td>
</tr>
<tr>
<td>Q</td>
<td>Quarter number (1 to 4)</td>
</tr>
<tr>
<td>MONTH, Month, month</td>
<td>Month name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)</td>
</tr>
<tr>
<td>MON, Mon, mon</td>
<td>Abbreviated month name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)</td>
</tr>
<tr>
<td>MM</td>
<td>Month number (01-12)</td>
</tr>
<tr>
<td>RM, rm</td>
<td>Month number in Roman numerals (I–XII, with I being January, uppercase or lowercase)</td>
</tr>
<tr>
<td>W</td>
<td>Week of month (1–5; the first week starts on the first day of the month.)</td>
</tr>
<tr>
<td>WW</td>
<td>Week number of year (1–53; the first week starts on the first day of the year.)</td>
</tr>
<tr>
<td>IW</td>
<td>ISO week number of year (the first Thursday of the new year is in week 1.)</td>
</tr>
<tr>
<td>DAY, Day, day</td>
<td>Day name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)</td>
</tr>
<tr>
<td>DY, Dy, dy</td>
<td>Abbreviated day name (uppercase, mixed-case, lowercase, blank-padded to 9 characters)</td>
</tr>
</tbody>
</table>
### Datepart or Timepart

<table>
<thead>
<tr>
<th>Datepart or Timepart</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDD</td>
<td>Day of year (001–366)</td>
</tr>
<tr>
<td>IDDD</td>
<td>Day of ISO 8601 week-numbering year (001-371; day 1 of the year is Monday of the first ISO week)</td>
</tr>
<tr>
<td>DD</td>
<td>Day of month as a number (01–31)</td>
</tr>
<tr>
<td>D</td>
<td>Day of week (1–7; Sunday is 1)</td>
</tr>
<tr>
<td>Note</td>
<td>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 Dateparts for Date or Time Stamp Functions (p. 776).</td>
</tr>
<tr>
<td>ID</td>
<td>ISO 8601 day of the week, Monday (1) to Sunday (7)</td>
</tr>
<tr>
<td>J</td>
<td>Julian day (days since January 1, 4712 BC)</td>
</tr>
<tr>
<td>HH24</td>
<td>Hour (24-hour clock, 00–23)</td>
</tr>
<tr>
<td>HH or HH12</td>
<td>Hour (12-hour clock, 01–12)</td>
</tr>
<tr>
<td>MI</td>
<td>Minutes (00–59)</td>
</tr>
<tr>
<td>SS</td>
<td>Seconds (00–59)</td>
</tr>
<tr>
<td>MS</td>
<td>Milliseconds (.000)</td>
</tr>
<tr>
<td>US</td>
<td>Microseconds (.000000)</td>
</tr>
<tr>
<td>AM or PM, A.M. or P.M., a.m. or p.m., am or pm</td>
<td>Upper and lowercase meridian indicators (for 12-hour clock)</td>
</tr>
<tr>
<td>TZ, tz</td>
<td>Upper and lowercase time zone abbreviation; valid for TIMESTAMPTZ only</td>
</tr>
<tr>
<td>OF</td>
<td>Offset from UTC; valid for TIMESTAMPTZ only</td>
</tr>
</tbody>
</table>

### 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.

The following example shows formatting for seconds, milliseconds, and microseconds.

```sql
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;
```

<table>
<thead>
<tr>
<th>timestamp</th>
<th>seconds</th>
<th>milliseconds</th>
<th>microseconds</th>
</tr>
</thead>
</table>
Numeric Format Strings

This topic provides a reference for numeric format strings.

The following format strings apply to functions such as TO_NUMBER and TO_CHAR:

<table>
<thead>
<tr>
<th>Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Numeric value with the specified number of digits.</td>
</tr>
<tr>
<td>0</td>
<td>Numeric value with leading zeros.</td>
</tr>
<tr>
<td>. (period), D</td>
<td>Decimal point.</td>
</tr>
<tr>
<td>, (comma)</td>
<td>Thousands separator.</td>
</tr>
<tr>
<td>CC</td>
<td>Century code. For example, the 21st century started on 2001-01-01 (supported for TO_CHAR only).</td>
</tr>
<tr>
<td>FM</td>
<td>Fill mode. Suppress padding blanks and zeroes.</td>
</tr>
<tr>
<td>PR</td>
<td>Negative value in angle brackets.</td>
</tr>
<tr>
<td>S</td>
<td>Sign anchored to a number.</td>
</tr>
<tr>
<td>L</td>
<td>Currency symbol in the specified position.</td>
</tr>
<tr>
<td>G</td>
<td>Group separator.</td>
</tr>
<tr>
<td>MI</td>
<td>Minus sign in the specified position for numbers that are less than 0.</td>
</tr>
<tr>
<td>PL</td>
<td>Plus sign in the specified position for numbers that are greater than 0.</td>
</tr>
<tr>
<td>SG</td>
<td>Plus or minus sign in the specified position.</td>
</tr>
<tr>
<td>RN</td>
<td>Roman numeral between 1 and 3999 (supported for TO_CHAR only).</td>
</tr>
<tr>
<td>TH or th</td>
<td>Ordinal number suffix. Does not convert fractional numbers or values that are less than zero.</td>
</tr>
</tbody>
</table>

System Administration Functions

Topics

- CHANGE_QUERY_PRIORITY (p. 891)
- CHANGE_SESSION_PRIORITY (p. 891)
- CHANGE_USER_PRIORITY (p. 893)
- CURRENT_SETTING (p. 894)
- PG_CANCEL_BACKEND (p. 894)
- PG_TERMINATE_BACKEND (p. 895)
- SET_CONFIG (p. 895)

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.

- `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

Example

The following example shows the column `query_priority` in the STV_WLM_QUERY_STATE system table.

```
select query, service_class, query_priority, state
from stv_wlm_query_state where service_class = 101;
```

<table>
<thead>
<tr>
<th>query</th>
<th>service_class</th>
<th>query_priority</th>
<th>state</th>
</tr>
</thead>
<tbody>
<tr>
<td>1076</td>
<td>101</td>
<td>Lowest</td>
<td>Running</td>
</tr>
<tr>
<td>1075</td>
<td>101</td>
<td>Lowest</td>
<td>Running</td>
</tr>
</tbody>
</table>

(2 rows)

The following example shows the results of a superuser running the function `change_query_priority` to change the priority to CRITICAL.

```
select change_query_priority(1076, 'Critical');
```

```
change_query_priority
--------------------------------------------------
Succeeded to change query priority. Priority changed from Lowest to Critical.
```

(1 row)

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.

- **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

## Example

The following example returns the process identifier of the server process handling the current session.

```
select pg_backend_pid();
```

```
pg_backend_pid
----------------
 30311
(1 row)
```

In this example, the priority is changed for the current session to LOWEST.

```
select change_session_priority(30311, 'Lowest');
```

```
change_session_priority
----------------------------------------
Succeeded to change session priority. Changed session (pid:30311) priority to lowest.
(1 row)
```

In this example, the priority is changed for the current session to HIGH.

```
select change_session_priority(-1, 'High');
```

```
change_session_priority
-------------------------------
Succeeded to change session priority. Changed session (pid:30311) priority from lowest to high.
(1 row)
```

In the following example, a stored procedure is created to change a session priority. 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

```

892
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

**Example**

In the following example, the priority is changed for the user analysis_user to LOWEST.

```
select change_user_priority('analysis_user', 'lowest');
```

```
change_user_priority
Succeeded to change user priority. Changed user (analysis_user) priority to lowest.
(1 row)
```

In the next statement, the priority is changed to LOW.

```
select change_user_priority('analysis_user', 'low');
```

```
change_user_priority
```
Succeeded to change user priority. Changed user (analysis_user) priority from Lowest to low.

(1 row)

In this example, the priority is reset.

```
select change_user_priority('analysis_user', 'reset');
```

```
change_user_priority
```

```
Succeeded to reset priority for user (analysis_user).
(1 row)
```

### CURRENT_SETTING

CURRENT_SETTING returns the current value of the specified configuration parameter.

This function is equivalent to the `SHOW (p. 639)` command.

#### Syntax

```
current_setting('parameter')
```

#### Argument

`parameter`

Parameter value to display. For a list of configuration parameters, see [Configuration Reference (p. 1101)](https://docs.amazon.com/redshift/latest/dg/)

#### Return Type

Returns a CHAR or VARCHAR string.

#### Example

The following query returns the current setting for the `query_group` parameter:

```
select current_setting('query_group');
```

```
current_setting
```

```
unset
```

(1 row)

### PG_CANCEL_BACKEND

Cancels a query. PG_CANCEL_BACKEND is functionally equivalent to the `CANCEL (p. 446)` 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, execute the following command:

```sql
select pid, trim(starttime) as start, duration, trim(user_name) as user, substring (query,1,40) as querytxt from stv_recents where status = 'Running';
```

<table>
<thead>
<tr>
<th>pid</th>
<th>starttime</th>
<th>duration</th>
<th>user</th>
<th>querytxt</th>
</tr>
</thead>
<tbody>
<tr>
<td>802</td>
<td>2013-10-14 09:19:03.55</td>
<td>132</td>
<td>dwuser</td>
<td>select venuename from venue</td>
</tr>
<tr>
<td>834</td>
<td>2013-10-14 08:33:49.47</td>
<td>1250414</td>
<td>dwuser</td>
<td>select * from listing;</td>
</tr>
<tr>
<td>964</td>
<td>2013-10-14 08:30:43.29</td>
<td>326179</td>
<td>dwuser</td>
<td>select sellerid from sales</td>
</tr>
</tbody>
</table>

The following statement cancels the query with process ID 802:

```sql
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

```sql
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

The following statement queries the SVV_TRANSACTIONS table to view all locks in effect for current transactions:

```
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             | true     
rsuser  | dev       | 96178  | 8585 | 2017-04-12 20:13:07 | AccessShareLock | relation             | true     
rsuser  | dev       | 96178  | 8585 | 2017-04-12 20:13:07 | AccessShareLock | relation             | true     
rsuser  | dev       | 96178  | 8585 | 2017-04-12 20:13:07 | ExclusiveLock   | transactionid        | true     
```

The following statement terminates the session holding the locks:

```
select pg_terminate_backend(8585);
```

### 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)
```

**Arguments**

- `parameter`
  
  Parameter 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

The following query sets the value of the query_group parameter to test for the current transaction only:

```sql
select set_config('query_group', 'test', true);

set_config

------------
test

(1 row)
```

System Information Functions

Topics

- CURRENT_DATABASE (p. 898)
- CURRENT_SCHEMA (p. 898)
- CURRENT_SCHEMAS (p. 898)
- CURRENT_USER (p. 899)
- CURRENT_USER_ID (p. 900)
- HAS_DATABASE_PRIVILEGE (p. 900)
- HAS_SCHEMA_PRIVILEGE (p. 901)
- HAS_TABLE_PRIVILEGE (p. 902)
- PG_BACKEND_PID (p. 903)
- PG_GET_COLS (p. 904)
- PG_GET_LATE_BINDING_VIEW_COLS (p. 905)
- PG_LAST_COPY_COUNT (p. 906)
- PG_LAST_COPY_ID (p. 906)
- PG_LAST_UNLOAD_ID (p. 907)
- PG_LAST_QUERY_ID (p. 908)
- PG_LAST_UNLOAD_COUNT (p. 909)
- SESSION_USER (p. 909)
- SLICE_NUM Function (p. 910)
- USER (p. 910)
- VERSION (p. 910)

Amazon Redshift supports numerous system information functions.
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:

```sql
select current_database();
current_database
------------------
tickit
(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:

```sql
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.

```sql
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:

```sql
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:

```sql
select current_schemas(true);
```

```
current_schemas            
--------------------------
(pg_catalog,public)        
(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**

```sql
current_user
```
Return Type

CURRENT_USER returns a CHAR or VARCHAR string.

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)
```

**HAS_DATABASE_PRIVILEGE**

Returns true if the user has the specified privilege for the specified database. For more information about privileges, see GRANT (p. 585).

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
```

Name of the user to check for database privileges. Default is to check the current user.
**database**

Database associated with the privilege.

**privilege**

Privilege to check. Valid values are:
- 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:

```sql
select has_database_privilege('guest', 'tickit', 'temp');
```

<table>
<thead>
<tr>
<th>has_database_privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>true</td>
</tr>
</tbody>
</table>

(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 (p. 585)](https://docs.aws.amazon.com/redshift/latest/dg/CUR-GRANT.html).

**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.

```sql
has_schema_privilege( [ user, ] schema, privilege)
```

**Arguments**

**user**

Name of the user to check for schema privileges. Default is to check the current user.

**schema**

Schema associated with the privilege.

**privilege**

Privilege to check. Valid values are:
- CREATE
- USAGE

**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:

```sql
select has_schema_privilege('guest', 'public', 'create');
```

<table>
<thead>
<tr>
<th>has_schema_privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>true</td>
</tr>
</tbody>
</table>

(1 row)

**HAS_TABLE_PRIVILEGE**

Returns true if the user has the specified privilege for the specified table.

**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 (p. 585).

```sql
has_table_privilege( [ user, ] table, privilege)
```

**Arguments**

- **user**
  
  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:

  - SELECT
  - INSERT
  - UPDATE
  - DELETE
  - REFERENCES

**Return Type**

Returns a CHAR or VARCHAR string.

**Examples**

The following query finds that the GUEST user does not have SELECT privilege on the LISTING table:

```sql
select has_table_privilege('guest', 'listing', 'select');
```

<table>
<thead>
<tr>
<th>has_table_privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------------------------</td>
</tr>
</tbody>
</table>

(1 row)
false
(1 row)

**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 executed in the current session.

```
select query, substring(text,1,40)
from stl_querytext
where pid =  PG_BACKEND_PID()
order by query desc;
```

<table>
<thead>
<tr>
<th>query</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>14831</td>
<td>select query, substring(text,1,40) from</td>
</tr>
<tr>
<td>14827</td>
<td>select query, substring(path,0,80) as pa</td>
</tr>
<tr>
<td>14826</td>
<td>copy category from 's3://dw-ticket/manif</td>
</tr>
<tr>
<td>14825</td>
<td>Count rows in target table</td>
</tr>
<tr>
<td>14824</td>
<td>unload ('select * from category') to 's3</td>
</tr>
</tbody>
</table>

You can correlate `PG_BACKEND_PID()` with the `pid` column in the following log tables (exceptions are noted in parentheses):

- **STL_CONNECTION_LOG** (p. 926)
- **STL_DDLTEXT** (p. 927)
- **STL_ERROR** (p. 934)
- **STL_QUERY** (p. 960)
- **STL_QUERYTEXT** (p. 965)
- **STL_SESSIONS** (p. 976) (process)
- **STL_TR_CONFLICT** (p. 980)
- **STL.UtilityTEXT** (p. 985)
- **STV_ACTIVE_CURSORS** (p. 995)
- **STV_INFLIGHT** (p. 1000)
- **STV_LOCKS** (p. 1003) (lock_owner_pid)
- **STV_RECENTS** (p. 1010) (process_id)
**PG_GET_COLS**

Returns the column metadata for a table or view definition.

**Syntax**

```sql
pg_get_cols('name')
```

**Arguments**

`name`

The name of an Amazon Redshift table or view.

**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.

**Example**

The following example returns the column metadata for a view named SALES_VW.

```sql
select pg_get_cols('sales_vw');
```

```sql
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(public,sales_vw,salesid, integer,1)</td>
<td>(public,sales_vw,listid, integer,2)</td>
<td>(public,sales_vw,sellerid, integer,3)</td>
<td>(public,sales_vw,buyerid, integer,4)</td>
<td>(public,sales_vw,eventid, integer,5)</td>
</tr>
<tr>
<td>(public,sales_vw,dateid, smallint,6)</td>
<td>(public,sales_vw,qtysold, smallint,7)</td>
<td>(public,sales_vw,pricepaid,&quot;numeric(8,2)&quot;,8)</td>
<td>(public,sales_vw,commission,&quot;numeric(8,2)&quot;,9)</td>
<td>(public,sales_vw,saletime,&quot;timestamp without time zone&quot;,10)</td>
</tr>
</tbody>
</table>
```

The following example returns the column metadata for the SALES_VW view in table format.

```sql
select * from pg_get_cols('sales_vw')
cols(view_schema name, view_name name, col_name name, col_type varchar, col_num int);
```

<table>
<thead>
<tr>
<th>view_schema</th>
<th>view_name</th>
<th>col_name</th>
<th>col_type</th>
<th>col_num</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>salesid</td>
<td>integer</td>
<td>1</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>listid</td>
<td>integer</td>
<td>2</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>sellerid</td>
<td>integer</td>
<td>3</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>buyerid</td>
<td>integer</td>
<td>4</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>eventid</td>
<td>integer</td>
<td>5</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>dateid</td>
<td>smallint</td>
<td>6</td>
</tr>
<tr>
<td>public</td>
<td>sales_vw</td>
<td>qtysold</td>
<td>smallint</td>
<td>7</td>
</tr>
</tbody>
</table>
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 (p. 562)

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,datetid,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
```
### PG_LAST_COPY_COUNT

Returns the number of rows that were loaded by the last COPY command executed 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 executed 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 (p. 906).

#### Syntax

```sql
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.

```sql
select pg_last_copy_count();
```

```
pg_last_copy_count
-------------------
192497
(1 row)
```

### PG_LAST_COPY_ID

Returns the query ID of the most recently executed COPY command in the current session. If no COPY commands have been executed 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. COPY performs compression analysis when the COMPUPDATE parameter is set to ON or when the target table is empty and all the table columns either have RAW encoding or no encoding.

**Syntax**

```sql
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.

```sql
select pg_last_copy_id();
```

```sql
<table>
<thead>
<tr>
<th>pg_last_copy_id</th>
</tr>
</thead>
<tbody>
<tr>
<td>5437</td>
</tr>
</tbody>
</table>
```

(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:

```sql
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();
```

```
<table>
<thead>
<tr>
<th>query</th>
<th>substring</th>
<th>line</th>
<th>value</th>
<th>err_reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>251</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>ZRU29FGR</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>Kaitlin</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>Walter</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
</tbody>
</table>
```

**PG_LAST_UNLOAD_ID**

Returns the query ID of the most recently executed UNLOAD command in the current session. If no UNLOAD commands have been executed 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();
```

<table>
<thead>
<tr>
<th>PG_LAST_UNLOAD_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>5437</td>
</tr>
</tbody>
</table>

PG_LAST_QUERY_ID

Returns the query ID of the most recently executed query in the current session. If no queries have been executed in the current session, PG_LAST_QUERY_ID returns -1. PG_LAST_QUERY_ID does not return the query ID for queries that execute exclusively on the leader node. For more information, see Leader Node-Only Functions (p. 667).

Syntax

```
pg_last_query_id()
```

Return Type

Returns an integer.

Example

The following query returns the ID of the latest query executed in the current session.

```
select pg_last_query_id();
```

<table>
<thead>
<tr>
<th>pg_last_query_id</th>
</tr>
</thead>
<tbody>
<tr>
<td>5437</td>
</tr>
</tbody>
</table>

The following query returns the query ID and text of the most recently executed query in the current session.

```
select query, trim(querytxt) as sqlquery
from stl_query
where query = pg_last_query_id();
```

<table>
<thead>
<tr>
<th>query</th>
<th>sqlquery</th>
</tr>
</thead>
<tbody>
<tr>
<td>5437</td>
<td>select name, loadtime from stl_file_scan where loadtime &gt; 1000000;</td>
</tr>
</tbody>
</table>
**PG_LAST_UNLOAD_COUNT**

Returns the number of rows that were unloaded by the last UNLOAD command executed 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 executed. 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 executed in the current session, or if the last UNLOAD failed during the unload operation, `PG_LAST_UNLOAD_COUNT` returns 0.

**Syntax**

```sql
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.

```sql
select pg_last_unload_count();
```

<table>
<thead>
<tr>
<th>pg_last_unload_count</th>
</tr>
</thead>
<tbody>
<tr>
<td>192497</td>
</tr>
</tbody>
</table>

**SESSION_USER**

Returns the name of the user associated with the current session. This is the user who initiated the current database connection.

**Note**

Do not use trailing parentheses when calling `SESSION_USER`.

**Syntax**

```sql
session_user
```

**Return Type**

Returns a CHAR or VARCHAR string.

**Example**

The following example returns the current session user:

```sql
select session_user;
```

<table>
<thead>
<tr>
<th>session_user</th>
</tr>
</thead>
<tbody>
<tr>
<td>909</td>
</tr>
</tbody>
</table>
**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;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>slice_num</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

(10 rows)

The following example returns a code (10000) to show that a query without a FROM statement executes on the leader node:

```
select slice_num();
```

slice_num
---------
10000

(1 row)

**USER**

Synonym for CURRENT_USER. See CURRENT_USER (p. 899).

**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:

```sql
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 quotes).

For more information, see Names and Identifiers (p. 367).

<table>
<thead>
<tr>
<th>AES128</th>
</tr>
</thead>
<tbody>
<tr>
<td>AES256</td>
</tr>
<tr>
<td>ALL</td>
</tr>
<tr>
<td>ALLOWOVERWRITE</td>
</tr>
<tr>
<td>ANALYSE</td>
</tr>
<tr>
<td>ANALYZE</td>
</tr>
<tr>
<td>AND</td>
</tr>
<tr>
<td>ANY</td>
</tr>
<tr>
<td>ARRAY</td>
</tr>
<tr>
<td>AS</td>
</tr>
<tr>
<td>ASC</td>
</tr>
<tr>
<td>AUTHORIZATION</td>
</tr>
<tr>
<td>AZ64</td>
</tr>
<tr>
<td>BACKUP</td>
</tr>
<tr>
<td>BETWEEN</td>
</tr>
<tr>
<td>BINARY</td>
</tr>
<tr>
<td>BLANKSASNULL</td>
</tr>
<tr>
<td>BOTH</td>
</tr>
<tr>
<td>BYTEDICT</td>
</tr>
<tr>
<td>BZIP2</td>
</tr>
<tr>
<td>CASE</td>
</tr>
<tr>
<td>CAST</td>
</tr>
<tr>
<td>CHECK</td>
</tr>
<tr>
<td>COLLATE</td>
</tr>
<tr>
<td>COLUMN</td>
</tr>
</tbody>
</table>
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
INTO
IS
ISNULL
JOIN
LANGUAGE
LEADING
LEFT
LIKE
LIMIT
LOCALTIME
LOCALTIMESTAMP
LUN
LUNS
LZO
LZOP
MINUS
MOSTLY13
MOSTLY32
MOSTLY8
<table>
<thead>
<tr>
<th>NATURAL</th>
<th>NEW</th>
<th>NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTNULL</td>
<td>NULL</td>
<td>NULLS</td>
</tr>
<tr>
<td>OFF</td>
<td>OFFLINE</td>
<td>OFFSET</td>
</tr>
<tr>
<td>OID</td>
<td>ON</td>
<td>ONLY</td>
</tr>
<tr>
<td>OPEN</td>
<td>OR</td>
<td>ORDER</td>
</tr>
<tr>
<td>OUTER</td>
<td>OVERLAPS</td>
<td>PARALLEL</td>
</tr>
<tr>
<td>PARTITION</td>
<td>PERCENT</td>
<td>PERMISSIONS</td>
</tr>
<tr>
<td>PLACING</td>
<td>PRIMARY</td>
<td>RAW</td>
</tr>
<tr>
<td>READRATIO</td>
<td>RECOVER</td>
<td>REFERENCES</td>
</tr>
<tr>
<td>RESPECT</td>
<td>REJECTLOG</td>
<td>RESORT</td>
</tr>
<tr>
<td>RESTORE</td>
<td>RIGHT</td>
<td>SELECT</td>
</tr>
<tr>
<td>SESSION_USER</td>
<td>SIMILAR</td>
<td>SNAPSHOT</td>
</tr>
<tr>
<td>SOME</td>
<td>SYSDATE</td>
<td>SYSTEM</td>
</tr>
<tr>
<td>TABLE</td>
<td>TAG</td>
<td>TDES</td>
</tr>
<tr>
<td>TEXT255</td>
<td>TEXT32K</td>
<td>THEN</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>TO</td>
<td>TOP</td>
</tr>
<tr>
<td>TRAILING</td>
<td>TRUE</td>
<td>TRUNCATECOLUMNS</td>
</tr>
<tr>
<td>UNION</td>
<td>UNIQUE</td>
<td>USER</td>
</tr>
<tr>
<td>USING</td>
<td>VERBOSE</td>
<td>WALLET</td>
</tr>
<tr>
<td>WHEN</td>
<td>WHERE</td>
<td>WITH</td>
</tr>
<tr>
<td>WITHOUT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
System Tables Reference

Topics
- System Tables and Views (p. 914)
- Types of System Tables and Views (p. 914)
- Visibility of Data in System Tables and Views (p. 915)
- STL Tables for Logging (p. 915)
- STV Tables for Snapshot Data (p. 994)
- System Views (p. 1024)
- System Catalog Tables (p. 1087)

System Tables and Views

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 log tables only retain approximately two to five days of log history, depending on log usage and available disk space. If you want to retain the log data, you will need to periodically copy it to other tables or unload it to Amazon S3.

Types of System Tables and Views

There are two types of system tables: STL and STV tables.

STL tables are generated from logs that have been persisted to disk to provide a history of the system. STV tables are virtual 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. System views that contain any reference to a transient STV table are called SVV views. Views containing only references to STL tables are called SVL views.

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:
Visibility of Data in System Tables and Views

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 (p. 585) SELECT privilege on that table to the regular user.

By default, in most user-visible tables, rows generated by another user are invisible to a regular user. If a regular user is given unrestricted SYSLOG ACCESS (p. 436), that user can see all rows in user-visible tables, including rows generated by another user. For more information, see ALTER USER (p. 435) or CREATE USER (p. 557). All rows in STV_RECENTS and SVV_TRANSACTIONS are visible to all users.

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 (p. 585) 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
```

STL Tables for Logging

STL system tables 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 tables take the information from the logs and format them into usable tables for system administrators.

To manage disk space, the STL log tables only retain approximately two to five days of log history, depending on log usage and available disk space. If you want to retain the log data, you will need to periodically copy it to other tables or unload it to Amazon S3.

Topics

- STL_AGGR (p. 917)
- STL_ALERT_EVENT_LOG (p. 919)
- STL_ANALYZE (p. 920)
- STL_ANALYZE_COMPRESSION (p. 922)
- STL_BCAST (p. 923)
- STL_COMMIT_STATS (p. 924)
- STL_CONNECTION_LOG (p. 926)
- STL_DDLTEXT (p. 927)
- STL_DELETE (p. 930)
- STL_DISK_FULL_DIAG (p. 932)
- STL_DIST (p. 933)
- STL_ERROR (p. 934)
- STL_EXPLAIN (p. 935)
- STL_FILE_SCAN (p. 937)
- STL_HASH (p. 938)
- STL_HASHJOIN (p. 940)
- STL_INSERT (p. 942)
- STL_LIMIT (p. 942)
- STL_LOAD_COMMITS (p. 944)
- STL_LOAD_ERRORS (p. 946)
- STL_LOADERROR_DETAIL (p. 948)
- STL_MERGE (p. 950)
- STL_MERGEJOIN (p. 951)
- STL_MV_STATE (p. 952)
- STL_NESTLOOP (p. 954)
- STL_PARSE (p. 955)
- STL_PLAN_INFO (p. 956)
- STL_PROJECT (p. 958)
- STL_QUERY (p. 960)
- STL_QUERY_METRICS (p. 962)
- STL_QUERYTEXT (p. 965)
- STL_REPLACEMENTS (p. 967)
- STL_RESTARTED_SESSIONS (p. 968)
- STL_RETURN (p. 969)
- STL_S3CLIENT (p. 970)
- STL_S3CLIENT_ERROR (p. 972)
STL_AGGR

Analyzes aggregate execution steps for queries. These steps occur during execution of aggregate functions and GROUP BY clauses.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>slots</td>
<td>integer</td>
<td>Number of hash buckets.</td>
</tr>
<tr>
<td>occupied</td>
<td>integer</td>
<td>Number of slots that contain records.</td>
</tr>
<tr>
<td>maxlength</td>
<td>integer</td>
<td>Size of the largest slot.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>If true (t), the query was executed as a disk-based operation. If false (f), the query was executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Number of bytes of working memory assigned to the step.</td>
</tr>
<tr>
<td>type</td>
<td>character(6)</td>
<td>The type of step. Valid values:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• HASHED. Indicates that the step used grouped, unsorted aggregation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PLAIN. Indicates that the step used ungrouped, scalar aggregation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SORTED. Indicates that the step used grouped, sorted aggregation.</td>
</tr>
<tr>
<td>resizes</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>flushable</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

**Sample Queries**

Returns information about aggregate execution steps for SLICE 1 and TBL 239.

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>segment</th>
<th>bytes</th>
<th>slots</th>
<th>occupied</th>
<th>maxlength</th>
<th>is_diskbased</th>
<th>workmem</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>562</td>
<td>1</td>
<td>0</td>
<td>4194304</td>
<td>0</td>
<td>0</td>
<td>f</td>
<td>383385600</td>
<td>HASHED</td>
</tr>
<tr>
<td>562</td>
<td>1</td>
<td>0</td>
<td>4194304</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>383385600</td>
<td></td>
</tr>
<tr>
<td>562</td>
<td>1</td>
<td>0</td>
<td>4194304</td>
<td>0</td>
<td>0</td>
<td>f</td>
<td>383385600</td>
<td></td>
</tr>
<tr>
<td>547</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>685</td>
<td>1</td>
<td>32</td>
<td>4194304</td>
<td>1</td>
<td>0</td>
<td>f</td>
<td>383385600</td>
<td></td>
</tr>
</tbody>
</table>
STL_ALERT_EVENT_LOG

Records an alert when the query optimizer identifies conditions that might indicate performance issues. Use the STL_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 (p. 281).

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the statement and slice. The same query might have multiple PIDs if it executes on multiple slices.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID associated with the statement.</td>
</tr>
<tr>
<td>event</td>
<td>character(1024)</td>
<td>Description of the alert event.</td>
</tr>
<tr>
<td>solution</td>
<td>character(1024)</td>
<td>Recommended solution.</td>
</tr>
<tr>
<td>event_time</td>
<td>timestamp</td>
<td>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.</td>
</tr>
</tbody>
</table>

Usage Notes

You can use the STL_ALERT_EVENT_LOG to identify potential issues in your queries, then follow the practices in Tuning Query Performance (p. 281) 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 (p. 27).

- **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 (p. 974) 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 Choosing Sort Keys (p. 66).

- **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 (p. 142).

- **Large Distribution**
  
  More than 1,000,000 rows were redistributed for hash join or aggregation. For more information, see Choosing a Data Distribution Style (p. 55).

- **Large Broadcast**
  
  More than 1,000,000 rows were broadcast for hash join. For more information, see Choosing a Data Distribution Style (p. 55).

- **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 Choosing a Data Distribution Style (p. 55).

**Sample Queries**

The following query shows alert events for four queries.

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>event</th>
<th>solution</th>
<th>event_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>6567</td>
<td>Missing query planner statist</td>
<td>Run the ANALYZE command</td>
<td>2014-01-03 18:20:58</td>
</tr>
<tr>
<td>7450</td>
<td>Scanned a large number of del</td>
<td>Run the VACUUM command to rec</td>
<td>2014-01-03 21:19:31</td>
</tr>
<tr>
<td>8406</td>
<td>Nested Loop Join in the query</td>
<td>Review the join predicates to</td>
<td>2014-01-04 00:34:22</td>
</tr>
<tr>
<td>29512</td>
<td>Very selective query filter:r</td>
<td>Review the choice of sort key</td>
<td>2014-01-06 22:00:00</td>
</tr>
</tbody>
</table>

(4 rows)

**STL_ANALYZE**

Records details for ANALYZE (p. 439) operations.
This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>long</td>
<td>The transaction ID.</td>
</tr>
<tr>
<td>database</td>
<td>char(30)</td>
<td>The database name.</td>
</tr>
<tr>
<td>table_id</td>
<td>integer</td>
<td>The table ID.</td>
</tr>
<tr>
<td>status</td>
<td>char(15)</td>
<td>The result of the analyze command. Possible values are Full, Skipped, and PredicateColumn.</td>
</tr>
<tr>
<td>rows</td>
<td>double</td>
<td>The total number of rows in the table.</td>
</tr>
<tr>
<td>modified_rows</td>
<td>double</td>
<td>The total number of rows that were modified since the last ANALYZE operation.</td>
</tr>
<tr>
<td>threshold_percent</td>
<td>integer</td>
<td>The value of the analyze_threshold_percent parameter.</td>
</tr>
<tr>
<td>is_auto</td>
<td>char(1)</td>
<td>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.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>The time in UTC that the analyze operation started running.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>The time in UTC that the analyze operation finished running.</td>
</tr>
<tr>
<td>prevtime</td>
<td>timestamp</td>
<td>The time in UTC that the table was previously analyzed.</td>
</tr>
<tr>
<td>num_predicate</td>
<td>integer</td>
<td>The current number of predicate columns in the table.</td>
</tr>
<tr>
<td>num_new_predicate</td>
<td>integer</td>
<td>The number of new predicate columns in the table since the previous analyze operation.</td>
</tr>
<tr>
<td>is_background</td>
<td>character</td>
<td>The value is true (t) if the analysis was run by an automatic analyze operation. Otherwise, the value is false (f).</td>
</tr>
<tr>
<td>auto_analyze</td>
<td>character</td>
<td>Reserved for internal use.</td>
</tr>
<tr>
<td>auto_analyze</td>
<td>character</td>
<td>Reserved for internal use.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following example joins STV_TBL_PERM to show the table name and execution details.

```sql
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;
```
<table>
<thead>
<tr>
<th>xid</th>
<th>name</th>
<th>status</th>
<th>rows</th>
<th>modified_rows</th>
<th>starttime</th>
<th>endtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1582</td>
<td>users</td>
<td>Full</td>
<td>49990</td>
<td>49990</td>
<td>2016-09-22 22:02:23</td>
<td>2016-09-22 22:02:28</td>
</tr>
<tr>
<td>245439</td>
<td>users</td>
<td>Skipped</td>
<td>49984</td>
<td>1982</td>
<td>2016-10-04 23:00:13</td>
<td>2016-10-04 23:00:13</td>
</tr>
</tbody>
</table>

5 rows

**STL_ANALYZE_COMPRESSION**

Records details for compression analysis operations during COPY or ANALYZE COMPRESSON commands.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user who generated the entry.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>The time when the compression analysis operation started.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID of the compression analysis operation.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>The table ID of the table that was analyzed.</td>
</tr>
<tr>
<td>tablename</td>
<td>character(128)</td>
<td>The name of the table that was analyzed.</td>
</tr>
<tr>
<td>col</td>
<td>integer</td>
<td>The index of the column in the table that was analyzed to determine the compression encoding.</td>
</tr>
<tr>
<td>old_encoding</td>
<td>character(15)</td>
<td>The encoding type before compression analysis.</td>
</tr>
<tr>
<td>new_encoding</td>
<td>character(15)</td>
<td>The encoding type after compression analysis.</td>
</tr>
<tr>
<td>mode</td>
<td>character(14)</td>
<td>The possible values are:</td>
</tr>
<tr>
<td>PRESET</td>
<td></td>
<td>Specifies that the new_encoding is determined by the Amazon Redshift COPY command based on the column data type. No data is sampled.</td>
</tr>
<tr>
<td>ON</td>
<td></td>
<td>Specifies that the new_encoding is determined by the Amazon Redshift COPY command based on an analysis of sample data.</td>
</tr>
</tbody>
</table>
## 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.

```sql
select xid, tbl, btrim(tablename) as tablename, col, old_encoding, new_encoding, mode
from stl_analyze_compression
where xid = (select xid from stl_query where query = pg_last_copy_id()) order by col;
```

<table>
<thead>
<tr>
<th>xid</th>
<th>tbl</th>
<th>tablename</th>
<th>col</th>
<th>old_encoding</th>
<th>new_encoding</th>
<th>mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>0</td>
<td>mostly32</td>
<td>mostly32</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>1</td>
<td>mostly32</td>
<td>lzo</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>2</td>
<td>lzo</td>
<td>delta32k</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>3</td>
<td>delta</td>
<td>delta</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>4</td>
<td>bytedict</td>
<td>bytedict</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>5</td>
<td>mostly32</td>
<td>mostly32</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>6</td>
<td>delta</td>
<td>delta</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>7</td>
<td>delta</td>
<td>delta</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>8</td>
<td>lzo</td>
<td>zstd</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>9</td>
<td>runlength</td>
<td>zstd</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>10</td>
<td>delta</td>
<td>lzo</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>11</td>
<td>delta</td>
<td>delta</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>12</td>
<td>delta</td>
<td>delta</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>13</td>
<td>bytedict</td>
<td>zstd</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>14</td>
<td>bytedict</td>
<td>zstd</td>
<td>ON</td>
</tr>
<tr>
<td>8196</td>
<td>248126</td>
<td>lineitem</td>
<td>15</td>
<td>text255</td>
<td>zstd</td>
<td>ON</td>
</tr>
</tbody>
</table>

(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.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>startime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>packets</td>
<td>integer</td>
<td>Total number of packets sent over the network.</td>
</tr>
</tbody>
</table>

**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.

```sql
select query, slice, step, rows, bytes, packets, datediff(seconds, startime, endtime)
from stl_bcast
where packets>0 and datediff(seconds, startime, endtime)>0;
```

<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>step</th>
<th>rows</th>
<th>bytes</th>
<th>packets</th>
<th>date_diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>453</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>798</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1408</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2993</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5045</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8073</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8163</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9212</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9873</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>264</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(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.
This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction id being committed.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>Node number. -1 is the leader node.</td>
</tr>
<tr>
<td>startqueue</td>
<td>timestamp</td>
<td>Start of queueing for commit.</td>
</tr>
<tr>
<td>startwork</td>
<td>timestamp</td>
<td>Start of commit.</td>
</tr>
<tr>
<td>endflush</td>
<td>timestamp</td>
<td>End of dirty block flush phase.</td>
</tr>
<tr>
<td>endstage</td>
<td>timestamp</td>
<td>End of metadata staging phase.</td>
</tr>
<tr>
<td>endlocal</td>
<td>timestamp</td>
<td>End of local commit phase.</td>
</tr>
<tr>
<td>startglobal</td>
<td>timestamp</td>
<td>Start of global phase.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>End of the commit.</td>
</tr>
<tr>
<td>queuelen</td>
<td>bigint</td>
<td>Number of transactions that were ahead of this transaction in the commit queue.</td>
</tr>
<tr>
<td>permblocks</td>
<td>bigint</td>
<td>Number of existing permanent blocks at the time of this commit.</td>
</tr>
<tr>
<td>newblocks</td>
<td>bigint</td>
<td>Number of new permanent blocks at the time of this commit.</td>
</tr>
<tr>
<td>dirtyblocks</td>
<td>bigint</td>
<td>Number of blocks that had to be written as part of this commit.</td>
</tr>
<tr>
<td>headers</td>
<td>bigint</td>
<td>Number of block headers that had to be written as part of this commit.</td>
</tr>
<tr>
<td>numxids</td>
<td>integer</td>
<td>The number of active DML transactions.</td>
</tr>
<tr>
<td>oldestxid</td>
<td>bigint</td>
<td>The XID of the oldest active DML transaction.</td>
</tr>
<tr>
<td>extwritelatency</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>metadatawritten</td>
<td>int</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>tombstonedblocks</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>tossedblocks</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>batched_by</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

### Sample Query

```sql
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;
```
STL_CONNECTION_LOG

Logs authentication attempts and connections and disconnections.

This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>event</td>
<td>character(50)</td>
<td>Connection or authentication event.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time the event occurred.</td>
</tr>
<tr>
<td>remotehost</td>
<td>character(32)</td>
<td>Name or IP address of remote host.</td>
</tr>
<tr>
<td>remoteport</td>
<td>character(32)</td>
<td>Port number for remote host.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the statement.</td>
</tr>
<tr>
<td>dbname</td>
<td>character(50)</td>
<td>Database name.</td>
</tr>
<tr>
<td>username</td>
<td>character(50)</td>
<td>User name.</td>
</tr>
<tr>
<td>authmethod</td>
<td>character(32)</td>
<td>Authentication method.</td>
</tr>
<tr>
<td>duration</td>
<td>integer</td>
<td>Duration of connection in microseconds.</td>
</tr>
<tr>
<td>sslversion</td>
<td>character(50)</td>
<td>Secure Sockets Layer (SSL) version.</td>
</tr>
<tr>
<td>sslcipher</td>
<td>character(128)</td>
<td>SSL cipher.</td>
</tr>
<tr>
<td>mtu</td>
<td>integer</td>
<td>Maximum transmission unit (MTU).</td>
</tr>
<tr>
<td>sslcompression</td>
<td>character(64)</td>
<td>SSL compression type.</td>
</tr>
<tr>
<td>sslexpansion</td>
<td>character(64)</td>
<td>SSL expansion type.</td>
</tr>
<tr>
<td>iamauthguid</td>
<td>character(36)</td>
<td>The IAM authentication ID for the CloudTrail request.</td>
</tr>
<tr>
<td>application_name</td>
<td>character(250)</td>
<td>The initial or updated name of the application for a session.</td>
</tr>
</tbody>
</table>

Sample Queries

To view the details for open connections, execute the following query.

```sql
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]       |            |

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     |

(C4 rows)

**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 tables provide a timeline of the SQL commands that are executed on the system; this history is useful for troubleshooting purposes 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.

This table 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

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID associated with the statement.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the statement.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>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.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>sequence</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>text</td>
<td>character(200)</td>
<td>SQL text, in 200-character increments. This field might contain special characters such as backslash () and newline (\n).</td>
</tr>
</tbody>
</table>

Sample Queries

The following query shows the DDL for four CREATE TABLE statements. The DDL text column is truncated for readability.

```
select xid, starttime, sequence, substring(text,1,40) as text
from stl_ddltext order by xid desc, sequence;
```

```
+-----+--------------------------+--------+---------------------------------------------------------------------------------------------------------------------------------------+
| xid | starttime                | sequence | CREATE TABLE supplier ( s_suppkey int4 NOT NULL , s_comment varchar(101) NOT NULL )                                                                 |
| 1806| 2013-10-23 00:11:14.709851 |        0 | CREATE TABLE supplier ( s_suppkey int4 NOT NULL , s_comment varchar(101) NOT NULL )                                                                 |
| 1806| 2013-10-23 00:11:14.709851 |        1 | CREATE TABLE region ( r_regionkey int4 NOT NULL , r_name varchar(25) NOT NULL )                                                                 |
| 1805| 2013-10-23 00:11:14.496153 |        0 | CREATE TABLE region ( r_regionkey int4 NOT NULL , r_name varchar(25) NOT NULL )                                                                 |
| 1804| 2013-10-23 00:11:14.285986 |        0 | CREATE TABLE partsupp ( ps_partkey int8 NOT NULL , ps_supplycost numeric(10,2) NOT NULL )                                                  |
| 1803| 2013-10-23 00:11:14.056901 |        0 | CREATE TABLE part ( p_partkey int8 NOT NULL , p_retailprice numeric(10,2) NOT NULL , p_name varchar(25) NOT NULL )                     |
| 1803| 2013-10-23 00:11:14.056901 |        1 | CREATE TABLE part ( p_partkey int8 NOT NULL , p_retailprice numeric(10,2) NOT NULL , p_name varchar(25) NOT NULL )                     |
|      |                          |         | (6 rows)                                                                                                                                 |
```

Reconstructing Stored SQL

To reconstruct the SQL stored in the `text` column of STL_DDLTEXT, 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.
### STLDDLTEXT

**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_ddltext GROUP BY query ORDER BY query desc;

For example, the following query runs several DDL statements. The query itself is longer than 200 characters and is stored in several parts in STLDDLTEXT.

**DROP TABLE IF EXISTS public.t_tx_trunc;**
**CREATE TABLE public.t_tx_trunc(a varchar);**
**CREATE OR REPLACE PROCEDURE public.sp_truncate_top_level()**
**LANGUAGE plpgsql AS $$
DECLARE
  row_cnt int;
BEGIN
  INSERT INTO public.t_tx_trunc VALUES ('Insert in SP: Before Truncate 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 1st Insert: %', row_cnt;
  truncate table public.t_tx_trunc;
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount After Truncate: %', row_cnt;
  INSERT INTO public.t_tx_trunc VALUES ('Insert 1 in SP: After Truncate');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 2nd Insert: %', row_cnt;
  INSERT INTO public.t_tx_trunc VALUES ('Insert 2 in SP: After Truncate');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 3rd Insert: %', row_cnt;
END $$;**
**DROP PROCEDURE sp_truncate_top_level();**
**DROP TABLE IF EXISTS public.t_tx_trunc;**

In this example, the query is stored in many parts (rows) in the `text` column of STLDDLTEXT.

**SELECT starttime, sequence, text**
**FROM stl_ddltext WHERE query=pg_last_query_id() ORDER BY starttime, sequence LIMIT 10;**

<table>
<thead>
<tr>
<th>starttime</th>
<th>sequence</th>
<th>text</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019-07-23 23:08:15.672457</td>
<td>0</td>
<td>DROP TABLE IF EXISTS public.t_tx_trunc;</td>
</tr>
<tr>
<td>2019-07-23 23:08:15.676281</td>
<td>0</td>
<td>CREATE TABLE public.t_tx_trunc(a varchar);</td>
</tr>
</tbody>
</table>
| 2019-07-23 23:08:15.727303 |        0 | CREATE OR REPLACE PROCEDURE public.sp_truncate_top_level() LANGUAGE plpgsql AS $$
| 2019-07-23 23:08:15.727303 |        1 | DECLARE
| 2019-07-23 23:08:15.727303 |        2 | BEGIN
| 2019-07-23 23:08:15.727303 |        3 | INSERT INTO public.t_tx_trunc VALUES ('Insert in SP: Before Truncate 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000');
| 2019-07-23 23:08:15.727303 |        4 | select count(*) into row_cnt from public.t_tx_trunc;
| 2019-07-23 23:08:15.727303 |        5 | RAISE INFO 'sp_truncate_top_level: RowCount after 1st Insert: %', row_cnt;
| 2019-07-23 23:08:15.727303 |        6 | truncate table public.t_tx_trunc;
| 2019-07-23 23:08:15.727303 |        7 | select count(*) into row_cnt from public.t_tx_trunc;
| 2019-07-23 23:08:15.727303 |        8 | RAISE INFO 'sp_truncate_top_level: RowCount After Truncate: %', row_cnt;
| 2019-07-23 23:08:15.727303 |        9 | INSERT INTO public.t_tx_trunc VALUES ('Insert 1 in SP: After Truncate');
| 2019-07-23 23:08:15.727303 |       10 | select count(*) into row_cnt from public.t_tx_trunc;
| 2019-07-23 23:08:15.727303 |       11 | RAISE INFO 'sp_truncate_top_level: RowCount after 2nd Insert: %', row_cnt;
| 2019-07-23 23:08:15.727303 |       12 | INSERT INTO public.t_tx_trunc VALUES ('Insert 2 in SP: After Truncate');
| 2019-07-23 23:08:15.727303 |       13 | select count(*) into row_cnt from public.t_tx_trunc;
| 2019-07-23 23:08:15.727303 |       14 | RAISE INFO 'sp_truncate_top_level: RowCount after 3rd Insert: %', row_cnt; END ##;**

##
To reconstruct the SQL stored in STLDDLTEXT, 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_ddltext GROUP BY xid order by xid;
```

To use the resulting reconstructed SQL in your client, replace any (\n) special characters with a new line.

```sql
DROP TABLE IF EXISTS public.t_tx_trunc;
CREATE TABLE public.t_tx_trunc(a varchar);
CREATE OR REPLACE PROCEDURE public.sp_truncate_top_level()
 LANGUAGE
plpgsql
AS $$
DECLARE
  row_cnt int;
BEGIN
  INSERT INTO
    public.t_tx_trunc VALUES ('Insert in SP: Before Truncate 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 1st Insert: %', row_cnt;
  truncate table
    public.t_tx_trunc;
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount After Truncate: %', row_cnt;
  INSERT INTO
    public.t_tx_trunc VALUES ('Insert 1 in SP: After Truncate');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 2nd Insert: %', row_cnt;
  INSERT INTO public.t_tx_trunc VALUES ('Insert 2 in SP: After Truncate');
  select count(*) into row_cnt from public.t_tx_trunc;
  RAISE INFO 'sp_truncate_top_level: RowCount after 3rd Insert: %', row_cnt;
END $$;
```

```
DROP PROCEDURE sp_truncate_top_level();
DROP TABLE IF EXISTS public.t_tx_trunc;
```

### STL_DELETE

Analyzes delete execution steps for queries.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
</tbody>
</table>
### STL_DELETE

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
</tbody>
</table>

### 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.

```sql
insert into event(eventid,venueid,catid,dateid,eventname) values ((select max(eventid)+1 from event),95,9,1857,'Lollapalooza');
```

```sql
select * from event
where eventname='Lollapalooza'
order by eventid;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>venueid</th>
<th>catid</th>
<th>dateid</th>
<th>eventname</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>4274</td>
<td>102</td>
<td>9</td>
<td>1965</td>
<td>Lollapalooza</td>
<td>2008-05-01 19:00:00</td>
</tr>
<tr>
<td>4684</td>
<td>114</td>
<td>9</td>
<td>2105</td>
<td>Lollapalooza</td>
<td>2008-10-06 14:00:00</td>
</tr>
<tr>
<td>5673</td>
<td>128</td>
<td>9</td>
<td>1973</td>
<td>Lollapalooza</td>
<td>2008-05-01 15:00:00</td>
</tr>
<tr>
<td>5740</td>
<td>51</td>
<td>9</td>
<td>1933</td>
<td>Lollapalooza</td>
<td>2008-04-17 15:00:00</td>
</tr>
<tr>
<td>5856</td>
<td>119</td>
<td>9</td>
<td>1831</td>
<td>Lollapalooza</td>
<td>2008-01-05 14:00:00</td>
</tr>
<tr>
<td>6040</td>
<td>126</td>
<td>9</td>
<td>2145</td>
<td>Lollapalooza</td>
<td>2008-11-15 15:00:00</td>
</tr>
<tr>
<td>7972</td>
<td>92</td>
<td>9</td>
<td>2026</td>
<td>Lollapalooza</td>
<td>2008-07-19 19:30:00</td>
</tr>
<tr>
<td>8046</td>
<td>65</td>
<td>9</td>
<td>1840</td>
<td>Lollapalooza</td>
<td>2008-01-14 15:00:00</td>
</tr>
<tr>
<td>8518</td>
<td>48</td>
<td>9</td>
<td>1904</td>
<td>Lollapalooza</td>
<td>2008-03-19 15:00:00</td>
</tr>
<tr>
<td>8799</td>
<td>95</td>
<td>9</td>
<td>1857</td>
<td>Lollapalooza</td>
<td>2009-06-12 11:29:19.131358</td>
</tr>
</tbody>
</table>

Now, delete the row that you added to the EVENT table and verify that it was deleted.

```sql
delete from event
where eventname='Lollapalooza' and eventid=(select max(eventid) from event);
```
select * from event
where eventname='Lollapalooza'
order by eventid;

<table>
<thead>
<tr>
<th>eventid</th>
<th>venueid</th>
<th>catid</th>
<th>dateid</th>
<th>eventname</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>4274</td>
<td>102</td>
<td>9</td>
<td>1965</td>
<td>Lollapalooza</td>
<td>2008-05-01 19:00:00</td>
</tr>
<tr>
<td>4684</td>
<td>114</td>
<td>9</td>
<td>2105</td>
<td>Lollapalooza</td>
<td>2008-10-06 14:00:00</td>
</tr>
<tr>
<td>5673</td>
<td>128</td>
<td>9</td>
<td>1973</td>
<td>Lollapalooza</td>
<td>2008-05-01 15:00:00</td>
</tr>
<tr>
<td>5740</td>
<td>51</td>
<td>9</td>
<td>1933</td>
<td>Lollapalooza</td>
<td>2008-04-17 15:00:00</td>
</tr>
<tr>
<td>5856</td>
<td>119</td>
<td>9</td>
<td>1831</td>
<td>Lollapalooza</td>
<td>2008-01-05 14:00:00</td>
</tr>
<tr>
<td>6040</td>
<td>126</td>
<td>9</td>
<td>2145</td>
<td>Lollapalooza</td>
<td>2008-11-15 15:00:00</td>
</tr>
<tr>
<td>7972</td>
<td>92</td>
<td>9</td>
<td>2026</td>
<td>Lollapalooza</td>
<td>2008-07-19 19:30:00</td>
</tr>
<tr>
<td>8046</td>
<td>65</td>
<td>9</td>
<td>1840</td>
<td>Lollapalooza</td>
<td>2008-01-14 15:00:00</td>
</tr>
<tr>
<td>8518</td>
<td>48</td>
<td>9</td>
<td>1904</td>
<td>Lollapalooza</td>
<td>2008-03-19 15:00:00</td>
</tr>
</tbody>
</table>

(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;

<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>segment</th>
<th>step</th>
<th>tasknum</th>
<th>rows</th>
<th>tbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100000</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100000</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>100001</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>100001</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>100002</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>100002</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>100003</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>100003</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>100253</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>100253</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100255</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100255</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>100257</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>100257</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>100259</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>100259</td>
</tr>
</tbody>
</table>

...
### 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.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
</tbody>
</table>
### Sample Queries

The following example returns distribution information for queries with one or more packets and duration greater than zero.

```sql
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)
Certain errors. An AWS support engineer might ask you to provide this information as part of the troubleshooting process.

This table 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 (p. 915).

For a list of error codes that can be generated while loading data with the Copy command, see Load Error Reference (p. 129).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>process</td>
<td>character(12)</td>
<td>Process that threw the exception.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time that the error occurred.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID. The STL_QUERY (p. 960) table contains process IDs and unique query IDs for executed queries.</td>
</tr>
<tr>
<td>errcode</td>
<td>integer</td>
<td>Error code corresponding to the error category.</td>
</tr>
<tr>
<td>file</td>
<td>character(90)</td>
<td>Name of the source file where the error occurred.</td>
</tr>
<tr>
<td>linenum</td>
<td>integer</td>
<td>Line number in the source file where the error occurred.</td>
</tr>
<tr>
<td>context</td>
<td>character(100)</td>
<td>Cause of the error.</td>
</tr>
<tr>
<td>error</td>
<td>character(512)</td>
<td>Error message.</td>
</tr>
</tbody>
</table>

### 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;
```

<table>
<thead>
<tr>
<th>process</th>
<th>errcode</th>
<th>line</th>
<th>err</th>
</tr>
</thead>
<tbody>
<tr>
<td>padbmaster</td>
<td>8001</td>
<td>194</td>
<td>Path prefix: s3://awssampledb/testnulls/venue.txt*</td>
</tr>
<tr>
<td>padbmaster</td>
<td>8001</td>
<td>529</td>
<td>Listing bucket=awssampledb prefix=tests/category-csv-quotes</td>
</tr>
<tr>
<td>padbmaster</td>
<td>2</td>
<td>190</td>
<td>database &quot;template0&quot; is not currently accepting</td>
</tr>
<tr>
<td>padbmaster</td>
<td>32</td>
<td>1956</td>
<td>pq_flush: could not send data to client: Broken pipe</td>
</tr>
</tbody>
</table>

### STL_EXPLAIN

Displays the EXPLAIN plan for a query that has been submitted for execution.

This table 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>nodeid</td>
<td>integer</td>
<td>Plan node identifier, where a node maps to one or more steps in the execution of the query.</td>
</tr>
<tr>
<td>parentid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>plannode</td>
<td>character(400)</td>
<td>The node text from the EXPLAIN output. Plan nodes that refer to execution on compute nodes are prefixed with XN in the EXPLAIN output.</td>
</tr>
<tr>
<td>info</td>
<td>character(400)</td>
<td>Qualifier and filter information for the plan node. For example, join conditions and WHERE clause restrictions are included in this column.</td>
</tr>
</tbody>
</table>

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

-----+--------+--------+--------------------------------+-------------------
10   |      1 |      0 |XN Aggregate  (cost=6717.61..6  | Merge Cond:("outer".listid = "inner".listid)  |
10   |      2 |      1 |  -> XN Merge Join DS_DIST_NO   | XN Seq Scan on lis |
10   |      3 |      2 |       -> XN Seq Scan on sales  | XN Seq Scan on sal |
(4 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;
```

```
<table>
<thead>
<tr>
<th>query</th>
<th>nodeid</th>
<th>parentid</th>
<th>substring</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>XN Aggregate  (cost=6717.61..6</td>
<td>Merge Cond:(&quot;outer&quot;</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1</td>
<td>-&gt; XN Merge Join DS_DIST_NO</td>
<td>XN Seq Scan on lis</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>2</td>
<td>-&gt; XN Seq Scan on sales</td>
<td>XN Seq Scan on sal</td>
</tr>
</tbody>
</table>
(4 rows)
```

Consider the following query:
If this query’s ID is 15, the following system table query returns the plan nodes that were executed. 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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>nodeid</th>
<th>parentid</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>8</td>
<td>7</td>
<td>-&gt; XN Seq Scan on eve</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>5</td>
<td>-&gt; XN Hash(cost=87.98..87.9</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>5</td>
<td>-&gt; XN Seq Scan on sales(cost</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>4</td>
<td>-&gt; XN Hash Join DS_DIST_OUTER(cost</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>3</td>
<td>-&gt; XN HashAggregate(cost=862286577.07..</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>2</td>
<td>-&gt; XN Sort(cost=1000862287175.47..1000862287175.47..1000862287197.46 rows=87</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>0</td>
<td>XN Merge(cost=1000862287175.47..1000862287197.46 rows=87</td>
</tr>
</tbody>
</table>

(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%';
```

<table>
<thead>
<tr>
<th>query</th>
<th>btrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>-&gt; XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)</td>
</tr>
<tr>
<td>27</td>
<td>-&gt; XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)</td>
</tr>
</tbody>
</table>

(2 rows)

**STL_FILE_SCAN**

Returns the files that Amazon Redshift read while loading data via the COPY command.

Querying this table 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.

This table 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>name</td>
<td>character(90)</td>
<td>Full path and name of the file that was loaded.</td>
</tr>
<tr>
<td>lines</td>
<td>bigint</td>
<td>Number of lines read from the file.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of bytes read from the file.</td>
</tr>
<tr>
<td>loadtime</td>
<td>bigint</td>
<td>Amount of time spent loading the file (in microseconds).</td>
</tr>
<tr>
<td>curtime</td>
<td>Timestamp</td>
<td>Timestamp representing the time that Amazon Redshift started processing the file.</td>
</tr>
</tbody>
</table>

Sample Queries

The following query retrieves the names and load times of any files that took over 1000000 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:

```
<table>
<thead>
<tr>
<th>name</th>
<th>loadtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>listings_pipe.txt</td>
<td>9458354</td>
</tr>
<tr>
<td>allusers_pipe.txt</td>
<td>2963761</td>
</tr>
<tr>
<td>allevents_pipe.txt</td>
<td>1409135</td>
</tr>
<tr>
<td>tickit/listings_pipe.txt</td>
<td>7071087</td>
</tr>
<tr>
<td>tickit/allevents_pipe.txt</td>
<td>1237364</td>
</tr>
<tr>
<td>tickit/allusers_pipe.txt</td>
<td>2535138</td>
</tr>
<tr>
<td>listings_pipe.txt</td>
<td>6706370</td>
</tr>
<tr>
<td>allusers_pipe.txt</td>
<td>3579461</td>
</tr>
<tr>
<td>allevents_pipe.txt</td>
<td>1313195</td>
</tr>
<tr>
<td>tickit/allusers_pipe.txt</td>
<td>3236060</td>
</tr>
<tr>
<td>tickit/listings_pipe.txt</td>
<td>4980108</td>
</tr>
</tbody>
</table>
(11 rows)
```

STL_HASH

Analyzes hash execution steps for queries.

This table 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 (p. 915).
# Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>slots</td>
<td>integer</td>
<td>Total number of hash buckets.</td>
</tr>
<tr>
<td>occupied</td>
<td>integer</td>
<td>Total number of slots that contain records.</td>
</tr>
<tr>
<td>maxlength</td>
<td>integer</td>
<td>Size of the largest slot.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character1</td>
<td>If true (t), the query was executed as a disk-based operation. If false (f), the query was executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Total number of bytes of working memory assigned to the step.</td>
</tr>
<tr>
<td>num_parts</td>
<td>integer</td>
<td>Total number of partitions that a hash table was divided into during a hash step. A hash table is partitioned when it is estimated that the entire hash table might not fit into memory.</td>
</tr>
<tr>
<td>est_rows</td>
<td>bigint</td>
<td>Estimated number of rows to be hashed.</td>
</tr>
<tr>
<td>num_blocks_per_merge</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>resizes</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>runtime_filter_size</td>
<td>integer</td>
<td>Size of the runtime filter in bytes.</td>
</tr>
<tr>
<td>max_runtime_filter_size</td>
<td>integer</td>
<td>Maximum size of the runtime filter in bytes.</td>
</tr>
</tbody>
</table>
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;
```

<table>
<thead>
<tr>
<th>slice</th>
<th>rows</th>
<th>bytes</th>
<th>occupied</th>
<th>workmem</th>
<th>num_parts</th>
<th>est_rows</th>
<th>num_blocks_permitted</th>
<th>is_diskbased</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>145</td>
<td>585800</td>
<td>1</td>
<td>88866816</td>
<td>16</td>
<td>1</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>1</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

(2 rows)

STL_HASHJOIN

Analyzes hash join execution steps for queries.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
--- | --- | ---
tbl | integer | Table ID.
num_parts | integer | Total number of partitions that a hash table was divided into during a hash step. A hash table is partitioned when it is estimated that the entire hash table might not fit into memory.
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.
checksum | bigint | 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.

```sql
select query, slice, tbl, num_parts
from stl_hashjoin
where query=720 limit 10;
```

```
<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>tbl</th>
<th>num_parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>720</td>
<td>0</td>
<td>243</td>
<td>1</td>
</tr>
<tr>
<td>720</td>
<td>1</td>
<td>243</td>
<td>1</td>
</tr>
</tbody>
</table>
```

(2 rows)
STL_INSERT

Analyzes insert execution steps for queries.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
</tbody>
</table>

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();
```

<table>
<thead>
<tr>
<th>slice</th>
<th>segment</th>
<th>step</th>
<th>tasknum</th>
<th>rows</th>
<th>tbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>24958</td>
<td>100548</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>25032</td>
<td>100548</td>
</tr>
</tbody>
</table>

(2 rows)

STL_LIMIT

Analyzes the execution steps that occur when a LIMIT clause is used in a SELECT query.
This table 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

### 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.

```sql
select * from venue
order by 1
limit 10;
```

<table>
<thead>
<tr>
<th>venueid</th>
<th>venuename</th>
<th>venuecity</th>
<th>venuestate</th>
<th>venueseats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toyota Park</td>
<td>Bridgeview</td>
<td>IL</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Columbus Crew Stadium</td>
<td>Columbus</td>
<td>OH</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>RFK Stadium</td>
<td>Washington</td>
<td>DC</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>CommunityAmerica Ballpark</td>
<td>Kansas City</td>
<td>KS</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gillette Stadium</td>
<td>Foxborough</td>
<td>MA</td>
<td>68756</td>
</tr>
<tr>
<td>6</td>
<td>New York Giants Stadium</td>
<td>East Rutherford</td>
<td>NJ</td>
<td>80242</td>
</tr>
<tr>
<td>7</td>
<td>BMO Field</td>
<td>Toronto</td>
<td>ON</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>The Home Depot Center</td>
<td>Carson</td>
<td>CA</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Dick's Sporting Goods Park</td>
<td>Commerce City</td>
<td>CO</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Pizza Hut Park</td>
<td>Frisco</td>
<td>TX</td>
<td>0</td>
</tr>
</tbody>
</table>

(10 rows)

Next, run the following query to find the query ID of the last query you ran against the VENUE table.

```sql
select * from venue
order by 1
limit 10;
```
```sql
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.

```sql
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.

```sql
select slice, segment, step, starttime, endtime, tasknum
from stl_limit
where query=127128
order by starttime, endtime;
```

```
slice | segment | step |         starttime          |          endtime           |
tasknum
-------+---------+------+----------------------------+----------------------------
          |         |      | 2013-09-06 22:56:43.608114 | 2013-09-06 22:56:43.609383 |
1      | 1       | 3    | 2013-09-06 22:56:43.608708 | 2013-09-06 22:56:43.609521 |
15     | 0       | 1    | 2013-09-06 22:56:43.612506 | 2013-09-06 22:56:43.612668 |
10000  | 2       | 2    | 2013-09-06 22:56:43.608114 | 2013-09-06 22:56:43.609383 |
0      |
(3 rows)
```

### STL_LOAD_COMMITS

Returns information to track or troubleshoot a data load.

This table records the progress of each data file as it is loaded into a database table.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Slice loaded for this entry.</td>
</tr>
<tr>
<td>name</td>
<td>character(256)</td>
<td>System-defined value.</td>
</tr>
<tr>
<td>filename</td>
<td>character(256)</td>
<td>Name of file being tracked.</td>
</tr>
<tr>
<td>byte_offset</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>lines_scanned</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>errors</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>curtime</td>
<td>timestamp</td>
<td>Time that this entry was last updated.</td>
</tr>
<tr>
<td>status</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>file_format</td>
<td>character(16)</td>
<td>Format of the load file. Possible values are as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Avro</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• JSON</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ORC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Parquet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Text</td>
</tr>
</tbody>
</table>

**Sample Queries**

The following example returns details for the last COPY operation.

```sql
select query, trim(filename) as file, curtime as updated
from stl_load_commits
where query = pg_last_copy_id();
```

<table>
<thead>
<tr>
<th>query</th>
<th>file</th>
<th>updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>28554</td>
<td>s3://dw-ticket/category_pipe.txt</td>
<td>2013-11-01 17:14:52.648486</td>
</tr>
</tbody>
</table>

(1 row)

The following query contains entries for a fresh load of the tables in the TICKIT database:

```sql
select query, trim(filename), curtime
from stl_load_commits
where filename like '%tickit%'
order by query;
```

<table>
<thead>
<tr>
<th>query</th>
<th>btrim</th>
<th>curtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>22475</td>
<td>tickit/allusers_pipe.txt</td>
<td>2013-02-08 20:58:23.274186</td>
</tr>
<tr>
<td>22478</td>
<td>tickit/venue_pipe.txt</td>
<td>2013-02-08 20:58:25.070604</td>
</tr>
<tr>
<td>22480</td>
<td>tickit/category_pipe.txt</td>
<td>2013-02-08 20:58:27.333472</td>
</tr>
</tbody>
</table>
The fact that a record is written to the log file for this system table does not mean that the load committed successfully as part of its containing transaction. To verify load commits, query the STL_PVUTILITYTEXT table 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_PVUTILITYTEXT:

```
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');
```

<table>
<thead>
<tr>
<th>query</th>
<th>rtrim</th>
<th>xid</th>
</tr>
</thead>
<tbody>
<tr>
<td>22600</td>
<td>tickit/date2008_pipe.txt</td>
<td>68311</td>
</tr>
<tr>
<td>22480</td>
<td>tickit/category_pipe.txt</td>
<td>68066</td>
</tr>
<tr>
<td>7508</td>
<td>allusers_pipe.txt</td>
<td>23365</td>
</tr>
<tr>
<td>7552</td>
<td>category_pipe.txt</td>
<td>23415</td>
</tr>
<tr>
<td>7576</td>
<td>allevents_pipe.txt</td>
<td>23429</td>
</tr>
<tr>
<td>7516</td>
<td>venue_pipe.txt</td>
<td>23390</td>
</tr>
<tr>
<td>7604</td>
<td>listings_pipe.txt</td>
<td>23445</td>
</tr>
<tr>
<td>22596</td>
<td>tickit/venue_pipe.txt</td>
<td>68309</td>
</tr>
<tr>
<td>22605</td>
<td>tickit/listings_pipe.txt</td>
<td>68316</td>
</tr>
<tr>
<td>22593</td>
<td>tickit/allusers_pipe.txt</td>
<td>68305</td>
</tr>
<tr>
<td>22485</td>
<td>tickit/allevents_pipe.txt</td>
<td>68071</td>
</tr>
<tr>
<td>7561</td>
<td>allevents_pipe.txt</td>
<td>23429</td>
</tr>
<tr>
<td>7541</td>
<td>category_pipe.txt</td>
<td>23415</td>
</tr>
<tr>
<td>7558</td>
<td>date2008_pipe.txt</td>
<td>23428</td>
</tr>
<tr>
<td>22478</td>
<td>tickit/venue_pipe.txt</td>
<td>68065</td>
</tr>
<tr>
<td>526</td>
<td>date2008_pipe.txt</td>
<td>2572</td>
</tr>
<tr>
<td>7466</td>
<td>allusers_pipe.txt</td>
<td>23365</td>
</tr>
<tr>
<td>22482</td>
<td>tickit/date2008_pipe.txt</td>
<td>68067</td>
</tr>
<tr>
<td>22598</td>
<td>tickit/category_pipe.txt</td>
<td>68310</td>
</tr>
<tr>
<td>22603</td>
<td>tickit/allevents_pipe.txt</td>
<td>68315</td>
</tr>
<tr>
<td>22475</td>
<td>tickit/allusers_pipe.txt</td>
<td>68061</td>
</tr>
<tr>
<td>547</td>
<td>date2008_pipe.txt</td>
<td>2572</td>
</tr>
<tr>
<td>22487</td>
<td>tickit/listings_pipe.txt</td>
<td>68072</td>
</tr>
<tr>
<td>7531</td>
<td>venue_pipe.txt</td>
<td>23390</td>
</tr>
<tr>
<td>7583</td>
<td>listings_pipe.txt</td>
<td>23445</td>
</tr>
</tbody>
</table>

(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 (p. 129) for a comprehensive list of possible load errors and explanations.
Query **STL_LOADERROR_DETAIL** (p. 948) 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.

This table 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** (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Slice where the error occurred.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Start time in UTC for the load.</td>
</tr>
<tr>
<td>session</td>
<td>integer</td>
<td>Session ID for the session performing the load.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>filename</td>
<td>character(256)</td>
<td>Complete path to the input file for the load.</td>
</tr>
<tr>
<td>line_number</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>colname</td>
<td>character(127)</td>
<td>Field with the error.</td>
</tr>
<tr>
<td>type</td>
<td>character(10)</td>
<td>Data Type of the field.</td>
</tr>
<tr>
<td>col_length</td>
<td>character(10)</td>
<td>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 &quot;character(3)&quot;, this column will contain the value &quot;3&quot;.</td>
</tr>
<tr>
<td>position</td>
<td>integer</td>
<td>Position of the error in the field.</td>
</tr>
<tr>
<td>raw_line</td>
<td>character(1024)</td>
<td>Raw load data that contains the error. Multibyte characters in the load data are replaced with a period.</td>
</tr>
<tr>
<td>raw_field_value</td>
<td>character(1024)</td>
<td>The pre-parsing value for the field &quot;colname&quot; that lead to the parsing error.</td>
</tr>
<tr>
<td>err_code</td>
<td>integer</td>
<td>Error code.</td>
</tr>
<tr>
<td>err_reason</td>
<td>character(100)</td>
<td>Explanation for the error.</td>
</tr>
</tbody>
</table>

### 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.

```sql
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();

<table>
<thead>
<tr>
<th>query</th>
<th>substring</th>
<th>line</th>
<th>value</th>
<th>err_reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>251</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>ZRU29FGR</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>Kaitlin</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
<tr>
<td>558</td>
<td>allusers_pipe.txt</td>
<td>251</td>
<td>Walter</td>
<td>String contains invalid or unsupported UTF8 code</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>table_name</th>
<th>query</th>
<th>line_number</th>
<th>colname</th>
<th>error</th>
<th>starttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>event</td>
<td>309</td>
<td>0</td>
<td>5</td>
<td>Error in Timestamp value or format [%Y-%m-%d %H:%M:%S]</td>
<td>2014-04-22 15:12:44</td>
</tr>
</tbody>
</table>

(1 row)

**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** (p. 946) to find out general information about the error.
The STL_LOADERROR_DETAIL table 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 table 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Slice where the error occurred.</td>
</tr>
<tr>
<td>session</td>
<td>integer</td>
<td>Session ID for the session performing the load.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>filename</td>
<td>character(256)</td>
<td>Complete path to the input file for the load.</td>
</tr>
<tr>
<td>line_number</td>
<td>bigint</td>
<td>Line number in the load file with the error.</td>
</tr>
<tr>
<td>field</td>
<td>integer</td>
<td>Field with the error.</td>
</tr>
<tr>
<td>colname</td>
<td>character(1024)</td>
<td>Column Name.</td>
</tr>
<tr>
<td>value</td>
<td>character(1024)</td>
<td>Parsed data value of the field. (May be truncated.) Multibyte characters in the load data are replaced with a period.</td>
</tr>
<tr>
<td>is_null</td>
<td>integer</td>
<td>Whether or not the parsed value is null.</td>
</tr>
<tr>
<td>type</td>
<td>character(10)</td>
<td>Data Type of the field.</td>
</tr>
<tr>
<td>col_length</td>
<td>character(10)</td>
<td>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 &quot;character(3)&quot;, this column will contain the value &quot;3&quot;.</td>
</tr>
</tbody>
</table>

### 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:

```sql
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:
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.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
</tbody>
</table>

#### Sample Queries

The following example returns 10 merge execution results.

```sql
select query, step, starttime, endtime, tasknum, rows
from stl_merge
limit 10;
```
STL_MERGEJOIN

Analyzes merge join execution steps for queries.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the query started executing, with 6 digits of precision for fractional seconds. For example: \texttt{2009-06-12 11:29:19.131358}.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: \texttt{2009-06-12 11:29:19.131358}.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID. This is the ID for the inner table that was used in the merge join.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

Sample Queries

The following example returns merge join results for the most recent query.
The **STL_MV_STATE** table contains a row for every state transition of a materialized view.

For more information about materialized views, see Creating Materialized Views in Amazon Redshift (p. 218).

**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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>bigint</td>
<td>The ID of the user who created the event.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>The start time of the event.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction id of the event.</td>
</tr>
<tr>
<td>event_desc</td>
<td>char(500)</td>
<td>The event that prompted the state change. Example values include the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ALTER TABLE APPEND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Column type was changed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Column was dropped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Column was renamed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Schema name was changed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Small table conversion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• TRUNCATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vacuum</td>
</tr>
<tr>
<td>db_name</td>
<td>char(128)</td>
<td>The database that contains the materialized view.</td>
</tr>
<tr>
<td>base_table_schema</td>
<td>char(128)</td>
<td>The schema of the base table.</td>
</tr>
</tbody>
</table>
### STL_MV_STATE

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>base_table_name</td>
<td>char(128)</td>
<td>The name of the base table.</td>
</tr>
<tr>
<td>mv_schema</td>
<td>char(128)</td>
<td>The schema of the materialized view.</td>
</tr>
<tr>
<td>mv_name</td>
<td>char(128)</td>
<td>The name of the materialized view.</td>
</tr>
</tbody>
</table>
| 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`.

<table>
<thead>
<tr>
<th>event_desc</th>
<th>state</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUNCATE</td>
<td>Recompute</td>
</tr>
<tr>
<td>ALTER TABLE APPEND</td>
<td>Recompute</td>
</tr>
<tr>
<td>ALTER TABLE APPEND</td>
<td>Recompute</td>
</tr>
<tr>
<td>TRUNCATE</td>
<td>Recompute</td>
</tr>
<tr>
<td>Small table conversion</td>
<td>Recompute</td>
</tr>
<tr>
<td>Vacuum</td>
<td>Recompute</td>
</tr>
<tr>
<td>Column was renamed</td>
<td>Unrefreshable</td>
</tr>
<tr>
<td>Column was dropped</td>
<td>Unrefreshable</td>
</tr>
<tr>
<td>Table was renamed</td>
<td>Unrefreshable</td>
</tr>
<tr>
<td>Column type was changed</td>
<td>Unrefreshable</td>
</tr>
<tr>
<td>Schema name was changed</td>
<td>Unrefreshable</td>
</tr>
</tbody>
</table>

### Sample Query

To view the log of state transitions of materialized views, run the following query.

```sql
select * from stl_mv_state;
```

This query returns the following sample output:

<table>
<thead>
<tr>
<th>userid</th>
<th>starttime</th>
<th>xid</th>
<th>event_desc</th>
<th>db_name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>138</td>
<td>2020-02-14 02:21:25</td>
<td>5180</td>
<td>TRUNCATE</td>
<td>dev</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>138</td>
<td>2020-02-14 02:23:40</td>
<td>5439</td>
<td>Column was dropped</td>
<td>dev</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>2020-02-13 22:09:22</td>
<td>1741</td>
<td>ALTER TABLE APPEND</td>
<td>dev</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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STL_NESTLOOP

Analyzes nested-loop join execution steps for queries.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
</tbody>
</table>
### 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.

```sql
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 table.

```sql
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();
```

<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>seg</th>
<th>step</th>
<th>duration</th>
<th>tasknum</th>
<th>rows</th>
<th>tbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>6028</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>41</td>
<td>22</td>
<td>24277</td>
<td>240</td>
</tr>
<tr>
<td>6028</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>26</td>
<td>23</td>
<td>24189</td>
<td>240</td>
</tr>
<tr>
<td>6028</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>25</td>
<td>23</td>
<td>24376</td>
<td>240</td>
</tr>
<tr>
<td>6028</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>54</td>
<td>22</td>
<td>23936</td>
<td>240</td>
</tr>
</tbody>
</table>

### STLPARSE

Analyzes query steps that parse strings into binary values for loading.

This table 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
</tbody>
</table>
### STL_PLAN_INFO

Use the STL_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.

This table 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 (p. 915).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following example returns all query step results for slice 1 and segment 0 where strings were parsed into binary values.

```sql
select query, step, starttime, endtime, tasknum, rows
from stl_parse
where slice=1 and segment=0;
```

<table>
<thead>
<tr>
<th>query</th>
<th>step</th>
<th>starttime</th>
<th>endtime</th>
<th>tasknum</th>
<th>rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>669</td>
<td>1</td>
<td>2013-08-12 22:35:13</td>
<td>2013-08-12 22:35:17</td>
<td>32</td>
<td>192497</td>
</tr>
<tr>
<td>696</td>
<td>1</td>
<td>2013-08-12 22:35:49</td>
<td>2013-08-12 22:35:49</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>525</td>
<td>1</td>
<td>2013-08-12 22:32:03</td>
<td>2013-08-12 22:32:03</td>
<td>13</td>
<td>49990</td>
</tr>
<tr>
<td>621</td>
<td>1</td>
<td>2013-08-12 22:34:03</td>
<td>2013-08-12 22:34:03</td>
<td>27</td>
<td>365</td>
</tr>
<tr>
<td>651</td>
<td>1</td>
<td>2013-08-12 22:34:47</td>
<td>2013-08-12 22:34:53</td>
<td>35</td>
<td>192497</td>
</tr>
<tr>
<td>590</td>
<td>1</td>
<td>2013-08-12 22:33:28</td>
<td>2013-08-12 22:33:28</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>675</td>
<td>1</td>
<td>2013-08-12 22:35:26</td>
<td>2013-08-12 22:35:27</td>
<td>38</td>
<td>3766</td>
</tr>
<tr>
<td>630</td>
<td>1</td>
<td>2013-08-12 22:34:17</td>
<td>2013-08-12 22:34:17</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>572</td>
<td>1</td>
<td>2013-08-12 22:33:04</td>
<td>2013-08-12 22:33:04</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>645</td>
<td>1</td>
<td>2013-08-12 22:34:37</td>
<td>2013-08-12 22:34:38</td>
<td>29</td>
<td>8798</td>
</tr>
<tr>
<td>604</td>
<td>1</td>
<td>2013-08-12 22:33:47</td>
<td>2013-08-12 22:33:47</td>
<td>37</td>
<td>0</td>
</tr>
</tbody>
</table>

(14 rows)
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>nodeid</td>
<td>integer</td>
<td>Plan node identifier, where a node maps to one or more steps in the execution of the query.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Number that identifies the query step.</td>
</tr>
<tr>
<td>locus</td>
<td>integer</td>
<td>Location where the step executes. 0 if on a compute node and 1 if on the leader node.</td>
</tr>
<tr>
<td>plannode</td>
<td>integer</td>
<td>Enumerated value of the plan node. See the following table for enums for plannode. (The PLANNODE column in STL_EXPLAIN (p. 935) contains the plan node text.)</td>
</tr>
<tr>
<td>startupcost</td>
<td>double precision</td>
<td>The estimated relative cost of returning the first row for this step.</td>
</tr>
<tr>
<td>totalcost</td>
<td>double precision</td>
<td>The estimated relative cost of executing the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>The estimated number of rows that will be produced by the step.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>The estimated number of bytes that will be produced by the step.</td>
</tr>
</tbody>
</table>

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 table.

```
explain select * from category;

query | nodeid | segment | step | locus | plannode | startupcost | totalcost | rows | bytes
-------+--------+---------+------|-------+----------+-------------+-----------+------+------+
957    |

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;
```
In this example, PLANNODE 104 refers to the sequential scan of the CATEGORY table.

```sql
select distinct eventname from event order by 1;
```

<table>
<thead>
<tr>
<th>eventname</th>
</tr>
</thead>
<tbody>
<tr>
<td>.38 Special</td>
</tr>
<tr>
<td>3 Doors Down</td>
</tr>
<tr>
<td>70s Soul Jam</td>
</tr>
<tr>
<td>A Bronx Tale</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

```sql
explain select distinct eventname from event order by 1;
```

QUERY PLAN

```sql
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)
```

```sql
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       | 0           | 1000000000136.38 | 1000000000137.82 | 576 | 9792 |
| 240   | 3      | 2       | 0    | 0     | 114       | 0           | 1000000000136.38 | 1000000000137.82 | 576 | 9792 |
| 240   | 2      | 2       | 1    | 0     | 123       | 0           | 1000000000136.38 | 1000000000137.82 | 576 | 9792 |
| 240   | 1      | 3       | 0    | 0     | 122       | 0           | 1000000000136.38 | 1000000000137.82 | 576 | 9792 |
|       |        |         |      |       |           |             | (8 rows)                                      |

**STL_PROJECT**

Contains rows for query steps that are used to evaluate expressions.

This table 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

Sample Queries

The following example returns all rows for query steps that were used to evaluate expressions for slice 0 and segment 1.

```sql
select query, step, starttime, endtime, tasknum, rows
from stl_project
where slice=0 and segment=1;
```

<table>
<thead>
<tr>
<th>query</th>
<th>step</th>
<th>starttime</th>
<th>endtime</th>
<th>tasknum</th>
<th>rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>719</td>
<td>1</td>
<td>2013-08-12 22:38:33</td>
<td>2013-08-12 22:38:33</td>
<td>7</td>
<td>-1</td>
</tr>
<tr>
<td>86383</td>
<td>1</td>
<td>2013-08-29 21:58:35</td>
<td>2013-08-29 21:58:35</td>
<td>7</td>
<td>-1</td>
</tr>
<tr>
<td>714</td>
<td>1</td>
<td>2013-08-12 22:38:17</td>
<td>2013-08-12 22:38:17</td>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>86397</td>
<td>2</td>
<td>2013-08-29 22:01:20</td>
<td>2013-08-29 22:01:20</td>
<td>19</td>
<td>-1</td>
</tr>
<tr>
<td>627</td>
<td>1</td>
<td>2013-08-12 22:34:13</td>
<td>2013-08-12 22:34:13</td>
<td>34</td>
<td>-1</td>
</tr>
<tr>
<td>86326</td>
<td>2</td>
<td>2013-08-29 21:45:28</td>
<td>2013-08-29 21:45:28</td>
<td>34</td>
<td>-1</td>
</tr>
<tr>
<td>86326</td>
<td>3</td>
<td>2013-08-29 21:45:28</td>
<td>2013-08-29 21:45:28</td>
<td>34</td>
<td>-1</td>
</tr>
<tr>
<td>86371</td>
<td>1</td>
<td>2013-08-29 21:57:42</td>
<td>2013-08-29 21:57:42</td>
<td>4</td>
<td>-1</td>
</tr>
<tr>
<td>111100</td>
<td>2</td>
<td>2013-09-03 19:04:45</td>
<td>2013-09-03 19:04:45</td>
<td>12</td>
<td>-1</td>
</tr>
<tr>
<td>704</td>
<td>2</td>
<td>2013-08-12 22:36:34</td>
<td>2013-08-12 22:36:34</td>
<td>37</td>
<td>-1</td>
</tr>
<tr>
<td>649</td>
<td>2</td>
<td>2013-08-12 22:34:47</td>
<td>2013-08-12 22:34:47</td>
<td>38</td>
<td>-1</td>
</tr>
<tr>
<td>649</td>
<td>3</td>
<td>2013-08-12 22:34:47</td>
<td>2013-08-12 22:34:47</td>
<td>38</td>
<td>-1</td>
</tr>
</tbody>
</table>

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STL_QUERY

Returns execution information about a database query.

**Note**
The STL_QUERY and STL_QUERYTEXT tables only contain information about queries, not other utility and DDL commands. For a listing and information on all statements executed by Amazon Redshift, you can also query the STL_DDLTEXT and STL_UTILITYTEXT tables. For a complete listing of all statements executed by Amazon Redshift, you can query the SVL_STATEMENTTEXT view.

To manage disk space, the STL log tables only retain approximately two to five days of log history, depending on log usage and available disk space. If you want to retain the log data, you will need to periodically copy it to other tables or unload it to Amazon S3.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>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.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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 (p. 968).</td>
</tr>
<tr>
<td>database</td>
<td>character(32)</td>
<td>The name of the database the user was connected to when the query was issued.</td>
</tr>
<tr>
<td>querytxt</td>
<td>character(4000)</td>
<td>Actual query text for the query.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>aborted</td>
<td>integer</td>
<td>If a query was aborted 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.</td>
</tr>
<tr>
<td>insert_pristine</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>concurrency_scaling_status</td>
<td>integer</td>
<td>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</td>
</tr>
</tbody>
</table>

**Sample Queries**

The following query lists the five most recent queries.

```sql
select query, trim(querytxt) as sqlquery
from stl_query
order by query desc limit 5;
```

<table>
<thead>
<tr>
<th>query</th>
<th>sqlquery</th>
</tr>
</thead>
<tbody>
<tr>
<td>129</td>
<td>select query, trim(querytxt) from stl_query order by query;</td>
</tr>
<tr>
<td>128</td>
<td>select node from stv_disk_read_speeds;</td>
</tr>
<tr>
<td>127</td>
<td>select system_status from stv_gui_status</td>
</tr>
<tr>
<td>126</td>
<td>select * from systable_topology order by slice</td>
</tr>
<tr>
<td>125</td>
<td>load global dict registry</td>
</tr>
</tbody>
</table>

(5 rows)

The following query returns the time elapsed in descending order for queries that ran on February 15, 2013.

```sql
select query, datediff(seconds, starttime, endtime),
trim(querytxt) as sqlquery
from stl_query
where starttime >= '2013-02-15 00:00' and endtime < '2013-02-15 23:59'
order by date_diff desc;
```
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 (p. 1006) 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 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 (p. 281). 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 (p. 3).

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 (p. 1046) view and the SVL_QUERY_METRICS_SUMMARY (p. 1047) view aggregate the data in this table and present the information in a more accessible form.

This table 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 (p. 915).
## Table Rows

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user that ran the query that generated the entry.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Metrics are reported only for user-defined queues.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>step_type</td>
<td>integer</td>
<td>Type of step that executed. For a description of step types, see Step Types (p. 1008).</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>slices</td>
<td>integer</td>
<td>Number of slices for the cluster.</td>
</tr>
<tr>
<td>max_rows</td>
<td>bigint</td>
<td>Maximum number of rows output for a step, aggregated across all slices.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of rows processed by a step.</td>
</tr>
<tr>
<td>max_cpu_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>cpu_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>max_blocks_read</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>blocks_read</td>
<td>bigint</td>
<td>Number of 1 MB blocks read by the query or segment.</td>
</tr>
<tr>
<td>max_run_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>run_time</td>
<td>bigint</td>
<td>Total run time, summed across slices. Run time doesn't include wait time.</td>
</tr>
<tr>
<td>Row Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Row Name</strong></td>
<td><strong>Data Type</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>max_blocks_to_disk bigint</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>blocks_to_disk bigint</td>
<td>bigint</td>
<td>The amount of disk space used by a query or segment to write intermediate results, in MB blocks.</td>
</tr>
<tr>
<td>step integer</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>max_query_scan_size bigint</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>query_scan_size bigint</td>
<td>bigint</td>
<td>The size of data scanned by a query, in MB.</td>
</tr>
<tr>
<td>query_priority integer</td>
<td>integer</td>
<td>The priority of the query. Possible values are -1, 0, 1, 2, 3, and 4, where -1 means that query priority isn't supported.</td>
</tr>
<tr>
<td>query_queue_time bigint</td>
<td>bigint</td>
<td>The amount of time in microseconds that the query was queued.</td>
</tr>
</tbody>
</table>

### Sample Query

To find queries with high CPU time (more than 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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>cpu_seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>25775</td>
<td>9540</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>25775</td>
<td>2621562702</td>
</tr>
</tbody>
</table>

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;

<table>
<thead>
<tr>
<th>query</th>
<th>run_time_seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>25775</td>
<td>114</td>
</tr>
</tbody>
</table>

**STL_QUERYTEXT**

Captures the query text for SQL commands.

Query the STL_QUERYTEXT table to capture the SQL that was logged for the following statements:

- SELECT, SELECT INTO
- INSERT, UPDATE, DELETE
- COPY
- UNLOAD
- VACUUM, ANALYZE
- CREATE TABLE AS (CTAS)

To query activity for these statements over a given time period, join the STL_QUERYTEXT and STL_QUERY tables.

**Note**
The STL_QUERY and STL_QUERYTEXT tables only contain information about queries, not other utility and DDL commands. For a listing and information on all statements executed by Amazon Redshift, you can also query the STL_DDLTEXT and STL_UTILITYTEXT tables. For a complete listing of all statements executed by Amazon Redshift, you can query the SVL_STATEMENTTEXT view.

See also STL_DDLTEXT (p. 927), STL_UTILITYTEXT (p. 985), and SVL_STATEMENTTEXT (p. 1072).

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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 (p. 968). You can use this column to join to the STL_ERROR (p. 934) table.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>sequence</td>
<td>integer</td>
<td>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.</td>
</tr>
</tbody>
</table>
### Column Name | Data Type  | Description
---|---|---
**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 executed in the current session.

```sql
SELECT query, substring(text, 1, 60)
FROM stl_querytext
WHERE pid = pg_backend_pid()
ORDER BY query DESC;
```

<table>
<thead>
<tr>
<th>query</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>28262</td>
<td>select query, substring(text, 1, 80) from stl_querytext where</td>
</tr>
<tr>
<td>28252</td>
<td>select query, substring(path, 0, 80) as path from stl_unload_l</td>
</tr>
<tr>
<td>28248</td>
<td>copy category from 's3://dw-tickit/manifest/category/1030_ma</td>
</tr>
<tr>
<td>28247</td>
<td>Count rows in target table</td>
</tr>
<tr>
<td>28240</td>
<td>select query, substring(text, 1, 40) from stl_querytext where</td>
</tr>
</tbody>
</table>

(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.

```sql
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.

```sql
SELECT query, sequence, text
FROM stl_querytext WHERE query=pg_last_query_id() ORDER BY query DESC, sequence LIMIT 10;
```

<table>
<thead>
<tr>
<th>query</th>
<th>sequence</th>
<th>text</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>966</td>
</tr>
</tbody>
</table>
To reconstruct the SQL stored in STL_QUERYTEXT, run the following SQL.

```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
```

### 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.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice number where the replacement occurred.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Start time in UTC for the COPY command.</td>
</tr>
<tr>
<td>session</td>
<td>integer</td>
<td>Session ID for the session performing the COPY command.</td>
</tr>
<tr>
<td>filename</td>
<td>character(256)</td>
<td>Complete path to the input file for the COPY command.</td>
</tr>
<tr>
<td>line_number</td>
<td>bigint</td>
<td>Line number in the input data file that contained an invalid UTF-8 character.</td>
</tr>
<tr>
<td>colname</td>
<td>character(127)</td>
<td>First field that contained an invalid UTF-8 character.</td>
</tr>
<tr>
<td>raw_line</td>
<td>character(1024)</td>
<td>Raw load data that contained an invalid UTF-8 character.</td>
</tr>
</tbody>
</table>
### Sample Queries

The following example returns replacements for the most recent COPY operation.

```sql
select query, session, filename, line_number, colname
from stl_replacements
where query = pg_last_copy_id();
```

<table>
<thead>
<tr>
<th>query</th>
<th>session</th>
<th>filename</th>
<th>line_number</th>
<th>colname</th>
</tr>
</thead>
<tbody>
<tr>
<td>96</td>
<td>6314</td>
<td>s3://mybucket/allusers_pipe.txt</td>
<td>251</td>
<td>city</td>
</tr>
<tr>
<td>96</td>
<td>6314</td>
<td>s3://mybucket/allusers_pipe.txt</td>
<td>317</td>
<td>city</td>
</tr>
<tr>
<td>96</td>
<td>6314</td>
<td>s3://mybucket/allusers_pipe.txt</td>
<td>569</td>
<td>city</td>
</tr>
<tr>
<td>96</td>
<td>6314</td>
<td>s3://mybucket/allusers_pipe.txt</td>
<td>623</td>
<td>city</td>
</tr>
<tr>
<td>96</td>
<td>6314</td>
<td>s3://mybucket/allusers_pipe.txt</td>
<td>694</td>
<td>city</td>
</tr>
</tbody>
</table>

... 

### 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.

This table 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>currenttime</td>
<td>timestamp</td>
<td>Time of the event.</td>
</tr>
<tr>
<td>dbname</td>
<td>character(50)</td>
<td>Name of the database associated with the session.</td>
</tr>
<tr>
<td>newpid</td>
<td>integer</td>
<td>Process ID for the restarted session.</td>
</tr>
<tr>
<td>oldpid</td>
<td>integer</td>
<td>Process ID for the original session.</td>
</tr>
<tr>
<td>username</td>
<td>character(50)</td>
<td>Name of the user associated with the session.</td>
</tr>
<tr>
<td>remotehost</td>
<td>character(32)</td>
<td>Name or IP address of the remote host.</td>
</tr>
<tr>
<td>remoteport</td>
<td>character(32)</td>
<td>Port number of the remote host.</td>
</tr>
<tr>
<td>parkedtime</td>
<td>timestamp</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>session_vars</td>
<td>character(2000)</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following example joins STL_RESTARTED_SESSIONS with STL_SESSIONS to show user names for sessions that have been restarted.

```sql
select process, stl_restarted_sessions.newpid, user_name
from stl_sessions
```
STL_RETURN

Contains details for return steps in queries. A return step returns the results of queries executed 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 executed 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 (p. 281).

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>packets</td>
<td>integer</td>
<td>Total number of packets sent over the network.</td>
</tr>
</tbody>
</table>

Sample Queries

The following query shows which steps in the most recent query were executed on each slice. (Slice 6411 is on the leader node.)

```sql
SELECT query, slice, segment, step, endtime, rows, packets
FROM stl_return
WHERE query = pg_last_query_id();
```
### STL_S3CLIENT

Records transfer time and other performance metrics.

Use the STL_S3CLIENT table to find the time spent transferring data from Amazon S3 as part of a COPY command.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time the record is logged.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>http_method</td>
<td>character(64)</td>
<td>HTTP method name corresponding to the Amazon S3 request.</td>
</tr>
<tr>
<td>bucket</td>
<td>character(64)</td>
<td>S3 bucket name.</td>
</tr>
<tr>
<td>key</td>
<td>character(256)</td>
<td>Key corresponding to the Amazon S3 object.</td>
</tr>
<tr>
<td>transfer_size</td>
<td>bigint</td>
<td>Number of bytes transferred.</td>
</tr>
<tr>
<td>data_size</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>start_time</td>
<td>bigint</td>
<td>Time when the transfer began (in microseconds since January 1, 2000).</td>
</tr>
<tr>
<td>end_time</td>
<td>bigint</td>
<td>Time when the transfer ended (in microseconds since January 1, 2000).</td>
</tr>
<tr>
<td>transfer_time</td>
<td>bigint</td>
<td>Time taken by the transfer (in microseconds).</td>
</tr>
<tr>
<td>compression_time</td>
<td>bigint</td>
<td>Portion of the transfer time that was spent uncompressing data (in microseconds).</td>
</tr>
</tbody>
</table>
### STL_S3CLIENT

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>connect_time</td>
<td>bigint</td>
<td>Time from the start until the connect to the remote server was completed (in microseconds).</td>
</tr>
<tr>
<td>app_connect_time</td>
<td>bigint</td>
<td>Time from the start until the SSL connect/handshake with the remote host was completed (in microseconds).</td>
</tr>
<tr>
<td>retries</td>
<td>bigint</td>
<td>Number of times the transfer was retried.</td>
</tr>
<tr>
<td>request_id</td>
<td>char(32)</td>
<td>Request ID from Amazon S3 HTTP response header</td>
</tr>
<tr>
<td>extended_request_id</td>
<td>char(128)</td>
<td>Extended request ID from Amazon S3 HTTP header response (x-amz-id-2).</td>
</tr>
<tr>
<td>ip_address</td>
<td>char(64)</td>
<td>IP address of the server (ip V4 or V6).</td>
</tr>
</tbody>
</table>

### Sample Query

The following query returns the time taken to load files using a COPY command.

```sql
select slice, key, transfer_time
from stl_s3client
where query = pg_last_copy_id();
```

#### Result

<table>
<thead>
<tr>
<th>slice</th>
<th>key</th>
<th>transfer_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>listing10M0003_part_00</td>
<td>16626716</td>
</tr>
<tr>
<td>1</td>
<td>listing10M0001_part_00</td>
<td>12894494</td>
</tr>
<tr>
<td>2</td>
<td>listing10M0002_part_00</td>
<td>14320978</td>
</tr>
<tr>
<td>3</td>
<td>listing10M0000_part_00</td>
<td>11293439</td>
</tr>
<tr>
<td>3371</td>
<td>prefix=listing10M;marker=</td>
<td>99395</td>
</tr>
</tbody>
</table>

The following query converts the start_time and end_time to a timestamp.

```sql
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;
```

<table>
<thead>
<tr>
<th>userid</th>
<th>query</th>
<th>slice</th>
<th>pid</th>
<th>recordtime</th>
<th>start_time</th>
<th>end_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23449</td>
<td>2019-07-14 16:27:17.207839</td>
<td>616436837154256</td>
<td>616436837207838</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23449</td>
<td>2019-07-14 16:27:17.154256</td>
<td>616436837208208</td>
<td>616436837208980</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23449</td>
<td>2019-07-14 16:27:17.208208</td>
<td>616436837208208</td>
<td>616436837208980</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23449</td>
<td>2019-07-14 16:27:17.208208</td>
<td>616436837208208</td>
<td>616436837208980</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23449</td>
<td>2019-07-14 16:27:17.208208</td>
<td>616436837208208</td>
<td>616436837208980</td>
</tr>
</tbody>
</table>

971
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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>sliceid</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time the record is logged.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>http_method</td>
<td>character(64)</td>
<td>HTTP method name corresponding to the Amazon S3 request.</td>
</tr>
<tr>
<td>bucket</td>
<td>character(64)</td>
<td>Amazon S3 bucket name.</td>
</tr>
<tr>
<td>key</td>
<td>character(256)</td>
<td>Key corresponding to the Amazon S3 object.</td>
</tr>
<tr>
<td>error</td>
<td>character(1024)</td>
<td>Error message.</td>
</tr>
</tbody>
</table>

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 executed during the current session.

```sql
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

<table>
<thead>
<tr>
<th>query</th>
<th>sliceid</th>
<th>file</th>
<th>error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 (p. 281).

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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>ID of the materialized transient table.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>Whether this step of the query was executed as a disk-based operation: true (t) or false (f).</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Number of bytes of working memory assigned to the step.</td>
</tr>
</tbody>
</table>
Sample Queries

The following query shows which save steps in the most recent query were executed on each slice.

```sql
select query, slice, segment, step, tasknum, rows, tbl
from stl_save where query = pg_last_query_id();
```

<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>segment</th>
<th>step</th>
<th>tasknum</th>
<th>rows</th>
<th>tbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>52236</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>21</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>21</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>21</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>239</td>
</tr>
<tr>
<td>52236</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>21</td>
<td>0</td>
<td>239</td>
</tr>
</tbody>
</table>

(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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>fetches</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>type</td>
<td>integer</td>
<td>ID of the scan type. For a list of valid values, see the following table.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>character(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step.</td>
</tr>
<tr>
<td>is_delayed_scan</td>
<td>character(1)</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>rows_pre_filter</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>rows_pre_user_filter</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>perm_table_name</td>
<td>character(136)</td>
<td>For scans of permanent tables, the name of the table scanned.</td>
</tr>
<tr>
<td>is_rlf_scan</td>
<td>character(1)</td>
<td>If true (t), indicates that row-level filtering was used on the step.</td>
</tr>
<tr>
<td>is_rlf_scan_reason</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>num_em_blocks</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
<tr>
<td>runtime_filtering</td>
<td>character(1)</td>
<td>If true (t), indicates that runtime filters are applied.</td>
</tr>
</tbody>
</table>

### Scan Types

<table>
<thead>
<tr>
<th>Type ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data from the network.</td>
</tr>
<tr>
<td>2</td>
<td>Permanent user tables in compressed shared memory.</td>
</tr>
<tr>
<td>3</td>
<td>Transient row-wise tables.</td>
</tr>
<tr>
<td>21</td>
<td>Load files from Amazon S3.</td>
</tr>
<tr>
<td>22</td>
<td>Load tables from Amazon DynamoDB.</td>
</tr>
<tr>
<td>23</td>
<td>Load data from a remote SSH connection.</td>
</tr>
<tr>
<td>24</td>
<td>Load data from remote cluster (sorted region). This is used for resizing.</td>
</tr>
<tr>
<td>25</td>
<td>Load data from remote cluster (unsorted region). This is used for resizing.</td>
</tr>
</tbody>
</table>

### 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).

```sql
SELECT slice, segment, step, rows, rows_pre_filter, rows_pre_user_filter
FROM stl_scan WHERE query = pg_last_query_id();
```

<table>
<thead>
<tr>
<th>query</th>
<th>slice</th>
<th>segment</th>
<th>step</th>
<th>rows</th>
<th>rows_pre_filter</th>
<th>rows_pre_user_filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>42915</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>43159</td>
<td>86318</td>
<td>43159</td>
</tr>
<tr>
<td>42915</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>42915</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>43091</td>
<td>86182</td>
<td>43091</td>
</tr>
<tr>
<td>42915</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>42915</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>42778</td>
<td>85556</td>
<td>42778</td>
</tr>
<tr>
<td>42915</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>42915</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>43428</td>
<td>86856</td>
<td>43428</td>
</tr>
<tr>
<td>42915</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>42915</td>
<td>10000</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(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.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the session started.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the session ended.</td>
</tr>
<tr>
<td>process</td>
<td>integer</td>
<td>Process ID for the session.</td>
</tr>
<tr>
<td>user_name</td>
<td>character(50)</td>
<td>User name associated with the session.</td>
</tr>
<tr>
<td>db_name</td>
<td>character(50)</td>
<td>Name of the database associated with the session.</td>
</tr>
</tbody>
</table>

**Sample Queries**

To view session history for the TICKIT database, type the following query:
select starttime, process, user_name
from stl_sessions
where db_name='tickit' order by starttime;

This query returns the following sample output:

<table>
<thead>
<tr>
<th>starttime</th>
<th>process</th>
<th>user_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-09-15 09:54:06.746705</td>
<td>32358</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 09:56:34.30275</td>
<td>32744</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 11:20:34.694837</td>
<td>14906</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 14:32:44.66112</td>
<td>14031</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 14:56:30.22161</td>
<td>18380</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 15:28:32.509354</td>
<td>24344</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 16:01:00.557326</td>
<td>30153</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 17:28:21.419858</td>
<td>12805</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-15 20:58:37.601937</td>
<td>14951</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 11:12:30.960564</td>
<td>27437</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 14:11:37.639092</td>
<td>23790</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 15:13:46.02195</td>
<td>1355</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 15:22:36.515106</td>
<td>2878</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 15:44:39.194579</td>
<td>6470</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-16 16:50:27.021368</td>
<td>17254</td>
<td>dwuser</td>
</tr>
<tr>
<td>2008-09-17 12:05:02.157208</td>
<td>8439</td>
<td>dwuser</td>
</tr>
</tbody>
</table>

(STL_SORT)

Displays sort execution steps for queries, such as steps that use ORDER BY processing.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Number of the query task process that was assigned to execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Total number of rows that were processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Size, in bytes, of all the output rows for the step.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>If true (t), the query was executed as a disk-based operation. If false (f), the query was executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Total number of bytes in working memory that were assigned to the step.</td>
</tr>
<tr>
<td>checksum</td>
<td>bigint</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

**Sample Queries**

The following example returns sort results for slice 0 and segment 1.

```sql
select query, bytes, tbl, is_diskbased, workmem
from stl_sort
where slice=0 and segment=1;
```

<table>
<thead>
<tr>
<th>query</th>
<th>bytes</th>
<th>tbl</th>
<th>is_diskbased</th>
<th>workmem</th>
</tr>
</thead>
<tbody>
<tr>
<td>567</td>
<td>3126968</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>604</td>
<td>5292</td>
<td>242</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>675</td>
<td>104776</td>
<td>251</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>525</td>
<td>3126968</td>
<td>251</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>585</td>
<td>5068</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>630</td>
<td>204808</td>
<td>266</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>704</td>
<td>0</td>
<td>242</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>669</td>
<td>4606416</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>696</td>
<td>104776</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>851</td>
<td>4606416</td>
<td>254</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>632</td>
<td>0</td>
<td>256</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>599</td>
<td>396</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>86397</td>
<td>0</td>
<td>242</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>621</td>
<td>5292</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>86325</td>
<td>0</td>
<td>242</td>
<td>f</td>
<td>0</td>
</tr>
<tr>
<td>572</td>
<td>5068</td>
<td>242</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>645</td>
<td>204808</td>
<td>241</td>
<td>f</td>
<td>383385600</td>
</tr>
<tr>
<td>590</td>
<td>396</td>
<td>242</td>
<td>f</td>
<td>383385600</td>
</tr>
</tbody>
</table>

(18 rows)

**STL_SSHCLIENT_ERROR**

Records all errors seen by the SSH client.

This table 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time that the error was logged.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process that logged the error.</td>
</tr>
<tr>
<td>ssh_username</td>
<td>character(1024)</td>
<td>The SSH user name.</td>
</tr>
<tr>
<td>endpoint</td>
<td>character(1024)</td>
<td>The SSH endpoint.</td>
</tr>
<tr>
<td>command</td>
<td>character(4096)</td>
<td>The complete SSH command.</td>
</tr>
<tr>
<td>error</td>
<td>character(1024)</td>
<td>The error message.</td>
</tr>
</tbody>
</table>

STL_STREAM_SEGS

Lists the relationship between streams and concurrent segments.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>stream</td>
<td>integer</td>
<td>The set of concurrent segments of a query.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
</tbody>
</table>

Sample Queries

To view the relationship between streams and concurrent segments for the most recent query, type the following query:

```sql
select *
from stl_stream_segs
where query = pg_last_query_id();
```
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 executes a statement that would break serializability is aborted 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 aborted transaction. For more information, see Serializable Isolation (p. 151).

This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xact_id</td>
<td>bigint</td>
<td>Transaction ID for the rolled back transaction.</td>
</tr>
<tr>
<td>process_id</td>
<td>bigint</td>
<td>Process associated with the transaction that was rolled back.</td>
</tr>
<tr>
<td>xact_start_ts</td>
<td>timestamp</td>
<td>Timestamp for the transaction start.</td>
</tr>
<tr>
<td>abort_time</td>
<td>timestamp</td>
<td>Time that the transaction was aborted.</td>
</tr>
<tr>
<td>table_id</td>
<td>bigint</td>
<td>Table ID for the table where the conflict occurred.</td>
</tr>
</tbody>
</table>

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;
```

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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xact_id</td>
<td>bigint</td>
<td>ID for the undo transaction.</td>
</tr>
<tr>
<td>xact_id_undone</td>
<td>bigint</td>
<td>ID for the transaction that was undone.</td>
</tr>
<tr>
<td>undo_start_ts</td>
<td>timestamp</td>
<td>Start time for the undo transaction.</td>
</tr>
<tr>
<td>undo_end_ts</td>
<td>timestamp</td>
<td>End time for the undo transaction.</td>
</tr>
<tr>
<td>table_id</td>
<td>bigint</td>
<td>ID for the table that was affected by the undo transaction.</td>
</tr>
</tbody>
</table>

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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
</tbody>
</table>
### 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 executed.
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.
endtime | timestamp | Time in UTC that the query finished executing, 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 execute the step.
rows | bigint | Total number of rows that were processed.
is_diskbased | character(1) | If true (t), the query was executed as a disk-based operation. If false (f), the query was executed 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.
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.

### Sample Queries

Suppose you execute the following query:

```sql
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.

```sql
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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the query statement.</td>
</tr>
<tr>
<td>path</td>
<td>character(1280)</td>
<td>The complete Amazon S3 object path for the file.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>Start time for the transaction.</td>
</tr>
<tr>
<td>end_time</td>
<td>timestamp</td>
<td>End time for the transaction.</td>
</tr>
<tr>
<td>line_count</td>
<td>bigint</td>
<td>Number of lines (rows) unloaded to the file.</td>
</tr>
<tr>
<td>transfer_size</td>
<td>bigint</td>
<td>Number of bytes transferred.</td>
</tr>
<tr>
<td>file_format</td>
<td>character(10)</td>
<td>Format of unloaded file.</td>
</tr>
</tbody>
</table>

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 STL_UNLOAD_LOG.

The following query returns the pathname for files that were created by an UNLOAD for the last query executed:
This command returns the following sample output:

<table>
<thead>
<tr>
<th>query</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0000_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0001_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0002_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0003_part_00</td>
</tr>
</tbody>
</table>

STL_USERLOG

Records details for the following changes to a database user:

- Create user
- Drop user
- Alter user (rename)
- Alter user (alter properties)

This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user affected by the change.</td>
</tr>
<tr>
<td>username</td>
<td>character(50)</td>
<td>User name of the user affected by the change.</td>
</tr>
<tr>
<td>oldusername</td>
<td>character(50)</td>
<td>For a rename action, the original user name. For any other action, this field is empty.</td>
</tr>
<tr>
<td>action</td>
<td>character(10)</td>
<td>Action that occurred. Valid values:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Alter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Create</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Drop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Rename</td>
</tr>
<tr>
<td>usecreatedb</td>
<td>integer</td>
<td>If true (1), indicates that the user has create database privileges.</td>
</tr>
<tr>
<td>usesuper</td>
<td>integer</td>
<td>If true (1), indicates that the user is a superuser.</td>
</tr>
<tr>
<td>usecatupd</td>
<td>integer</td>
<td>If true (1), indicates that the user can update system catalogs.</td>
</tr>
<tr>
<td>valuntil</td>
<td>timestamp</td>
<td>Password expiration date.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time in UTC that the query started.</td>
</tr>
</tbody>
</table>

## Sample Queries

The following example performs four user actions, then queries the STL_USERLOG table.

```sql
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;
```

<table>
<thead>
<tr>
<th>userid</th>
<th>username</th>
<th>oldusername</th>
<th>action</th>
<th>usecreatedb</th>
<th>usesuper</th>
</tr>
</thead>
<tbody>
<tr>
<td>108</td>
<td>userlog2</td>
<td></td>
<td>drop</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>108</td>
<td>userlog2</td>
<td>userlog1</td>
<td>rename</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>108</td>
<td>userlog1</td>
<td></td>
<td>alter</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>108</td>
<td>userlog1</td>
<td></td>
<td>create</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(4 rows)

## STLUTILITYTEXT

Captures the text of non-SELECT SQL commands run on the database.

Query the STLUTILITYTEXT table to capture the following subset of SQL statements that were run on the system:

- ABORT, BEGIN, COMMIT, END, ROLLBACK
- CALL
- CANCEL
- COMMENT
- CREATE, ALTER, DROP DATABASE
- CREATE, ALTER, DROP USER
- EXPLAIN
- GRANT, REVOKE
- LOCK
- RESET
- SET
- SHOW
TRUNCATE

See also STL_DDLTEXT (p. 927), STL_QUERYTEXT (p. 965), and SVL_STATEMENTTEXT (p. 1072).

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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the query statement.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>Either the name of the file used to run the query or a label defined with a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SET QUERY_GROUP command. If the query is not file-based or the QUERY_GROUP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>parameter is not set, this field is blank.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the query started executing, with 6 digits of precision for</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query finished executing, with 6 digits of precision</td>
</tr>
<tr>
<td>sequence</td>
<td>integer</td>
<td>When a single statement contains more than 200 characters, additional rows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>are logged for that statement. Sequence 0 is the first row, 1 is the second,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and so on.</td>
</tr>
<tr>
<td>text</td>
<td>character(200)</td>
<td>SQL text, in 200-character increments. This field might contain special</td>
</tr>
<tr>
<td></td>
<td></td>
<td>characters such as backslash (\ ) and newline (\n)).</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>starttime</th>
<th>sequence</th>
<th>rtrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-01-26 13:05:52.529235</td>
<td>0</td>
<td>show all;</td>
</tr>
<tr>
<td>2012-01-26 13:20:31.660255</td>
<td>0</td>
<td>SET query_group to ''</td>
</tr>
</tbody>
</table>
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.

```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 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.

```sql
set query_group to
'000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000000
000000';
```

In this example, the query is stored in 2 parts (rows) in the text column of STL_UTILITYTEXT.

```sql
select query, sequence, text
from stl_utilitytext where query=pg_last_query_id() order by query desc, sequence limit 10;
```

<table>
<thead>
<tr>
<th>starttime</th>
<th>sequence</th>
<th>text</th>
</tr>
</thead>
</table>
| 2019-07-23 22:55:34 |        0 | set query_group to '00000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000
000000'; |
| 2019-07-23 22:55:34 |        1 | 000000;                                                              |

To reconstruct the SQL stored in STL_UTILITYTEXT, run the following SQL.

```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.

```sql
query_statement

set query_group to
'000000000000000000000000000000000000000000000000000000000000000
000000';
```
STL_VACUUM

Displays row and block statistics for tables that have been vacuumed.

The table 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 (p. 663) command description.

This table is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID for the VACUUM statement. You can join this table to the STL_QUERY table 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.</td>
</tr>
<tr>
<td>table_id</td>
<td>integer</td>
<td>The Table ID.</td>
</tr>
<tr>
<td>status</td>
<td>character(30)</td>
<td>The status of the VACUUM operation for each table. Possible values are the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Started</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Started Delete Only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Started Delete Only (Sorted &gt;= nn%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Started Sort Only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Started Reindex</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Finished</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skipped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The table was skipped because the table was fully sorted and no rows were marked for deletion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skipped (delete only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The table was skipped because DELETE ONLY was specified and no rows were marked for deletion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skipped (sort only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The table was skipped because SORT ONLY was specified and the table was already sorted fully sorted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skipped (sort only, sorted&gt;=xx%).</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The table was skipped because SORT ONLY was specified and the table was already sorted at or above the sort threshold.</td>
<td></td>
<td>• <strong>Skipped (0 rows).</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The table was skipped because it was empty.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>VacuumBG.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>An automatic vacuum operation was performed in the background.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For more information about the VACUUM sort threshold setting, see <strong>VACUUM (p. 663)</strong>.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>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 <strong>Started</strong> status, and the count after the vacuum for rows with a <strong>Finished</strong> status.</td>
</tr>
<tr>
<td>sortedrows</td>
<td>integer</td>
<td>The number of rows in the table that are sorted. This column shows the count before the vacuum started for rows with <strong>Started</strong> in the Status column, and the count after the vacuum for rows with <strong>Finished</strong> in the Status column.</td>
</tr>
<tr>
<td>blocks</td>
<td>integer</td>
<td>The total number of data blocks used to store the table data before the vacuum operation (rows with a <strong>Started</strong> status) and after the vacuum operation (<strong>Finished</strong> column). Each data block uses 1 MB.</td>
</tr>
<tr>
<td>max_merge_partitions</td>
<td>integer</td>
<td>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.)</td>
</tr>
<tr>
<td>eventtime</td>
<td>timestamp</td>
<td>When the vacuum operation started or finished.</td>
</tr>
</tbody>
</table>

**Sample Queries**

The following query reports vacuum statistics for table 108313. The table was vacuumed following a series of inserts and deletes.

```sql
select xid, table_id, status, rows, sortedrows, blocks, eventtime
from stl_vacuum where table_id=108313 order by eventtime;
```

<table>
<thead>
<tr>
<th>xid</th>
<th>table_id</th>
<th>status</th>
<th>rows</th>
<th>sortedrows</th>
<th>blocks</th>
<th>eventtime</th>
</tr>
</thead>
</table>
At the start of the VACUUM, the table contained 1,950,266,199 rows stored in 280,887 1 MB blocks. In the delete phase (transaction 14294) completed, vacuum reclaimed space for the deleted rows. The ROWS column shows a value of 400,043,488, and the BLOCKS column has dropped from 280,887 to 88,978. The vacuum reclaimed 191,909 blocks (191.9 GB) of disk space.

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 execute window functions.

This table 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Number that identifies the slice where the query was running.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the query started executing, with 6 digits of precision for fractional seconds. For example: <code>2009-06-12 11:29:19.131358</code>.</td>
</tr>
</tbody>
</table>
### Sample Queries

The following example returns window function results for slice 0 and segment 3.

```sql
select query, tasknum, rows, is_diskbased, workmem
from stl_window
where slice=0 and segment=3;
```

<table>
<thead>
<tr>
<th>query</th>
<th>tasknum</th>
<th>rows</th>
<th>is_diskbased</th>
<th>workmem</th>
</tr>
</thead>
<tbody>
<tr>
<td>86326</td>
<td>36</td>
<td>1857</td>
<td>f</td>
<td>95256616</td>
</tr>
<tr>
<td>705</td>
<td>15</td>
<td>1857</td>
<td>f</td>
<td>95256616</td>
</tr>
<tr>
<td>86399</td>
<td>27</td>
<td>1857</td>
<td>f</td>
<td>95256616</td>
</tr>
<tr>
<td>649</td>
<td>10</td>
<td>0</td>
<td>f</td>
<td>95256616</td>
</tr>
</tbody>
</table>

(4 rows)

### STL_WLM_ERROR

Records all WLM-related errors as they occur.

This table 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time that the error occurred.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>ID for the process that generated the error.</td>
</tr>
<tr>
<td>error_string</td>
<td>character(256)</td>
<td>Error description.</td>
</tr>
</tbody>
</table>
# 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 (p. 347).

This table 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 (p. 915).

## Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>User that ran the query.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Service classes greater than 5 are user-defined queues.</td>
</tr>
<tr>
<td>rule</td>
<td>character(256)</td>
<td>Name of a query monitoring rule.</td>
</tr>
<tr>
<td>action</td>
<td>character(256)</td>
<td>Resulting action. Possible values are as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• log</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• hop(reassign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• hop(restart)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• abort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• change_query_priority</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time the action was logged.</td>
</tr>
<tr>
<td>action_value</td>
<td>character(256)</td>
<td>If action is change_query_priority, then possible values are highest, high, normal, low, and lowest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If action is log, hop, or abort then the value is empty.</td>
</tr>
</tbody>
</table>

## Sample Queries

The following example finds queries that were aborted by a query monitoring rule.

```sql
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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>integer</td>
<td>Transaction ID of the query or subquery.</td>
</tr>
<tr>
<td>task</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>slot_count</td>
<td>integer</td>
<td>Number of WLM query slots.</td>
</tr>
<tr>
<td>service_class_start_time</td>
<td>timestamp</td>
<td>Time that the query was assigned to the service class.</td>
</tr>
<tr>
<td>queue_start_time</td>
<td>timestamp</td>
<td>Time that the query entered the queue for the service class.</td>
</tr>
<tr>
<td>queue_end_time</td>
<td>timestamp</td>
<td>Time when the query left the queue for the service class.</td>
</tr>
<tr>
<td>total_queue_time</td>
<td>bigint</td>
<td>Total number of microseconds that the query spent in the queue.</td>
</tr>
<tr>
<td>exec_start_time</td>
<td>timestamp</td>
<td>Time that the query began executing in the service class.</td>
</tr>
<tr>
<td>exec_end_time</td>
<td>timestamp</td>
<td>Time that the query completed execution in the service class.</td>
</tr>
<tr>
<td>total_exec_time</td>
<td>bigint</td>
<td>Number of microseconds that the query spent executing.</td>
</tr>
<tr>
<td>service_class_end_time</td>
<td>timestamp</td>
<td>Time that the query left the service class.</td>
</tr>
<tr>
<td>final_state</td>
<td>character(16)</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>est_peak_mem</td>
<td>bigint</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>query_priority</td>
<td>char(20)</td>
<td>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.</td>
</tr>
</tbody>
</table>
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 (p. 353).

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_ACTIVE_CURSORS (p. 995)
- STV_BLOCKLIST (p. 996)
STV_ACTIVE_CURSORS displays details for currently open cursors. For more information, see `DECLARE (p. 564)`.  

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 (p. 915). A user can only view cursors opened by that user. A superuser can view all cursors.

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>name</td>
<td>character(256)</td>
<td>name.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction context.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Leader process running the query.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time when the cursor was declared.</td>
</tr>
<tr>
<td>row_count</td>
<td>bigint</td>
<td>Number of rows in the cursor result set.</td>
</tr>
<tr>
<td>byte_count</td>
<td>bigint</td>
<td>Number of bytes in the cursor result set.</td>
</tr>
</tbody>
</table>
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 (p. 1005) 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice.</td>
</tr>
<tr>
<td>col</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID for the database table.</td>
</tr>
<tr>
<td>blocknum</td>
<td>integer</td>
<td>ID for the data block.</td>
</tr>
<tr>
<td>num_values</td>
<td>integer</td>
<td>Number of values contained on the block.</td>
</tr>
<tr>
<td>extended_limits</td>
<td>integer</td>
<td>For internal use.</td>
</tr>
<tr>
<td>minvalue</td>
<td>bigint</td>
<td>Minimum data value of the block. Stores first eight characters as 64-bit integer for non-numeric data. Used for disk scanning.</td>
</tr>
<tr>
<td>maxvalue</td>
<td>bigint</td>
<td>Maximum data value of the block. Stores first eight characters as 64-bit integer for non-numeric data. Used for disk scanning.</td>
</tr>
<tr>
<td>sb_pos</td>
<td>integer</td>
<td>Internal Amazon Redshift identifier for super block position on the disk.</td>
</tr>
<tr>
<td>pinned</td>
<td>integer</td>
<td>Whether or not the block is pinned into memory as part of pre-load. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>on_disk</td>
<td>integer</td>
<td>Whether or not the block is automatically stored on disk. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>modified</td>
<td>integer</td>
<td>Whether or not the block has been modified. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>hdr_modified</td>
<td>integer</td>
<td>Whether or not the block header has been modified. 0 = false; 1 = true. Default is false.</td>
</tr>
</tbody>
</table>
### 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:

```sql
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:

<table>
<thead>
<tr>
<th>col</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

(8 rows)

The following query shows whether or not table data is actually distributed over all slices:

```sql
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;
```

```
<table>
<thead>
<tr>
<th>slice</th>
<th>col</th>
<th>tbl</th>
<th>blocknum</th>
<th>newblock</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>101285</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>101285</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>101285</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>101285</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>101285</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>101285</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>101285</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(24 rows)

**STV_CURSOR_CONFIGURATION**

**STV_CURSOR_CONFIGURATION** displays cursor configuration constraints. For more information, see [Cursor Constraints](p. 564).

**STV_CURSOR_CONFIGURATION** is visible only to superusers. For more information, see [Visibility of Data in System Tables and Views](p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>current_cursor_count</td>
<td>integer</td>
<td>Number of cursors currently open.</td>
</tr>
<tr>
<td>max_diskspace_used</td>
<td>integer</td>
<td>Amount of disk space available for cursors, in megabytes. This constraint is based on the maximum cursor result set size for the cluster.</td>
</tr>
<tr>
<td>current_diskspace</td>
<td>integer</td>
<td>Amount of disk space currently used by cursors, in megabytes.</td>
</tr>
</tbody>
</table>

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice where the step executed.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Segment of the query that executed. A query segment is a series of steps.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Step of the query segment that executed. A step is the smallest unit of query execution.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time that the step executed.</td>
</tr>
<tr>
<td>currenttime</td>
<td>timestamp</td>
<td>Current time.</td>
</tr>
<tr>
<td>tasknum</td>
<td>integer</td>
<td>Query task process that is assigned to the execute the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of rows processed.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of bytes processed.</td>
</tr>
<tr>
<td>label</td>
<td>char(256)</td>
<td>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.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>char(1)</td>
<td>Whether this step of the query was executed 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 executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Number of bytes of working memory assigned to the step.</td>
</tr>
<tr>
<td>num_parts</td>
<td>integer</td>
<td>Number of partitions a hash table is divided into during a hash step. The hash table is partitioned when it is estimated that the entire hash table might not fit into memory. A positive number in this column does not imply that the hash step executed as a disk-based operation. Check the value in the IS_DISKBASED column to see if the hash step was disk-based.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>char(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>is_delayed_scan</td>
<td>char(1)</td>
<td>If true (t), indicates that delayed scan was used on the step. Default is false (f).</td>
</tr>
</tbody>
</table>

**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 (p. 1055) or SVV_QUERY_STATE (p. 1051) table documentation for more details.

**STV_INFLIGHT**

Use the STV_INFLIGHT table to determine what queries are currently running on the cluster. STV_INFLIGHT does not show leader-node only queries. For more information, see Leader Node–Only Functions (p. 667).

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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Slice where the query is running.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>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.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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 (p. 934) table.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time that the query started.</td>
</tr>
<tr>
<td>text</td>
<td>character(100)</td>
<td>Query text, truncated to 100 characters if the statement exceeds that limit.</td>
</tr>
<tr>
<td>suspended</td>
<td>integer</td>
<td>Whether the query is suspended or not. 0 = false; 1 = true.</td>
</tr>
<tr>
<td>insert_pristine</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>concurrency_scaling_status</td>
<td>integer</td>
<td>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</td>
</tr>
</tbody>
</table>

Sample Queries

To view all active queries currently running on the database, type the following query:

```sql
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:

```sql
select slice, query, trim(label) querylabel, pid, starttime, substring(text,1,20) querytext
from stv_inflight;
```

<table>
<thead>
<tr>
<th>slice</th>
<th>query</th>
<th>querylabel</th>
<th>pid</th>
<th>starttime</th>
<th>querytext</th>
</tr>
</thead>
<tbody>
<tr>
<td>1011</td>
<td>21</td>
<td></td>
<td>646</td>
<td>2012-01-26 13:23:15.645503</td>
<td>select slice, query, trim(label) querylabel, pid, starttime, substring(text,1,20) querytext</td>
</tr>
<tr>
<td>1011</td>
<td>20</td>
<td>avgwait.sql</td>
<td>499</td>
<td>2012-01-26 13:23:14.159912</td>
<td>select avg(datediff(</td>
</tr>
</tbody>
</table>

(2 rows)

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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>session</td>
<td>integer</td>
<td>Session PID of process doing the load.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice number.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>recordtime</td>
<td>timestamp</td>
<td>Time the record is logged.</td>
</tr>
<tr>
<td>bytes_to_load</td>
<td>bigint</td>
<td>Total number of bytes to be loaded by this slice. This is 0 if the data being loaded is compressed</td>
</tr>
<tr>
<td>bytes_loaded</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>bytes_to_load_compressed</td>
<td>bigint</td>
<td>Total number of bytes of compressed data to be loaded by this slice. This is 0 if the data being loaded is not compressed.</td>
</tr>
<tr>
<td>bytes_loaded_compressed</td>
<td>bigint</td>
<td>Number of bytes of compressed data loaded by this slice. This is 0 if the data being loaded is not compressed.</td>
</tr>
<tr>
<td>lines</td>
<td>integer</td>
<td>Number of lines loaded by this slice.</td>
</tr>
<tr>
<td>num_files</td>
<td>integer</td>
<td>Number of files to be loaded by this slice.</td>
</tr>
<tr>
<td>num_files_complete</td>
<td>integer</td>
<td>Number of files loaded by this slice.</td>
</tr>
<tr>
<td>current_file</td>
<td>character(256)</td>
<td>Name of the file being loaded by this slice.</td>
</tr>
<tr>
<td>pct_complete</td>
<td>integer</td>
<td>Percentage of data load completed by this slice.</td>
</tr>
</tbody>
</table>

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.

```sql
select slice, bytes_loaded, bytes_to_load, pct_complete from stv_load_state where query = pg_last_copy_id();
```

<table>
<thead>
<tr>
<th>slice</th>
<th>bytes_loaded</th>
<th>bytes_to_load</th>
<th>pct_complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>12840898</td>
<td>39104640</td>
<td>32</td>
</tr>
</tbody>
</table>
(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 (p. 980) table to see a log of lock conflicts. Use the SVV_TRANSACTIONS (p. 1079) 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_id</td>
<td>bigint</td>
<td>Table ID for the table acquiring the lock.</td>
</tr>
<tr>
<td>last_commit</td>
<td>timestamp</td>
<td>Timestamp for the last commit in the table.</td>
</tr>
<tr>
<td>last_update</td>
<td>timestamp</td>
<td>Timestamp for the last update for the table.</td>
</tr>
<tr>
<td>lock_owner</td>
<td>bigint</td>
<td>Transaction ID associated with the lock.</td>
</tr>
<tr>
<td>lock_owner_pid</td>
<td>bigint</td>
<td>Process ID associated with the lock.</td>
</tr>
<tr>
<td>lock_owner_start_ts</td>
<td>timestamp</td>
<td>Timestamp for the transaction start time.</td>
</tr>
<tr>
<td>lock_owner_end_ts</td>
<td>timestamp</td>
<td>Timestamp for the transaction end time.</td>
</tr>
<tr>
<td>lock_status</td>
<td>character (22)</td>
<td>Status of the process either waiting for or holding a lock.</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>table_id</th>
<th>last_update</th>
<th>lock_owner</th>
<th>lock_owner_pid</th>
</tr>
</thead>
<tbody>
<tr>
<td>100004</td>
<td>2008-12-23 10:08:48.882319</td>
<td>1043</td>
<td>5656</td>
</tr>
<tr>
<td>100003</td>
<td>2008-12-23 10:08:48.779543</td>
<td>1043</td>
<td>5656</td>
</tr>
<tr>
<td>100140</td>
<td>2008-12-23 10:08:48.021576</td>
<td>1043</td>
<td>5656</td>
</tr>
</tbody>
</table>

(3 rows)

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 Creating Materialized Views in Amazon Redshift (p. 218).
STV_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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>db_name</td>
<td>char(128)</td>
<td>The database that contains the materialized view.</td>
</tr>
<tr>
<td>schema</td>
<td>char(128)</td>
<td>The schema of the database.</td>
</tr>
<tr>
<td>name</td>
<td>char(128)</td>
<td>The materialized view name.</td>
</tr>
<tr>
<td>updated_upto_xid</td>
<td>bigint</td>
<td>Reserved for internal use.</td>
</tr>
<tr>
<td>is_stale</td>
<td>char(1)</td>
<td>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.</td>
</tr>
<tr>
<td>owner_user_name</td>
<td>char(128)</td>
<td>The user who owns the materialized view.</td>
</tr>
<tr>
<td>state</td>
<td>integer</td>
<td>The state of the materialized view as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 0 – The materialized view can be recomputed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1 – The materialized view is incremental.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 101 – The materialized view can't be refreshed due to a dropped column.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 102 – The materialized view can't be refreshed due to a changed column type. This constraint applies even if the column isn't used in the materialized view.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 103 – The materialized view can't be refreshed due to a renamed table.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 104 – The materialized view can't be refreshed due to a renamed column.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 105 – The materialized view can't be refreshed due to a renamed schema.</td>
</tr>
</tbody>
</table>

Sample Query

To view the state of all materialized views, run the following query.

```sql
select * from stv_mv_info;
```

This query returns the following sample output.

```
<table>
<thead>
<tr>
<th>db_name</th>
<th>schema</th>
<th>name</th>
<th>updated_upto_xid</th>
<th>is_stale</th>
<th>owner_user_name</th>
<th>state</th>
</tr>
</thead>
</table>
```

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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 partition, or slice.

STV_PARTITIONS is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>owner</td>
<td>integer</td>
<td>Disk node that owns the partition.</td>
</tr>
<tr>
<td>host</td>
<td>integer</td>
<td>Node that is physically attached to the partition.</td>
</tr>
<tr>
<td>diskno</td>
<td>integer</td>
<td>Disk containing the partition.</td>
</tr>
<tr>
<td>part_begin</td>
<td>bigint</td>
<td>Offset of the partition. Raw devices are logically partitioned to open space for mirror blocks.</td>
</tr>
<tr>
<td>part_end</td>
<td>bigint</td>
<td>End of the partition.</td>
</tr>
<tr>
<td>used</td>
<td>integer</td>
<td>Number of 1 MB disk blocks currently in use on the partition.</td>
</tr>
<tr>
<td>tossed</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>capacity</td>
<td>integer</td>
<td>Total capacity of the partition in 1 MB disk blocks.</td>
</tr>
<tr>
<td>reads</td>
<td>bigint</td>
<td>Number of reads that have occurred since the last cluster restart.</td>
</tr>
<tr>
<td>writes</td>
<td>bigint</td>
<td>Number of writes that have occurred since the last cluster restart.</td>
</tr>
<tr>
<td>seek_forward</td>
<td>integer</td>
<td>Number of times that a request is not for the subsequent address given the previous request address.</td>
</tr>
<tr>
<td>seek_back</td>
<td>integer</td>
<td>Number of times that a request is not for the previous address given the subsequent address.</td>
</tr>
<tr>
<td>is_san</td>
<td>integer</td>
<td>Whether the partition belongs to a SAN. Valid values are 0 (false) or 1 (true).</td>
</tr>
</tbody>
</table>
### 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.

```sql
select owner, host, diskno, used, capacity, 
(used-tossed)/capacity::numeric *100 as pctused
from stv_partitions order by owner;
```

<table>
<thead>
<tr>
<th>owner</th>
<th>host</th>
<th>diskno</th>
<th>used</th>
<th>capacity</th>
<th>pctused</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>236480</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>236420</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2</td>
<td>236440</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>235150</td>
<td>949954</td>
<td>24.8</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>237100</td>
<td>949954</td>
<td>25.0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>237090</td>
<td>949954</td>
<td>25.0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>236310</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>236300</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>236300</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>2</td>
<td>236320</td>
<td>949954</td>
<td>24.9</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>237910</td>
<td>949954</td>
<td>25.0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>235640</td>
<td>949954</td>
<td>24.8</td>
</tr>
</tbody>
</table>

(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** (p. 962) 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** (p. 281).
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 (p. 3).

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.

This table 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 (p. 915).

### Table Rows

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user that ran the query that generated the entry.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the WLM query queue (service class). Query queues are defined in the WLM configuration. Metrics are reported only for user-defined queues.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>slices</td>
<td>integer</td>
<td>Number of slices for the cluster.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>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 <code>-1</code>, metrics segment values are rolled up to the query level.</td>
</tr>
<tr>
<td>step_type</td>
<td>integer</td>
<td>Type of step that executed. For a description of step types, see Step Types (p. 1008).</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of rows processed by a step.</td>
</tr>
<tr>
<td>max_rows</td>
<td>bigint</td>
<td>Maximum number of rows output for a step, aggregated across all slices.</td>
</tr>
<tr>
<td>cpu_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>max_cpu_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>blocks_read</td>
<td>bigint</td>
<td>Number of 1 MB blocks read by the query or segment.</td>
</tr>
<tr>
<td>max_blocks_read</td>
<td>bigint</td>
<td>Maximum number of 1 MB blocks read by the segment, aggregated across all slices. At the segment level, the maximum</td>
</tr>
</tbody>
</table>
### Row Name Data Type Description

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number_of_1_MB_blocks_read_for_the_segment_across_all_slices</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>run_time</td>
<td>bigint</td>
<td>Total run time, summed across slices. Run time doesn't include wait time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>max_run_time</td>
<td>bigint</td>
<td>The maximum elapsed time for a segment, in microseconds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>max_blocks_to_disk</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>blocks_to_disk</td>
<td>bigint</td>
<td>The amount of disk space used by a query or segment to write intermediate results, in 1 MB blocks.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>max_query_scan_size</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>query_scan_size</td>
<td>bigint</td>
<td>The size of data scanned by a query, in MB.</td>
</tr>
<tr>
<td>query_priority</td>
<td>integer</td>
<td>The priority of the query. Possible values are -1, 0, 1, 2, 3, and 4, where -1 means that query priority isn't supported.</td>
</tr>
<tr>
<td>query_queue_time</td>
<td>bigint</td>
<td>The amount of time in microseconds that the query was queued.</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Step Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scan table</td>
</tr>
<tr>
<td>2</td>
<td>Insert rows</td>
</tr>
<tr>
<td>3</td>
<td>Aggregate rows</td>
</tr>
<tr>
<td>6</td>
<td>Sort step</td>
</tr>
<tr>
<td>7</td>
<td>Merge step</td>
</tr>
</tbody>
</table>
### Step Type | Description
---|---
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 than 1,000 seconds), run the following query.

```sql
select query, cpu_time / 1000000 as cpu_seconds
from stv_query_metrics where segment = -1 and cpu_time > 1000000000
order by cpu_time;
```

<table>
<thead>
<tr>
<th>query</th>
<th>cpu_seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>25775</td>
<td>9540</td>
</tr>
</tbody>
</table>

To find active queries with a nested loop join that returned more than one million rows, run the following query.

```sql
select query, rows
from stv_query_metrics
where step_type = 15 and rows > 1000000
order by rows;
```

<table>
<thead>
<tr>
<th>query</th>
<th>rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1009</td>
<td></td>
</tr>
</tbody>
</table>
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 > 6000000 and cpu_time < 10000000;
```

<table>
<thead>
<tr>
<th>query</th>
<th>run_time_seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>25775</td>
<td>114</td>
</tr>
</tbody>
</table>

**STV_RECENTS**

Use the STV_RECENTS table to find out information about the currently active and recently run queries
against a database.

All rows in STV_RECENTS, including rows generated by another user, are visible to all users.

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>status</td>
<td>character(20)</td>
<td>Query status. Valid values are Running, Done.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time that the query started.</td>
</tr>
<tr>
<td>duration</td>
<td>integer</td>
<td>Number of microseconds since the session started.</td>
</tr>
<tr>
<td>user_name</td>
<td>character(50)</td>
<td>User name who ran the process.</td>
</tr>
<tr>
<td>db_name</td>
<td>character(50)</td>
<td>Name of the database.</td>
</tr>
<tr>
<td>query</td>
<td>character(600)</td>
<td>Query text, up to 600 characters. Any additional characters are truncated.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID for the session associated with the query, which is always -1 for queries that have completed.</td>
</tr>
</tbody>
</table>

**Sample Queries**

To determine what queries are currently running against the database, type 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:

<table>
<thead>
<tr>
<th>user_name</th>
<th>db_name</th>
<th>pid</th>
<th>query</th>
</tr>
</thead>
</table>
The following example returns a list of queries (if any) that are running or waiting in queue to be executed:

```
select * from stv_recent where status<>'Done';
```

<table>
<thead>
<tr>
<th>status</th>
<th>starttime</th>
<th>duration</th>
<th>user_name</th>
<th>db_name</th>
<th>query</th>
<th>pid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running</td>
<td>2010-04-21 16:11...</td>
<td>28156454</td>
<td>dwuser</td>
<td>tickit</td>
<td>select venuename, venueseats from venue where venueseats &gt; 50000 order by venueseats desc;</td>
<td>23347</td>
</tr>
</tbody>
</table>

This query does not return results unless you are running a number of concurrent queries and some of those queries are in 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_recent where status<>'Done'
and pid not in (select pid from stv_inflight);
```

---

**STV_SESSIONS**

Use the STV_SESSIONS table to view information about the active user sessions for Amazon Redshift.

To view session history, use the STL_SESSIONS (p. 976) table instead of STV_SESSIONS.

All rows in STV_SESSIONS, including rows generated by another user, are visible to all users.

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time that the session started.</td>
</tr>
<tr>
<td>process</td>
<td>integer</td>
<td>Process ID for the session.</td>
</tr>
<tr>
<td>user_name</td>
<td>character(50)</td>
<td>User associated with the session.</td>
</tr>
<tr>
<td>db_name</td>
<td>character(50)</td>
<td>Name of the database associated with the session.</td>
</tr>
</tbody>
</table>

**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 into the database.
To view all active sessions for Amazon Redshift, type the following query:

```sql
select *
from stv_sessions;
```

The following result shows four active sessions currently running on Amazon Redshift:

<table>
<thead>
<tr>
<th>starttime</th>
<th>process</th>
<th>user_name</th>
<th>db_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018-08-06 08:44:07.50</td>
<td>13779</td>
<td>IAMA:aws_admin:admin_grp</td>
<td>dev</td>
</tr>
<tr>
<td>2008-08-06 08:54:20.50</td>
<td>19829</td>
<td>dwuser</td>
<td>dev</td>
</tr>
<tr>
<td>2008-08-06 08:56:34.50</td>
<td>20279</td>
<td>dwuser</td>
<td>dev</td>
</tr>
<tr>
<td>2008-08-06 08:55:00.50</td>
<td>19996</td>
<td>dwuser</td>
<td>tickit</td>
</tr>
</tbody>
</table>

(3 rows)

The user name prefixed with IAMA indicates that the user signed on using federated single sign-on (SSO). 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>node</td>
<td>integer</td>
<td>Cluster node where the slice is located.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice.</td>
</tr>
<tr>
<td>localslice</td>
<td>integer</td>
<td>This information is for internal use only.</td>
</tr>
</tbody>
</table>

#### Sample Query

To view which cluster nodes are managing which slices, type the following query:

```sql
select * from stv_slices;
```

This query returns the following sample output:

<table>
<thead>
<tr>
<th>node</th>
<th>slice</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(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 only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>db_id</td>
<td>integer</td>
<td>Database ID.</td>
</tr>
<tr>
<td>table_id</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>table_name</td>
<td>character(137)</td>
<td>Table name.</td>
</tr>
</tbody>
</table>

Sample Queries

To monitor which tables are temporarily locked, execute the following query after a cluster restart.

```sql
select * from STV_STARTUP_RECOVERY_STATE;
```

```
+----+--------+--------------+
<table>
<thead>
<tr>
<th>db_id</th>
<th>tbl_id</th>
<th>table_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>100044</td>
<td>100058</td>
<td>lineorder</td>
</tr>
<tr>
<td>100044</td>
<td>100068</td>
<td>part</td>
</tr>
<tr>
<td>100044</td>
<td>100072</td>
<td>customer</td>
</tr>
<tr>
<td>100044</td>
<td>100192</td>
<td>supplier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4 rows)</td>
</tr>
</tbody>
</table>
```

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 (p. 1015), 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice allocated to the table.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>id</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>name</td>
<td>character(72)</td>
<td>Table name.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of data rows in the slice.</td>
</tr>
<tr>
<td>sorted_rows</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>temp</td>
<td>integer</td>
<td>Whether or not the table is a temporary table. 0 = false; 1 = true.</td>
</tr>
<tr>
<td>db_id</td>
<td>integer</td>
<td>ID of the database where the table was created.</td>
</tr>
<tr>
<td>insert_pristine</td>
<td>integer</td>
<td>For internal use.</td>
</tr>
<tr>
<td>delete_pristine</td>
<td>integer</td>
<td>For internal use.</td>
</tr>
<tr>
<td>backup</td>
<td>integer</td>
<td>Value that indicates whether the table is included in cluster snapshots. 0 = no; 1 = yes. For more information, see the BACKUP (p. 542) parameter for the CREATE TABLE command.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following query returns a list of distinct table IDs and names:

```sql
select distinct id, name
from stv_tbl_perm order by name;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>100571</td>
<td>category</td>
</tr>
<tr>
<td>100575</td>
<td>date</td>
</tr>
<tr>
<td>100580</td>
<td>event</td>
</tr>
<tr>
<td>100596</td>
<td>listing</td>
</tr>
<tr>
<td>100003</td>
<td>padb_config_harvest</td>
</tr>
<tr>
<td>100612</td>
<td>sales</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

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:

```sql
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'
order by col;
```

<table>
<thead>
<tr>
<th>col</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
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:

```sql
delete from venue
where venueid in (1,2);

select count(*) from venue;

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
</tbody>
</table>

(1 row)

select trim(name) tablename, sum(rows)
from stv_tbl_perm where name='venue' group by name;

<table>
<thead>
<tr>
<th>tablename</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>venue</td>
<td>202</td>
</tr>
</tbody>
</table>

(1 row)
```

To synchronize the data in STV_TBL_PERM, run a full vacuum the VENUE table.

```sql
vacuum venue;

select trim(name) tablename, sum(rows)
from stv_tbl_perm where name='venue' group by name;

<table>
<thead>
<tr>
<th>tablename</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>venue</td>
<td>200</td>
</tr>
</tbody>
</table>

(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 (p. 1013) 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>slice</td>
<td>integer</td>
<td>Node slice allocated to the table.</td>
</tr>
<tr>
<td>id</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of data rows in the table.</td>
</tr>
<tr>
<td>size</td>
<td>bigint</td>
<td>Number of bytes allocated to the table.</td>
</tr>
<tr>
<td>query_id</td>
<td>bigint</td>
<td>Query ID.</td>
</tr>
<tr>
<td>ref_cnt</td>
<td>integer</td>
<td>Number of references.</td>
</tr>
<tr>
<td>from_suspended</td>
<td>integer</td>
<td>Whether or not this table was created during a query that is now suspended.</td>
</tr>
<tr>
<td>prep_swap</td>
<td>integer</td>
<td>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.)</td>
</tr>
</tbody>
</table>

Sample Queries

To view transient table information for a query with a query ID of 90, type the following command:

```sql
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_id | ref_cnt | from_suspended | prep_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_QMR_CONFIG**

Records the configuration for WLM query monitoring rules (QMR). For more information, see WLM Query Monitoring Rules (p. 347).

STV_WLM_QMR_CONFIG is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>service_class</td>
<td>integer</td>
<td>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 (p. 353).</td>
</tr>
<tr>
<td>rule_name</td>
<td>character(256)</td>
<td>Name of the query monitoring rule.</td>
</tr>
<tr>
<td>action</td>
<td>character(256)</td>
<td>Rule action. Possible values are log, hop, abort, and change_query_priority.</td>
</tr>
<tr>
<td>metric_name</td>
<td>character(256)</td>
<td>Name of the metric.</td>
</tr>
<tr>
<td>metric_operator</td>
<td>character(256)</td>
<td>The metric operator. Possible values are &gt;, =, &lt;.</td>
</tr>
<tr>
<td>metric_value</td>
<td>double</td>
<td>The threshold value for the specified metric that triggers an action.</td>
</tr>
<tr>
<td>action_value</td>
<td>character(256)</td>
<td>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.</td>
</tr>
</tbody>
</table>

**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 (p. 353).

```sql
Select *
from stv_wlm_qmr_config
where service_class > 5
order by service_class;
```

**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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>Service class ID. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>condition</td>
<td>character(128)</td>
<td>Query conditions.</td>
</tr>
<tr>
<td>action_seq</td>
<td>integer</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>action</td>
<td>character(64)</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>action_service_class</td>
<td>integer</td>
<td>The service class where the action takes place.</td>
</tr>
</tbody>
</table>

Sample Query

```sql
select * from STV_WLM_CLASSIFICATION_CONFIG;
```

```
<table>
<thead>
<tr>
<th>id</th>
<th>condition</th>
<th>action_seq</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(system user) and (query group: health)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>2</td>
<td>(system user) and (query group: metrics)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>3</td>
<td>(system user) and (query group: cmstats)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>4</td>
<td>(system user)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>5</td>
<td>(super user) and (query group: superuser)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>6</td>
<td>(query group: querygroup1)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>7</td>
<td>(user group: usergroup1)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>8</td>
<td>(user group: usergroup2)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>9</td>
<td>(query group: querygroup3)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>10</td>
<td>(query group: querygroup4)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>11</td>
<td>(user group: usergroup4)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>12</td>
<td>(query group: querygroup*)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>13</td>
<td>(user group: usergroup*)</td>
<td>0</td>
<td>assign</td>
</tr>
<tr>
<td>14</td>
<td>(querytype: any)</td>
<td>0</td>
<td>assign</td>
</tr>
</tbody>
</table>
```

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 (p. 915).
## Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see [WLM Service Class IDs](p. 353).</td>
</tr>
<tr>
<td>position</td>
<td>integer</td>
<td>Position of the query in the queue. The query with the smallest position value runs next.</td>
</tr>
<tr>
<td>task</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.</td>
</tr>
<tr>
<td>slot_count</td>
<td>integer</td>
<td>Number of WLM query slots.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>Time that the query entered the queue.</td>
</tr>
<tr>
<td>queue_time</td>
<td>bigint</td>
<td>Number of microseconds that the query has been in the queue.</td>
</tr>
</tbody>
</table>

## Sample Query

The following query shows the queries in the queue for service classes greater than 4.

```sql
select * from stv_wlm_query_queue_state
where service_class > 4
order by service_class;
```

This query returns the following sample output.

```
<table>
<thead>
<tr>
<th>service_class</th>
<th>position</th>
<th>task</th>
<th>query</th>
<th>slot_count</th>
<th>start_time</th>
<th>queue_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>455</td>
<td>476</td>
<td>5</td>
<td>2010-10-06 13:18:24.065838</td>
<td>20937257</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>456</td>
<td>478</td>
<td>5</td>
<td>2010-10-06 13:18:26.652906</td>
<td>18350191</td>
</tr>
</tbody>
</table>
```

## 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xid</td>
<td>integer</td>
<td>Transaction ID of the query or subquery.</td>
</tr>
<tr>
<td>task</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>slot_count</td>
<td>integer</td>
<td>Number of WLM query slots.</td>
</tr>
<tr>
<td>wlm_start_time</td>
<td>timestamp</td>
<td>Time that the query entered the system table queue or short query queue.</td>
</tr>
</tbody>
</table>
| state       | character(16) | Current state of the query or subquery. Possible values are:  
  - Classified  
  - Completed  
  - Dequeued  
  - Evicted  
  - Evicting  
  - Initialized  
  - Invalid  
  - Queued  
  - QueuedWaiting  
  - Rejected  
  - Returning  
  - Running  
  - TaskAssigned |
| 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 executing. |
| 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 (p. 353).
```
select xid, query, trim(state), queue_time, exec_time
from stv_wlm_query_state
where service_class > 4;
```

This query returns the following sample output:

```
xid    | query | trim | 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>task</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. If a query is restarted, the query is assigned a new query ID but not a new task ID.</td>
</tr>
<tr>
<td>slot_count</td>
<td>integer</td>
<td>Number of WLM query slots.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>Time that the query began executing.</td>
</tr>
<tr>
<td>exec_time</td>
<td>bigint</td>
<td>Number of microseconds that the query has been executing.</td>
</tr>
</tbody>
</table>

**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 (p. 353).

```
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
```
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>queueing_strategy</td>
<td>character(32)</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>num_query_tasks</td>
<td>integer</td>
<td>Current actual concurrency level of the service class.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>is configured.</td>
</tr>
<tr>
<td>target_num_query_tasks</td>
<td>integer</td>
<td>Concurrency level set by the most recent WLM configuration change.</td>
</tr>
<tr>
<td>evictable</td>
<td>character(8)</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>eviction_threshold</td>
<td>bigint</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>query_working_mem</td>
<td>integer</td>
<td>Current actual amount of working memory, in MB per slot, per node, assigned to the service class. If query_working_mem and target_query_working_mem are different, a dynamic WLM transition is in process. A value of -1 indicates that Auto WLM is configured.</td>
</tr>
<tr>
<td>target_query_working_mem</td>
<td>integer</td>
<td>The amount of working memory, in MB per slot, per node, set by the most recent WLM configuration change.</td>
</tr>
<tr>
<td>min_step_mem</td>
<td>integer</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>name</td>
<td>character(64)</td>
<td>Description of the service class.</td>
</tr>
<tr>
<td>max_execution_time</td>
<td>bigint</td>
<td>Number of milliseconds that the query can execute before being terminated.</td>
</tr>
<tr>
<td>user_group_wild_card</td>
<td>Boolean</td>
<td>If TRUE, the WLM queue treats an asterisk (*) as a wildcard character in user group strings in the WLM configuration.</td>
</tr>
<tr>
<td>query_group_wild_card</td>
<td>Boolean</td>
<td>If TRUE, the WLM queue treats an asterisk (*) as a wildcard character in query group strings in the WLM configuration.</td>
</tr>
</tbody>
</table>

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 (p. 353).
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;

<table>
<thead>
<tr>
<th>name</th>
<th>slots</th>
<th>mem</th>
<th>max_time</th>
<th>user_wildcard</th>
<th>query_wildcard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service class for super user</td>
<td>1</td>
<td>535</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Service class #1</td>
<td>5</td>
<td>125</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Service class #2</td>
<td>5</td>
<td>125</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Service class #3</td>
<td>5</td>
<td>125</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Service class #4</td>
<td>5</td>
<td>627</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Service class #5</td>
<td>5</td>
<td>125</td>
<td>0</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>Service class #6</td>
<td>5</td>
<td>125</td>
<td>0</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>
(6 rows)

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 (p. 344).

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;

<table>
<thead>
<tr>
<th>name</th>
<th>slots</th>
<th>target_slots</th>
<th>memory</th>
<th>target_mem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service class #3</td>
<td>5</td>
<td>15</td>
<td>125</td>
<td>375</td>
</tr>
<tr>
<td>Service class #5</td>
<td>10</td>
<td>5</td>
<td>250</td>
<td>125</td>
</tr>
</tbody>
</table>
(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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. For a list of service class IDs, see WLM Service Class IDs (p. 353).</td>
</tr>
<tr>
<td>num_queued_queries</td>
<td>integer</td>
<td>Number of queries currently in the queue.</td>
</tr>
<tr>
<td>num_executing_queries</td>
<td>integer</td>
<td>Number of queries currently executing.</td>
</tr>
<tr>
<td>num_serviced_queries</td>
<td>integer</td>
<td>Number of queries that have ever been in the service class.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>num_executed_queries</td>
<td>integer</td>
<td>Number of queries that have executed since Amazon Redshift was restarted.</td>
</tr>
<tr>
<td>num_evicted_queries</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>num_concurrency_scaling</td>
<td>integers</td>
<td>Number of queries run on a concurrency scaling cluster since Amazon Redshift was restarted.</td>
</tr>
</tbody>
</table>

**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 (p. 353).

```sql
select service_class, num_executing_queries, num_executed_queries
from stv_wlm_service_class_state
where service_class > 5
order by service_class;
```

<table>
<thead>
<tr>
<th>service_class</th>
<th>num_executing_queries</th>
<th>num_executed_queries</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>222</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>135</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>39</td>
</tr>
</tbody>
</table>

(3 rows)

**System Views**

System views contain a subset of data found in several of the STL and STV system tables.

These views provide quicker and easier access to commonly queried data found in those tables.

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.

**Note**

The SVL_QUERY_SUMMARY view only contains information about queries executed by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements executed by Amazon Redshift, including DDL and utility commands, you can query the SVL_STATEMENTTEXT view.

**Topics**

- SVCS_ALERT_EVENT_LOG (p. 1026)
- SVV_COLUMNS (p. 1027)
- SVCS_COMPILE (p. 1029)
- SVL_COMPILE (p. 1030)
- SVCS_CONCURRENCY_SCALING_USAGE (p. 1031)
• SVV_DISKUSAGE (p. 1032)
• SVCS_EXPLAIN (p. 1034)
• SVVEXTERNAL_COLUMNS (p. 1036)
• SVVEXTERNAL_DATABASES (p. 1036)
• SVVEXTERNAL_PARTITIONS (p. 1037)
• SVVEXTERNAL_SCHEMAS (p. 1037)
• SVVEXTERNAL_TABLES (p. 1038)
• SVVINTERLEAVED_COLUMNS (p. 1039)
• SVL_MV_REFRESH_STATUS (p. 1040)
• SVCS_PLAN_INFO (p. 1041)
• SVL_QERROR (p. 1043)
• SVL_QLOG (p. 1043)
• SVVQUERY_INFLIGHT (p. 1045)
• SVL_QUERY_METRICS (p. 1046)
• SVL_QUERY_METRICS_SUMMARY (p. 1047)
• SVL_QUERY_QUEUE_INFO (p. 1048)
• SVL_QUERY_REPORT (p. 1049)
• SVVQUERY_STATE (p. 1051)
• SVCS_QUERY_SUMMARY (p. 1053)
• SVL_QUERY_SUMMARY (p. 1055)
• SVCS_S3LIST (p. 1057)
• SVL_S3LIST (p. 1058)
• SVCS_S3LOG (p. 1059)
• SVL_S3LOG (p. 1060)
• SVL_S3PARTITION (p. 1061)
• SVCS_S3PARTITION_SUMMARY (p. 1062)
• SVL_S3PARTITION_SUMMARY (p. 1063)
• SVL_S3QUERY (p. 1064)
• SVCS_S3QUERY_SUMMARY (p. 1066)
• SVL_S3QUERY_SUMMARY (p. 1068)
• SVL_S3RETRIES (p. 1071)
• SVL_STATEMENTTEXT (p. 1072)
• SVL_STORED_PROC_CALL (p. 1074)
• SVCS_STREAM_SEGS (p. 1075)
• SVV_TABLES (p. 1076)
• SVV_TABLE_INFO (p. 1076)
• SVV_TRANSACTIIONS (p. 1079)
• SVL_UDF_LOG (p. 1080)
• SVCS_UNLOAD_LOG (p. 1082)
• SVL_USER_INFO (p. 1083)
• SVV_VACUUM_PROGRESS (p. 1084)
• SVV_VACUUM_SUMMARY (p. 1085)
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 (p. 281).

**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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the statement and slice. The same query might have multiple PIDs if it executes on multiple slices.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID associated with the statement.</td>
</tr>
<tr>
<td>event</td>
<td>character(1024)</td>
<td>Description of the alert event.</td>
</tr>
<tr>
<td>solution</td>
<td>character(1024)</td>
<td>Recommended solution.</td>
</tr>
<tr>
<td>event_time</td>
<td>timestamp</td>
<td>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.</td>
</tr>
</tbody>
</table>

**Usage Notes**

You can use the SVCS_ALERT_EVENT_LOG to identify potential issues in your queries, then follow the practices in Tuning Query Performance (p. 281) 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 (p. 27).
- **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` (p. 974) 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 Choosing Sort Keys (p. 66).

- **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 (p. 142).

- **Large Distribution**

More than 1,000,000 rows were redistributed for hash join or aggregation. For more information, see Choosing a Data Distribution Style (p. 55).

- **Large Broadcast**

More than 1,000,000 rows were broadcast for hash join. For more information, see Choosing a Data Distribution Style (p. 55).

- **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 Choosing a Data Distribution Style (p. 55).

### Sample Queries

The following query shows alert events for four queries.

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>event</th>
<th>solution</th>
<th>event_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>6567</td>
<td>Missing query planner statistic</td>
<td>Run the ANALYZE command</td>
<td>2014-01-03 18:20:58</td>
</tr>
<tr>
<td>7450</td>
<td>Scanned a large number of deleted rows</td>
<td>Run the VACUUM command to rec</td>
<td>2014-01-03 21:19:31</td>
</tr>
<tr>
<td>8406</td>
<td>Nested Loop Join in the query</td>
<td>Review the join predicates to</td>
<td>2014-01-04 00:34:22</td>
</tr>
<tr>
<td>29512</td>
<td>Very selective query filter:r</td>
<td>Review the choice of sort key</td>
<td>2014-01-06 22:00:00</td>
</tr>
</tbody>
</table>

(4 rows)

### SVV_COLUMNS

Use SVV_COLUMNS to view catalog information about the columns of local and external tables and views, including late-binding views (p. 562).

SVV_COLUMNS is visible to all users. Superusers can see all rows; regular users can see only metadata to which they have access.
The SVV_COLUMNS view joins table metadata from the System Catalog Tables (p. 1087) (tables with a PG prefix) and the SVV_EXTERNAL_COLUMNS (p. 1036) 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 SVVEXTERNAL_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 the user-defined tables if they own the table or have been granted access.

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_catalog</td>
<td>text</td>
<td>The name of the catalog where the table is.</td>
</tr>
<tr>
<td>table_schema</td>
<td>text</td>
<td>The schema name for the table.</td>
</tr>
<tr>
<td>table_name</td>
<td>text</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>column_name</td>
<td>text</td>
<td>The name of the column.</td>
</tr>
<tr>
<td>ordinal_position</td>
<td>int</td>
<td>The position of the column in the table.</td>
</tr>
<tr>
<td>column_default</td>
<td>text</td>
<td>The default value of the column.</td>
</tr>
<tr>
<td>is_nullable</td>
<td>text</td>
<td>A value that indicates whether the column is nullable.</td>
</tr>
<tr>
<td>data_type</td>
<td>text</td>
<td>The data type of the column.</td>
</tr>
<tr>
<td>character_maximum_length</td>
<td>int</td>
<td>The maximum number of characters in the column.</td>
</tr>
<tr>
<td>numeric_precision</td>
<td>int</td>
<td>The numeric precision.</td>
</tr>
<tr>
<td>numeric_precision_radix</td>
<td>int</td>
<td>The numeric precision radix.</td>
</tr>
<tr>
<td>numeric_scale</td>
<td>int</td>
<td>The numeric scale.</td>
</tr>
<tr>
<td>datetime_precision</td>
<td>int</td>
<td>The datetime precision.</td>
</tr>
<tr>
<td>interval_type</td>
<td>text</td>
<td>The interval type.</td>
</tr>
<tr>
<td>interval_precision</td>
<td>text</td>
<td>The interval precision.</td>
</tr>
<tr>
<td>character_set_catalog</td>
<td>text</td>
<td>The character set catalog.</td>
</tr>
<tr>
<td>character_set_schema</td>
<td>text</td>
<td>The character set schema.</td>
</tr>
<tr>
<td>character_set_name</td>
<td>text</td>
<td>The character set name.</td>
</tr>
<tr>
<td>collation_catalog</td>
<td>text</td>
<td>The collation catalog.</td>
</tr>
<tr>
<td>collation_schema</td>
<td>text</td>
<td>The collation scheme.</td>
</tr>
<tr>
<td>collation_name</td>
<td>text</td>
<td>The collation name.</td>
</tr>
<tr>
<td>domain_name</td>
<td>text</td>
<td>The domain name.</td>
</tr>
</tbody>
</table>
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.

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID associated with the statement.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID associated with the statement.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID. You can use this ID to join various other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The query segment to be compiled.</td>
</tr>
<tr>
<td>locus</td>
<td>integer</td>
<td>The location where the segment executes, 1 if on a compute node and 2 if on the leader node.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>The time in Universal Coordinated Time (UTC) that the compile started.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>The time in UTC that the compile ended.</td>
</tr>
<tr>
<td>compile</td>
<td>integer</td>
<td>A value that is 0 if the compile was reused and 1 if the segment was compiled.</td>
</tr>
</tbody>
</table>

**Sample Queries**

In this example, queries 35878 and 35879 executed 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.

```sql
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;
```
SVL_COMPILE

Records compile time and location for each query segment of queries.

SVL_COMPILE is visible to all users.

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID associated with the statement.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the statement.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The query segment to be compiled.</td>
</tr>
<tr>
<td>locus</td>
<td>integer</td>
<td>Location where the segment executes. 1 if on a compute node and 2 if on the leader node.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the compile started.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the compile ended.</td>
</tr>
<tr>
<td>compile</td>
<td>integer</td>
<td>0 if the compile was reused, 1 if the segment was compiled.</td>
</tr>
</tbody>
</table>

Sample Queries

In this example, queries 35878 and 35879 executed 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.
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.

By default, this view is visible by a superuser only. The database superuser can choose to open it up to all users.

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>start_time</td>
<td>timestamp without time zone</td>
<td>When the usage period starts.</td>
</tr>
<tr>
<td>end_time</td>
<td>timestamp without time zone</td>
<td>When the usage period ends.</td>
</tr>
<tr>
<td>queries</td>
<td>bigint</td>
<td>Number of queries run during this usage period.</td>
</tr>
<tr>
<td>usage_in_seconds</td>
<td>numeric(27,0)</td>
<td>Total seconds in this usage period.</td>
</tr>
</tbody>
</table>

**Sample Queries**

To view the usage duration in seconds for a specific period, enter the following query:
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 (p. 1005) 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>db_id</td>
<td>integer</td>
<td>Database ID.</td>
</tr>
<tr>
<td>name</td>
<td>character(72)</td>
<td>Table name.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Data slice allocated to the table.</td>
</tr>
<tr>
<td>col</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>blocknum</td>
<td>integer</td>
<td>ID for the data block.</td>
</tr>
<tr>
<td>num_values</td>
<td>integer</td>
<td>Number of values contained on the block.</td>
</tr>
<tr>
<td>minvalue</td>
<td>bigint</td>
<td>Minimum value contained on the block.</td>
</tr>
<tr>
<td>maxvalue</td>
<td>bigint</td>
<td>Maximum value contained on the block.</td>
</tr>
<tr>
<td>sb_pos</td>
<td>integer</td>
<td>Internal identifier for the position of the super block on disk.</td>
</tr>
<tr>
<td>pinned</td>
<td>integer</td>
<td>Whether or not the block is pinned into memory as part of pre-load. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>on_disk</td>
<td>integer</td>
<td>Whether or not the block is automatically stored on disk. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>modified</td>
<td>integer</td>
<td>Whether or not the block has been modified. 0 = false; 1 = true. Default is false.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>hdr_modified</td>
<td>integer</td>
<td>Whether or not the block header has been modified. 0 = false; 1 = true.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default is false.</td>
</tr>
<tr>
<td>unsorted</td>
<td>integer</td>
<td>Whether or not a block is unsorted. 0 = false; 1 = true. Default is true.</td>
</tr>
<tr>
<td>tombstone</td>
<td>integer</td>
<td>For internal use.</td>
</tr>
<tr>
<td>preferred_diskno</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>temporary</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>newblock</td>
<td>integer</td>
<td>Indicates whether or not a block is new (true) or was never committed to disk (false). 0 = false; 1 = true.</td>
</tr>
</tbody>
</table>

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):

```sql
select db_id, trim(name) as tablename, max(blocknum) from svv_diskusage
where name='users' and col=6
group by db_id, name;
```

<table>
<thead>
<tr>
<th>db_id</th>
<th>tablename</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>175857</td>
<td>users</td>
<td>2</td>
</tr>
</tbody>
</table>

(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.)

```sql
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;
```

<table>
<thead>
<tr>
<th>db_id</th>
<th>tablename</th>
<th>col</th>
<th>tbl</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>0</td>
<td>187605</td>
<td>154</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>1</td>
<td>187605</td>
<td>154</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>2</td>
<td>187605</td>
<td>154</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>3</td>
<td>187605</td>
<td>154</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>4</td>
<td>187605</td>
<td>154</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>5</td>
<td>187605</td>
<td>79</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>6</td>
<td>187605</td>
<td>79</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>7</td>
<td>187605</td>
<td>302</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>8</td>
<td>187605</td>
<td>302</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>9</td>
<td>187605</td>
<td>302</td>
</tr>
<tr>
<td>175857</td>
<td>salesnew</td>
<td>10</td>
<td>187605</td>
<td>3</td>
</tr>
</tbody>
</table>
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.

This table 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>nodeid</td>
<td>integer</td>
<td>Plan node identifier, where a node maps to one or more steps in the execution of the query.</td>
</tr>
<tr>
<td>parentid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>plannode</td>
<td>character(400)</td>
<td>The node text from the EXPLAIN output. Plan nodes that refer to execution on compute nodes are prefixed with XN in the EXPLAIN output.</td>
</tr>
<tr>
<td>info</td>
<td>character(400)</td>
<td>Qualifier and filter information for the plan node. For example, join conditions and WHERE clause restrictions are included in this column.</td>
</tr>
</tbody>
</table>

Sample Queries

Consider the following EXPLAIN output for an aggregate join query:

```sql
explain select avg(datediff(day, listtime, saletime)) as avgwait
from sales, listing where sales.listid = listing.listid;
```
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:

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>nodeid</th>
<th>parentid</th>
<th>substring</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>XN Aggregate (cost=6717.61..6)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1</td>
<td>-&gt; XN Merge Join DS_DIST_NO Merge Cond:&quot;outer&quot;</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>2</td>
<td>-&gt; XN Seq Scan on lis</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>2</td>
<td>-&gt; XN Seq Scan on sal</td>
<td></td>
</tr>
</tbody>
</table>

(4 rows)

Consider the following query:

```sql
select event.eventid, sum(pricepaid)
from event, sales
where event.eventid=sales.eventid
group by event.eventid order by 2 desc;
```

<table>
<thead>
<tr>
<th>eventid</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>289</td>
<td>51846.00</td>
</tr>
<tr>
<td>7895</td>
<td>51049.00</td>
</tr>
<tr>
<td>1602</td>
<td>50301.00</td>
</tr>
<tr>
<td>851</td>
<td>49956.00</td>
</tr>
<tr>
<td>7315</td>
<td>49823.00</td>
</tr>
</tbody>
</table>

If this query’s ID is 15, the following system table query returns the plan nodes that were executed. In this case, the order of the nodes is reversed to show the actual order of execution:

```sql
select query,nodeid,parentid,substring(plannode from 1 for 56)
from svcs_explain where query=15 order by 1, 2 desc;
```

<table>
<thead>
<tr>
<th>query</th>
<th>nodeid</th>
<th>parentid</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>8</td>
<td>7</td>
<td>-&gt; XN Seq Scan on eve</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>5</td>
<td>-&gt; XN Hash(cost=87.98..87.9)</td>
</tr>
</tbody>
</table>
| 15    | 6      | 5        | -> XN Seq Scan on sales(cost=862286577.07..1000862287175.47..1000862287197.46 rows=87)
| 15    | 5      | 4        | -> XN Hash Join DS_DIST_OUTER(cost=862286577.07..1000862287175.47..1000862287197.46 rows=87) |
| 15    | 4      | 3        | -> XN HashAggregate(cost=862286577.07..1000862287175.47..1000862287197.46 rows=87) |
| 15    | 3      | 2        | -> XN Sort(cost=1000862287175.47..1000862287197.46 rows=87) |
| 15    | 2      | 1        | -> XN Network(cost=1000862287175.47..1000862287197.46 rows=87) |
| 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:

```sql
select query, trim(plannode) from svcs_explain
where plannode like '%Window%';
```

<table>
<thead>
<tr>
<th>query</th>
<th>btrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>-&gt; XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)</td>
</tr>
<tr>
<td>27</td>
<td>-&gt; XN Window(cost=1000985348268.57..1000985351256.98 rows=170 width=33)</td>
</tr>
</tbody>
</table>

(2 rows)
**SVV_EXTERNAL_COLUMNS**

Use SVV_EXTERNAL_COLUMNS to view details for columns in external tables.

SVV_EXTERNAL_COLUMNS 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 (p. 510).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>schemaname</td>
<td>text</td>
<td>The name of the Amazon Redshift external schema for the external table.</td>
</tr>
<tr>
<td>tablename</td>
<td>text</td>
<td>The name of the external table.</td>
</tr>
<tr>
<td>columnname</td>
<td>text</td>
<td>The name of the column.</td>
</tr>
<tr>
<td>external_type</td>
<td>text</td>
<td>The data type of the column.</td>
</tr>
<tr>
<td>columnnum</td>
<td>integer</td>
<td>The external column number, starting from 1.</td>
</tr>
<tr>
<td>part_key</td>
<td>integer</td>
<td>If the column is a partition key, the order of the key. If the column isn’t a partition, the value is 0.</td>
</tr>
</tbody>
</table>

**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 metadata to which they have access. For more information, see CREATE EXTERNAL SCHEMA (p. 510).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eskind</td>
<td>integer</td>
<td>The type of the external catalog for the database; 1 indicates a data catalog, 2 indicates a Hive metastore.</td>
</tr>
<tr>
<td>esoptions</td>
<td>text</td>
<td>Details of the catalog where the database resides.</td>
</tr>
<tr>
<td>databasename</td>
<td>text</td>
<td>The name of the database in the external catalog.</td>
</tr>
<tr>
<td>location</td>
<td>text</td>
<td>The location of the database.</td>
</tr>
<tr>
<td>parameters</td>
<td>text</td>
<td>Database parameters.</td>
</tr>
</tbody>
</table>
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 metadata to which they have access. For more information, see CREATE EXTERNAL SCHEMA (p. 510).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>schemaname</td>
<td>text</td>
<td>The name of the Amazon Redshift external schema for the external table with the specified partitions.</td>
</tr>
<tr>
<td>tablename</td>
<td>text</td>
<td>The name of the external table.</td>
</tr>
<tr>
<td>values</td>
<td>text</td>
<td>Values for the partition.</td>
</tr>
<tr>
<td>location</td>
<td>text</td>
<td>The location of the partition. The column size is limited to 128 characters. Longer values are truncated.</td>
</tr>
<tr>
<td>input_format</td>
<td>text</td>
<td>The input format.</td>
</tr>
<tr>
<td>output_format</td>
<td>text</td>
<td>The output format.</td>
</tr>
<tr>
<td>serialization_lib</td>
<td>text</td>
<td>The serialization library.</td>
</tr>
<tr>
<td>serde_parameters</td>
<td>text</td>
<td>SerDe parameters.</td>
</tr>
<tr>
<td>compressed</td>
<td>integer</td>
<td>A value that indicates whether the partition is compressed; 1 indicates compressed, 0 indicates not compressed.</td>
</tr>
<tr>
<td>parameters</td>
<td>text</td>
<td>Partition properties.</td>
</tr>
</tbody>
</table>

SVV_EXTERNAL_SCHEMAS

Use SVV_EXTERNAL_SCHEMAS to view information about external schemas. For more information, see CREATE EXTERNAL SCHEMA (p. 510).

SVV_EXTERNAL_SCHEMAS is visible to all users. Superusers can see all rows; regular users can see only metadata to which they have access.

Table Columns

<table>
<thead>
<tr>
<th>Column Name Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>esoid</td>
<td>oid</td>
<td>External schema ID.</td>
</tr>
</tbody>
</table>
### SVV_EXTERNAL_TABLES

Use SVV_EXTERNAL_TABLES to view details for external tables. For more information, see CREATE EXTERNAL SCHEMA (p. 510).

SVV_EXTERNAL_TABLES is visible to all users. Superusers can see all rows; regular users can see only metadata to which they have access.

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>schemaname</td>
<td>text</td>
<td>The name of the Amazon Redshift external schema for the external table.</td>
</tr>
<tr>
<td>tablename</td>
<td>text</td>
<td>The name of the external table.</td>
</tr>
<tr>
<td>location</td>
<td>text</td>
<td>The location of the table.</td>
</tr>
<tr>
<td>input_format</td>
<td>text</td>
<td>The input format.</td>
</tr>
<tr>
<td>output_format</td>
<td>text</td>
<td>The output format.</td>
</tr>
<tr>
<td>serialization_lib</td>
<td>text</td>
<td>The serialization library.</td>
</tr>
<tr>
<td>serde_parameters</td>
<td>text</td>
<td>SerDe parameters.</td>
</tr>
<tr>
<td>compressed</td>
<td>integer</td>
<td>A value that indicates whether the table is compressed;</td>
</tr>
</tbody>
</table>
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 (p. 664). For more information about how to determine how often to run VACUUM and when to run a VACUUM REINDEX, see Managing Vacuum Times (p. 144).

SVV_INTERLEAVED_COLUMNS is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tbl</td>
<td>integer</td>
<td>Table ID.</td>
</tr>
<tr>
<td>col</td>
<td>integer</td>
<td>Zero-based index for the column.</td>
</tr>
<tr>
<td>interleaved_skew</td>
<td>numeric(19,2)</td>
<td>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.</td>
</tr>
<tr>
<td>last_reindex</td>
<td>timestamp</td>
<td>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.</td>
</tr>
</tbody>
</table>

Sample Queries

To identify tables that might need to be reindexed, execute the following query.

```sql
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;
```
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 Creating Materialized Views in Amazon Redshift (p. 218).

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>db_name</td>
<td>char(128)</td>
<td>The database that contains the materialized view.</td>
</tr>
<tr>
<td>userid</td>
<td>bigint</td>
<td>The ID of the user who performed the refresh.</td>
</tr>
<tr>
<td>schema_name</td>
<td>char(128)</td>
<td>The schema of the materialized view.</td>
</tr>
<tr>
<td>mv_name</td>
<td>char(128)</td>
<td>The materialized view name.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID of the refresh.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>The start time of the refresh.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>The end time of the refresh.</td>
</tr>
<tr>
<td>status</td>
<td>text</td>
<td>The status of the refresh. Example values include the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh successfully updated MV incrementally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh successfully recomputed MV from scratch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh partially updated MV incrementally up to an active transaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• MV was already updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed. A base table column was renamed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed. A base table column type was changed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed. A base table was renamed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed due to an internal error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed. Schema of MV was renamed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Refresh failed. MV was not found</td>
</tr>
</tbody>
</table>

Sample Query

To view the refresh status of materialized views, run the following query.
This query returns the following sample output:

```
select * from svl_mv_refresh;
```

```
db_name | userid | schema   | name   | xid  | starttime          | endtime           | status
---------+--------+-----------+---------+-------+----------------------------+------------------------------------------------------
 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
 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
 dev     | 162    | mv_schema | mv_test | 6388  | 2020-02-14 02:26:27.918307 | 2020-02-14 02:26:27.918307 | Refresh successfully recomputed MV from scratch
 dev     | 161    | mv_schema | mv_test | 6323  | 2020-02-14 02:26:20.080002 | 2020-02-14 02:26:20.080002 | Refresh successfully updated MV incrementally
 dev     | 161    | mv_schema | mv_test | 6301  | 2020-02-14 02:26:05.796146 | 2020-02-14 02:26:05.796146 | Refresh successfully recomputed MV from scratch
 dev     | 153    | mv_schema | mv_test | 6024  | 2020-02-14 02:25:18.762335 | 2020-02-14 02:25:18.762335 | MV was already updated
 dev     | 143    | mv_schema | mv_test | 5557  | 2020-02-14 02:24:23.100633 | 2020-02-14 02:24:23.100633 | MV was already updated
 dev     | 141    | mv_schema | mv_test | 5447  | 2020-02-14 02:23:54.102837 | 2020-02-14 02:23:54.102837 | Refresh successfully updated MV incrementally
 dev     | 1      | mv_schema | mv_test | 5329  | 2020-02-14 02:22:26.328481 | 2020-02-14 02:22:26.328481 | Refresh successfully recomputed MV from scratch
 dev     | 138    | mv_schema | mv_test | 5290  | 2020-02-14 02:21:56.885093 | 2020-02-14 02:21:56.885093 | Refresh failed. MV was not found
```

**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.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>nodeid</td>
<td>integer</td>
<td>Plan node identifier, where a node maps to one or more steps in the execution of the query.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
</tbody>
</table>
### SVCS_PLAN_INFO

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>step</td>
<td>integer</td>
<td>Number that identifies the query step.</td>
</tr>
<tr>
<td>locus</td>
<td>integer</td>
<td>Location where the step executes. 0 if on a compute node and 1 if on the leader node.</td>
</tr>
<tr>
<td>plannode</td>
<td>integer</td>
<td>Enumerated value of the plan node. See the following table for enums for plannode. (The PLANNODE column in SVCS_EXPLAIN (p. 1034) contains the plan node text.)</td>
</tr>
<tr>
<td>startupcost</td>
<td>double precision</td>
<td>The estimated relative cost of returning the first row for this step.</td>
</tr>
<tr>
<td>totalcost</td>
<td>double precision</td>
<td>The estimated relative cost of executing the step.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>The estimated number of rows that will be produced by the step.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>The estimated number of bytes that will be produced by the step.</td>
</tr>
</tbody>
</table>

### 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.

```sql
explain select * from category;
```

```
QUERY PLAN
-------------------------------------------------------------
XN Seq Scan on category (cost=0.00..0.11 rows=11 width=49)
(1 row)
```

```sql
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
...
```

```sql
select * from svcs_plan_info where query=256;
```

```
query | nodeid | segment | step | locus | plannode | startupcost | totalcost | rows | bytes
-------+--------+---------+------+-------+----------+-------------+-----------+------+
256 | 1 | 0 | 1 | 0 | 104 | 0.11 | 11 | 539
256 | 1 | 0 | 0 | 0 | 104 | 0.11 | 11 | 539
(2 rows)
```

In this example, PLANNODE 104 refers to the sequential scan of the CATEGORY table.

```sql
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=1000000000136.82..1000000000137.82 rows=576 width=17)
Merge Key: eventname
-> XN Network (cost=1000000000136.82..1000000000137.82 rows=576
width=17)
Send to leader
-> XN Sort (cost=1000000000136.82..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)

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 (p. 960) 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
</tbody>
</table>
### SVL_QLOG

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. You can use this ID to join various other system tables and views.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the query.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Exact time when the statement started executing, with six digits of precision for fractional seconds—for example: <code>2009-06-12 11:29:19.131358</code></td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Exact time when the statement finished executing, with six digits of precision for fractional seconds—for example: <code>2009-06-12 11:29:19.193640</code></td>
</tr>
<tr>
<td>elapsed</td>
<td>bigint</td>
<td>Length of time that it took the query to execute (in microseconds).</td>
</tr>
<tr>
<td>aborted</td>
<td>integer</td>
<td>If a query was aborted by the system or cancelled by the user, this column contains 1. If the query ran to completion, this column contains 0. Queries that are aborted for workload management purposes and subsequently restarted also have a value of 1 in this column.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>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.</td>
</tr>
<tr>
<td>substring</td>
<td>character(60)</td>
<td>Truncated query text.</td>
</tr>
<tr>
<td>source_query</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>from_sp_call</td>
<td>integer</td>
<td>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.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following example returns the query ID, execution time, and truncated query text for the five most recent database queries executed by the user with `userid = 100`.

```sql
select query, pid, elapsed, substring from svl_qlog
where userid = 100
order by starttime desc
limit 5;
```

<table>
<thead>
<tr>
<th>query</th>
<th>pid</th>
<th>elapsed</th>
<th>substring</th>
</tr>
</thead>
<tbody>
<tr>
<td>187752</td>
<td>18921</td>
<td>18465685</td>
<td>select query, elapsed, substring from svl_qlog...</td>
</tr>
<tr>
<td>204168</td>
<td>5117</td>
<td>59603</td>
<td>insert into testtable values (100);</td>
</tr>
<tr>
<td>187561</td>
<td>17046</td>
<td>1003052</td>
<td>select * from pg_table_def where tablename...</td>
</tr>
<tr>
<td>187549</td>
<td>17046</td>
<td>1108584</td>
<td>select * from STV_WLM_SERVICE_CLASS_CONFIG</td>
</tr>
<tr>
<td>187468</td>
<td>17046</td>
<td>5670661</td>
<td>select * from pg_table_def where schemaname...</td>
</tr>
</tbody>
</table>
The following example returns the SQL script name (LABEL column) and elapsed time for a query that was cancelled (aborted=1):

```
select query, elapsed, label
from svl_qlog where aborted=1;
```

<table>
<thead>
<tr>
<th>query</th>
<th>elapsed</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>6935292</td>
<td>alltickittablesjoin.sql</td>
</tr>
</tbody>
</table>

SVV_QUERY_INFLIGHT

Use the SVV_QUERY_INFLIGHT view to determine what queries are currently running on the database. This view joins STV_INFLIGHT (p. 1000) to STL_QUERYTEXT (p. 965). SVV_QUERY_INFLIGHT does not show leader-node only queries. For more information, see Leader Node–Only Functions (p. 667).

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Slice where the query is running.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>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 (p. 934) table.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time that the query started.</td>
</tr>
<tr>
<td>suspended</td>
<td>integer</td>
<td>Whether the query is suspended: 0 = false; 1 = true.</td>
</tr>
<tr>
<td>text</td>
<td>character(200)</td>
<td>Query text, in 200-character increments.</td>
</tr>
<tr>
<td>sequence</td>
<td>integer</td>
<td>Sequence number for segments of query statements.</td>
</tr>
</tbody>
</table>

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;
```
### SVL_QUERY_METRICS

The SVL_QUERY_METRICS view shows the metrics for completed queries. This view is derived from the STL_QUERY_METRICS (p. 962) 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 (p. 347).

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 (p. 915).

### Table Rows

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user that ran the query that generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>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 (p. 353).</td>
</tr>
<tr>
<td>dimension</td>
<td>varchar(24)</td>
<td>Dimension on which the metric is reported. Possible values are query, segment, step.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>ID for the type of step that executed. The description for the step type is shown in the step_label column.</td>
</tr>
<tr>
<td>step_label</td>
<td>varchar(30)</td>
<td>Type of step that executed.</td>
</tr>
<tr>
<td>query_cpu_time</td>
<td>bigint</td>
<td>CPU time used by the query, in seconds. CPU time is distinct from query run time.</td>
</tr>
<tr>
<td>query_blocks_read</td>
<td>bigint</td>
<td>Number of 1 MB blocks read by the query.</td>
</tr>
<tr>
<td>query_execution_time</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>query_cpu_usage_percent</td>
<td>bigint</td>
<td>Percent of CPU capacity used by the query.</td>
</tr>
<tr>
<td>query_temp_blocks_written</td>
<td>bigint</td>
<td>The amount of disk space used by a query to write intermediate results, in MB.</td>
</tr>
</tbody>
</table>
### 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 (p. 962) 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 (p. 347).

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 (p. 915).

#### Table Rows

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user that ran the query that generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>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 (p. 353).</td>
</tr>
<tr>
<td>query_cpu_time</td>
<td>bigint</td>
<td>CPU time used by the query, in seconds. CPU time is distinct from query run time.</td>
</tr>
<tr>
<td>query_blocks_read</td>
<td>bigint</td>
<td>Number of 1 MB blocks read by the query.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Row Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>segment_execution_time</td>
<td>bigint</td>
<td>Elapsed execution time for a single segment, in seconds.</td>
</tr>
<tr>
<td>cpu_skew</td>
<td>numeric(38,2)</td>
<td>The ratio of maximum CPU usage for any slice to average CPU usage for all slices. This metric is defined at the segment level.</td>
</tr>
<tr>
<td>io_skew</td>
<td>numeric(38,2)</td>
<td>The ratio of maximum blocks read (I/O) for any slice to average blocks read for all slices.</td>
</tr>
<tr>
<td>scan_row_count</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>join_row_count</td>
<td>bigint</td>
<td>The number of rows processed in a join step.</td>
</tr>
<tr>
<td>nested_loop_join_row</td>
<td>bigint</td>
<td>The number of rows in a nested loop join.</td>
</tr>
<tr>
<td>return_row_count</td>
<td>bigint</td>
<td>The number of rows returned by the query.</td>
</tr>
<tr>
<td>spectrum_scan_row</td>
<td>bigint</td>
<td>The number of rows scanned by Amazon Redshift Spectrum in Amazon S3.</td>
</tr>
<tr>
<td>spectrum_scan_size</td>
<td>bigint</td>
<td>The amount of data, in MB, scanned by Amazon Redshift Spectrum in Amazon S3.</td>
</tr>
<tr>
<td>query_queue_time</td>
<td>bigint</td>
<td>The amount of time in seconds that the query was queued.</td>
</tr>
</tbody>
</table>
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 executed by the system and shows only queries executed by a user.

The SVL_QUERY_QUEUE_INFO view summarizes information from the STL_QUERY (p. 960), STL_WLM_QUERY (p. 993), and STL_COMMIT_STATS (p. 924) system tables.

This view is visible only to superusers. For more information, see Visibility of Data in System Tables and Views (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>database</td>
<td>text</td>
<td>The name of the database the user was connected to when the query was issued.</td>
</tr>
</tbody>
</table>
### 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 executed query steps.

This view breaks down the information about executed 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 (p. 915).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user that generated the query.</td>
</tr>
<tr>
<td>querytxt</td>
<td>text</td>
<td>First 100 characters of the query text.</td>
</tr>
<tr>
<td>queue_start_time</td>
<td>timestamp</td>
<td>Time in UTC when the query entered the WLM queue.</td>
</tr>
<tr>
<td>exec_start_time</td>
<td>timestamp</td>
<td>Time in UTC when query execution started.</td>
</tr>
<tr>
<td>service_class</td>
<td>integer</td>
<td>ID for the service class. Service classes are defined in the WLM configuration file.</td>
</tr>
<tr>
<td>slots</td>
<td>integer</td>
<td>Number of WLM query slots.</td>
</tr>
<tr>
<td>queue_elapsed</td>
<td>bigint</td>
<td>Time that the query spent waiting in a WLM queue (in seconds).</td>
</tr>
<tr>
<td>exec_elapsed</td>
<td>bigint</td>
<td>Time spent executing the query (in seconds).</td>
</tr>
<tr>
<td>wlm_total_elapsed</td>
<td>bigint</td>
<td>Time that the query spent in a WLM queue (queue_elapsed), plus time spent executing the query (exec_elapsed).</td>
</tr>
<tr>
<td>commit_queue_elapsed</td>
<td>bigint</td>
<td>Time that the query spent waiting in the commit queue (in seconds).</td>
</tr>
<tr>
<td>commit_exec_time</td>
<td>bigint</td>
<td>Time that the query spent in the commit operation (in seconds).</td>
</tr>
</tbody>
</table>

#### Sample Queries

The following example shows the time that queries spent in WLM queues.

```sql
select query, service_class, queue_elapsed, exec_elapsed, wlm_total_elapsed
from svl_query_queue_info
where wlm_total_elapsed > 0;
```

<table>
<thead>
<tr>
<th>query</th>
<th>service_class</th>
<th>queue_elapsed</th>
<th>exec_elapsed</th>
<th>wlm_total_elapsed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2742669</td>
<td>6</td>
<td>2</td>
<td>916</td>
<td>918</td>
</tr>
<tr>
<td>2742668</td>
<td>6</td>
<td>4</td>
<td>197</td>
<td>201</td>
</tr>
</tbody>
</table>
```

(2 rows)
# Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>Data slice where the step executed.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>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</td>
</tr>
<tr>
<td>end_time</td>
<td>timestamp</td>
<td>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</td>
</tr>
<tr>
<td>elapsed_time</td>
<td>bigint</td>
<td>Time (in microseconds) that it took the segment to execute.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of bytes produced by the step (per slice).</td>
</tr>
<tr>
<td>label</td>
<td>char(256)</td>
<td>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.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>Whether this step of the query was executed 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 executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>character(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step.</td>
</tr>
<tr>
<td>is_delayed_scan</td>
<td>character(1)</td>
<td>If true (t), indicates that delayed scan was used on the step.</td>
</tr>
<tr>
<td>rows_pre_filter</td>
<td>bigint</td>
<td>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.</td>
</tr>
</tbody>
</table>
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:

```sql
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:

<table>
<thead>
<tr>
<th>query</th>
<th>segment</th>
<th>step</th>
<th>max</th>
<th>min</th>
<th>case</th>
</tr>
</thead>
<tbody>
<tr>
<td>279</td>
<td>0</td>
<td>0</td>
<td>19721687</td>
<td>19721687</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>0</td>
<td>1</td>
<td>19721687</td>
<td>19721687</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>1</td>
<td>0</td>
<td>986085</td>
<td>986084</td>
<td>1.01411202804304e-06</td>
</tr>
<tr>
<td>279</td>
<td>1</td>
<td>1</td>
<td>986085</td>
<td>986084</td>
<td>1.01411202804304e-06</td>
</tr>
<tr>
<td>279</td>
<td>1</td>
<td>4</td>
<td>986085</td>
<td>986084</td>
<td>1.01411202804304e-06</td>
</tr>
<tr>
<td>279</td>
<td>2</td>
<td>0</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>2</td>
<td>2</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>0</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>2</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>3</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>4</td>
<td>0</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>4</td>
<td>1</td>
<td>1775517</td>
<td>788460</td>
<td>1.00098637606408</td>
</tr>
<tr>
<td>279</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>6</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>279</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

SVV_QUERY_STATE

Use SVV_QUERY_STATE to view information about the execution 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>seg</td>
<td>integer</td>
<td>Number of the query segment that is executing. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
</tbody>
</table>
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 execute and how many data rows Amazon Redshift processed:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>step</td>
<td>integer</td>
<td>Number of the query step that is executing. A step is the smallest unit of query execution. Each step represents a discrete unit of work, such as scanning a table, returning results, or sorting data.</td>
</tr>
<tr>
<td>maxtime</td>
<td>interval</td>
<td>Maximum amount of time (in microseconds) for this step to execute.</td>
</tr>
<tr>
<td>avgtime</td>
<td>interval</td>
<td>Average time (in microseconds) for this step to execute.</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of rows produced by the step that is executing.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of bytes produced by the step that is executing.</td>
</tr>
<tr>
<td>cpu</td>
<td>bigint</td>
<td>For internal use.</td>
</tr>
<tr>
<td>memory</td>
<td>bigint</td>
<td>For internal use.</td>
</tr>
<tr>
<td>rate_row</td>
<td>double precision</td>
<td>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.</td>
</tr>
<tr>
<td>rate_byte</td>
<td>double precision</td>
<td>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.</td>
</tr>
<tr>
<td>label</td>
<td>character(25)</td>
<td>Query label: a name for the step, such as scan or sort.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>Whether this step of the query is executing 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 executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Amount of working memory (in bytes) assigned to the query step.</td>
</tr>
<tr>
<td>num_parts</td>
<td>integer</td>
<td>Number of partitions a hash table is divided into during a hash step. The hash table is partitioned when it is estimated that the entire hash table might not fit into memory. A positive number in this column does not imply that the hash step executed as a disk-based operation. Check the value in the IS_DISKBASED column to see if the hash step was disk-based.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>character(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>is_delayed</td>
<td>character(1)</td>
<td>If true (t), indicates that delayed scan was used on the step. Default is false (f).</td>
</tr>
</tbody>
</table>
This query retrieves the processing information about query 279, as shown in the following sample output:

<table>
<thead>
<tr>
<th>query</th>
<th>seg</th>
<th>step</th>
<th>maxtime</th>
<th>avgtime</th>
<th>rows</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>279</td>
<td>3</td>
<td>0</td>
<td>1658054</td>
<td>1645711</td>
<td>1405360</td>
<td>scan</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>1</td>
<td>1658072</td>
<td>1645809</td>
<td>0</td>
<td>project</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>2</td>
<td>1658074</td>
<td>1645812</td>
<td>1405434</td>
<td>insert</td>
</tr>
<tr>
<td>279</td>
<td>3</td>
<td>3</td>
<td>1658080</td>
<td>1645816</td>
<td>1405437</td>
<td>distribute</td>
</tr>
<tr>
<td>279</td>
<td>4</td>
<td>0</td>
<td>1677443</td>
<td>1666189</td>
<td>1268431</td>
<td>scan</td>
</tr>
<tr>
<td>279</td>
<td>4</td>
<td>1</td>
<td>1677446</td>
<td>1666192</td>
<td>1268434</td>
<td>insert</td>
</tr>
</tbody>
</table>

(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:

```sql
select query, label, is_diskbased from svv_query_state
where is_diskbased = 't';
```

This sample output shows any active queries currently running on disk:

<table>
<thead>
<tr>
<th>query</th>
<th>label</th>
<th>is_diskbased</th>
</tr>
</thead>
<tbody>
<tr>
<td>1025</td>
<td>hash tbl=142</td>
<td>t</td>
</tr>
</tbody>
</table>

(1 row)

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 executed by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements executed 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>stm</td>
<td>integer</td>
<td>Stream: A set of concurrent segments in a query. A query has one or more streams.</td>
</tr>
<tr>
<td>seg</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>maxtime</td>
<td>bigint</td>
<td>Maximum amount of time for the step to execute (in microseconds).</td>
</tr>
<tr>
<td>avgttime</td>
<td>bigint</td>
<td>Average time for the step to execute (in microseconds).</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of data rows involved in the query step.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of data bytes involved in the query step.</td>
</tr>
<tr>
<td>rate_row</td>
<td>double precision</td>
<td>Query execution rate per row.</td>
</tr>
<tr>
<td>rate_byte</td>
<td>double precision</td>
<td>Query execution rate per byte.</td>
</tr>
<tr>
<td>label</td>
<td>text</td>
<td>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.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>Whether this step of the query was executed 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 executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Amount of working memory (in bytes) assigned to the query step.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>character(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>is_delayed_scan</td>
<td>character(1)</td>
<td>If true (t), indicates that delayed scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>rows_pre_filter</td>
<td>bigint</td>
<td>For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows).</td>
</tr>
</tbody>
</table>

**Sample Queries**

**Viewing Processing Information for a Query Step**

The following query shows basic processing information for each step of query 87:

```sql
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:

<table>
<thead>
<tr>
<th>query</th>
<th>stm</th>
<th>seg</th>
<th>step</th>
<th>rows</th>
<th>bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>1890</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>90</td>
<td>360</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>90</td>
<td>360</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>90</td>
<td>1440</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>210494</td>
<td>4209880</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>89500</td>
<td>0</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>87</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>87</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(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 (p. 1043) 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:

<table>
<thead>
<tr>
<th>query</th>
<th>step</th>
<th>rows</th>
<th>workmem</th>
<th>label</th>
<th>is_diskbased</th>
</tr>
</thead>
<tbody>
<tr>
<td>1025</td>
<td>0</td>
<td>1600000</td>
<td>141557760</td>
<td>scan tbl=9</td>
<td>f</td>
</tr>
<tr>
<td>1025</td>
<td>2</td>
<td>1600000</td>
<td>135266304</td>
<td>hash tbl=142</td>
<td>t</td>
</tr>
<tr>
<td>1025</td>
<td>0</td>
<td>1600000</td>
<td>128974848</td>
<td>scan tbl=116536</td>
<td>f</td>
</tr>
<tr>
<td>1025</td>
<td>2</td>
<td>1600000</td>
<td>122683392</td>
<td>dist</td>
<td>f</td>
</tr>
</tbody>
</table>

(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, agg, 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_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 executed by Amazon Redshift, not other utility and DDL commands. For a complete listing and information on all statements executed 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 (p. 915).
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. Can be used to join various other system tables and views.</td>
</tr>
<tr>
<td>stm</td>
<td>integer</td>
<td>Stream: A set of concurrent segments in a query. A query has one or more streams.</td>
</tr>
<tr>
<td>seg</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>Query step that executed.</td>
</tr>
<tr>
<td>maxtime</td>
<td>bigint</td>
<td>Maximum amount of time for the step to execute (in microseconds).</td>
</tr>
<tr>
<td>avgtime</td>
<td>bigint</td>
<td>Average time for the step to execute (in microseconds).</td>
</tr>
<tr>
<td>rows</td>
<td>bigint</td>
<td>Number of data rows involved in the query step.</td>
</tr>
<tr>
<td>bytes</td>
<td>bigint</td>
<td>Number of data bytes involved in the query step.</td>
</tr>
<tr>
<td>rate_row</td>
<td>double precision</td>
<td>Query execution rate per row.</td>
</tr>
<tr>
<td>rate_byte</td>
<td>double precision</td>
<td>Query execution rate per byte.</td>
</tr>
<tr>
<td>label</td>
<td>text</td>
<td>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.</td>
</tr>
<tr>
<td>is_diskbased</td>
<td>character(1)</td>
<td>Whether this step of the query was executed 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 executed in memory.</td>
</tr>
<tr>
<td>workmem</td>
<td>bigint</td>
<td>Amount of working memory (in bytes) assigned to the query step.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>character(1)</td>
<td>If true (t), indicates that range-restricted scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>is_delayed_scan</td>
<td>character(1)</td>
<td>If true (t), indicates that delayed scan was used on the step. Default is false (f).</td>
</tr>
<tr>
<td>rows_pre_filter</td>
<td>bigint</td>
<td>For scans of permanent tables, the total number of rows emitted before filtering rows marked for deletion (ghost rows).</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>query</th>
<th>stm</th>
<th>seg</th>
<th>step</th>
<th>rows</th>
<th>bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>1890</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>90</td>
<td>360</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>90</td>
<td>360</td>
</tr>
<tr>
<td>87</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>90</td>
<td>1440</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>210494</td>
<td>4209880</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>89500</td>
<td>0</td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>87</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>87</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>87</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(D13 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 (p. 1043) 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:

<table>
<thead>
<tr>
<th>query</th>
<th>step</th>
<th>rows</th>
<th>workmem</th>
<th>label</th>
<th>is_diskbased</th>
</tr>
</thead>
<tbody>
<tr>
<td>1025</td>
<td>0</td>
<td>16000000</td>
<td>141557760</td>
<td>scan tbl=9</td>
<td>f</td>
</tr>
<tr>
<td>1025</td>
<td>2</td>
<td>16000000</td>
<td>135266304</td>
<td>hash tbl=142</td>
<td>t</td>
</tr>
<tr>
<td>1025</td>
<td>0</td>
<td>16000000</td>
<td>128974848</td>
<td>scan tbl=116536</td>
<td>f</td>
</tr>
<tr>
<td>1025</td>
<td>2</td>
<td>16000000</td>
<td>122683392</td>
<td>dist</td>
<td>f</td>
</tr>
</tbody>
</table>

(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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>eventtime</td>
<td>timestamp</td>
<td>The time in UTC that the event is recorded.</td>
</tr>
<tr>
<td>bucket</td>
<td>char(256)</td>
<td>The Amazon S3 bucket name.</td>
</tr>
<tr>
<td>prefix</td>
<td>char(256)</td>
<td>The prefix of the Amazon S3 bucket location.</td>
</tr>
<tr>
<td>recursive</td>
<td>char(1)</td>
<td>Whether there is recursive scan for subfolders.</td>
</tr>
<tr>
<td>retrieved_files</td>
<td>integer</td>
<td>The number of listed files.</td>
</tr>
<tr>
<td>max_file_size</td>
<td>bigint</td>
<td>The maximum file size among listed files.</td>
</tr>
<tr>
<td>avg_file_size</td>
<td>double precision</td>
<td>The average file size among listed files.</td>
</tr>
<tr>
<td>generated_splits</td>
<td>integer</td>
<td>The number of file splits.</td>
</tr>
<tr>
<td>avg_split_length</td>
<td>double precision</td>
<td>The average length of file splits in bytes.</td>
</tr>
<tr>
<td>duration</td>
<td>bigint</td>
<td>The duration of file listing, in microseconds.</td>
</tr>
</tbody>
</table>

Sample Query

The following example queries SVCS_S3LIST for the last query executed.

```sql
select *
from svcs_s3list
where query = pg_last_query_id()
order by query, segment;
```

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The data slice that a particular segment executed against.</td>
</tr>
<tr>
<td>eventtime</td>
<td>timestamp</td>
<td>The time in UTC that the event is recorded.</td>
</tr>
<tr>
<td>bucket</td>
<td>text</td>
<td>The Amazon S3 bucket name.</td>
</tr>
<tr>
<td>prefix</td>
<td>text</td>
<td>The prefix of the Amazon S3 bucket location.</td>
</tr>
<tr>
<td>recursive</td>
<td>char(1)</td>
<td>Whether there is recursive scan for subfolders.</td>
</tr>
<tr>
<td>retrieved_files</td>
<td>integer</td>
<td>The number of listed files.</td>
</tr>
<tr>
<td>max_file_size</td>
<td>bigint</td>
<td>The maximum file size among listed files.</td>
</tr>
<tr>
<td>avg_file_size</td>
<td>double precision</td>
<td>The average file size among listed files.</td>
</tr>
<tr>
<td>generated_splits</td>
<td>integer</td>
<td>The number of file splits.</td>
</tr>
<tr>
<td>avg_split_length</td>
<td>double precision</td>
<td>The average length of file splits in bytes.</td>
</tr>
<tr>
<td>duration</td>
<td>bigint</td>
<td>The duration of file listing, in microseconds.</td>
</tr>
</tbody>
</table>

**Sample Query**

The following example queries SVL_S3LIST for the last query executed.

```sql
select *
from svl_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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID.</td>
</tr>
</tbody>
</table>
### 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 (p. 915).

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>The query step that executed.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The data slice that a particular segment executed against.</td>
</tr>
<tr>
<td>eventtime</td>
<td>timestamp</td>
<td>Time in UTC that the step started executing.</td>
</tr>
<tr>
<td>message</td>
<td>text</td>
<td>Message for the log entry.</td>
</tr>
</tbody>
</table>
Sample Query

The following example queries SVL_S3LOG for the last query executed.

```sql
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>A segment number. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The data slice that a particular segment executed against.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp without time zone</td>
<td>Time in UTC that the partition pruning started executing.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp without time zone</td>
<td>Time in UTC that the partition pruning completed.</td>
</tr>
<tr>
<td>duration</td>
<td>bigint</td>
<td>Elapsed time (in microseconds).</td>
</tr>
<tr>
<td>total_partitions</td>
<td>integer</td>
<td>Number of total partitions.</td>
</tr>
<tr>
<td>qualified_partitions</td>
<td>integer</td>
<td>Number of qualified partitions.</td>
</tr>
<tr>
<td>assigned_partitions</td>
<td>integer</td>
<td>Number of assigned partitions on the slice.</td>
</tr>
<tr>
<td>assignment</td>
<td>character</td>
<td>Type of assignment.</td>
</tr>
</tbody>
</table>

Sample Query

The following example gets the partition details for the last query executed.

```sql
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

<table>
<thead>
<tr>
<th>query</th>
<th>segment</th>
<th>starttime</th>
<th>endtime</th>
<th>dur_ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>2526</td>
<td>334</td>
<td>p</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID. You can use this value to join various other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments.</td>
</tr>
<tr>
<td>assignment</td>
<td>char(1)</td>
<td>The type of partition assignment across nodes.</td>
</tr>
<tr>
<td>min_starttime</td>
<td>timestamp</td>
<td>The time in UTC that the partition processing started.</td>
</tr>
<tr>
<td>max_endtime</td>
<td>timestamp</td>
<td>The time in UTC that the partition processing completed.</td>
</tr>
<tr>
<td>min_duration</td>
<td>bigint</td>
<td>The minimum partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>max_duration</td>
<td>bigint</td>
<td>The maximum partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>avg_duration</td>
<td>bigint</td>
<td>The average partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>total_partitions</td>
<td>integer</td>
<td>The total number of partitions in an external table.</td>
</tr>
<tr>
<td>qualified_partitions</td>
<td>integer</td>
<td>The total number of qualified partitions.</td>
</tr>
<tr>
<td>min_assigned_partitions</td>
<td>integer</td>
<td>The minimum number of partitions assigned on one node.</td>
</tr>
</tbody>
</table>
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID. You can use this value to join various other system tables and views.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments.</td>
</tr>
<tr>
<td>assignment</td>
<td>char(1)</td>
<td>The type of partition assignment across nodes.</td>
</tr>
<tr>
<td>min_starttime</td>
<td>timestamp</td>
<td>The time in UTC that the partition processing started.</td>
</tr>
<tr>
<td>max_endtime</td>
<td>timestamp</td>
<td>The time in UTC that the partition processing completed.</td>
</tr>
<tr>
<td>min_duration</td>
<td>bigint</td>
<td>The minimum partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>max_duration</td>
<td>bigint</td>
<td>The maximum partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>avg_duration</td>
<td>bigint</td>
<td>The average partition processing time used by a node for this query (in microseconds).</td>
</tr>
<tr>
<td>total_partitions</td>
<td>integer</td>
<td>The total number of partitions in an external table.</td>
</tr>
<tr>
<td>qualified_partitions</td>
<td>integer</td>
<td>The total number of qualified partitions.</td>
</tr>
<tr>
<td>min_assigned_partitions</td>
<td>integer</td>
<td>The minimum number of partitions assigned on one node.</td>
</tr>
<tr>
<td>max_assigned_partitions</td>
<td>integer</td>
<td>The maximum number of partitions assigned on one node.</td>
</tr>
</tbody>
</table>
Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>avg_assigned_partitions</td>
<td>bigint</td>
<td>The average number of partitions assigned on one node.</td>
</tr>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of user who generated a given entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>A segment number. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>The query step that executed.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The data slice that a particular segment executed against.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the query started executing.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query execution completed</td>
</tr>
<tr>
<td>elapsed</td>
<td>integer</td>
<td>Elapsed time (in microseconds).</td>
</tr>
<tr>
<td>external_table</td>
<td>char(136)</td>
<td>Internal format of external table name for the s3 scan step.</td>
</tr>
<tr>
<td>is_partitioned</td>
<td>char(1)</td>
<td>If true (\texttt{t}), this column value indicates that the external table is partitioned.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>char(1)</td>
<td>If true (\texttt{t}), this column value indicates that a range-restricted scan was applied.</td>
</tr>
<tr>
<td>s3_scanned_rows</td>
<td>long</td>
<td>The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>s3_scanned_bytes</td>
<td>long</td>
<td>The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer.</td>
</tr>
<tr>
<td>s3query_returned_rows</td>
<td>long</td>
<td>The number of rows returned from the Redshift Spectrum layer to the cluster.</td>
</tr>
<tr>
<td>s3query_returned_bytes</td>
<td>long</td>
<td>The number of bytes returned from the Redshift Spectrum layer to the cluster.</td>
</tr>
<tr>
<td>files</td>
<td>integer</td>
<td>The number of files that were processed for this S3 scan step on this slice.</td>
</tr>
<tr>
<td>splits</td>
<td>int</td>
<td>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.</td>
</tr>
<tr>
<td>total_split_size</td>
<td>bigint</td>
<td>The total size of all splits processed on this slice, in bytes.</td>
</tr>
<tr>
<td>max_split_size</td>
<td>bigint</td>
<td>The maximum split size processed for this slice, in bytes.</td>
</tr>
<tr>
<td>total_retries</td>
<td>integer</td>
<td>The total number of retries for the processed files.</td>
</tr>
<tr>
<td>max_retries</td>
<td>integer</td>
<td>The maximum number of retries for an individual processed file.</td>
</tr>
<tr>
<td>max_request_duration</td>
<td>integer</td>
<td>The maximum duration of an individual Redshift Spectrum request (in microseconds).</td>
</tr>
<tr>
<td>avg_request_duration</td>
<td>double precision</td>
<td>The average duration of the Redshift Spectrum requests (in microseconds).</td>
</tr>
<tr>
<td>max_request_parallelism</td>
<td>integer</td>
<td>The maximum number of outstanding Redshift Spectrum on this slice for this S3 scan step.</td>
</tr>
<tr>
<td>avg_request_parallelism</td>
<td>double precision</td>
<td>The average number of parallel Redshift Spectrum requests on this slice for this S3 scan step.</td>
</tr>
</tbody>
</table>

Sample Query

The following example gets the scan step details for the last query executed.

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>segment</th>
<th>slice</th>
<th>elapsed</th>
<th>s3_scanned_rows</th>
<th>s3_scanned_bytes</th>
<th>s3query_returned_rows</th>
<th>s3query_returned_bytes</th>
<th>files</th>
</tr>
</thead>
<tbody>
<tr>
<td>4587</td>
<td>2</td>
<td>0</td>
<td>67811</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4587</td>
<td>2</td>
<td>1</td>
<td>591568</td>
<td>172462</td>
<td>11260097</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8513</td>
<td>170260</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user that generated the given entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID. You can use this value to join various other system tables and views.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>The query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>The time in UTC that the Redshift Spectrum query in this segment started running. One segment can have one external table scan.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>The time in UTC that the Redshift Spectrum query in this segment completed. One segment can have one external table scan.</td>
</tr>
<tr>
<td>elapsed</td>
<td>integer</td>
<td>The length of time that it took the Redshift Spectrum query in this segment to run (in microseconds).</td>
</tr>
<tr>
<td>aborted</td>
<td>integer</td>
<td>If a query was aborted by the system or canceled by the user, this column contains 1. If the query ran to completion, this column contains 0.</td>
</tr>
<tr>
<td>external_table_name</td>
<td>char(136)</td>
<td>The internal format of name of the external name of the table for the external table scan.</td>
</tr>
<tr>
<td>file_format</td>
<td>character(16)</td>
<td>The file format of the external table data.</td>
</tr>
<tr>
<td>is_partitioned</td>
<td>char(1)</td>
<td>If true (t), this column value indicates that the external table is partitioned.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>char(1)</td>
<td>If true (t), this column value indicates that a range-restricted scan was applied.</td>
</tr>
<tr>
<td>is_nested</td>
<td>varchar(1)</td>
<td>If true (t), this column value indicates that the nested column data type is accessed.</td>
</tr>
<tr>
<td>s3_scanned_rows</td>
<td>bigint</td>
<td>The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.</td>
</tr>
<tr>
<td>s3_scanned_bytes</td>
<td>bigint</td>
<td>The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer, based on compressed data.</td>
</tr>
<tr>
<td>s3query_returned_rows</td>
<td>bigint</td>
<td>The number of rows returned from the Redshift Spectrum layer to the cluster.</td>
</tr>
<tr>
<td>s3query_returned_bytes</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>files</td>
<td>integer</td>
<td>The number of files that were processed for this Redshift Spectrum query. A small number of files limits the benefits of parallel processing.</td>
</tr>
<tr>
<td>files_max</td>
<td>integer</td>
<td>The maximum number of file processed on one slice.</td>
</tr>
<tr>
<td>files_avg</td>
<td>integer</td>
<td>The average number of file processed on one slice.</td>
</tr>
<tr>
<td>splits</td>
<td>bigint</td>
<td>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.</td>
</tr>
<tr>
<td>splits_max</td>
<td>integer</td>
<td>The maximum number of splits processed on this slice.</td>
</tr>
<tr>
<td>splits_avg</td>
<td>bigint</td>
<td>The average number of splits processed on this slice.</td>
</tr>
<tr>
<td>total_split_size</td>
<td>bigint</td>
<td>The total size of all splits processed.</td>
</tr>
<tr>
<td>max_split_size</td>
<td>bigint</td>
<td>The maximum split size processed, in bytes.</td>
</tr>
<tr>
<td>avg_split_size</td>
<td>bigint</td>
<td>The average split size processed, in bytes.</td>
</tr>
<tr>
<td>total_retries</td>
<td>bigint</td>
<td>The total number of retries for the Redshift Spectrum query in this segment.</td>
</tr>
<tr>
<td>max_retries</td>
<td>integer</td>
<td>The maximum number of retries for one individual processed file.</td>
</tr>
<tr>
<td>max_request_duration</td>
<td>bigint</td>
<td>The maximum duration of an individual file request (in microseconds). Long running queries might indicate a bottleneck.</td>
</tr>
<tr>
<td>avg_request_duration</td>
<td>bigint</td>
<td>The average duration of the file requests (in microseconds).</td>
</tr>
<tr>
<td>max_request_parallelism</td>
<td>bigint</td>
<td>The maximum number of parallel requests at one slice for this Redshift Spectrum query.</td>
</tr>
</tbody>
</table>
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user that generated the given entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID. You can use this value to join various other system tables and views.</td>
</tr>
<tr>
<td>xid</td>
<td>long</td>
<td>The transaction ID.</td>
</tr>
<tr>
<td><strong>Column Name</strong></td>
<td><strong>Data Type</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>The segment number. A query consists of multiple segments, and each segment consists of one or more steps.</td>
</tr>
<tr>
<td>step</td>
<td>integer</td>
<td>The query step that executed.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Time in UTC that the query started executing.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Time in UTC that the query completed.</td>
</tr>
<tr>
<td>elapsed</td>
<td>integer</td>
<td>The length of time that it took the query to execute (in microseconds).</td>
</tr>
<tr>
<td>aborted</td>
<td>integer</td>
<td>If a query was aborted by the system or canceled by the user, this column contains 1. If the query ran to completion, this column contains 0.</td>
</tr>
<tr>
<td>external_table_name</td>
<td>char(136)</td>
<td>The internal format of name of the external name of the table for the external table scan.</td>
</tr>
<tr>
<td>file_format</td>
<td>character(16)</td>
<td>The file format of the external table data.</td>
</tr>
<tr>
<td>is_partitioned</td>
<td>char(1)</td>
<td>If true (t), this column value indicates that the external table is partitioned.</td>
</tr>
<tr>
<td>is_rrscan</td>
<td>char(1)</td>
<td>If true (t), this column value indicates that a range-restricted scan was applied.</td>
</tr>
<tr>
<td>is_nested</td>
<td>varchar</td>
<td>If true (t), this column value indicates that the nested column data type is accessed.</td>
</tr>
<tr>
<td>s3_scanned_rows</td>
<td>long</td>
<td>The number of rows scanned from Amazon S3 and sent to the Redshift Spectrum layer.</td>
</tr>
<tr>
<td>s3_scanned_bytels</td>
<td>long</td>
<td>The number of bytes scanned from Amazon S3 and sent to the Redshift Spectrum layer, based on compressed data.</td>
</tr>
<tr>
<td>s3query_returned_rows</td>
<td>long</td>
<td>The number of rows returned from the Redshift Spectrum layer to the cluster.</td>
</tr>
<tr>
<td>s3query_returned_bytels</td>
<td>long</td>
<td>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.</td>
</tr>
<tr>
<td>files</td>
<td>integer</td>
<td>The number of files that were processed for this Redshift Spectrum query. A small number of files limits the benefits of parallel processing.</td>
</tr>
<tr>
<td>files_max</td>
<td>integer</td>
<td>The maximum number of files processed on one slice.</td>
</tr>
<tr>
<td>files_avg</td>
<td>integer</td>
<td>The average number of files processed on one slice.</td>
</tr>
<tr>
<td>splits</td>
<td>int</td>
<td>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.</td>
</tr>
</tbody>
</table>
### SVL_S3QUERY_SUMMARY

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>splits_max</td>
<td>int</td>
<td>The maximum number of splits processed on this slice.</td>
</tr>
<tr>
<td>splits_avg</td>
<td>int</td>
<td>The average number of splits processed on this slice.</td>
</tr>
<tr>
<td>total_split_size</td>
<td>bigint</td>
<td>The total size of all splits processed.</td>
</tr>
<tr>
<td>max_split_size</td>
<td>bigint</td>
<td>The maximum split size processed, in bytes.</td>
</tr>
<tr>
<td>avg_split_size</td>
<td>bigint</td>
<td>The average split size processed, in bytes.</td>
</tr>
<tr>
<td>total_retries</td>
<td>integer</td>
<td>The total number of retries for one individual processed file.</td>
</tr>
<tr>
<td>max_retries</td>
<td>integer</td>
<td>The maximum number of retries for any of processed files.</td>
</tr>
<tr>
<td>max_request_duration</td>
<td>double precision</td>
<td>The maximum duration of an individual file request (in microseconds). Long running queries might indicate a bottleneck.</td>
</tr>
<tr>
<td>avg_request_duration</td>
<td>double precision</td>
<td>The average duration of the file requests (in microseconds).</td>
</tr>
<tr>
<td>max_request_parallelism</td>
<td>integer</td>
<td>The maximum number of parallel requests at one slice for this Redshift Spectrum query.</td>
</tr>
<tr>
<td>avg_request_parallelism</td>
<td>double precision</td>
<td>The average number of parallel requests at one slice for this Redshift Spectrum query.</td>
</tr>
<tr>
<td>total_slowdown_count</td>
<td>bigint</td>
<td>The total number of Amazon S3 requests with a slow down error that occurred during the external table scan.</td>
</tr>
<tr>
<td>max_slowdown_count</td>
<td>integer</td>
<td>The maximum number of Amazon S3 requests with a slow down error that occurred during the external table scan on one slice.</td>
</tr>
</tbody>
</table>

**Sample Query**

The following example gets the scan step details for the last query executed.

```sql
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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>segment</th>
<th>elapsed</th>
<th>s3_scanned_rows</th>
<th>s3_scanned_bytes</th>
<th>s3query_returned_rows</th>
<th>s3query_returned_bytes</th>
<th>files</th>
</tr>
</thead>
<tbody>
<tr>
<td>4587</td>
<td>2</td>
<td>67811</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4587</td>
<td>2</td>
<td>591568</td>
<td>172462</td>
<td>11260097</td>
<td>8513</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4587</td>
<td>2</td>
<td>216849</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4587</td>
<td>2</td>
<td>216671</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
```
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node number.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The data slice that a particular segment executed against.</td>
</tr>
<tr>
<td>eventtime</td>
<td>timestamp without timezone</td>
<td>Time in UTC that the step started executing.</td>
</tr>
<tr>
<td>retries</td>
<td>integer</td>
<td>The number of retries for the query.</td>
</tr>
<tr>
<td>successful_fetches</td>
<td>integer</td>
<td>The number of times data was returned.</td>
</tr>
<tr>
<td>file_size</td>
<td>bigint</td>
<td>This size of the file.</td>
</tr>
<tr>
<td>location</td>
<td>text</td>
<td>The location of the table,</td>
</tr>
<tr>
<td>message</td>
<td>text</td>
<td>The error message.</td>
</tr>
</tbody>
</table>

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_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 (p. 927), STL_QUERYTEXT (p. 965), and STL.UtilityTEXT (p. 985) 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of user who generated entry.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID associated with the statement.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID for the statement.</td>
</tr>
<tr>
<td>label</td>
<td>character(30)</td>
<td>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.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>Exact time when the statement started executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.131358</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>Exact time when the statement finished executing, with 6 digits of precision for fractional seconds. For example: 2009-06-12 11:29:19.193640</td>
</tr>
<tr>
<td>sequence</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>type</td>
<td>varchar(10)</td>
<td>Type of SQL statement: QUERY, DDL, or UTILITY.</td>
</tr>
<tr>
<td>text</td>
<td>character(200)</td>
<td>SQL text, in 200-character increments. This field might contain special characters such as backslash () and newline (\n).</td>
</tr>
</tbody>
</table>

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;
```

<table>
<thead>
<tr>
<th>starttime</th>
<th>type</th>
<th>rtrim</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-06-16 10:36:50.625097</td>
<td>DDL</td>
<td>create table ddltest(c1 int);</td>
</tr>
<tr>
<td>2009-06-16 15:02:16.006341</td>
<td>DDL</td>
<td>drop view alltickitjoin;</td>
</tr>
</tbody>
</table>
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.

```sql
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`.

```sql
select
1 AS a0123456789012345678901234567890123456789012345678901234567890,
2 AS b0123456789012345678901234567890123456789012345678901234567890,
3 AS b01234567890123456789012345678901234567890123456789012345678901234
FROM stl_querytext;
```

In this example, the query is stored in 2 parts (rows) in the `text` column of `SVL_STATEMENTTEXT`.

```sql
select sequence, text from SVL_STATEMENTTEXT where pid = pg_backend_pid() order by starttime, sequence;
```

<table>
<thead>
<tr>
<th>sequence</th>
<th>text</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>select\n1 AS a0123456789012345678901234567890123456789012345678901234567890,</td>
</tr>
<tr>
<td></td>
<td>\n2 AS b0123456789012345678901234567890123456789012345678901234567890,</td>
</tr>
<tr>
<td></td>
<td>\n3 AS b0123456789012345678901234567890123456789012345678901234567890,</td>
</tr>
<tr>
<td>1</td>
<td>\nFROM stl_querytext;</td>
</tr>
</tbody>
</table>

To reconstruct the SQL stored in `SVL_STATEMENTTEXT`, run the following SQL.

```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.

```sql
select\n1 AS a0123456789012345678901234567890123456789012345678901234567890,
\n2 AS b0123456789012345678901234567890123456789012345678901234567890,\n\n3 AS b012345678901234567890123456789012345678901234567890,\n\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 aborted. 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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>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.</td>
</tr>
<tr>
<td>session_userid</td>
<td>integer</td>
<td>The ID of the user that created the session and is the invoker of the top-level stored procedure call.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID of the procedure call.</td>
</tr>
<tr>
<td>label</td>
<td>character(15)</td>
<td>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.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>The transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>The 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 value. For more information, see STL_RESTARTED_SESSIONS (p. 968) .</td>
</tr>
<tr>
<td>database</td>
<td>character(32)</td>
<td>The name of the database that the user was connected to when the query was issued.</td>
</tr>
<tr>
<td>querytext</td>
<td>character(4000)</td>
<td>The actual text of the procedure call query.</td>
</tr>
<tr>
<td>starttime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>endtime</td>
<td>timestamp</td>
<td>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.</td>
</tr>
<tr>
<td>aborted</td>
<td>integer</td>
<td>If a stored procedure was aborted by the system or canceled by the user, this column contains 1. If the call runs to completion, this column contains 0.</td>
</tr>
<tr>
<td>from_sp_call</td>
<td>integer</td>
<td>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.</td>
</tr>
</tbody>
</table>
Sample Query

The following query returns the elapsed time in descending order and the completion status for stored procedure calls in the past day.

```sql
select query, datediff(seconds, starttime, endtime) as elapsed_time, aborted,
       trim(querytxt) as call
from svl_stored_proc_call where starttime >= current_timestamp - interval '1 day' order by 2 desc;
```

<table>
<thead>
<tr>
<th>query</th>
<th>elapsed_time</th>
<th>aborted</th>
<th>call</th>
</tr>
</thead>
<tbody>
<tr>
<td>4166</td>
<td>7</td>
<td>0</td>
<td>call search_batch_status(35,'succeeded')</td>
</tr>
<tr>
<td>2433</td>
<td>3</td>
<td>0</td>
<td>call test_batch (123456)</td>
</tr>
<tr>
<td>1810</td>
<td>1</td>
<td>0</td>
<td>call prod_benchmark (123456)</td>
</tr>
<tr>
<td>1836</td>
<td>1</td>
<td>0</td>
<td>call prod_testing (123456)</td>
</tr>
<tr>
<td>1808</td>
<td>1</td>
<td>0</td>
<td>call prod_portfolio ('N', 123456)</td>
</tr>
<tr>
<td>1816</td>
<td>1</td>
<td>1</td>
<td>call prod_portfolio ('Y', 123456)</td>
</tr>
</tbody>
</table>

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.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>Query ID. The query column can be used to join other system tables and views.</td>
</tr>
<tr>
<td>stream</td>
<td>integer</td>
<td>The set of concurrent segments of a query.</td>
</tr>
<tr>
<td>segment</td>
<td>integer</td>
<td>Number that identifies the query segment.</td>
</tr>
</tbody>
</table>

Sample Queries

To view the relationship between streams and concurrent segments for the most recent query, type the following query:

```sql
select *
from svcs_stream_segs
where query = pg_last_query_id();
```
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 metadata to which they have access.

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_catalog</td>
<td>text</td>
<td>The name of the catalog where the table exists.</td>
</tr>
<tr>
<td>table_schema</td>
<td>text</td>
<td>The name the schema for the table.</td>
</tr>
<tr>
<td>table_name</td>
<td>text</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>table_type</td>
<td>text</td>
<td>The type of table. The following are possible values:</td>
</tr>
<tr>
<td>remarks</td>
<td>text</td>
<td>Remarks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• VIEW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EXTERNAL TABLE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BASE TABLE</td>
</tr>
</tbody>
</table>

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, including 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 (p. 996), STV_PARTITIONS (p. 1005), STV_TBL_PERM (p. 1013), and STV_SLICES (p. 1012) 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 (p. 915). To permit a user to query the view, grant SELECT privilege on SVV_TABLE_INFO to the user.
### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>database</td>
<td>text</td>
<td>Database name.</td>
</tr>
<tr>
<td>schema</td>
<td>text</td>
<td>Schema name.</td>
</tr>
<tr>
<td>table_id</td>
<td>oid</td>
<td>Table ID.</td>
</tr>
<tr>
<td>table</td>
<td>text</td>
<td>Table name.</td>
</tr>
<tr>
<td>encoded</td>
<td>text</td>
<td>Value that indicates whether any column has compression encoding defined.</td>
</tr>
<tr>
<td>diststyle</td>
<td>text</td>
<td>Distribution style or distribution key column, if key distribution is defined.</td>
</tr>
<tr>
<td>sortkey1</td>
<td>text</td>
<td>First column in the sort key, if a sort key is defined.</td>
</tr>
<tr>
<td>max_varchar</td>
<td>integer</td>
<td>Size of the largest column that uses a VARCHAR data type.</td>
</tr>
<tr>
<td>sortkey1_enc</td>
<td>character(32)</td>
<td>Compression encoding of the first column in the sort key, if a sort key is defined.</td>
</tr>
<tr>
<td>sortkey_num</td>
<td>integer</td>
<td>Number of columns defined as sort keys.</td>
</tr>
<tr>
<td>size</td>
<td>bigint</td>
<td>Size of the table, in 1 MB data blocks.</td>
</tr>
<tr>
<td>pct_used</td>
<td>numeric(10,4)</td>
<td>Percent of available space that is used by the table.</td>
</tr>
<tr>
<td>empty</td>
<td>bigint</td>
<td>For internal use. This column is deprecated and will be removed in a future release.</td>
</tr>
<tr>
<td>unsorted</td>
<td>numeric(5,2)</td>
<td>Percent of unsorted rows in the table.</td>
</tr>
<tr>
<td>stats_off</td>
<td>numeric(5,2)</td>
<td>Number that indicates how stale the table's statistics are; 0 is current, 100 is out of date.</td>
</tr>
<tr>
<td>tbl_rows</td>
<td>numeric(38,0)</td>
<td>Total number of rows in the table. This value includes rows marked for deletion, but not yet vacuumed.</td>
</tr>
<tr>
<td>skew_sortkey1</td>
<td>numeric(19,2)</td>
<td>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.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>skew_rows</td>
<td>numeric(19,2)</td>
<td>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.</td>
</tr>
<tr>
<td>estimated_visible_rows</td>
<td>numeric(38,0)</td>
<td>The estimated rows in the table. This value does not include rows marked for deletion.</td>
</tr>
<tr>
<td>risk_event</td>
<td>text</td>
<td>Risk information about a table. The field is separated into parts: risk_type</td>
</tr>
<tr>
<td>vacuum_sort_benefit</td>
<td>numeric(12,2)</td>
<td>The estimated maximum percentage improvement of scan query performance when you run vacuum sort.</td>
</tr>
</tbody>
</table>

### Sample Queries

The following example shows encoding, distribution style, sorting, and data skew for all user-defined tables in the database. Note that "table" must be enclosed in double quotes because it is a reserved word.

```sql
select "table", encoded, diststyle, sortkey1, skew_sortkey1, skew_rows
from svv_table_info
order by 1;
```

<table>
<thead>
<tr>
<th>table</th>
<th>encoded</th>
<th>diststyle</th>
<th>sortkey1</th>
<th>skew_sortkey1</th>
<th>skew_rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1078</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 (p. 151) and LOCK (p. 596).

All rows in SVV_TRANSACTIONS, including rows generated by another user, are visible to all users.

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>txn_owner</td>
<td>text</td>
<td>Name of the owner of the transaction.</td>
</tr>
<tr>
<td>txn_db</td>
<td>text</td>
<td>Name of the database associated with the transaction.</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>Process ID associated with the lock.</td>
</tr>
<tr>
<td>txn_start</td>
<td>timestamp</td>
<td>Start time of the transaction.</td>
</tr>
<tr>
<td>lock_mode</td>
<td>text</td>
<td>Name of the lock mode held or requested by this process. If lock_mode is ExclusiveLock and granted is true (t), then this transaction ID is an open transaction.</td>
</tr>
<tr>
<td>lockable_object_type</td>
<td>text</td>
<td>Type of object requesting or holding the lock, either relation if it is a table or transactionid if it is a transaction.</td>
</tr>
<tr>
<td>relation</td>
<td>integer</td>
<td>Table ID for the table (relation) acquiring the lock. This value is NULL if lockable_object_type is transactionid.</td>
</tr>
<tr>
<td>granted</td>
<td>boolean</td>
<td>Value that indicates whether that the lock has been granted (t) or is pending (f).</td>
</tr>
</tbody>
</table>
Sample Queries

The following command shows all active transactions and the locks requested by each transaction.

```sql
select * from svv_transactions;
```

<table>
<thead>
<tr>
<th>txn_lockable_</th>
<th>owner</th>
<th>txn_db</th>
<th>xid</th>
<th>pid</th>
<th>txn_start</th>
<th>lock_mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>object_type</td>
<td>relation</td>
<td>granted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>----------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438484</td>
<td>22223</td>
<td>2016-03-02 18:42:18.862254</td>
<td>AccessShareLock</td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>100068</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438484</td>
<td>22223</td>
<td>2016-03-02 18:42:18.862254</td>
<td>ExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>transactionid</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>50860</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>52310</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>tickit</td>
<td>438490</td>
<td>22277</td>
<td>2016-03-02 18:42:48.084037</td>
<td>ExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>transactionid</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438505</td>
<td>22378</td>
<td>2016-03-02 18:43:27.611292</td>
<td>AccessExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>100064</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438505</td>
<td>22378</td>
<td>2016-03-02 18:43:27.611292</td>
<td>AccessShareLock</td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>100166</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438505</td>
<td>22378</td>
<td>2016-03-02 18:43:27.611292</td>
<td>AccessExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>100171</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438505</td>
<td>22378</td>
<td>2016-03-02 18:43:27.611292</td>
<td>AccessExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>relation</td>
<td>100190</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>root</td>
<td>dev</td>
<td>438505</td>
<td>22378</td>
<td>2016-03-02 18:43:27.611292</td>
<td>ExclusiveLock</td>
<td></td>
</tr>
<tr>
<td>transactionid</td>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SVL_UDF_LOG

Records system-defined error and warning messages generating during user-defined function (UDF) execution.

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>query</td>
<td>bigint</td>
<td>The query ID. You can use this ID to join various other system tables and views.</td>
</tr>
<tr>
<td>message</td>
<td>char(4096)</td>
<td>The message generated by the function.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>created</td>
<td>timestamp</td>
<td>The time that the log was created.</td>
</tr>
<tr>
<td>traceback</td>
<td>char(4096)</td>
<td>If available, this value provides a stack traceback for the UDF. For more information, see traceback in the Python Standard Library.</td>
</tr>
<tr>
<td>funcname</td>
<td>character(256)</td>
<td>The name of the UDF that is executing.</td>
</tr>
<tr>
<td>node</td>
<td>integer</td>
<td>The node where the message was generated.</td>
</tr>
<tr>
<td>slice</td>
<td>integer</td>
<td>The slice where the message was generated.</td>
</tr>
<tr>
<td>seq</td>
<td>integer</td>
<td>The sequence of the message on the slice.</td>
</tr>
</tbody>
</table>

**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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>created</th>
<th>message</th>
</tr>
</thead>
<tbody>
<tr>
<td>2211</td>
<td>2015-08-22 00:11:12.04819</td>
<td>ZeroDivisionError: long division or modulo by zero</td>
</tr>
</tbody>
</table>

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.
Returning zero instead of error.
')
return 0
else:
    return 1/a
## LANGUAGE plpythonu;

The following example runs the function, then queries SVL_UDF_LOG to view the message.

```sql
-- 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 svi_udf_log;

<table>
<thead>
<tr>
<th>query</th>
<th>created</th>
<th>message</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2015-08-22 00:11:12.04819</td>
<td>You attempted to divide by zero.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Returning zero instead of error.</td>
</tr>
</tbody>
</table>
```

**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.

This table 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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>userid</td>
<td>integer</td>
<td>The ID of the user who generated the entry.</td>
</tr>
<tr>
<td>query</td>
<td>integer</td>
<td>The query ID.</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>The process ID associated with the query statement.</td>
</tr>
<tr>
<td>path</td>
<td>character(1280)</td>
<td>The complete Amazon S3 object path for the file.</td>
</tr>
<tr>
<td>start_time</td>
<td>timestamp</td>
<td>The start time for the UNLOAD operation.</td>
</tr>
<tr>
<td>end_time</td>
<td>timestamp</td>
<td>The end time for the UNLOAD operation.</td>
</tr>
</tbody>
</table>
### 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 with for the last query executed:

```sql
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:

<table>
<thead>
<tr>
<th>query</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0000_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0001_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0002_part_00</td>
</tr>
<tr>
<td>2320</td>
<td>s3://my-bucket/venue0003_part_00</td>
</tr>
<tr>
<td></td>
<td>(4 rows)</td>
</tr>
</tbody>
</table>

### SVL_USER_INFO

You can retrieve data about Amazon Redshift database users with the SVL_USER_INFO view.

#### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>usename</td>
<td>text</td>
<td>The user name for the role.</td>
</tr>
<tr>
<td>usesysid</td>
<td>integer</td>
<td>The user ID for the user.</td>
</tr>
<tr>
<td>usecreatedb</td>
<td>boolean</td>
<td>A value that indicates whether the user has permissions to create databases.</td>
</tr>
<tr>
<td>usesuper</td>
<td>boolean</td>
<td>A value that indicates whether the user is a superuser.</td>
</tr>
<tr>
<td>usecatupd</td>
<td>boolean</td>
<td>A value that indicates whether the user can update system catalogs.</td>
</tr>
<tr>
<td>useconnlim</td>
<td>text</td>
<td>The number of connections that the user can open.</td>
</tr>
</tbody>
</table>
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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_name</td>
<td>text</td>
<td>Name of the table currently being vacuumed, or the table that was last vacuumed if no operation is in progress.</td>
</tr>
<tr>
<td>status</td>
<td>text</td>
<td>Description of the current activity being done as part of the vacuum operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Initialize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Merge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Delete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Select</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Failed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skipped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Building INTERLEAVED SORTKEY order</td>
</tr>
<tr>
<td>time_remaining_estimatetext</td>
<td>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</td>
<td></td>
</tr>
</tbody>
</table>
that was executed 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.

```sql
select * from svv_vacuum_progress;
```

<table>
<thead>
<tr>
<th>table_name</th>
<th>status</th>
<th>time_remaining_estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>salesnew</td>
<td>Vacuum: initialize salesnew</td>
<td></td>
</tr>
<tr>
<td>(1 row)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

```sql
select * from svv_vacuum_progress;
```

<table>
<thead>
<tr>
<th>table_name</th>
<th>status</th>
<th>time_remaining_estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>salesnew</td>
<td>Vacuum salesnew sort</td>
<td>33m 21s</td>
</tr>
<tr>
<td>(1 row)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following query shows that no vacuum operation is currently in progress. The last table to be vacuumed was the `SALES` table.

```sql
select * from svv_vacuum_progress;
```

<table>
<thead>
<tr>
<th>table_name</th>
<th>status</th>
<th>time_remaining_estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales</td>
<td>Complete</td>
<td></td>
</tr>
<tr>
<td>(1 row)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_name</td>
<td>text</td>
<td>Name of the vacuumed table.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID of the VACUUM operation.</td>
</tr>
<tr>
<td>sort_partitions</td>
<td>bigint</td>
<td>Number of sorted partitions created during the sort phase of the vacuum operation.</td>
</tr>
<tr>
<td>merge_increments</td>
<td>bigint</td>
<td>Number of merge increments required to complete the merge phase of the vacuum operation.</td>
</tr>
<tr>
<td>elapsed_time</td>
<td>bigint</td>
<td>Elapsed run time of the vacuum operation (in microseconds).</td>
</tr>
<tr>
<td>row_delta</td>
<td>bigint</td>
<td>Difference in the total number of table rows before and after the vacuum.</td>
</tr>
<tr>
<td>sortedrow_delta</td>
<td>bigint</td>
<td>Difference in the number of sorted table rows before and after the vacuum.</td>
</tr>
<tr>
<td>block_delta</td>
<td>integer</td>
<td>Difference in block count for the table before and after the vacuum.</td>
</tr>
<tr>
<td>max_merge_partitions</td>
<td>integer</td>
<td>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.)</td>
</tr>
</tbody>
</table>

**Sample Query**

The following query returns statistics for vacuum operations on three different tables. The SALES table was vacuumed twice.

```sql
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>
<thead>
<tr>
<th>table_name</th>
<th>xid</th>
<th>parts</th>
<th>merges</th>
<th>elapsed_time</th>
<th>row_</th>
<th>sorted_</th>
<th>block_</th>
</tr>
</thead>
<tbody>
<tr>
<td>users</td>
<td>2985</td>
<td>1</td>
<td>1</td>
<td>61919653</td>
<td>0</td>
<td>49990</td>
<td>20</td>
</tr>
<tr>
<td>category</td>
<td>3982</td>
<td>1</td>
<td>1</td>
<td>24136484</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>sales</td>
<td>3992</td>
<td>2</td>
<td>1</td>
<td>71736163</td>
<td>0</td>
<td>1207192</td>
<td>32</td>
</tr>
<tr>
<td>sales</td>
<td>4000</td>
<td>1</td>
<td>1</td>
<td>15363010</td>
<td>-851648</td>
<td>-851648</td>
<td>-140</td>
</tr>
</tbody>
</table>

(4 rows)

**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 (p. 663) 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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xid</td>
<td>bigint</td>
<td>Transaction ID for the vacuum statement.</td>
</tr>
<tr>
<td>table_id</td>
<td>integer</td>
<td>Table ID for the vacuumed table.</td>
</tr>
<tr>
<td>percentage</td>
<td>bigint</td>
<td>Percentage of data blocks after a vacuum (relative to the number of blocks in the table before the vacuum was run).</td>
</tr>
</tbody>
</table>

### Sample Query

The following query displays the percentage for a specific operation on table 100238:

```sql
select * from svl_vacuum_percentage
where table_id=100238 and xid=2200;
```

```
<table>
<thead>
<tr>
<th>xid</th>
<th>table_id</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1337</td>
<td>100238</td>
<td>60</td>
</tr>
</tbody>
</table>
```

After this vacuum operation, the table contained 60 percent of the original blocks.

### System Catalog Tables

#### Topics

- PG_ATTRIBUTE_INFO (p. 1088)
- PG_CLASS_INFO (p. 1088)
- PG_DATABASE_INFO (p. 1089)
- PG_DEFAULT_ACL (p. 1090)
- PG_EXTERNAL_SCHEMA (p. 1091)
- PG_LIBRARY (p. 1092)
- PG_PROC_INFO (p. 1093)
- PG_STATISTIC_INDICATOR (p. 1093)
- PG_TABLE_DEF (p. 1094)
- Querying the Catalog Tables (p. 1096)

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.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>attacl</td>
<td>aclitem[]</td>
<td>The column-level access privileges, if any, that have been granted specifically on this column.</td>
</tr>
</tbody>
</table>

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 Choosing a Data Distribution Style (p. 55).

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 (p. 915).

Table Columns

PG_CLASS_INFO shows the following columns in addition to the columns in PG_CLASS.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>relcreationtime</td>
<td>timestamp</td>
<td>Time in UTC that the table was created.</td>
</tr>
<tr>
<td>releffectivediststyle</td>
<td>integer</td>
<td>The distribution style of a table or, if the table uses automatic distribution, the current distribution style assigned by Amazon Redshift.</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>RELEFFECTIVEDISTSTYLE</th>
<th>Current Distribution style</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EVEN</td>
</tr>
<tr>
<td>1</td>
<td>KEY</td>
</tr>
<tr>
<td>8</td>
<td>ALL</td>
</tr>
</tbody>
</table>
## Example

The following query returns the current distribution style of tables in the catalog.

```sql
select relid 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
ELSE '<<UNKNOWN>>'::text END as diststyle, relcreationtime
from pg_class_info a left join pg_namespace b on a.relnamespace=b.oid;
```

<table>
<thead>
<tr>
<th>tableid</th>
<th>schemaname</th>
<th>tablename</th>
<th>reldiststyle</th>
<th>releffectivediststyle</th>
<th>diststyle</th>
<th>relcreationtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>3638033</td>
<td>public</td>
<td>customer</td>
<td>0</td>
<td></td>
<td>EVEN</td>
<td>2019-06-13 15:02:50.666718</td>
</tr>
<tr>
<td>3638037</td>
<td>public</td>
<td>sales</td>
<td>1</td>
<td></td>
<td>KEY</td>
<td>2019-06-13 15:03:29.595007</td>
</tr>
<tr>
<td>3638035</td>
<td>public</td>
<td>lineitem</td>
<td>8</td>
<td></td>
<td>ALL</td>
<td>2019-06-13 15:03:01.378538</td>
</tr>
<tr>
<td>3638039</td>
<td>public</td>
<td>product</td>
<td>9</td>
<td></td>
<td>AUTO(ALL)</td>
<td>2019-06-13 15:03:42.691611</td>
</tr>
<tr>
<td>3638041</td>
<td>public</td>
<td>shipping</td>
<td>9</td>
<td></td>
<td>AUTO(EVEN)</td>
<td>2019-06-13 15:03:53.69192</td>
</tr>
</tbody>
</table>

(Please note: the above output is truncated for presentation purposes. Full output would be necessary for a complete understanding.)

## 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. For more information, see the [PostgreSQL 8.0 documentation](https://www.postgresql.org/docs/8.0/). The columns include:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>datid</td>
<td>oid</td>
<td>The object identifier (OID) used internally by system tables.</td>
</tr>
<tr>
<td>datconnlimit</td>
<td>text</td>
<td>The maximum number of concurrent connections that can be made to this database. A value of -1 means no limit.</td>
</tr>
</tbody>
</table>
**PG_DEFAULT_ACL**

Stores information about default access privileges. For more information on default access privileges, see ALTER DEFAULT PRIVILEGES (p. 416).

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 (p. 915).

**Table Columns**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>defacluser</td>
<td>integer</td>
<td>ID of the user to which the listed privileges are applied.</td>
</tr>
<tr>
<td>defaclnamespace</td>
<td>oid</td>
<td>The object ID of the schema where default privileges are applied. The default value is 0 if no schema is specified.</td>
</tr>
</tbody>
</table>
| 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.  
Valid values are:  
- r–SELECT (read)  
- a–INSERT (append)  
- w–UPDATE (write)  
- d–DELETE  
- x–Grants the privilege to create a foreign key constraint (REFERENCES).  
- X–EXECUTE |
### Column Names
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>esoid</td>
<td>oid</td>
<td>External schema ID.</td>
</tr>
<tr>
<td>eskind</td>
<td>integer</td>
<td>Kind of external schema.</td>
</tr>
<tr>
<td>esdbname</td>
<td>text</td>
<td>External database name.</td>
</tr>
</tbody>
</table>

### 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.

```
dbuser=r*a+w*d*x*/admin
```

### Example
The following query returns all default privileges defined for the database.

```sql
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;
```

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 (p. 510).

### Table Columns
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>esoid</td>
<td>oid</td>
<td>External schema ID.</td>
</tr>
<tr>
<td>eskind</td>
<td>integer</td>
<td>Kind of external schema.</td>
</tr>
<tr>
<td>esdbname</td>
<td>text</td>
<td>External database name.</td>
</tr>
</tbody>
</table>
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 (p. 915).

### Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>name</td>
<td>Library name.</td>
</tr>
<tr>
<td>language_oid</td>
<td>oid</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>file_store_id</td>
<td>integer</td>
<td>Reserved for system use.</td>
</tr>
<tr>
<td>owner</td>
<td>integer</td>
<td>User ID of the library owner.</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>prooid</td>
<td>oid</td>
<td>The object ID of the function or stored procedure.</td>
</tr>
<tr>
<td>prokind</td>
<td>&quot;char&quot;</td>
<td>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.</td>
</tr>
<tr>
<td>proargmodes</td>
<td>&quot;char&quot;[ ]</td>
<td>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.</td>
</tr>
<tr>
<td>proallargtypes</td>
<td>oid[ ]</td>
<td>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 1-based. In contrast, proargtypes is subscripted from 0.</td>
</tr>
</tbody>
</table>

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 (p. 915).

Table Columns

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sunairelid</td>
<td>oid</td>
<td>Table ID</td>
</tr>
<tr>
<td>sunairrows</td>
<td>float</td>
<td>Total number of rows in the table.</td>
</tr>
<tr>
<td>sunains</td>
<td>float</td>
<td>Number of rows inserted since the last ANALYZE.</td>
</tr>
</tbody>
</table>
### Column Name

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>staidels</td>
<td>Number of rows deleted or updated since the last ANALYZE.</td>
</tr>
</tbody>
</table>

#### Example

The following example returns information for table changes since the last ANALYZE.

```sql
select * from pg_statistic_indicator;
```

<table>
<thead>
<tr>
<th>stairelid</th>
<th>stairows</th>
<th>staiins</th>
<th>staidels</th>
</tr>
</thead>
<tbody>
<tr>
<td>108271</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>108275</td>
<td>365</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>108278</td>
<td>8798</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>108280</td>
<td>91865</td>
<td>0</td>
<td>100632</td>
</tr>
<tr>
<td>108267</td>
<td>89981</td>
<td>49990</td>
<td>9999</td>
</tr>
<tr>
<td>108269</td>
<td>808</td>
<td>606</td>
<td>374</td>
</tr>
<tr>
<td>108282</td>
<td>152220</td>
<td>76110</td>
<td>248566</td>
</tr>
</tbody>
</table>

### 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 (p. 1106) parameter is set correctly to include the relevant schemas.

You can use SVV_TABLE_INFO (p. 1076) to view more comprehensive information about a table, including data distribution skew, key distribution skew, table size, and statistics.

#### Table Columns

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>schemaname</td>
<td>Schema name.</td>
</tr>
<tr>
<td>tablenamename</td>
<td>Table name.</td>
</tr>
<tr>
<td>column</td>
<td>Column name.</td>
</tr>
<tr>
<td>type</td>
<td>Datatype of column.</td>
</tr>
<tr>
<td>encoding</td>
<td>Encoding of column.</td>
</tr>
<tr>
<td>distkey</td>
<td>True if this column is the distribution key for the table.</td>
</tr>
<tr>
<td>sortkey</td>
<td>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 all each column that is part of the sort key has a value that is alternately positive or negative, where the...</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>absolute value indicates the position of the column in the sort key. If 0, the column is not part of a sort key.</td>
<td></td>
</tr>
<tr>
<td>notnull</td>
<td>boolean</td>
</tr>
</tbody>
</table>

**Example**

The following example shows the compound sort key columns for the LINEORDER_COMPOUND table.

```sql
select "column", type, encoding, distkey, sortkey, "notnull"
from pg_table_def
where tablename = 'lineorder_compound'
and sortkey <> 0;
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
<th>notnull</th>
</tr>
</thead>
<tbody>
<tr>
<td>lo_orderkey</td>
<td>integer</td>
<td>delta32k</td>
<td>false</td>
<td>1</td>
<td>true</td>
</tr>
<tr>
<td>lo_custkey</td>
<td>integer</td>
<td>none</td>
<td>false</td>
<td>2</td>
<td>true</td>
</tr>
<tr>
<td>lo_partkey</td>
<td>integer</td>
<td>none</td>
<td>true</td>
<td>3</td>
<td>true</td>
</tr>
<tr>
<td>lo_suppkey</td>
<td>integer</td>
<td>delta32k</td>
<td>false</td>
<td>4</td>
<td>true</td>
</tr>
<tr>
<td>lo_orderdate</td>
<td>integer</td>
<td>delta</td>
<td>false</td>
<td>5</td>
<td>true</td>
</tr>
</tbody>
</table>

(5 rows)

The following example shows the interleaved sort key columns for the LINEORDER_INTERLEAVED table.

```sql
select "column", type, encoding, distkey, sortkey, "notnull"
from pg_table_def
where tablename = 'lineorder_interleaved'
and sortkey <> 0;
```

<table>
<thead>
<tr>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
<th>notnull</th>
</tr>
</thead>
<tbody>
<tr>
<td>lo_orderkey</td>
<td>integer</td>
<td>delta32k</td>
<td>false</td>
<td>-1</td>
<td>true</td>
</tr>
<tr>
<td>lo_custkey</td>
<td>integer</td>
<td>none</td>
<td>false</td>
<td>2</td>
<td>true</td>
</tr>
<tr>
<td>lo_partkey</td>
<td>integer</td>
<td>none</td>
<td>true</td>
<td>-3</td>
<td>true</td>
</tr>
<tr>
<td>lo_suppkey</td>
<td>integer</td>
<td>delta32k</td>
<td>false</td>
<td>4</td>
<td>true</td>
</tr>
<tr>
<td>lo_orderdate</td>
<td>integer</td>
<td>delta</td>
<td>false</td>
<td>-5</td>
<td>true</td>
</tr>
</tbody>
</table>

(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 (p. 1106).

For example, suppose you create a new schema and a new table, then query PG_TABLE_DEF.

```sql
create schema demo;
create table demo.demotable (one int);
select * from pg_table_def where tablename = 'demotable';
```

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
<th>notnull</th>
</tr>
</thead>
</table>

The query returns no rows for the new table. Examine the setting for search_path.

```sql
show search_path;
```
search_path
-------------
$user, public
(1 row)

Add the demo schema to the search path and execute the query again.

```
set search_path to '$user', 'public', 'demo';
select * from pg_table_def where tablename = 'demotable';
```

<table>
<thead>
<tr>
<th>schemaname</th>
<th>tablename</th>
<th>column</th>
<th>type</th>
<th>encoding</th>
<th>distkey</th>
<th>sortkey</th>
<th>notnull</th>
</tr>
</thead>
<tbody>
<tr>
<td>demo</td>
<td>demotable</td>
<td>one</td>
<td>integer</td>
<td>none</td>
<td>f</td>
<td>0</td>
<td>f</td>
</tr>
</tbody>
</table>

(1 row)

Querying the Catalog Tables

Topics

• Examples of Catalog Queries (p. 1098)

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 PGSETTINGS and PGLOCKS 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 execute 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.

The following Amazon Redshift functions are compute-node only functions:

System information functions

• LISTAGG
• MEDIAN
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.

```sql
create view tables_vw as
select distinct(id) table_id,
   trim(datname) db_name,
   trim(nspname) schema_name,
   trim(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 = relnamespace
join pg_database on pg_database.oid = stv_tbl_perm.db_id;
```

The following example returns the information for table ID 117855.

```sql
select * from tables_vw where table_id = 117855;
```

<table>
<thead>
<tr>
<th>table_id</th>
<th>db_name</th>
<th>schema_name</th>
<th>table_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>117855</td>
<td>dev</td>
<td>public</td>
<td>customer</td>
</tr>
</tbody>
</table>

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.

```sql
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;
```

<table>
<thead>
<tr>
<th>nspname</th>
<th>relname</th>
<th>num_cols</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>category</td>
<td>4</td>
</tr>
<tr>
<td>public</td>
<td>date</td>
<td>8</td>
</tr>
<tr>
<td>public</td>
<td>event</td>
<td>6</td>
</tr>
<tr>
<td>public</td>
<td>listing</td>
<td>8</td>
</tr>
<tr>
<td>public</td>
<td>sales</td>
<td>10</td>
</tr>
<tr>
<td>public</td>
<td>users</td>
<td>18</td>
</tr>
</tbody>
</table>
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.)

```sql
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;
```

<table>
<thead>
<tr>
<th>datname</th>
<th>nspname</th>
<th>relname</th>
<th>rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>tickit</td>
<td>public</td>
<td>category</td>
<td>11</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>date</td>
<td>365</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>event</td>
<td>8798</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>listing</td>
<td>192497</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>sales</td>
<td>172456</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>users</td>
<td>49990</td>
</tr>
<tr>
<td>tickit</td>
<td>public</td>
<td>venue</td>
<td>202</td>
</tr>
</tbody>
</table>

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:

```sql
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;
```

<table>
<thead>
<tr>
<th>attrelid</th>
<th>rtrim</th>
<th>attname</th>
<th>typname</th>
</tr>
</thead>
<tbody>
<tr>
<td>100133</td>
<td>users</td>
<td>likebroadway</td>
<td>bool</td>
</tr>
<tr>
<td>100133</td>
<td>users</td>
<td>likeclassical</td>
<td>bool</td>
</tr>
<tr>
<td>100133</td>
<td>users</td>
<td>likeconcerts</td>
<td>bool</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100137</td>
<td>venue</td>
<td>venuestate</td>
<td>bpchar</td>
</tr>
<tr>
<td>100137</td>
<td>venue</td>
<td>venueid</td>
<td>int2</td>
</tr>
<tr>
<td>100137</td>
<td>venue</td>
<td>venueseats</td>
<td>int4</td>
</tr>
<tr>
<td>100137</td>
<td>venue</td>
<td>venuecity</td>
<td>varchar</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

```sql
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**

**Topics**
- Modifying the Server Configuration (p. 1101)
- analyze_threshold_percent (p. 1102)
- auto_analyze (p. 1102)
- datestyle (p. 1103)
- describe_field_name_in_uppercase (p. 1103)
- enable_result_cache_for_session (p. 1104)
- enable_vacuum_boost (p. 1104)
- extra_float_digits (p. 1104)
- max_concurrency_scaling_clusters (p. 1104)
- max_cursor_result_set_size (p. 1105)
- query_group (p. 1105)
- search_path (p. 1106)
- statement_timeout (p. 1107)
- timezone (p. 1108)
- wlm_query_slot_count (p. 1110)

**Modifying the Server Configuration**

You can change the server configuration in the following ways:

- By using a **SET (p. 636)** command to override a setting for the duration of the current session only.
  
  For example:

  ```sql
  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 Cluster Management Guide.

- By using the **ALTER USER (p. 435)** command to set a configuration parameter to a new value for all sessions run by the specified user.

  ```sql
  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 (p. 636)** command.

```sql
show all;

<table>
<thead>
<tr>
<th>name</th>
<th>setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>analyze_threshold_percent</td>
<td>10</td>
</tr>
<tr>
<td>datestyle</td>
<td>ISO, MDY</td>
</tr>
<tr>
<td>extra_float_digits</td>
<td>2</td>
</tr>
</tbody>
</table>
```
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 changes 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

```sql
set analyze_threshold_percent to 15;
set analyze_threshold_percent to 0.01;
set analyze_threshold_percent to 0;
```

auto_analyze

Values (Default in Bold)

true, false

Description

If auto_analyze is set to true, 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.

Example

```sql
set auto_analyze to true;
```
**datestyle**

Values (Default in Bold)

Format specification (ISO, Postgres, SQL, or German), and year/month/day ordering (DMY, MDY, YMD).

ISO, MDY

Description

Sets the display format for date and time values as well as the rules for interpreting ambiguous date input values. The string contains two parameters that can be changed separately or together.

Example

```
show datestyle;
DateStyle
------------
ISO, MDY
(1 row)

set datestyle to 'SQL,DMY';
```

**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 on, column names are returned in uppercase. If 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
```
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 execute the query. If enable_result_cache_for_session is off, Amazon Redshift ignores the results cache and executes all queries when they are submitted.

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 (p. 663).

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 needs to be restored exactly. Or it can be set negative to suppress unwanted digits.

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.

You can request an increase by submitting an Amazon Redshift Limit Increase Form.

max_cursor_result_set_size

Values (Default in Bold)

0 (defaults to maximum) - 14400000 MB

Description

The max_cursor_result_set_size parameter is deprecated. For more information about cursor result set size, see Cursor Constraints (p. 564).

query_group

Values (Default in Bold)

No default; the value can be any character string.

Description

This parameter 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 and can be used 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 does not 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 executed 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;
```

<table>
<thead>
<tr>
<th>query</th>
<th>pid</th>
<th>substring</th>
<th>elapsed</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>1105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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. If public is present and no schema with the name public exists, it is ignored.

Description

This parameter 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 are not supported with external schemas and external tables. External tables must be explicitly qualified by an external schema.
- 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 is not 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)

---

statement_timeout

Values (Default in Bold)

0 (turns off limitation), x milliseconds

Description

Aborts 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 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 (p. 319).

Example

Because the following query takes longer than 1 millisecond, it times out and is cancelled.

set statement_timeout to 1;
select * from listing where listid>5000;
timezone

Values (Default in Bold)

UTC, time zone

Syntax

```sql
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 Coordinated Universal 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 (p. 435) 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.

```sql
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 as well as a time zone name, a POSIX-style format offset, or an ISO-8601 format offset, as shown following.

```sql
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.

```sql
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
Examples

The following example sets the time zone for the current session to New York.

```sql
set timezone = 'America/New_York';
```

The following example sets the time zone for the current session to UTC–8 (PST).

```sql
set timezone to '-8:00';
```

The following example uses INTERVAL to set the time zone to PST.

```sql
set timezone interval '-8 hours';
```

The following example resets the time zone for the current session to the system default time zone (UTC).

```sql
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.

```sql
ALTER USER dbuser SET timezone to 'America/New_York';
```

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 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 Implementing Workload Management (p. 309).

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 Vacuum, 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 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 executed within the same service class. Subsequent queries wait in the queue until currently executing 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;
```
Sample Database

Topics

- CATEGORY Table (p. 1113)
- DATE Table (p. 1113)
- EVENT Table (p. 1114)
- VENUE Table (p. 1114)
- USERS Table (p. 1115)
- LISTING Table (p. 1115)
- SALES Table (p. 1116)

Most of the examples in the Amazon Redshift documentation use a sample database called TICKIT. 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 6: Load Sample Data from Amazon S3 in the Amazon Redshift Getting Started.

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
```
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

### CATEGORY Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATID</td>
<td>SMALLINT</td>
<td>Primary key, a unique ID value for each row. Each row represents a specific type of event for which tickets are bought and sold.</td>
</tr>
<tr>
<td>CATGROUP</td>
<td>VARCHAR(10)</td>
<td>Descriptive name for a group of events, such as Shows and Sports.</td>
</tr>
<tr>
<td>CATNAME</td>
<td>VARCHAR(10)</td>
<td>Short descriptive name for a type of event within a group, such as Opera and Musicals.</td>
</tr>
<tr>
<td>CATDESC</td>
<td>VARCHAR(30)</td>
<td>Longer descriptive name for the type of event, such as Musical theatre.</td>
</tr>
</tbody>
</table>

### DATE Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATEID</td>
<td>SMALLINT</td>
<td>Primary key, a unique ID value for each row. Each row represents a day in the calendar year.</td>
</tr>
<tr>
<td>CALDATE</td>
<td>DATE</td>
<td>Calendar date, such as 2008-06-24.</td>
</tr>
</tbody>
</table>
### EVENT Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAY</td>
<td>CHAR(3)</td>
<td>Day of week (short form), such as SA.</td>
</tr>
<tr>
<td>WEEK</td>
<td>SMALLINT</td>
<td>Week number, such as 26.</td>
</tr>
<tr>
<td>MONTH</td>
<td>CHAR(5)</td>
<td>Month name (short form), such as JUN.</td>
</tr>
<tr>
<td>QTR</td>
<td>CHAR(5)</td>
<td>Quarter number (1 through 4).</td>
</tr>
<tr>
<td>YEAR</td>
<td>SMALLINT</td>
<td>Four-digit year (2008).</td>
</tr>
<tr>
<td>HOLIDAY</td>
<td>BOOLEAN</td>
<td>Flag that denotes whether the day is a public holiday (U.S.).</td>
</tr>
</tbody>
</table>

### EVENT Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVENTID</td>
<td>INTEGER</td>
<td>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.</td>
</tr>
<tr>
<td>VENUEID</td>
<td>SMALLINT</td>
<td>Foreign-key reference to the VENUE table.</td>
</tr>
<tr>
<td>CATID</td>
<td>SMALLINT</td>
<td>Foreign-key reference to the CATEGORY table.</td>
</tr>
<tr>
<td>DATEID</td>
<td>SMALLINT</td>
<td>Foreign-key reference to the DATE table.</td>
</tr>
<tr>
<td>EVENTNAME</td>
<td>VARCHAR(200)</td>
<td>Name of the event, such as Hamlet or La Traviata.</td>
</tr>
<tr>
<td>STARTTIME</td>
<td>TIMESTAMP</td>
<td>Full date and start time for the event, such as 2008-10-10 19:30:00.</td>
</tr>
</tbody>
</table>

### VENUE Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VENUEID</td>
<td>SMALLINT</td>
<td>Primary key, a unique ID value for each row. Each row represents a specific venue where events take place.</td>
</tr>
<tr>
<td>VENUENAME</td>
<td>VARCHAR(100)</td>
<td>Exact name of the venue, such as Cleveland Browns Stadium.</td>
</tr>
<tr>
<td>VENUECITY</td>
<td>VARCHAR(30)</td>
<td>City name, such as Cleveland.</td>
</tr>
<tr>
<td>VENUESTATE</td>
<td>CHAR(2)</td>
<td>Two-letter state or province abbreviation (United States and Canada), such as OH.</td>
</tr>
<tr>
<td>VENUESEATS</td>
<td>INTEGER</td>
<td>Maximum number of seats available at the venue, if known, such as 73200. For demonstration purposes, this column contains some null values and zeroes.</td>
</tr>
</tbody>
</table>
## USERS Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USERID</td>
<td>INTEGER</td>
<td>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.</td>
</tr>
<tr>
<td>USERNAME</td>
<td>CHAR(8)</td>
<td>An 8-character alphanumeric username, such as PGL08LJ1.</td>
</tr>
<tr>
<td>FIRSTNAME</td>
<td>VARCHAR(30)</td>
<td>The user's first name, such as Victor.</td>
</tr>
<tr>
<td>LASTNAME</td>
<td>VARCHAR(30)</td>
<td>The user's last name, such as Hernandez.</td>
</tr>
<tr>
<td>CITY</td>
<td>VARCHAR(30)</td>
<td>The user's home city, such as Naperville.</td>
</tr>
<tr>
<td>STATE</td>
<td>CHAR(2)</td>
<td>The user's home state, such as GA.</td>
</tr>
<tr>
<td>EMAIL</td>
<td>VARCHAR(100)</td>
<td>The user's email address; this column contains random Latin values, such as <a href="mailto:turpis@accumsanlaoreet.org">turpis@accumsanlaoreet.org</a>.</td>
</tr>
<tr>
<td>PHONE</td>
<td>CHAR(14)</td>
<td>The user's 14-character phone number, such as (818) 765-4255.</td>
</tr>
<tr>
<td>LIKESPORTS,...</td>
<td>BOOLEAN</td>
<td>A series of 10 different columns that identify the user's likes and dislikes with true and false values.</td>
</tr>
</tbody>
</table>

## LISTING Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISTID</td>
<td>INTEGER</td>
<td>Primary key, a unique ID value for each row. Each row represents a listing of a batch of tickets for a specific event.</td>
</tr>
<tr>
<td>SELLERID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the USERS table, identifying the user who is selling the tickets.</td>
</tr>
<tr>
<td>EVENTID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the EVENT table.</td>
</tr>
<tr>
<td>DATEID</td>
<td>SMALLINT</td>
<td>Foreign-key reference to the DATE table.</td>
</tr>
<tr>
<td>NUMTICKETS</td>
<td>SMALLINT</td>
<td>The number of tickets available for sale, such as 2 or 20.</td>
</tr>
<tr>
<td>PRICEPERTICKET</td>
<td>DECIMAL(8,2)</td>
<td>The fixed price of an individual ticket, such as 27.00 or 206.00.</td>
</tr>
<tr>
<td>TOTALPRICE</td>
<td>DECIMAL(8,2)</td>
<td>The total price for this listing (NUMTICKETS*PRICEPERTICKET).</td>
</tr>
<tr>
<td>LISTTIME</td>
<td>TIMESTAMP</td>
<td>The full date and time when the listing was posted, such as 2008-03-18 07:19:35.</td>
</tr>
</tbody>
</table>
### SALES Table

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALESID</td>
<td>INTEGER</td>
<td>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.</td>
</tr>
<tr>
<td>LISTID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the LISTING table.</td>
</tr>
<tr>
<td>SELLERID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the USERS table (the user who sold the tickets).</td>
</tr>
<tr>
<td>BUYERID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the USERS table (the user who bought the tickets).</td>
</tr>
<tr>
<td>EVENTID</td>
<td>INTEGER</td>
<td>Foreign-key reference to the EVENT table.</td>
</tr>
<tr>
<td>DATEID</td>
<td>SMALLINT</td>
<td>Foreign-key reference to the DATE table.</td>
</tr>
<tr>
<td>QTYSOLD</td>
<td>SMALLINT</td>
<td>The number of tickets that were sold, from 1 to 8. (A maximum of 8 tickets can be sold in a single transaction.)</td>
</tr>
<tr>
<td>PRICEPAID</td>
<td>DECIMAL(8,2)</td>
<td>The total price paid for the tickets, such as <code>75.00</code> or <code>488.00</code>. The individual price of a ticket is <code>PRICEPAID / QTYSOLD</code>.</td>
</tr>
<tr>
<td>COMMISSION</td>
<td>DECIMAL(8,2)</td>
<td>The 15% commission that the business collects from the sale, such as <code>11.25</code> or <code>73.20</code>. The seller receives 85% of the <code>PRICEPAID</code> value.</td>
</tr>
<tr>
<td>SALETIME</td>
<td>TIMESTAMP</td>
<td>The full date and time when the sale was completed, such as <code>2008-05-24 06:21:47</code>.</td>
</tr>
</tbody>
</table>
Appendix: Time Zone Names and Abbreviations

Topics

- Time Zone Names (p. 1117)
- Time Zone Abbreviations (p. 1126)

The following lists contain most of the valid time zone names and time zone abbreviations that can be specified with the `CONVERT_TIMEZONE` Function (p. 751).

Time Zone Names

The following list contains most of the valid time zone names that can be specified with the `CONVERT_TIMEZONE` Function (p. 751). For a current, complete list of time zone names, execute the following command.

```
select pg_timezone_names();
```

Even though some of the time zone names in this list are capitalized initialisms or acronyms (for example, GB, PRC, ROK), the `CONVERT_TIMEZONE` function treats them as time zone names, not time zone abbreviations.

Africa/Abidjan
Africa/Accra
Africa/Addis_Ababa
Africa/Algiers
Africa/Asmara
Africa/Asmera
Africa/Bamako
Africa/Bangui
Africa/Banjul
Africa/Bissau
Africa/Blantyre
Africa/Brazzaville
Africa/Bujumbura
Africa/Cairo
Africa/Casablanca
Africa/Ceuta
Africa/Conakry
Africa/Dakar
Africa/Dar_es_Salaam
Africa/Djibouti
Africa/Douala
Africa/El_Aaiun
Africa/Freetown
Africa/Gaborone
Africa/Harare
Africa/Johannesburg
Africa/Juba
Africa/Kampala
Africa/Khartoum
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<th>Time Zone Names</th>
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<td>Africa/Kinshasa</td>
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<tr>
<td>Africa/Libreville</td>
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<td>Africa/Lubumbashi</td>
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<td>Africa/Mbabane</td>
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America/Nassau
America/New_York
America/Nipigon
America/Nome
America/Noronha
America/North_Dakota/Beulah
America/North_Dakota/Central
America/North_Dakota/New_Salem
America/Ojinaga
America/Panama
America/Pangnirtung
America/Paramaribo
America/Phoenix
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America/Port-au-Prince
America/Porto_Acre
America/Porto_Velho
America/Puerto_Rico
America/Rainy_River
America/Rankin_Inlet
America/Recife
America/Regina
America/Resolute
America/Rio_Branco
America/Rosario
America/Santa_Isabel
America/Santarem
America/Santiago
America/Santo_Domingo
America/Sao_Paulo
America/Scoresbysund
America/Shiprock
America/Sitka
America/St_Barthelemy
America/St_Johns
America/St_Kitts
America/St_Lucia
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America/St_Vincent
America/Swift_Current
America/Tegucigalpa
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America/Thunder_Bay
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America/Vancouver
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America/Winnipeg
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America/Yellowknife
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Antarctica/Davis
Antarctica/DumontDUrville
Antarctica/Macquarie
Antarctica/Mawson
Antarctica/McMurdo
Antarctica/Palmer
Antarctica/Rothera
Antarctica/South_Pole
Antarctica/Syowa
Antarctica/Vostok
Arctic/Longyearbyen
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Asia/Almaty
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Asia/Aqtobe
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Asia/Omsk
Asia/Oral
Asia/Phnom Penh
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1122
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Europe/Zagreb
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Europe/Zurich
GB
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GMT
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GMT0
GMT-0
Greenwich
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HST
Iceland
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Indian/Christmas
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Japan
Kwajalein
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Mexico/General
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Mideast/Riyadh88
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MST
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NZ
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Pacific/Chatham
Pacific/Chuuk
Pacific/Easter
Pacific/Efate
Pacific/Enderbury
Pacific/Fakaofo
Pacific/Fiji
Pacific/Funafuti
Pacific/Galapagos
Pacific/Gambier
Pacific/Guadalcanal
Pacific/Guam
Pacific/Honolulu
Pacific/Johnston
Pacific/Kiritimati
Pacific/Kosrae
Pacific/Kwajalein
Pacific/Majuro
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Pacific/Noumea
Pacific/Pago_Pago
Pacific/Palau
Pacific/Pitcairn
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Pacific/Port_Moresby
Pacific/Rarotonga
Pacific/Saipan
Pacific/Samoa
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Pacific/Truk
Pacific/Wake
Pacific/Wallis
Pacific/Yap
Time Zone Abbreviations

The following list contains all of the valid time zone abbreviations that can be specified with the CONVERT_TIMEZONE Function (p. 751).

For a current, complete list of time zone abbreviations, execute the following command.

```
select pg_timezone_abbrevs();
```
<table>
<thead>
<tr>
<th>Time Zone Abbreviation</th>
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## Document History

The following table describes the important changes in each release of 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**

**Latest documentation update: February 19, 2020**

For a list of the changes to the Amazon Redshift Cluster Management Guide, see Amazon Redshift Cluster 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.

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<th>update-history-change</th>
<th>update-history-description</th>
<th>update-history-date</th>
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<tr>
<td><strong>Support for materialized views general availability</strong></td>
<td>Materialized views are generally available starting with cluster version 1.0.13059.</td>
<td>February 19, 2020</td>
</tr>
<tr>
<td><strong>Support for column-level privileges</strong></td>
<td>Column-level privileges are available starting with cluster version 1.0.13059.</td>
<td>February 19, 2020</td>
</tr>
<tr>
<td><strong>ALTER TABLE</strong></td>
<td>You can use an ALTER TABLE command with the ALTER DISTSTYLE ALL clause to change the distribution style of a table.</td>
<td>February 11, 2020</td>
</tr>
<tr>
<td><strong>Support for federated query</strong></td>
<td>Updated the guide to describe federated query with an updated CREATE EXTERNAL SCHEMA.</td>
<td>December 3, 2019</td>
</tr>
<tr>
<td><strong>Support for data lake export</strong></td>
<td>Updated the guide to describe new parameters of the UNLOAD command.</td>
<td>December 3, 2019</td>
</tr>
<tr>
<td><strong>Support for spatial data</strong></td>
<td>Updated the guide to describe support for spatial data.</td>
<td>November 21, 2019</td>
</tr>
<tr>
<td><strong>Support for the new console</strong></td>
<td>Updated the guide to describe the new Amazon Redshift console.</td>
<td>November 11, 2019</td>
</tr>
<tr>
<td><strong>Support for automatic table sort</strong></td>
<td>Amazon Redshift can automatically sort table data.</td>
<td>November 7, 2019</td>
</tr>
<tr>
<td><strong>Support for VACUUM BOOST option</strong></td>
<td>You can use the BOOST option when vacuuming tables.</td>
<td>November 7, 2019</td>
</tr>
<tr>
<td><strong>Support for default IDENTITY columns</strong></td>
<td>You can create tables with default IDENTITY columns.</td>
<td>September 19, 2019</td>
</tr>
<tr>
<td><strong>Support for AZ64 compression encoding</strong></td>
<td>You can encode some columns with AZ64 compression encoding.</td>
<td>September 19, 2019</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
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<tr>
<td>Support for query priority</td>
<td>You can set the query priority of an automatic WLM queue.</td>
<td>August 22, 2019</td>
</tr>
<tr>
<td>Support for AWS Lake Formation</td>
<td>You can use a Lake Formation Data Catalog with Amazon Redshift Spectrum.</td>
<td>August 8, 2019</td>
</tr>
<tr>
<td>COMPUPDATE PRESET</td>
<td>You can use a COPY command with COMPUPDATE PRESET to enable Amazon Redshift to choose the compression encoding.</td>
<td>June 13, 2019</td>
</tr>
<tr>
<td>ALTER COLUMN</td>
<td>You can use an ALTER TABLE command with ALTER COLUMN to increase the size of a VARCHAR column.</td>
<td>May 22, 2019</td>
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<tr>
<td>Support for stored procedures</td>
<td>You can define PL/pgSQL stored procedures in Amazon Redshift.</td>
<td>April 24, 2019</td>
</tr>
<tr>
<td>Support for an automatic workload management (WLM) configuration</td>
<td>You can enable Amazon Redshift to run with automatic WLM.</td>
<td>April 24, 2019</td>
</tr>
<tr>
<td>UNLOAD to Zstandard</td>
<td>You can use the UNLOAD command to apply Zstandard compression to text and comma-separated value (CSV) files unloaded to Amazon S3.</td>
<td>April 3, 2019</td>
</tr>
<tr>
<td>Concurrency scaling</td>
<td>When concurrency scaling is enabled, Amazon Redshift automatically adds additional cluster capacity when you need it to process an increase in concurrent read queries.</td>
<td>March 21, 2019</td>
</tr>
<tr>
<td>UNLOAD to CSV</td>
<td>You can use the UNLOAD command to unload to a file formatted as CSV text.</td>
<td>March 13, 2019</td>
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<tr>
<td>AUTO distribution style</td>
<td>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.</td>
<td>January 23, 2019</td>
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<tr>
<td>Feature</td>
<td>Description</td>
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<td>---------------------------------------------------</td>
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<tr>
<td>COPY from Parquet supports SMALLINT (p. 1130)</td>
<td>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.</td>
<td>January 2, 2019</td>
</tr>
<tr>
<td>DROP EXTERNAL DATABASE</td>
<td>You can drop an external database by including the DROP EXTERNAL DATABASE clause with a DROP SCHEMA command.</td>
<td>December 3, 2018</td>
</tr>
<tr>
<td>Cross-region UNLOAD</td>
<td>You can UNLOAD to an Amazon S3 bucket in another AWS Region by specifying the REGION parameter.</td>
<td>October 31, 2018</td>
</tr>
<tr>
<td>Automatic vacuum delete</td>
<td>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.</td>
<td>October 31, 2018</td>
</tr>
<tr>
<td>Automatic distribution</td>
<td>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.</td>
<td>October 31, 2018</td>
</tr>
<tr>
<td>Fine grained access control for the AWS Glue Data Catalog</td>
<td>You can now specify levels of access to data stored in the AWS Glue data catalog.</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td>UNLOAD with data types</td>
<td>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.</td>
<td>October 10, 2018</td>
</tr>
<tr>
<td>Add multiple partitions using a single ALTER TABLE statement</td>
<td>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.</td>
<td>October 10, 2018</td>
</tr>
<tr>
<td>Feature</td>
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<tr>
<td>UNLOAD with header</td>
<td>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.</td>
<td>September 19, 2018</td>
</tr>
<tr>
<td>New system table and views</td>
<td>SVL_S3Retries, SVL_USER_INFO, and STL_DISK_FULL_DIAG documentation added.</td>
<td>August 31, 2018</td>
</tr>
<tr>
<td>Support for nested data in Amazon Redshift Spectrum</td>
<td>You can now query nested data stored in Amazon Redshift Spectrum tables. For more information, see Tutorial: Querying Nested Data with Amazon Redshift Spectrum.</td>
<td>August 8, 2018</td>
</tr>
<tr>
<td>SQA on by default</td>
<td>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.</td>
<td>August 8, 2018</td>
</tr>
<tr>
<td>Amazon Redshift Advisor</td>
<td>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.</td>
<td>July 26, 2018</td>
</tr>
<tr>
<td>Immediate alias reference</td>
<td>You can now refer to an aliased expression immediately after you define it. For more information, see SELECT List.</td>
<td>July 18, 2018</td>
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<tr>
<td>Specify compression type when creating an external table</td>
<td>You can now specify compression type when creating an external table with Amazon Redshift Spectrum. For more information, see Create External Tables.</td>
<td>June 27, 2018</td>
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<tr>
<td>PG_LAST_UNLOAD_ID</td>
<td>Documentation added for a new System Information function: PG_LAST_UNLOAD_ID. For more information, see PG_LAST_UNLOAD_ID.</td>
<td>June 27, 2018</td>
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<tr>
<td>ALTER TABLE RENAME COLUMN</td>
<td>ALTER TABLE now supports renaming columns for external tables. For more information, see Alter External Table Examples.</td>
<td>June 7, 2018</td>
</tr>
</tbody>
</table>
## Earlier Updates

The following table describes the important changes in each release of the *Amazon Redshift Database Developer Guide* before June 2018.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date Changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPY from Parquet includes SMALLINT</td>
<td>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](p. 492).</td>
<td>January 2, 2019</td>
</tr>
<tr>
<td>COPY from columnar formats</td>
<td>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](p. 492).</td>
<td>May 17, 2018</td>
</tr>
<tr>
<td>Dynamic maximum run time for SQA</td>
<td>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](p. 339).</td>
<td>May 17, 2018</td>
</tr>
<tr>
<td>New column in STL_LOAD_COMMITS</td>
<td>The STL_LOAD_COMMITS (p. 944) system table has a new column, <code>file_format</code>.</td>
<td>May 10, 2018</td>
</tr>
<tr>
<td>New columns in STL_HASHJOIN and other system log tables</td>
<td>The STL_HASHJOIN (p. 940) system table has three new columns, <code>hash_segment</code>, <code>hash_step</code>, and <code>checksum</code>. Also, a checksum was added to STL_MERGEJOIN, STL_NESTLOOP, STL_HASH, STL_SCAN, STL_SORT, STL_LIMIT, and STL_PROJECT.</td>
<td>May 17, 2018</td>
</tr>
<tr>
<td>New columns in STL_AGGR</td>
<td>The STL_AGGR (p. 917) system table has two new columns, <code>resizes</code> and <code>flushable</code>.</td>
<td>April 19, 2018</td>
</tr>
<tr>
<td>New options for REGEX functions</td>
<td>For the <code>REGEXP_INSTR</code> (p. 858) and <code>REGEXP_SUBSTR</code> (p. 861) functions, you can now specify which occurrence of a match to use and whether to perform a case-sensitive match. <code>REGEXP_INSTR</code> 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.</td>
<td>March 22, 2018</td>
</tr>
<tr>
<td>New columns in system tables</td>
<td>The tombstonedblocks, tossedblocks, and batched_by columns were added to the STL_COMMIT_STATS (p. 924) system table. The localslice column was added to the STV_SLICES (p. 1012) system view.</td>
<td>March 22, 2018</td>
</tr>
<tr>
<td>Add and drop columns in external tables</td>
<td><code>ALTER TABLE</code> (p. 421) now supports <code>ADD COLUMN</code> and <code>DROP COLUMN</code> for Amazon Redshift Spectrum external tables.</td>
<td>March 22, 2018</td>
</tr>
<tr>
<td>Amazon Redshift Spectrum new AWS Regions</td>
<td>Redshift Spectrum is now available in the Mumbai and São Paulo Regions. For a list of supported Regions, see [Amazon Redshift Spectrum Regions](p. 235).</td>
<td>March 22, 2018</td>
</tr>
<tr>
<td>Table limit increased to 20,000</td>
<td>The maximum number of tables is now 20,000 for 8xlarge cluster node types. The limit for large and xlarge</td>
<td>March 13, 2018</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
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</tr>
<tr>
<td>node types</td>
<td>node types is 9,900. For more information, see Limits and Quotas (p. 544).</td>
<td></td>
</tr>
<tr>
<td>Amazon Redshift Spectrum support for JSON and Ion</td>
<td>Using Redshift Spectrum, you can reference files with scalar data in JSON or Ion data formats. For more information, see CREATE EXTERNAL TABLE (p. 513).</td>
<td>February 26, 2018</td>
</tr>
<tr>
<td>IAM role chaining for Amazon Redshift Spectrum</td>
<td>You can chain AWS Identity and Access Management (IAM) roles so that your cluster can assume other roles not attached to the cluster, including roles belonging to another AWS account. For more information, see Chaining IAM Roles in Amazon Redshift Spectrum (p. 246).</td>
<td>February 1, 2018</td>
</tr>
<tr>
<td>ADD PARTITION supports IF NOT EXISTS</td>
<td>The ADD PARTITION clause for ALTER TABLE now supports an IF NOT EXISTS option. For more information, see ALTER TABLE (p. 421).</td>
<td>January 11, 2018</td>
</tr>
<tr>
<td>DATE data for external tables</td>
<td>Amazon Redshift Spectrum external tables now support the DATE data type. For more information, see CREATE EXTERNAL TABLE (p. 513).</td>
<td>January 11, 2018</td>
</tr>
<tr>
<td>Amazon Redshift Spectrum new AWS Regions</td>
<td>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 (p. 235).</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>Short query acceleration in Amazon Redshift workload management (WLM)</td>
<td>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 Working with Short Query Acceleration (p. 338).</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>WLM reassigns hopped queries</td>
<td>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 (p. 320).</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>System log access for users</td>
<td>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 (p. 435) or CREATE USER (p. 557) and set the SYSLOG ACCESS (p. 436) parameter to UNRESTRICTED.</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
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<tr>
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</tr>
<tr>
<td>Result caching</td>
<td>With Result Caching (p. 7), 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 execute the query. Result caching is enabled by default. To disable result caching, set the enable_result_cache_for_session (p. 1104) configuration parameter to off.</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>Column metadata functions</td>
<td>PG_GET_COLS (p. 904) and PG_GET_LATE_BINDING_VIEW_COLS (p. 905) return column metadata for Amazon Redshift tables, views, and late-binding views.</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>WLM queue hopping for CTAS</td>
<td>Amazon Redshift workload management (WLM) now supports query queue hopping for CREATE TABLE AS (p. 550) (CTAS) statements as well as read-only queries, such as SELECT statements. For more information, see WLM Query Queue Hopping (p. 320).</td>
<td>October 19, 2017</td>
</tr>
<tr>
<td>Amazon Redshift Spectrum manifest files</td>
<td>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 (p. 513).</td>
<td>October 19, 2017</td>
</tr>
<tr>
<td>Amazon Redshift Spectrum new AWS Regions</td>
<td>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 Considerations (p. 235).</td>
<td>October 19, 2017</td>
</tr>
<tr>
<td>Amazon Redshift Spectrum added file formats</td>
<td>You can now create Redshift Spectrum external tables based on Regex, OpenCSV, and Avro data file formats. For more information, see CREATE EXTERNAL TABLE (p. 513).</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>Pseudocolumns for Amazon Redshift Spectrum external tables</td>
<td>You can select the $path and $size pseudocolumns in a Redshift Spectrum external table to view the location and size of the referenced data files in Amazon S3. For more information, see Pseudocolumns (p. 261).</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>Functions to validate JSON</td>
<td>You can use the IS_VALID_JSON (p. 875) and IS_VALID_JSON_ARRAY (p. 876) functions to check for valid JSON formatting. The other JSON functions now have an optional null_if_invalid argument.</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>LISTAGG DISTINCT</td>
<td>You can use the DISTINCT clause with the LISTAGG (p. 673) aggregate function and the LISTAGG (p. 700) window function to eliminate duplicate values from the specified expression before concatenating.</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>View column names in uppercase</td>
<td>To view column names in SELECT results in uppercase, you can set the describe_field_name_in_uppercase (p. 1103) configuration parameter to true.</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>Change</td>
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</tr>
<tr>
<td>Skip header lines in external tables</td>
<td>You can set the <code>skip.header.line.count</code> property in the <code>CREATE EXTERNAL TABLE</code> (p. 513) command to skip header lines at the beginning of Redshift Spectrum data files.</td>
<td>October 5, 2017</td>
</tr>
<tr>
<td>Scan row count</td>
<td>WLM query monitor rules uses the <code>scan_row_count</code> 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 <code>Query Monitoring Metrics</code> (p. 348).</td>
<td>September 21, 2017</td>
</tr>
<tr>
<td>SQL user-defined functions</td>
<td>A scalar SQL user-defined function (UDF) incorporates a SQL SELECT clause that executes when the function is called and returns a single value. For more information, see <code>Creating a Scalar SQL UDF</code> (p. 182).</td>
<td>August 31, 2017</td>
</tr>
<tr>
<td>Late-binding views</td>
<td>A late-binding view is not 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. To create a late-binding view, specify the <code>WITH NO SCHEMA BINDING</code> clause with your <code>CREATE VIEW</code> statement. For more information, see <code>CREATE VIEW</code> (p. 561).</td>
<td>August 31, 2017</td>
</tr>
<tr>
<td>OCTET_LENGTH function</td>
<td><code>OCTET_LENGTH</code> (p. 854) returns the length of the specified string as the number of bytes.</td>
<td>August 18, 2017</td>
</tr>
<tr>
<td>ORC and Grok files types supported</td>
<td>Amazon Redshift Spectrum now supports the ORC and Grok data formats for Redshift Spectrum data files. For more information, see <code>Creating Data Files for Queries in Amazon Redshift Spectrum</code> (p. 253).</td>
<td>August 18, 2017</td>
</tr>
<tr>
<td>RegexSerDe now supported</td>
<td>Amazon Redshift Spectrum now supports the RegexSerDe data format. For more information, see <code>Creating Data Files for Queries in Amazon Redshift Spectrum</code> (p. 253).</td>
<td>July 19, 2017</td>
</tr>
<tr>
<td>New columns added to SVV_TABLES and SVV_COLUMNS</td>
<td>The columns <code>domain_name</code> and <code>remarks</code> were added to <code>SVV_COLUMNS</code> (p. 1027). A remarks column was added to <code>SVV_TABLES</code> (p. 1076).</td>
<td>July 19, 2017</td>
</tr>
<tr>
<td>SVV_TABLES and SVV_COLUMNS system views</td>
<td>The <code>SVV_TABLES</code> (p. 1076) and <code>SVV_COLUMNS</code> (p. 1027) system views provide information about columns and other details for local and external tables and views.</td>
<td>July 7, 2017</td>
</tr>
<tr>
<td>VPC no longer required for Amazon Redshift Spectrum with Amazon EMR Hive metastore</td>
<td>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 <code>Working with Amazon Redshift Spectrum External Catalogs</code> (p. 255).</td>
<td>July 7, 2017</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
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</tr>
<tr>
<td><strong>UNLOAD to smaller file sizes</strong></td>
<td>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 <strong>UNLOAD (p. 642)</strong>.</td>
<td>July 7, 2017</td>
</tr>
<tr>
<td><strong>TABLE PROPERTIES</strong></td>
<td>You can now set the TABLE PROPERTIES numRows parameter for CREATE EXTERNAL TABLE (p. 513) or ALTER TABLE (p. 421) to update table statistics to reflect the number of rows in the table.</td>
<td>June 6, 2017</td>
</tr>
<tr>
<td><strong>ANALYZE PREDICATE COLUMNS</strong></td>
<td>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 <strong>Analyzing Tables (p. 137)</strong>.</td>
<td>May 25, 2017</td>
</tr>
<tr>
<td><strong>IAM Policies for Amazon Redshift Spectrum</strong></td>
<td>To grant access to an Amazon S3 bucket only using Redshift Spectrum, you can include a condition that allows access for the user agent &quot;AWS Redshift/Spectrum&quot;. For more information, see <strong>IAM Policies for Amazon Redshift Spectrum (p. 243)</strong>.</td>
<td>May 25, 2017</td>
</tr>
<tr>
<td><strong>Amazon Redshift Spectrum Recursive Scan</strong></td>
<td>Redshift Spectrum now scans files in subfolders as well as the specified folder in Amazon S3. For more information, see <strong>Creating External Tables for Amazon Redshift Spectrum (p. 260)</strong>.</td>
<td>May 25, 2017</td>
</tr>
<tr>
<td><strong>Query Monitoring Rules</strong></td>
<td>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 <strong>WLM Query Monitoring Rules (p. 347)</strong>.</td>
<td>April 21, 2017</td>
</tr>
<tr>
<td><strong>Amazon Redshift Spectrum</strong></td>
<td>Using Redshift Spectrum, you can efficiently query and retrieve data from files in Amazon S3 without having to load the data into tables. Redshift Spectrum 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 <strong>Querying External Data Using Amazon Redshift Spectrum (p. 234)</strong>.</td>
<td>April 19, 2017</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>New system tables to support Redshift</td>
<td>The following new system views have been added to support Redshift Spectrum:</td>
<td>April 19, 2017</td>
</tr>
<tr>
<td>Spectrum</td>
<td>• SVL_S3QUERY (p. 1064)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SVL_S3QUERY_SUMMARY (p. 1068)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SVV_EXTERNAL_COLUMNS (p. 1036)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SVV_EXTERNAL_Databases (p. 1036)</td>
<td></td>
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<tr>
<td></td>
<td>• SVV_EXTERNAL_PARTITIONS (p. 1037)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SVV_EXTERNAL_TABLES (p. 1038)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• PG_EXTERNAL_SCHEMA (p. 1091)</td>
<td></td>
</tr>
<tr>
<td>APPROXIMATE PERCENTILE_DISC aggregate function</td>
<td>The APPROXIMATE PERCENTILE_DISC (p. 669) aggregate function is now available.</td>
<td>April 4, 2017</td>
</tr>
<tr>
<td>Server-side encryption with KMS</td>
<td>You can now unload data to Amazon S3 using server-side encryption with an AWS Key Management Service key (SSE-KMS). In addition, COPY (p. 450) now transparently loads KMS-encrypted data files from Amazon S3. For more information, see UNLOAD (p. 642).</td>
<td>February 9, 2017</td>
</tr>
<tr>
<td>New authorization syntax</td>
<td>You can now use the IAM_ROLE, MASTER_SYMMETRIC_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 (p. 465).</td>
<td>February 9, 2017</td>
</tr>
<tr>
<td>Schema limit increase</td>
<td>You can now create up to 9,900 schemas per cluster. For more information, see CREATE SCHEMA (p. 536).</td>
<td>February 9, 2017</td>
</tr>
<tr>
<td>Default table encoding</td>
<td>CREATE TABLE (p. 537) and ALTER TABLE (p. 421) 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 (p. 540).</td>
<td>February 6, 2017</td>
</tr>
<tr>
<td>ZSTD compression encoding</td>
<td>Amazon Redshift now supports ZSTD (p. 50) column compression encoding.</td>
<td>January 19, 2017</td>
</tr>
<tr>
<td>PERCENTILE_CONT and MEDIAN aggregate functions</td>
<td>PERCENTILE_CONT (p. 679) and MEDIAN (p. 676) are now available as aggregate functions as well as window functions.</td>
<td>January 19, 2017</td>
</tr>
<tr>
<td>User-defined function (UDF) User Logging</td>
<td>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 (p. 1080) system view to retrieve logged messages. For more information about user-defined messages, see Logging Errors and Warnings in UDFs (p. 189)</td>
<td>December 8, 2016</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
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<tr>
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</tr>
<tr>
<td>ANALYZE COMPRESSION</td>
<td>The ANALYZE COMPRESSION command now reports an estimate for percentage reduction in disk space for each column. For more information, see ANALYZE COMPRESSION (p. 441).</td>
<td>November 10, 2016</td>
</tr>
<tr>
<td>Connection limits</td>
<td>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 (p. 557) and CREATE DATABASE (p. 509).</td>
<td>November 10, 2016</td>
</tr>
<tr>
<td>COPY sort order enhancement</td>
<td>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 Loading Your Data in Sort Key Order (p. 149)</td>
<td>November 10, 2016</td>
</tr>
<tr>
<td>CTAS with compression</td>
<td>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 (p. 552).</td>
<td>October 28, 2016</td>
</tr>
<tr>
<td>Time stamp with time zone data type</td>
<td>Amazon Redshift now supports a time stamp with time zone (TIMESTAMPTZ (p. 381)) data type. Also, several new functions have been added to support the new data type. For more information, see Date and Time Functions (p. 742).</td>
<td>September 29, 2016</td>
</tr>
<tr>
<td>Analyze threshold</td>
<td>To reduce processing time and improve overall system performance for ANALYZE (p. 439) 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 (p. 1102) parameter. By default, analyze_threshold_percent is 10.</td>
<td>August 9, 2016</td>
</tr>
<tr>
<td>New STL_RESTARTED_SESSIONS</td>
<td>When Amazon Redshift restarts a session, the new session records the new process ID (PID) and the old PID.</td>
<td>August 9, 2016</td>
</tr>
<tr>
<td>Updated the Date and Time Functions documentation</td>
<td>Added a summary of functions with links to the Date and Time Functions (p. 742), and updated the function references for consistency.</td>
<td>June 24, 2016</td>
</tr>
<tr>
<td>New columns in STL_CONNECTION_LOG</td>
<td>The STL_CONNECTION_LOG (p. 926) 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: sscomprssion and ssлексpansion.</td>
<td>May 5, 2016</td>
</tr>
<tr>
<td>MD5-hash password</td>
<td>You can specify the password for a CREATE USER (p. 557) or ALTER USER (p. 435) command by supplying the MD5-hash string of the password and user name.</td>
<td>April 21, 2016</td>
</tr>
<tr>
<td>New column in STV_TBL_PERM</td>
<td>The backup column in the STV_TBL_PERM (p. 1013) system view indicates whether the table is included in cluster snapshots. For more information, see BACKUP (p. 542).</td>
<td>April 21, 2016</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
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</tr>
<tr>
<td>No-backup tables</td>
<td>For tables, such as staging tables, that won't contain critical data, you can specify BACKUP NO in your CREATE TABLE (p. 537) or CREATE TABLE AS (p. 550) 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.</td>
<td>April 7, 2016</td>
</tr>
<tr>
<td>VACUUM delete threshold</td>
<td>By default, the VACUUM (p. 663) 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.</td>
<td>April 7, 2016</td>
</tr>
<tr>
<td>SVV_TRANSACTIONS system table</td>
<td>The SVV_TRANSACTIONS (p. 1079) system view records information about transactions that currently hold locks on tables in the database.</td>
<td>April 7, 2016</td>
</tr>
<tr>
<td>Using IAM roles to access other AWS resources</td>
<td>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. As a more secure alternative to providing an access key pair with COPY, UNLOAD, or CREATE LIBRARY commands, you can now specify an IAM role that your cluster uses for authentication and authorization. For more information, see Role-Based Access Control (p. 485).</td>
<td>March 29, 2016</td>
</tr>
<tr>
<td>VACUUM sort threshold</td>
<td>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 (p. 663) command.</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>New columns in STL_CONNECTION_LOG</td>
<td>The STL_CONNECTION_LOG (p. 926) 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.</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>UNLOAD with bzip2 compression</td>
<td>You now have the option to UNLOAD (p. 642) using bzip2 compression.</td>
<td>February 8, 2016</td>
</tr>
<tr>
<td>ALTER TABLE APPEND</td>
<td>ALTER TABLE APPEND (p. 432) 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 (p. 550) or INSERT (p. 592) INTO operation because data is moved, not duplicated.</td>
<td>February 8, 2016</td>
</tr>
<tr>
<td>Change</td>
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<tr>
<td>WLM Query Queue Hopping</td>
<td>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 (p. 320)</td>
<td>January 7, 2016</td>
</tr>
<tr>
<td>ALTER DEFAULT PRIVILEGES</td>
<td>You can use the ALTER DEFAULT PRIVILEGES (p. 416) command to define the default set of access privileges to be applied to objects that are created in the future by the specified user.</td>
<td>December 10, 2015</td>
</tr>
<tr>
<td>bzip2 file compression</td>
<td>The COPY (p. 450) command supports loading data from files that were compressed using bzip2.</td>
<td>December 10, 2015</td>
</tr>
<tr>
<td>NULLS FIRST and NULLS LAST</td>
<td>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 (p. 629) and Window Function Syntax Summary (p. 691).</td>
<td>November 19, 2015</td>
</tr>
<tr>
<td>REGION keyword for CREATE LIBRARY</td>
<td>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 (p. 529).</td>
<td>November 19, 2015</td>
</tr>
<tr>
<td>User-defined scalar functions (UDFs)</td>
<td>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 Creating User-Defined Functions (p. 182).</td>
<td>September 11, 2015</td>
</tr>
<tr>
<td>Dynamic properties in WLM configuration</td>
<td>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 (p. 344) and Implementing Workload Management (p. 309).</td>
<td>August 3, 2015</td>
</tr>
<tr>
<td>LISTAGG function</td>
<td>The LISTAGG Function (p. 673) and LISTAGG Window Function (p. 700) return a string created by concatenating a set of column values.</td>
<td>July 30, 2015</td>
</tr>
<tr>
<td>Deprecated parameter</td>
<td>The max_cursor_result_set_size configuration parameter is deprecated. The size of cursor result sets are constrained based on the cluster's node type. For more information, see Cursor Constraints (p. 564).</td>
<td>July 24, 2015</td>
</tr>
<tr>
<td>Revised COPY command documentation</td>
<td>The COPY (p. 450) command reference has been extensively revised to make the material friendlier and more accessible.</td>
<td>July 15, 2015</td>
</tr>
<tr>
<td>Change</td>
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<tr>
<td>COPY from Avro format</td>
<td>The COPY (p. 450) 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 (p. 469) and Copy from Avro Examples (p. 506).</td>
<td>July 8, 2015</td>
</tr>
<tr>
<td>STV_STARTUP_RECOVERY_STATE</td>
<td>The STV_STARTUP_RECOVERY_STATE (p. 1013) 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.</td>
<td>May 25, 2015</td>
</tr>
<tr>
<td>ORDER BY optional for ranking functions</td>
<td>The ORDER BY clause is now optional for certain window ranking functions. For more information, see CUME_DIST Window Function (p. 695), DENSE_RANK Window Function (p. 696), RANK Window Function (p. 709), NTILE Window Function (p. 705), PERCENT_RANK Window Function (p. 706), and ROW_NUMBER Window Function (p. 711).</td>
<td>May 25, 2015</td>
</tr>
<tr>
<td>Interleaved Sort Keys</td>
<td>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 Choosing Sort Keys (p. 66) and CREATE TABLE (p. 537).</td>
<td>May 11, 2015</td>
</tr>
<tr>
<td>Revised Tuning Query Performance topic</td>
<td>Tuning Query Performance (p. 281) 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 (p. 27) has more information about how to write queries to improve performance.</td>
<td>March 23, 2015</td>
</tr>
<tr>
<td>SVL_QUERY_QUEUE_INFO</td>
<td>The SVL_QUERY_QUEUE_INFO (p. 1048) view summarizes details for queries that spent time in a WLM query queue or commit queue.</td>
<td>February 19, 2015</td>
</tr>
<tr>
<td>SVV_TABLE_INFO</td>
<td>You can use the SVV_TABLE_INFO (p. 1076) 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.</td>
<td>February 19, 2015</td>
</tr>
<tr>
<td>UNLOAD uses server-side file encryption</td>
<td>The UNLOAD (p. 642) 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.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>Change</td>
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<tr>
<td>CUME_DIST window function</td>
<td>The CUME_DIST Window Function (p. 695) calculates the cumulative distribution of a value within a window or partition.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>MONTHS_BETWEEN function</td>
<td>The MONTHS_BETWEEN Function (p. 766) determines the number of months between two dates.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>NEXT_DAY function</td>
<td>The NEXT_DAY Function (p. 767) returns the date of the first instance of a specified day that is later than the given date.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>PERCENT_RANK window function</td>
<td>The PERCENT_RANK Window Function (p. 706) calculates the percent rank of a given row.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>RATIO_TO_REPORT window function</td>
<td>The RATIO_TO_REPORT Window Function (p. 710) calculates the ratio of a value to the sum of the values in a window or partition.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>TRANSLATE function</td>
<td>The TRANSLATE Function (p. 871) replaces all occurrences of specified characters within a given expression with specified substitutes.</td>
<td>October 31, 2014</td>
</tr>
<tr>
<td>NVL2 function</td>
<td>The NVL2 Expression (p. 739) returns one of two values based on whether a specified expression evaluates to NULL or NOT NULL.</td>
<td>October 16, 2014</td>
</tr>
<tr>
<td>MEDIAN window function</td>
<td>The MEDIAN Window Function (p. 702) calculates the median value for the range of values in a window or partition.</td>
<td>October 16, 2014</td>
</tr>
<tr>
<td>ON ALL TABLES IN SCHEMA schema_name clause for GRANT and REVOKE commands</td>
<td>The GRANT (p. 585) and REVOKE (p. 600) 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.</td>
<td>October 16, 2014</td>
</tr>
<tr>
<td>IF EXISTS clause for DROP SCHEMA, DROP TABLE, DROP USER, and DROP VIEW commands</td>
<td>The DROP SCHEMA (p. 572), DROP TABLE (p. 573), DROP USER (p. 576), and DROP VIEW (p. 577) 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.</td>
<td>October 16, 2014</td>
</tr>
<tr>
<td>IF NOT EXISTS clause for CREATE SCHEMA and CREATE TABLE commands</td>
<td>The CREATE SCHEMA (p. 536) and CREATE TABLE (p. 537) 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.</td>
<td>October 16, 2014</td>
</tr>
<tr>
<td>COPY support for UTF-16 encoding</td>
<td>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 (p. 478).</td>
<td>September 29, 2014</td>
</tr>
<tr>
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<tr>
<td>New Workload Management Tutorial</td>
<td>Tutorial: Configuring Manual Workload Management (WLM) Queues (p. 322) walks you through the process of configuring Workload Management (WLM) queues to improve query processing and resource allocation.</td>
<td>September 25, 2014</td>
</tr>
<tr>
<td>AES 128-bit Encryption</td>
<td>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 (p. 109).</td>
<td>September 29, 2014</td>
</tr>
<tr>
<td>PG_LAST_UNLOAD_COUNT function</td>
<td>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 (p. 909).</td>
<td>September 15, 2014</td>
</tr>
<tr>
<td>New Troubleshooting Queries section</td>
<td>Troubleshooting Queries (p. 304) 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.</td>
<td>July 7, 2014</td>
</tr>
<tr>
<td>New Loading Data tutorial</td>
<td>Tutorial: Loading Data from Amazon S3 (p. 156) 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.</td>
<td>July 1, 2014</td>
</tr>
<tr>
<td>PERCENTILE_CONT window function</td>
<td>PERCENTILE_CONT Window Function (p. 707) 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.</td>
<td>June 30, 2014</td>
</tr>
<tr>
<td>PERCENTILE_DISC window function</td>
<td>PERCENTILE_DISC Window Function (p. 708) 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.</td>
<td>June 30, 2014</td>
</tr>
<tr>
<td>GREATEST and LEAST functions</td>
<td>The GREATEST and LEAST (p. 737) functions return the largest or smallest value from a list of expressions.</td>
<td>June 30, 2014</td>
</tr>
<tr>
<td>Cross-region COPY</td>
<td>The COPY (p. 450) 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 (p. 458) in the COPY command reference.</td>
<td>June 30, 2014</td>
</tr>
<tr>
<td>Best Practices expanded</td>
<td>Amazon Redshift Best Practices (p. 21) has been expanded, reorganized, and moved to the top of the navigation hierarchy to make it more discoverable.</td>
<td>May 28, 2014</td>
</tr>
<tr>
<td>UNLOAD to a single file</td>
<td>The UNLOAD (p. 642) 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.</td>
<td>May 6, 2014</td>
</tr>
<tr>
<td>Change</td>
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<tr>
<td>REGEXP functions</td>
<td>The <code>REGEXP_COUNT (p. 857)</code>, <code>REGEXP_INSTR (p. 858)</code>, and <code>REGEXP_REPLACE (p. 859)</code> functions manipulate strings based on regular expression pattern matching.</td>
<td>May 6, 2014</td>
</tr>
<tr>
<td>New Tutorial</td>
<td>The new Tutorial: Tuning Table Design (p. 73) walks you through the steps to optimize the design of your tables, including testing load and query performance before and after tuning.</td>
<td>May 2, 2014</td>
</tr>
<tr>
<td>COPY from Amazon EMR</td>
<td>The <code>COPY (p. 450)</code> command supports loading data directly from Amazon EMR clusters. For more information, see Loading Data from Amazon EMR (p. 110).</td>
<td>April 18, 2014</td>
</tr>
<tr>
<td>WLM concurrency limit increase</td>
<td>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 (p. 316).</td>
<td>April 18, 2014</td>
</tr>
<tr>
<td>New configuration parameter to manage cursor size</td>
<td>The <code>max_cursor_result_set_size</code> 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 (p. 564) in this guide and Configure Maximum Size of a Cursor Result Set in the Amazon Redshift Cluster Management Guide.</td>
<td>March 28, 2014</td>
</tr>
<tr>
<td>COPY from JSON format</td>
<td>The <code>COPY (p. 450)</code> 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 (p. 489) usage notes.</td>
<td>March 25, 2014</td>
</tr>
<tr>
<td>New system table STL_PLAN_INFO</td>
<td>The <code>STL_PLAN_INFO (p. 956)</code> table supplements the EXPLAIN command as another way to look at query plans.</td>
<td>March 25, 2014</td>
</tr>
<tr>
<td>New function REGEXP_SUBSTR</td>
<td>The <code>REGEXP_SUBSTR Function (p. 861)</code> returns the characters extracted from a string by searching for a regular expression pattern.</td>
<td>March 25, 2014</td>
</tr>
<tr>
<td>New columns for STL_COMMIT_STATS</td>
<td>The <code>STL_COMMIT_STATS (p. 924)</code> table has two new columns: <code>numxids</code> and <code>oldestxid</code>.</td>
<td>March 6, 2014</td>
</tr>
<tr>
<td>COPY from SSH support for gzip and lzop</td>
<td>The <code>COPY (p. 450)</code> command supports gzip and lzop compression when loading data through an SSH connection.</td>
<td>February 13, 2014</td>
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<tr>
<td>New functions</td>
<td>The <strong>ROW_NUMBER Window Function</strong> (p. 711) returns the number of the current row. The <strong>STRTOL Function</strong> (p. 868) converts a string expression of a number of the specified base to the equivalent integer value. <strong>PG_CANCEL_BACKEND</strong> (p. 894) and <strong>PG_TERMINATE_BACKEND</strong> (p. 895) enable users to cancel queries and session connections. The <strong>LAST_DAY</strong> (p. 765) function has been added for Oracle compatibility.</td>
<td>February 13, 2014</td>
</tr>
<tr>
<td>New system table</td>
<td>The <strong>STL_COMMIT_STATS</strong> (p. 924) system table provides metrics related to commit performance, including the timing of the various stages of commit and the number of blocks committed.</td>
<td>February 13, 2014</td>
</tr>
<tr>
<td>FETCH with single-node clusters</td>
<td>When using a cursor on a single-node cluster, the maximum number of rows that can be fetched using the FETCH (p. 584) command is 1000. FETCH FORWARD ALL is not supported for single-node clusters.</td>
<td>February 13, 2014</td>
</tr>
<tr>
<td>DS_DIST_ALL_INNER redistribution strategy</td>
<td><strong>DS_DIST_ALL_INNER</strong> in the Explain plan output indicates that the entire inner table was redistributed to a single slice because the outer table uses DISTSTYLE ALL. For more information, see <strong>Join Type Examples</strong> (p. 286) and <strong>Evaluating the Query Plan</strong> (p. 59).</td>
<td>January 13, 2014</td>
</tr>
<tr>
<td>New system tables for queries</td>
<td>Amazon Redshift has added new system tables that customers can use to evaluate query execution for tuning and troubleshooting. For more information, see <strong>SVL_COMPILE</strong> (p. 1030), <strong>STL_SCAN</strong> (p. 974), <strong>STL_RETURN</strong> (p. 969), <strong>STL_SAVE</strong> (p. 973) <strong>STL_ALERT_EVENT_LOG</strong> (p. 919).</td>
<td>January 13, 2014</td>
</tr>
<tr>
<td>Single-node cursors</td>
<td>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 information, see <strong>DECLARE</strong> (p. 564).</td>
<td>December 13, 2013</td>
</tr>
<tr>
<td>ALL distribution style</td>
<td>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 distributed 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 information, see <strong>Choosing a Data Distribution Style</strong> (p. 55).</td>
<td>November 11, 2013</td>
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</tr>
<tr>
<td>COPY from remote hosts</td>
<td>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 information, see Loading Data from Remote Hosts (p. 114).</td>
<td>November 11, 2013</td>
</tr>
<tr>
<td>WLM Memory Percent Used</td>
<td>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 (p. 316).</td>
<td>November 11, 2013</td>
</tr>
<tr>
<td>APPROXIMATE COUNT(DISTINCT)</td>
<td>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 (p. 672).</td>
<td>November 11, 2013</td>
</tr>
<tr>
<td>New SQL functions to retrieve recent query details</td>
<td>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 (p. 903), PG_LAST_COPY_ID (p. 906), PG_LAST_COPY_COUNT (p. 906), PG_LAST_QUERY_ID (p. 908).</td>
<td>November 1, 2013</td>
</tr>
<tr>
<td>MANIFEST option for UNLOAD</td>
<td>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 (p. 176) and UNLOAD Examples (p. 649).</td>
<td>November 1, 2013</td>
</tr>
<tr>
<td>MANIFEST option for COPY</td>
<td>You can use the MANIFEST option with the COPY command to explicitly list the data files that will be loaded from Amazon S3.</td>
<td>October 18, 2013</td>
</tr>
<tr>
<td>System tables for troubleshooting queries</td>
<td>Added documentation for system tables that are used to troubleshoot queries. The STL Tables for Logging (p. 915) 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.</td>
<td>October 3, 2013</td>
</tr>
<tr>
<td>CONVERT_TIMEZONE function</td>
<td>The CONVERT_TIMEZONE Function (p. 751) converts a timestamp from one time zone to another, with the option to automatically adjust for daylight savings time.</td>
<td>October 3, 2013</td>
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<tr>
<td>SPLIT_PART function</td>
<td>The SPLIT_PART Function (p. 866) splits a string on the specified delimiter and returns the part at the specified position.</td>
<td>October 3, 2013</td>
</tr>
<tr>
<td>STL_USERLOG system table</td>
<td>STL_USERLOG (p. 984) records details for changes that occur when a database user is created, altered, or deleted.</td>
<td>October 3, 2013</td>
</tr>
<tr>
<td>LZO column encoding and LZOP</td>
<td>LZO (p. 48) column compression encoding combines a very high compression ratio with good performance. COPY from Amazon S3 supports loading from files compressed using LZOP (p. 477) compression.</td>
<td>September 19, 2013</td>
</tr>
<tr>
<td></td>
<td>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 (p. 874), Pattern-Matching Conditions (p. 400), and DECLARE (p. 564).</td>
<td>September 10, 2013</td>
</tr>
<tr>
<td>JSON, Regular Expressions, and Cursors</td>
<td>You can successfully load data that contains invalid UTF-8 characters by specifying the ACCEPTINVCHAR option with the COPY (p. 450) command.</td>
<td>August 29, 2013</td>
</tr>
<tr>
<td>CSV option for COPY</td>
<td>The COPY (p. 450) command now supports loading from CSV formatted input files.</td>
<td>August 9, 2013</td>
</tr>
<tr>
<td>WLM wildcards</td>
<td>Workload management (WLM) supports wildcards for adding user groups and query groups to queues. For more information, see Wildcards (p. 319).</td>
<td>August 1, 2013</td>
</tr>
<tr>
<td>WLM timeout</td>
<td>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 (p. 319).</td>
<td>August 1, 2013</td>
</tr>
<tr>
<td>New COPY options 'auto' and 'epochsecs'</td>
<td>The COPY (p. 450) command performs automatic recognition of date and time formats. New time formats, 'epochsecs' and 'epochmillisecs' enable COPY to load data in epoch format.</td>
<td>July 25, 2013</td>
</tr>
<tr>
<td>CONVERT_TIMEZONE function</td>
<td>The CONVERT_TIMEZONE Function (p. 751) converts a timestamp from one timezone to another.</td>
<td>July 25, 2013</td>
</tr>
<tr>
<td>FUNC_SHA1 function</td>
<td>The FUNC_SHA1 Function (p. 846) converts a string using the SHA1 algorithm.</td>
<td>July 15, 2013</td>
</tr>
<tr>
<td>max_execution_time</td>
<td>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 (p. 310).</td>
<td>July 22, 2013</td>
</tr>
<tr>
<td>Four-byte UTF-8 characters</td>
<td>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 (p. 378).</td>
<td>July 18, 2013</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date Changed</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>SVL_QERROR</td>
<td>The SVL_QERROR system view has been deprecated.</td>
<td>July 12, 2013</td>
</tr>
<tr>
<td>Revised Document History</td>
<td>The Document History page now shows the date the documentation was updated.</td>
<td>July 12, 2013</td>
</tr>
<tr>
<td>STL_UNLOAD_LOG</td>
<td>STL_UNLOAD_LOG (p. 983) records the details for an unload operation.</td>
<td>July 5, 2013</td>
</tr>
<tr>
<td>JDBC fetch size parameter</td>
<td>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 (p. 308).</td>
<td>June 27, 2013</td>
</tr>
<tr>
<td>UNLOAD encrypted files</td>
<td>UNLOAD (p. 642) now supports unloading table data to encrypted files on Amazon S3.</td>
<td>May 22, 2013</td>
</tr>
<tr>
<td>Temporary credentials</td>
<td>COPY (p. 450) and UNLOAD (p. 642) now support the use of temporary credentials.</td>
<td>April 11, 2013</td>
</tr>
<tr>
<td>Added clarifications</td>
<td>Clarified and expanded discussions of Designing Tables and Loading Data.</td>
<td>February 14, 2013</td>
</tr>
<tr>
<td>Clarified password constraints</td>
<td>Clarified password constraints for CREATE USER and ALTER USER, various minor revisions.</td>
<td>February 14, 2013</td>
</tr>
<tr>
<td>New Guide</td>
<td>This is the first release of the Amazon Redshift Developer Guide.</td>
<td>February 14, 2013</td>
</tr>
</tbody>
</table>