AWS Glue: User Guide

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## AWS Glue Data Quality

### Benefits and key features

- **How it works**
  - Data quality for the AWS Glue Data Catalog
  - Data quality for AWS Glue ETL jobs
  - Comparing AWS Glue Data Quality entry points
- **Considerations**
- **Terminology**
- **Release notes for AWS Glue Data Quality**
  - General availability: new features
  - Nov 27, 2023 (Preview)
- **Anomaly detection in AWS Glue Data Quality**
  - How it works
  - Using analyzers to inspect your data
  - Using the DetectAnomaly Rule
  - Benefits and use cases of Anomaly Detection
- **IAM permissions for AWS Glue Data Quality**

### IAM permissions for AWS Glue Data Quality

- **Migrate Spark programs**
- **Working with Ray jobs**
  - Getting started with AWS Glue for Ray
  - Supported Ray runtime environments
  - Accounting for workers in Ray jobs
  - Ray job parameters
  - Ray job metrics
- **Python shell jobs**
  - Defining job properties for Python shell jobs
  - Supported libraries for Python shell jobs
  - Limitations
  - Providing your own Python library
- **Monitoring**
  - AWS tags
  - Automating with CloudWatch Events
  - AWS Glue resource monitoring
  - Logging using CloudTrail
  - Job run statuses

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What is AWS Glue?

AWS Glue is a serverless data integration service that makes it easy for analytics users to discover, prepare, move, and integrate data from multiple sources. You can use it for analytics, machine learning, and application development. It also includes additional productivity and data ops tooling for authoring, running jobs, and implementing business workflows.

With AWS Glue, you can discover and connect to more than 70 diverse data sources and manage your data in a centralized data catalog. You can visually create, run, and monitor extract, transform, and load (ETL) pipelines to load data into your data lakes. Also, you can immediately search and query cataloged data using Amazon Athena, Amazon EMR, and Amazon Redshift Spectrum.

AWS Glue consolidates major data integration capabilities into a single service. These include data discovery, modern ETL, cleansing, transforming, and centralized cataloging. It's also serverless, which means there's no infrastructure to manage. With flexible support for all workloads like ETL, ELT, and streaming in one service, AWS Glue supports users across various workloads and types of users.

Also, AWS Glue makes it easy to integrate data across your architecture. It integrates with AWS analytics services and Amazon S3 data lakes. AWS Glue has integration interfaces and job-authoring tools that are easy to use for all users, from developers to business users, with tailored solutions for varied technical skill sets.

With the ability to scale on demand, AWS Glue helps you focus on high-value activities that maximize the value of your data. It scales for any data size, and supports all data types and schema variances. To increase agility and optimize costs, AWS Glue provides built-in high availability and pay-as-you-go billing.

For pricing information, see AWS Glue pricing.

AWS Glue Studio

AWS Glue Studio is a graphical interface that makes it easy to create, run, and monitor data integration jobs in AWS Glue. You can visually compose data transformation workflows and seamlessly run them on the Apache Spark–based serverless ETL engine in AWS Glue.

With AWS Glue Studio, you can create and manage jobs that gather, transform, and clean data. You can also use AWS Glue Studio to troubleshoot and edit job scripts.
• **AWS Glue features**

• **Learning about innovations in AWS Glue**

• **Getting started with AWS Glue**

• **Accessing AWS Glue**

• **Related services**

---

**AWS Glue features**

AWS Glue features fall into three major categories:

- Discover and organize data
- Transform, prepare, and clean data for analysis
- Build and monitor data pipelines

**Discover and organize data**

- **Unify and search across multiple data stores** – Store, index, and search across multiple data sources and sinks by cataloging all your data in AWS.

- **Automatically discover data** – Use AWS Glue crawlers to automatically infer schema information and integrate it into your AWS Glue Data Catalog.

- **Manage schemas and permissions** – Validate and control access to your databases and tables.

- **Connect to a wide variety of data sources** – Tap into multiple data sources, both on premises and on AWS, using AWS Glue connections to build your data lake.

**Transform, prepare, and clean data for analysis**

- **Visually transform data with a drag-and-drop interface** – Define your ETL process in the drag-and-drop job editor and automatically generate the code to extract, transform, and load your data.

- **Build complex ETL pipelines with simple job scheduling** – Invoke AWS Glue jobs on a schedule, on demand, or based on an event.

- **Clean and transform streaming data in transit** – Enable continuous data consumption, and clean and transform it in transit. This makes it available for analysis in seconds in your target data store.
• **Deduplicate and cleanse data with built-in machine learning** – Clean and prepare your data for analysis without becoming a machine learning expert by using the FindMatches feature. This feature deduplicates and finds records that are imperfect matches for each other.

• **Built-in job notebooks** – AWS Glue job notebooks provide serverless notebooks with minimal setup in AWS Glue so you can get started quickly.

• **Edit, debug, and test ETL code** – With AWS Glue interactive sessions, you can interactively explore and prepare data. You can explore, experiment on, and process data interactively using the IDE or notebook of your choice.

• **Define, detect, and remediate sensitive data** – AWS Glue sensitive data detection lets you define, identify, and process sensitive data in your data pipeline and in your data lake.

**Build and monitor data pipelines**

• **Automatically scale based on workload** – Dynamically scale resources up and down based on workload. This assigns workers to jobs only when needed.

• **Automate jobs with event-based triggers** – Start crawlers or AWS Glue jobs with event-based triggers, and design a chain of dependent jobs and crawlers.

• **Run and monitor jobs** – Run AWS Glue jobs with your choice of engine, Spark or Ray. Monitor them with automated monitoring tools, AWS Glue job run insights, and AWS CloudTrail. Improve your monitoring of Spark-backed jobs with the Apache Spark UI.

• **Define workflows for ETL and integration activities** – Define workflows for ETL and integration activities for multiple crawlers, jobs, and triggers.

**Learning about innovations in AWS Glue**

Learn about the latest innovations in AWS Glue and hear how customers use AWS Glue to enable self-service data preparation across their organization.

Learn about how customers scale AWS Glue beyond the traditional setup and how they configure AWS Glue for job monitoring and performance.

**Getting started with AWS Glue**

We recommend that you start with the following sections:

• [Overview of using AWS Glue](#)
Accessing AWS Glue

You can create, view, and manage your AWS Glue jobs using the following interfaces:

- **AWS Glue console** – Provides a web interface for you to create, view, and manage your AWS Glue jobs. To access the console, see [AWS Glue](#).
- **AWS Glue Studio** – Provides a graphical interface for you to create and edit your AWS Glue jobs visually. For more information, see [What is AWS Glue Studio](#).
- **AWS Glue section of the AWS CLI Reference** – Provides AWS CLI commands that you can use with AWS Glue. For more information, see [AWS CLI Reference for AWS Glue](#).
- **AWS Glue API** – Provides a complete API reference for developers. For more information, see [AWS Glue API](#).

Related services

Users of AWS Glue also use:

- **AWS Lake Formation** – A service that is an authorization layer that provides fine-grained access control to resources in the AWS Glue Data Catalog.
- **AWS Glue Data Brew** – A visual data preparation tool that you can use to clean and normalize data without writing any code.
AWS Glue: How it works

AWS Glue uses other AWS services to orchestrate your ETL (extract, transform, and load) jobs to build data warehouses and data lakes and generate output streams. AWS Glue calls API operations to transform your data, create runtime logs, store your job logic, and create notifications to help you monitor your job runs. The AWS Glue console connects these services into a managed application, so you can focus on creating and monitoring your ETL work. The console performs administrative and job development operations on your behalf. You supply credentials and other properties to AWS Glue to access your data sources and write to your data targets.

AWS Glue takes care of provisioning and managing the resources that are required to run your workload. You don't need to create the infrastructure for an ETL tool because AWS Glue does it for you. When resources are required, to reduce startup time, AWS Glue uses an instance from its warm pool of instances to run your workload.

With AWS Glue, you create jobs using table definitions in your Data Catalog. Jobs consist of scripts that contain the programming logic that performs the transformation. You use triggers to initiate jobs either on a schedule or as a result of a specified event. You determine where your target data resides and which source data populates your target. With your input, AWS Glue generates the code that’s required to transform your data from source to target. You can also provide scripts in the AWS Glue console or API to process your data.

Data sources and destinations

AWS Glue for Spark allows you to read and write data from multiple systems and databases including:

- Amazon S3
- Amazon DynamoDB
- Amazon Redshift
- Amazon Relational Database Service (Amazon RDS)
- Third-party JDBC-accessible databases
- MongoDB and Amazon DocumentDB (with MongoDB compatibility)
- Other marketplace connectors and Apache Spark plugins

Data streams
AWS Glue for Spark can stream data from the following systems:

- Amazon Kinesis Data Streams
- Apache Kafka

AWS Glue is available in several AWS Regions. For more information, see [AWS Regions and Endpoints](#) in the Amazon Web Services General Reference.

**Topics**

- [Serverless ETL jobs run in isolation](#)
- [AWS Glue concepts](#)
- [AWS Glue components](#)
- [AWS Glue for Spark and AWS Glue for Ray](#)
- [Converting semi-structured schemas to relational schemas with AWS Glue](#)
- [AWS Glue type systems](#)

**Serverless ETL jobs run in isolation**

AWS Glue runs your ETL jobs in a serverless environment with your choice of engine, Spark or Ray. AWS Glue runs these jobs on virtual resources that it provisions and manages in its own service account.

AWS Glue is designed to do the following:

- Segregate customer data.
- Protect customer data in transit and at rest.
- Access customer data only as needed in response to customer requests, using temporary, scoped-down credentials, or with a customer's consent to IAM roles in their account.

During provisioning of an ETL job, you provide input data sources and output data targets in your virtual private cloud (VPC). In addition, you provide the IAM role, VPC ID, subnet ID, and security group that are needed to access data sources and targets. For each tuple (customer account ID, IAM role, subnet ID, and security group), AWS Glue creates a new environment that is isolated at the network and management level from all other environments inside the AWS Glue service account.
AWS Glue creates elastic network interfaces in your subnet using private IP addresses. Jobs use these elastic network interfaces to access your data sources and data targets. Traffic in, out, and within the job run environment is governed by your VPC and networking policies with one exception: Calls made to AWS Glue libraries can proxy traffic to AWS Glue API operations through the AWS Glue VPC. All AWS Glue API calls are logged; thus, data owners can audit API access by enabling AWS CloudTrail, which delivers audit logs to your account.

AWS Glue managed environments that run your ETL jobs are protected with the same security practices followed by other AWS services. For an overview of the practices and shared security responsibilities, see the Introduction to AWS Security Processes whitepaper.

### AWS Glue concepts

The following diagram shows the architecture of an AWS Glue environment.
You define jobs in AWS Glue to accomplish the work that's required to extract, transform, and load (ETL) data from a data source to a data target. You typically perform the following actions:

- For data store sources, you define a crawler to populate your AWS Glue Data Catalog with metadata table definitions. You point your crawler at a data store, and the crawler creates table definitions in the Data Catalog. For streaming sources, you manually define Data Catalog tables and specify data stream properties.

  In addition to table definitions, the AWS Glue Data Catalog contains other metadata that is required to define ETL jobs. You use this metadata when you define a job to transform your data.

- AWS Glue can generate a script to transform your data. Or, you can provide the script in the AWS Glue console or API.

- You can run your job on demand, or you can set it up to start when a specified trigger occurs. The trigger can be a time-based schedule or an event.

When your job runs, a script extracts data from your data source, transforms the data, and loads it to your data target. The script runs in an Apache Spark environment in AWS Glue.

⚠️ Important

Tables and databases in AWS Glue are objects in the AWS Glue Data Catalog. They contain metadata; they don't contain data from a data store.

Text-based data, such as CSVs, must be encoded in UTF-8 for AWS Glue to process it successfully. For more information, see UTF-8 in Wikipedia.

AWS Glue terminology

AWS Glue relies on the interaction of several components to create and manage your extract, transform, and load (ETL) workflow.
AWS Glue Data Catalog

The persistent metadata store in AWS Glue. It contains table definitions, job definitions, and other control information to manage your AWS Glue environment. Each AWS account has one AWS Glue Data Catalog per region.

Classifier

Determines the schema of your data. AWS Glue provides classifiers for common file types, such as CSV, JSON, AVRO, XML, and others. It also provides classifiers for common relational database management systems using a JDBC connection. You can write your own classifier by using a grok pattern or by specifying a row tag in an XML document.

Connection

A Data Catalog object that contains the properties that are required to connect to a particular data store.

Crawler

A program that connects to a data store (source or target), progresses through a prioritized list of classifiers to determine the schema for your data, and then creates metadata tables in the AWS Glue Data Catalog.

Database

A set of associated Data Catalog table definitions organized into a logical group.

Data store, data source, data target

A data store is a repository for persistently storing your data. Examples include Amazon S3 buckets and relational databases. A data source is a data store that is used as input to a process or transform. A data target is a data store that a process or transform writes to.

Development endpoint

An environment that you can use to develop and test your AWS Glue ETL scripts.

Dynamic Frame

A distributed table that supports nested data such as structures and arrays. Each record is self-describing, designed for schema flexibility with semi-structured data. Each record contains both
data and the schema that describes that data. You can use both dynamic frames and Apache Spark DataFrames in your ETL scripts, and convert between them. Dynamic frames provide a set of advanced transformations for data cleaning and ETL.

**Job**

The business logic that is required to perform ETL work. It is composed of a transformation script, data sources, and data targets. Job runs are initiated by triggers that can be scheduled or triggered by events.

**Job performance dashboard**

AWS Glue provides a comprehensive run dashboard for your ETL jobs. The dashboard displays information about job runs from a specific time frame.

**Notebook interface**

An enhanced notebook experience with one-click setup for easy job authoring and data exploration. The notebook and connections are configured automatically for you. You can use the notebook interface based on Jupyter Notebook to interactively develop, debug, and deploy scripts and workflows using AWS Glue serverless Apache Spark ETL infrastructure. You can also perform ad-hoc queries, data analysis, and visualization (for example, tables and graphs) in the notebook environment.

**Script**

Code that extracts data from sources, transforms it, and loads it into targets. AWS Glue generates PySpark or Scala scripts.

**Table**

The metadata definition that represents your data. Whether your data is in an Amazon Simple Storage Service (Amazon S3) file, an Amazon Relational Database Service (Amazon RDS) table, or another set of data, a table defines the schema of your data. A table in the AWS Glue Data Catalog consists of the names of columns, data type definitions, partition information, and other metadata about a base dataset. The schema of your data is represented in your AWS Glue table definition. The actual data remains in its original data store, whether it be in a file or a relational database table. AWS Glue catalogs your files and relational database tables in the AWS Glue Data Catalog. They are used as sources and targets when you create an ETL job.
Transform

The code logic that is used to manipulate your data into a different format.

Trigger

Initiates an ETL job. Triggers can be defined based on a scheduled time or an event.

Visual job editor

The visual job editor is a graphical interface that makes it easy to create, run, and monitor extract, transform, and load (ETL) jobs in AWS Glue. You can visually compose data transformation workflows, seamlessly run them on AWS Glue’s Apache Spark-based serverless ETL engine, and inspect the schema and data results in each step of the job.

Worker

With AWS Glue, you only pay for the time your ETL job takes to run. There are no resources to manage, no upfront costs, and you are not charged for startup or shutdown time. You are charged an hourly rate based on the number of Data Processing Units (or DPUs) used to run your ETL job. A single Data Processing Unit (DPU) is also referred to as a worker. AWS Glue comes with three worker types to help you select the configuration that meets your job latency and cost requirements. Workers come in Standard, G.1X, G.2X, and G.025X configurations.

AWS Glue components

AWS Glue provides a console and API operations to set up and manage your extract, transform, and load (ETL) workload. You can use API operations through several language-specific SDKs and the AWS Command Line Interface (AWS CLI). For information about using the AWS CLI, see AWS CLI Command Reference.

AWS Glue uses the AWS Glue Data Catalog to store metadata about data sources, transforms, and targets. The Data Catalog is a drop-in replacement for the Apache Hive Metastore. The AWS Glue Jobs system provides a managed infrastructure for defining, scheduling, and running ETL operations on your data. For more information about the AWS Glue API, see AWS Glue API.
AWS Glue console

You use the AWS Glue console to define and orchestrate your ETL workflow. The console calls several API operations in the AWS Glue Data Catalog and AWS Glue Jobs system to perform the following tasks:

- Define AWS Glue objects such as jobs, tables, crawlers, and connections.
- Schedule when crawlers run.
- Define events or schedules for job triggers.
- Search and filter lists of AWS Glue objects.
- Edit transformation scripts.

AWS Glue Data Catalog

The AWS Glue Data Catalog is your persistent technical metadata store in the AWS Cloud.

Each AWS account has one AWS Glue Data Catalog per AWS Region. Each Data Catalog is a highly scalable collection of tables organized into databases. A table is metadata representation of a collection of structured or semi-structured data stored in sources such as Amazon RDS, Apache Hadoop Distributed File System, Amazon OpenSearch Service, and others. The AWS Glue Data Catalog provides a uniform repository where disparate systems can store and find metadata to keep track of data in data silos. You can then use the metadata to query and transform that data in a consistent manner across a wide variety of applications.

You use the Data Catalog together with AWS Identity and Access Management policies and Lake Formation to control access to the tables and databases. By doing this, you can allow different groups in your enterprise to safely publish data to the wider organization while protecting sensitive information in a highly granular fashion.

The Data Catalog, along with CloudTrail and Lake Formation, also provides you with comprehensive audit and governance capabilities, with schema change tracking and data access controls. This helps ensure that data is not inappropriately modified or inadvertently shared.

For information about securing and auditing the AWS Glue Data Catalog, see:

- **AWS Lake Formation** – For more information, see [What Is AWS Lake Formation?](https://docs.aws.amazon.com/lakeformation/latest/dg/what-is-lake-formation.html) in the [AWS Lake Formation Developer Guide](https://docs.aws.amazon.com/lakeformation/latest/dg/).
The following are other AWS services and open-source projects that use the AWS Glue Data Catalog:

- **Amazon Athena** – For more information, see [Understanding Tables, Databases, and the Data Catalog](https://docs.aws.amazon.com/athena/latest/ug/tables-databases-data-catalog.html) in the *Amazon Athena User Guide*.

- **Amazon Redshift Spectrum** – For more information, see [Using Amazon Redshift Spectrum to Query External Data](https://docs.aws.amazon.com/redshift/latest/api/API_ExternalTable.html) in the *Amazon Redshift Database Developer Guide*.

- **Amazon EMR** – For more information, see [Use Resource-Based Policies for Amazon EMR Access to AWS Glue Data Catalog](https://docs.aws.amazon.com/emr/latest/managementguide/data-catalog-policy.html) in the *Amazon EMR Management Guide*.

- **AWS Glue Data Catalog client for Apache Hive metastore** – For more information about this GitHub project, see [AWS Glue Data Catalog Client for Apache Hive Metastore](https://github.com/aws-data-lab/aws-glue-data-catalog-client-for-apache-hive-metastore).

**AWS Glue crawlers and classifiers**

AWS Glue also lets you set up crawlers that can scan data in all kinds of repositories, classify it, extract schema information from it, and store the metadata automatically in the AWS Glue Data Catalog. The AWS Glue Data Catalog can then be used to guide ETL operations.

For information about how to set up crawlers and classifiers, see [Defining crawlers in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/add-crawler.html). For information about how to program crawlers and classifiers using the AWS Glue API, see [Crawlers and classifiers API](https://docs.aws.amazon.com/glue/latest/dg/api-aws-glue.html).

**AWS Glue ETL operations**

Using the metadata in the Data Catalog, AWS Glue can automatically generate Scala or PySpark (the Python API for Apache Spark) scripts with AWS Glue extensions that you can use and modify to perform various ETL operations. For example, you can extract, clean, and transform raw data, and then store the result in a different repository, where it can be queried and analyzed. Such a script might convert a CSV file into a relational form and save it in Amazon Redshift.

For more information about how to use AWS Glue ETL capabilities, see [Programming Spark scripts](https://docs.aws.amazon.com/glue/latest/dg/programming-sql.html).

**Streaming ETL in AWS Glue**

AWS Glue enables you to perform ETL operations on streaming data using continuously-running jobs. AWS Glue streaming ETL is built on the Apache Spark Structured Streaming engine, and can
ingest streams from Amazon Kinesis Data Streams, Apache Kafka, and Amazon Managed Streaming for Apache Kafka (Amazon MSK). Streaming ETL can clean and transform streaming data and load it into Amazon S3 or JDBC data stores. Use Streaming ETL in AWS Glue to process event data like IoT streams, clickstreams, and network logs.

If you know the schema of the streaming data source, you can specify it in a Data Catalog table. If not, you can enable schema detection in the streaming ETL job. The job then automatically determines the schema from the incoming data.

The streaming ETL job can use both AWS Glue built-in transforms and transforms that are native to Apache Spark Structured Streaming. For more information, see Operations on streaming DataFrames/Datasets on the Apache Spark website.

For more information, see the section called “Streaming ETL jobs”.

The AWS Glue jobs system

The AWS Glue Jobs system provides managed infrastructure to orchestrate your ETL workflow. You can create jobs in AWS Glue that automate the scripts you use to extract, transform, and transfer data to different locations. Jobs can be scheduled and chained, or they can be triggered by events such as the arrival of new data.

For more information about using the AWS Glue Jobs system, see Monitoring AWS Glue. For information about programming using the AWS Glue Jobs system API, see Jobs API.

Visual ETL components

AWS Glue allows you to create ETL jobs through a visual canvas that you can manipulate.
ETL job menu

Menu options at the top of the canvas allow you to access the various views and configuration details about your job.

- **Visual** – The Visual job editor canvas. This is where you can add nodes to create a job.
- **Script** – The script representation of your ETL job. AWS Glue generates the script based on the visual representation of your job. You can also edit your script or download it.

⚠️ **Note**

If you choose to edit the script, the job authoring experience is permanently converted to a script-only mode. Afterwards, you cannot use the visual editor to edit the job anymore.
You should add all the job sources, transforms, and targets, and make all the changes you require with the visual editor before choosing to edit the script.

- **Job details** – The Job details tab allows you to configure your job by setting job properties. There are basic properties, such as name and description of your job, IAM role, job type, AWS Glue version, language, worker type, number of workers, job bookmark, flex execution, number of retries, and job timeout, and there are advanced properties, such as connections, libraries, job parameters, and tags.

- **Runs** – After your job runs, this tab can be accessed to view your past job runs.

- **Data quality** – Data quality evaluates and monitors the quality of your data assets. You can learn more about how to use data quality on this tab and add a data quality transform to your job.

- **Schedules** – Jobs that you've scheduled appear in this tab. If there are no schedules attached to this job, then this tab is not accessible.

- **Version control** – You can use Git with your job by configuring your job to a Git repository.

**Visual ETL panels**

When you work in the canvas, several panels are available to help you configure your nodes, or help you to preview your data and view the output schema.

- **Properties** – The Properties panel appears when you choose a node on your canvas.

- **Data preview** – The Data preview panel provides a preview of the data output so that you can make decisions before you run your job and examine your output.

- **Output schema** – The Output schema tab allows you to view and edit the schema of your transform nodes.

**Resizing panels**

You can resize the Properties panel on the right-hand side of the screen and the bottom panel which contains the Data preview and Output schema tabs by clicking on the edge of the panel and dragging it left and right or up and down.

- **Properties panel** – Resize the properties panel by clicking and dragging the edge of the canvas on the right side of the screen and drag it left to expand its width. By default, the panel is collapsed and when a node is selected, the properties panel opens up to its default size.
• **Data preview and Output schema panel** – Resize the bottom panel by clicking and dragging the bottom edge of the canvas at the bottom of the screen and drag it up to expand its height. By default, the panel is collapsed and when a node is selected, the bottom panel opens up to its default size.

**Job canvas**

You can add, remove, and move/reorder nodes directly on the Visual ETL canvas. Think of it as your workspace to create a fully functional ETL job that starts with a data source and can end with a data target.

When you work with nodes on the canvas, you have a toolbar that can help you zoom in and out, remove nodes, make or edit connections between nodes, change the job flow orientation, and undo or redo an action.

The floating toolbar is anchored to the upper right-hand size of the canvas and contains several images that perform actions:

• **Layout icon** – The first icon in the toolbar is the layout icon. By default, the direction of visual jobs is top to bottom. It rearranges the direction of your visual job by arranging the nodes horizontally from left to right. Clicking the layout icon again changes the direction back to top to bottom.
- **Recenter icon** – The recenter icon changes the canvas view by centering it. You can use this with large jobs to get back to the center position.

- **Zoom in icon** – The zoom in icon enlarges the size of the nodes on the canvas.

- **Zoom out icon** – The zoom out icon decreases the size of the nodes on the canvas.

- **Trash icon** – The trash icon removes a node from the visual job. You must select a node first.

- **Undo icon** – The undo icon reverses the last action taken on the visual job.

- **Redo icon** – The redo icon repeats the last action taken on the visual job.

**Using the mini-map**

![Mini-map Image]

**Resource panel**

The resource panel contains all of the data sources, transform actions, and connections available to you. Open the resource panel on the canvas by clicking the "+" icon. This will open the resource panel.

To close the resource panel, click the X in the upper-right hand corner of the resource panel. This will hide the panel until you're ready to open it again.
## Visual ETL components

### Popular transforms & data

<table>
<thead>
<tr>
<th>Transform</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon S3 (source)</td>
<td>Read from an Amazon S3 data store.</td>
</tr>
<tr>
<td>Amazon Redshift (source)</td>
<td>Read from an Amazon Redshift data store.</td>
</tr>
<tr>
<td>Change Schema</td>
<td>Change the schema of the data.</td>
</tr>
<tr>
<td>SQL Query</td>
<td>Run a SQL query on the data.</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Aggregate the data.</td>
</tr>
<tr>
<td>Custom Transform</td>
<td>Custom transform for data processing.</td>
</tr>
<tr>
<td>Filter</td>
<td>Apply a filter to the data.</td>
</tr>
</tbody>
</table>

### Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Glue Data Catalog</td>
<td>AWS Glue Data Catalog table as the data source.</td>
</tr>
<tr>
<td>Amazon S3</td>
<td>JSON, CSV, or Parquet files stored in S3.</td>
</tr>
<tr>
<td>Amazon Kinesis</td>
<td>Read from an Amazon Kinesis Data Stream.</td>
</tr>
<tr>
<td>Apache Kafka</td>
<td>Read from an Apache Kafka or Amazon MSK topic.</td>
</tr>
<tr>
<td>Relational DB</td>
<td>AWS Glue Data Catalog table with a relational database as the data source.</td>
</tr>
<tr>
<td>Amazon Redshift</td>
<td>Read your data from Amazon Redshift.</td>
</tr>
<tr>
<td>MySQL</td>
<td>AWS Glue Data Catalog table with MySQL as the data source.</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>AWS Glue Data Catalog table with PostgreSQL as the data source.</td>
</tr>
<tr>
<td>Oracle SQL</td>
<td>AWS Glue Data Catalog table with Oracle SQL as the data source.</td>
</tr>
<tr>
<td>Microsoft SQL Server</td>
<td>AWS Glue Data Catalog table with SQL Server as the data source.</td>
</tr>
<tr>
<td>Amazon DynamoDB</td>
<td>AWS Glue Data Catalog table with DynamoDB as the data source.</td>
</tr>
<tr>
<td>Snowflake</td>
<td>Read your data from Snowflake.</td>
</tr>
</tbody>
</table>
Popular transforms & data

At the top of the panel is a collection of Popular transforms & data. These nodes are commonly used in AWS Glue. Choose one to add it to the canvas. You can also hide the Popular transforms & data by clicking the triangle next to the Popular transforms & data heading.

Beneath the Popular transforms & data section, you can search for transforms and data source nodes. Results appear as you type. The more letters you add to your search query, the list of results will get smaller. Search results are populated from the node name and/or description. Choose the node to add it to your canvas.

Transforms and Data

There are two tabs that organize the nodes into Transforms and Data.

Transforms – When you choose the Transforms tab, all of the available transforms can be selected. Choose a transform to add it to the canvas. You can also choose Add Transform at the bottom of the Transforms list which will open a new page to the documentation for creating Custom visual transforms. Following the steps will allow you to create transforms of your own. Your transforms will then appear in the list of available transforms.

Data – The data tab contains all of the nodes for Sources and Targets. You can hide the Sources and Targets by clicking the triangle next to the Sources or Targets heading. You can unhide the Sources and Targets by clicking the triangle again. Choose a source or target node to add it to the canvas. You can also choose Manage Connections to add a new connection. This will open the Connectors page in the console.

AWS Glue for Spark and AWS Glue for Ray

In AWS Glue on Apache Spark (AWS Glue ETL), you can use PySpark to write Python code to handle data at scale. Spark is a familiar solution for this problem, but data engineers with Python-focused backgrounds can find the transition unintuitive. The Spark DataFrame model is not seamlessly "Pythonic", which reflects the Scala language and Java runtime it is built upon.

In AWS Glue, you can use Python shell jobs to run native Python data integrations. These jobs run on a single Amazon EC2 instance and are limited by the capacity of that instance. This restricts the throughput of the data you can process, and becomes expensive to maintain when dealing with big data.
AWS Glue for Ray allows you to scale up Python workloads without substantial investment into learning Spark. You can take advantage of certain scenarios where Ray performs better. By offering you a choice, you can use the strengths of both Spark and Ray.

AWS Glue ETL and AWS Glue for Ray are different underneath, so they support different features. Please check the documentation to determine supported features.

**What is AWS Glue for Ray?**

Ray is an open-source distributed computation framework that you can use to scale up workloads, with a focus on Python. For more information about Ray, see the [Ray website](https://ray-project.org). AWS Glue Ray jobs and interactive sessions allow you to use Ray within AWS Glue.

You can use AWS Glue for Ray to write Python scripts for computations that will run in parallel across multiple machines. In Ray jobs and interactive sessions, you can use familiar Python libraries, like pandas, to make your workflows easy to write and run. For more information about Ray datasets, see [Ray Datasets](https://ray-project.org/datasets) in the Ray documentation. For more information about pandas, see the [Pandas website](https://pandas.pydata.org).

When you use AWS Glue for Ray, you can run your pandas workflows against big data at enterprise scale—with only a few lines of code. You can create a Ray job from the AWS Glue console or the AWS SDK. You can also open an AWS Glue interactive session to run your code on a serverless Ray environment. Visual jobs in AWS Glue Studio are not yet supported.

AWS Glue for Ray jobs allow you to run a script on a schedule or in response to an event from Amazon EventBridge. Jobs store log information and monitoring statistics in CloudWatch that enable you to understand the health and reliability of your script. For more information about the AWS Glue job system, see [the section called “Working with Ray jobs”](https://docs.aws.amazon.com/glue/latest/dg/ray-parallel-execution.html).

AWS Glue for Ray interactive sessions (preview) allow you to run snippets of code one after another against the same provisioned resources. You can use this to efficiently prototype and develop scripts, or build your own interactive applications. You can use AWS Glue interactive sessions from AWS Glue Studio Notebooks in the AWS Management Console. For more information, see [Using Notebooks with AWS Glue Studio and AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/using-notebooks.html). You can also use them through a Jupyter kernel, which allows you to run interactive sessions from existing code editing tools that support Jupyter Notebooks, such as VSCode. For more information, see [the section called “AWS Glue for Ray interactive sessions (preview)”](https://docs.aws.amazon.com/glue/latest/dg/using-notebooks.html).

Ray automates the work of scaling Python code by distributing the processing across a cluster of machines that it reconfigures in real time, based on the load. This can lead to improved
performance per dollar for certain workloads. With Ray jobs, we have built auto scaling natively into the AWS Glue job model, so you can fully take advantage of this feature. Ray jobs run on AWS Graviton, leading to higher overall price performance.

In addition to cost savings, you can use native auto scaling to run Ray workloads without investing time into cluster maintenance, tuning, and administration. You can use familiar open-source libraries out of the box, such as pandas, and the AWS SDK for Pandas. These improve iteration speed while you're developing on AWS Glue for Ray. When you use AWS Glue for Ray, you will be able to rapidly develop and run cost-effective data integration workloads.

Converting semi-structured schemas to relational schemas with AWS Glue

It's common to want to convert semi-structured data into relational tables. Conceptually, you are flattening a hierarchical schema to a relational schema. AWS Glue can perform this conversion for you on-the-fly.

Semi-structured data typically contains mark-up to identify entities within the data. It can have nested data structures with no fixed schema. For more information about semi-structured data, see Semi-structured data in Wikipedia.

Relational data is represented by tables that consist of rows and columns. Relationships between tables can be represented by a primary key (PK) to foreign key (FK) relationship. For more information, see Relational database in Wikipedia.

AWS Glue uses crawlers to infer schemas for semi-structured data. It then transforms the data to a relational schema using an ETL (extract, transform, and load) job. For example, you might want to parse JSON data from Amazon Simple Storage Service (Amazon S3) source files to Amazon Relational Database Service (Amazon RDS) tables. Understanding how AWS Glue handles the differences between schemas can help you understand the transformation process.

This diagram shows how AWS Glue transforms a semi-structured schema to a relational schema.
The diagram illustrates the following:

- Single value A converts directly to a relational column.
- The pair of values, B1 and B2, convert to two relational columns.
- Structure C, with children X and Y, converts to two relational columns.
- Array D[ ] converts to a relational column with a foreign key (FK) that points to another relational table. Along with a primary key (PK), the second relational table has columns that contain the offset and value of the items in the array.
AWS Glue type systems

AWS Glue uses multiple type systems to provide a versatile interface over data systems that store data in very different ways. This document disambiguates AWS Glue type systems and data standards.

AWS Glue Data Catalog Types

The Data Catalog is a registry of tables and fields stored in various data systems, a metastore. When AWS Glue components, such as AWS Glue crawlers and AWS Glue with Spark jobs, write to the Data Catalog, they do so with an internal type system for tracking the types of fields. These values are shown in the Data type column of the table schema in the AWS Glue Console. This type system is based on Apache Hive's type system. For more information about the Apache Hive type system, see Types in the Apache Hive wiki. For more information about specific types and support, examples are provided in the AWS Glue Console, as part of the Schema Builder.

Validation, compatibility and other uses

The Data Catalog does not validate types written to type fields. When AWS Glue components read and write to the Data Catalog, they will be compatible with each other. AWS Glue components also aim to preserve a high degree of compatibility with the Hive types. However, AWS Glue components do not guarantee compatibility with all Hive types. This allows for interoperability with tools like Athena DDL when working with tables in the Data Catalog.

Since the Data Catalog does not validate types, other services may use the Data Catalog to track types using systems that strictly conform to the Hive type system, or any other system.

Types in AWS Glue with Spark scripts

When a AWS Glue with Spark script interprets or transforms a dataset, we provide DynamicFrame, an in-memory representation of your dataset as it is used in your script. The goal of a DynamicFrame is similar to that of the Spark DataFrame— it models your dataset so that Spark can schedule and execute transforms on your data. We guarantee that the type representation of DynamicFrame is intercompatible with DataFrame by providing the toDF and fromDF methods.

If type information can be inferred or provided to a DataFrame, it can be inferred or provided to a DynamicFrame, unless otherwise documented. When we provide optimized readers or writers for specific data formats, if Spark can read or write your data, our provided readers and writers will
be able to, subject to documented limitations. For more information about readers and writers, see the section called “Data format options”.

The Choice Type

DynamicFrames provide a mechanism for modeling fields in a dataset whose value may have inconsistent types on disk across rows. For instance, a field may hold a number stored as a string in certain rows, and an integer in others. This mechanism is an in-memory type called Choice. We provide transforms such as the ResolveChoice method, to resolve Choice columns to a concrete type. AWS Glue ETL will not write the Choice type to the Data Catalog in the normal course of operation; Choice types only exist in the context of DynamicFrame memory models of datasets. For an example of Choice type usage, see the section called “Data preparation sample”.

AWS Glue Crawler Types

Crawlers aim to produce a consistent, usable schema for your dataset, then store it in Data Catalog for use in other AWS Glue components and Athena. Crawlers deal with types as described in the previous section on the Data Catalog, the section called “AWS Glue Data Catalog Types”. To produce a usable type in "Choice" type scenarios, where a column contains values of two or more types, Crawlers will create a struct type that models the potential types.
Getting started with AWS Glue

The following sections provide information on setting up AWS Glue. Not all of the setting up sections are required to start using AWS Glue. You can use the instructions as needed to set up IAM permissions, encryption, and DNS (if you're using a VPC environment to access data stores or if you're using interactive sessions).

Topics

- Overview of using AWS Glue
- Setting up IAM permissions for AWS Glue
- Getting started with the AWS Glue Data Catalog
- Setting up network access to data stores
- Setting up encryption in AWS Glue
- Setting up networking for development for AWS Glue

Overview of using AWS Glue

With AWS Glue, you store metadata in the AWS Glue Data Catalog. You use this metadata to orchestrate ETL jobs that transform data sources and load your data warehouse or data lake. The following steps describe the general workflow and some of the choices that you make when working with AWS Glue.

Note

You can use the following steps, or you can create a workflow that automatically performs steps 1 through 3. For more information, see the section called “Performing complex ETL activities using blueprints and workflows”.

1. Populate the AWS Glue Data Catalog with table definitions.

   In the console, for persistent data stores, you can add a crawler to populate the AWS Glue Data Catalog. You can start the Add crawler wizard from the list of tables or the list of crawlers. You choose one or more data stores for your crawler to access. You can also create a schedule to determine the frequency of running your crawler. For data streams, you can manually create the table definition, and define stream properties.
Optionally, you can provide a custom classifier that infers the schema of your data. You can create custom classifiers using a grok pattern. However, AWS Glue provides built-in classifiers that are automatically used by crawlers if a custom classifier does not recognize your data. When you define a crawler, you don't have to select a classifier. For more information about classifiers in AWS Glue, see Adding classifiers to a crawler in AWS Glue.

Crawling some types of data stores requires a connection that provides authentication and location information. If needed, you can create a connection that provides this required information in the AWS Glue console.

The crawler reads your data store and creates data definitions and named tables in the AWS Glue Data Catalog. These tables are organized into a database of your choosing. You can also populate the Data Catalog with manually created tables. With this method, you provide the schema and other metadata to create table definitions in the Data Catalog. Because this method can be a bit tedious and error prone, it's often better to have a crawler create the table definitions.

For more information about populating the AWS Glue Data Catalog with table definitions, see AWS Glue tables.

2. Define a job that describes the transformation of data from source to target.

Generally, to create a job, you have to make the following choices:

- Choose a table from the AWS Glue Data Catalog to be the source of the job. Your job uses this table definition to access your data source and interpret the format of your data.
- Choose a table or location from the AWS Glue Data Catalog to be the target of the job. Your job uses this information to access your data store.
- Tell AWS Glue to generate a script to transform your source to target. AWS Glue generates the code to call built-in transforms to convert data from its source schema to target schema format. These transforms perform operations such as copy data, rename columns, and filter data to transform data as necessary. You can modify this script in the AWS Glue console.

For more information about defining jobs in AWS Glue, see Building visual ETL jobs with AWS Glue Studio.

3. Run your job to transform your data.

You can run your job on demand, or start it based on one of these trigger types:

- A trigger that is based on a cron schedule.
• A trigger that is event-based; for example, the successful completion of another job can start an AWS Glue job.

• A trigger that starts a job on demand.

For more information about triggers in AWS Glue, see Starting jobs and crawlers using triggers.

4. Monitor your scheduled crawlers and triggered jobs.

Use the AWS Glue console to view the following:

• Job run details and errors.

• Crawler run details and errors.

• Any notifications about AWS Glue activities

For more information about monitoring your crawlers and jobs in AWS Glue, see Monitoring AWS Glue.

Setting up IAM permissions for AWS Glue

The instructions in this topic help you quickly set up AWS Identity and Access Management (IAM) permissions for AWS Glue. You will complete the following tasks:

• Grant your IAM identities access to AWS Glue resources.

• Create a service role for running jobs, accessing data, and running AWS Glue Data Quality tasks.

For detailed instructions that you can use to customize IAM permissions for AWS Glue, see Configuring IAM permissions for AWS Glue.

To set up IAM permissions for AWS Glue in the AWS Management Console

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.

2. Choose Getting started.

3. Under Prepare your account for AWS Glue, choose Set up IAM permissions.

4. Choose the IAM identities (roles or users) that you want to give AWS Glue permissions to. AWS Glue attaches the AWSGlueConsoleFullAccess managed policy to these identities. You can skip this step if you want to set these permissions manually or only want to set a default service role.
5. Choose **Next**.
6. Choose the level of Amazon S3 access that your roles and users need. The options that you choose in this step are applied to all of the identities that you selected.

   a. Under **Choose S3 locations**, choose the Amazon S3 locations that you want to grant access to.
   
   b. Next, select whether your identities should have **Read only (recommended)** or **Read and write** access to the locations that you previously selected. AWS Glue adds permissions policies to your identities based on the combination of locations and read or write permissions you select.

   The following table displays the permissions that AWS Glue attaches for Amazon S3 access.

<table>
<thead>
<tr>
<th>If you choose ...</th>
<th>AWS Glue attaches ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change</td>
<td>No permissions. AWS Glue won't make any changes to your identity's permissions.</td>
</tr>
<tr>
<td>Grant access to specific Amazon S3 locations (read only)</td>
<td>An inline policy embedded in your selected IAM identities. For more information, see <a href="#">Inline policies</a> in the IAM User Guide.</td>
</tr>
<tr>
<td></td>
<td>AWS Glue names the policy using the following convention: AWSGlueConsole &lt;Role/User&gt; InlinePolicy-read-specific-access- &lt;UUID&gt;. For example: AWSGlueConsoleRoleInlinePolicy-read-specific-access-123456780123.</td>
</tr>
<tr>
<td></td>
<td>The following is an example of an inline policy that AWS Glue attaches to grant read-only access to a specified Amazon S3 location.</td>
</tr>
<tr>
<td>If you choose ...</td>
<td>AWS Glue attaches ...</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>`{</td>
</tr>
<tr>
<td></td>
<td>&quot;Version&quot;: &quot;2012-10-17&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Statement&quot;: [</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;Effect&quot;: &quot;Allow&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Action&quot;: [</td>
</tr>
<tr>
<td></td>
<td>&quot;s3:Get*&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;s3:List*&quot;</td>
</tr>
<tr>
<td></td>
<td>]</td>
</tr>
<tr>
<td></td>
<td>&quot;Resource&quot;: [</td>
</tr>
<tr>
<td></td>
<td>&quot;arn:aws:s3:::DOC-EXAMPLE-BUCKET/*&quot;</td>
</tr>
<tr>
<td></td>
<td>]</td>
</tr>
<tr>
<td></td>
<td>}</td>
</tr>
</tbody>
</table>
### If you choose ...

<table>
<thead>
<tr>
<th>Grant access to specific Amazon S3 locations (read and write)</th>
</tr>
</thead>
</table>

### AWS Glue attaches ...

An inline policy embedded in your selected IAM identities. For more information, see [Inline policies](#) in the IAM User Guide.

AWS Glue names the policy using the following convention: `AWSGlueConsole <Role/User> InlinePolicy-read-and-write-specific-access-<UUID>`. For example: `AWSGlueConsoleRoleInlinePolicy-read-and-write-specific-access-123456780123`.

The following is an example of an inline policy that AWS Glue attaches to grant read and write access to specified Amazon S3 locations.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "s3:Get*",
            "s3:List*",
            "s3:*Object*
         ],
         "Resource": [
            "arn:aws:s3:::DOC-EXAMPLE-BUCKET1/*",
            "arn:aws:s3:::DOC-EXAMPLE-BUCKET2/*"
         ]
      }
   ]
}
```
### Setting up IAM permissions

<table>
<thead>
<tr>
<th>If you choose ...</th>
<th>AWS Glue attaches ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant full access to Amazon S3 (read only)</td>
<td>The <a href="https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html">AmazonS3ReadOnlyAccess</a> managed IAM policy. To learn more, see <a href="https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html">AWS managed policy: AmazonS3ReadOnlyAccess</a>.</td>
</tr>
<tr>
<td>Grant full access to Amazon S3 (read and write)</td>
<td>The <a href="https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html">AmazonS3FullAccess</a> managed IAM policy. To learn more, see <a href="https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html">AWS managed policy: AmazonS3FullAccess</a>.</td>
</tr>
</tbody>
</table>

7. Choose **Next**.

8. Choose a default AWS Glue service role for your account. A service role is an IAM role that AWS Glue uses to access resources in other AWS services on your behalf. For more information, see [Service roles for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/security-access-control-servicerole.html).

   - When you choose the standard AWS Glue service role, AWS Glue creates a new IAM role in your AWS account named `AWSGlueServiceRole` with the following managed policies attached. If your account already has an IAM role named `AWSGlueServiceRole`, AWS Glue attaches these policies to the existing role.
     - [AWSGlueServiceRole](https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html)
     - [AmazonS3FullAccess](https://docs.aws.amazon.com/IAM/latest/userguide/policies_s3.html)

   - When you choose an existing IAM role, AWS Glue sets the role as the default, but doesn't add any permissions to it. Ensure that you've configured the role to use as a service role for AWS Glue. For more information, see [Step 1: Create an IAM policy for the AWS Glue service](https://docs.aws.amazon.com/glue/latest/dg/security-access-control-servicerole.html) and [Step 2: Create an IAM role for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/security-access-control-servicerole.html).

9. Choose **Next**.

10. Finally, review the permissions you've selected and then choose **Apply changes**. When you apply the changes, AWS Glue adds IAM permissions to the identities that you selected. You can view or modify the new permissions in the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).
You've now completed the minimum IAM permissions setup for AWS Glue. In a production environment, we recommend that you familiarize yourself with Security in AWS Glue and Identity and access management for AWS Glue to help you secure AWS resources for your use case.

Next steps

Now that you have IAM permissions set up, you can explore the following topics to get started using AWS Glue:

- Getting Started with AWS Glue in AWS Skill Builder
- Getting started with the AWS Glue Data Catalog

Setting up for AWS Glue Studio

Complete the tasks in this section when you're using AWS Glue for the visual ETL for the first time:

Topics

- Review IAM permissions needed for the AWS Glue Studio user
- Review IAM permissions needed for ETL jobs
- Set up IAM permissions for AWS Glue Studio
- Configure a VPC for your ETL job

Review IAM permissions needed for the AWS Glue Studio user

To use AWS Glue Studio, the user must have access to various AWS resources. The user must be able to view and select Amazon S3 buckets, IAM policies and roles, and AWS Glue Data Catalog objects.

AWS Glue service permissions

AWS Glue Studio uses the actions and resources of the AWS Glue service. Your user needs permissions on these actions and resources to effectively use AWS Glue Studio. You can grant the AWS Glue Studio user the AWSGlueConsoleFullAccess managed policy, or create a custom policy with a smaller set of permissions.
Important

Per security best practices, it is recommended to restrict access by tightening policies to further restrict access to Amazon S3 bucket and Amazon CloudWatch log groups. For an example Amazon S3 policy, see Writing IAM Policies: How to Grant Access to an Amazon S3 Bucket.

Creating Custom IAM Policies for AWS Glue Studio

You can create a custom policy with a smaller set of permissions for AWS Glue Studio. The policy can grant permissions for a subset of objects or actions. Use the following information when creating a custom policy.

To use the AWS Glue Studio APIs, include glue:UseGlueStudio in the action policy in your IAM permissions. Using glue:UseGlueStudio will allow you to access all AWS Glue Studio actions even as more actions are added to the API over time.

Directed acyclic graph (DAG) Actions

- CreateDag
- UpdateDag
- GetDag
- DeleteDag

Job Actions

- SaveJob
- GetJob
- CreateJob
- DeleteJob
- GetJobs
- UpdateJob

Job run Actions
• StartJobRun
• GetJobRuns
• BatchStopJobRun
• GetJobRun
• QueryJobRuns
• QueryJobs
• QueryJobRunsAggregated

Schema Actions
• GetSchema
• GetInferredSchema

Database Actions
• GetDatabases

Plan Actions
• GetPlan

Table Actions
• SearchTables
• GetTables
• GetTable

Connection Actions
• CreateConnection
• DeleteConnection
• UpdateConnection
• GetConnections
• GetConnection
Mapping Actions

- GetMapping

S3 Proxy Actions

- ListBuckets
- ListObjectsV2
- GetBucketLocation

Security Configuration Actions

- GetSecurityConfigurations

Script Actions

- CreateScript (different from API of same name in AWS Glue)

Accessing AWS Glue Studio APIs

To access AWS Glue Studio, add glue:UseGlueStudio in the actions policy list in the IAM permissions.

In the example below, glue:UseGlueStudio is included in the action policy, but the AWS Glue Studio APIs are not individually identified. That is because when you include glue:UseGlueStudio, you are automatically granted access to the internal APIs without having to specify the individual AWS Glue Studio APIs in the IAM permissions.

In the example, the additional listed action policies (for example, glue:SearchTables) are not AWS Glue Studio APIs, so they will need to be included in the IAM permissions as required. You may also want to include Amazon S3 Proxy actions to specify the level of Amazon S3 access to grant. The example policy below provides access to open AWS Glue Studio, create a visual job, and save/run it if the IAM role selected has sufficient access.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
```
"Sid": "VisualEditor0",
"Effect": "Allow",
"Action": [
    "glue:UseGlueStudio",
    "iam:ListRoles",
    "iam:ListUsers",
    "iam:ListGroups",
    "iam:ListRolePolicies",
    "iam:GetRole",
    "iam:GetRolePolicy",
    "glue:SearchTables",
    "glue:GetConnections",
    "glue:GetJobs",
    "glue:GetTables",
    "glue:BatchStopJobRun",
    "glue:GetSecurityConfigurations",
    "glue:DeleteJob",
    "glue:GetDatabases",
    "glue:CreateConnection",
    "glue:GetSchema",
    "glue:GetTable",
    "glue:GetMapping",
    "glue:CreateJob",
    "glue:DeleteConnection",
    "glue:CreateScript",
    "glue:UpdateConnection",
    "glue:GetConnection",
    "glue:StartJobRun",
    "glue:GetJobRun",
    "glue:UpdateJob",
    "glue:GetPlan",
    "glue:GetJobRuns",
    "glue:GetTags",
    "glue:GetJob",
    "glue:QueryJobRuns",
    "glue:QueryJobs",
    "glue:QueryJobRunsAggregated"
],
"Resource": "*"
},
{
    "Action": [
        "iam:PassRole"
    ]
}
Notebook and data preview permissions

Data previews and notebooks allow you to see a sample of your data at any stage of your job (reading, transforming, writing), without having to run the job. You specify an AWS Identity and Access Management (IAM) role for AWS Glue Studio to use when accessing the data. IAM roles are intended to be assumable and do not have standard long-term credentials such as a password or access keys associated with it. Instead, when AWS Glue Studio assumes the role, IAM provides it with temporary security credentials.

To ensure data previews and notebook commands work correctly, use a role that has a name that starts with the string `AWSGlueServiceRole`. If you choose to use a different name for your role, then you must add the `iam:passrole` permission and configure a policy for the role in IAM. For more information, see Create an IAM policy for roles not named "AWSGlueServiceRole*".

⚠️ Warning

If a role grants the `iam:passrole` permission for a notebook, and you implement role chaining, a user could unintentionally gain access to the notebook. There is currently no auditing implemented which would allow you to monitor which users have been granted access to the notebook.

If you would like to deny an IAM identity the ability to create data preview sessions, consult the following example the section called “Deny an identity the ability to create data preview sessions”.

IAM permissions for using the visual ETL
Amazon CloudWatch permissions

You can monitor your AWS Glue Studio jobs using Amazon CloudWatch, which collects and processes raw data from AWS Glue into readable, near-real-time metrics. By default, AWS Glue metrics data is sent to CloudWatch automatically. For more information, see What Is Amazon CloudWatch? in the Amazon CloudWatch User Guide, and AWS Glue Metrics in the AWS Glue Developer Guide.

To access CloudWatch dashboards, the user accessing AWS Glue Studio needs one of the following:

- The AdministratorAccess policy
- The CloudWatchFullAccess policy
- A custom policy that includes one or more of these specific permissions:
  - cloudwatch:GetDashboard and cloudwatch:ListDashboards to view dashboards
  - cloudwatch:PutDashboard to create or modify dashboards
  - cloudwatch:DeleteDashboards to delete dashboards

For more information for changing permissions for an IAM user using policies, see Changing Permissions for an IAM User in the IAM User Guide.

Review IAM permissions needed for ETL jobs

When you create a job using AWS Glue Studio, the job assumes the permissions of the IAM role that you specify when you create it. This IAM role must have permission to extract data from your data source, write data to your target, and access AWS Glue resources.

The name of the role that you create for the job must start with the string AWSGlueServiceRole for it to be used correctly by AWS Glue Studio. For example, you might name your role AWSGlueServiceRole-FlightDataJob.

Data source and data target permissions

An AWS Glue Studio job must have access to Amazon S3 for any sources, targets, scripts, and temporary directories that you use in your job. You can create a policy to provide fine-grained access to specific Amazon S3 resources.

- Data sources require s3:ListBucket and s3:GetObject permissions.
- Data targets require s3:ListBucket, s3:PutObject, and s3:DeleteObject permissions.
If you choose Amazon Redshift as your data source, you can provide a role for cluster permissions. Jobs that run against a Amazon Redshift cluster issue commands that access Amazon S3 for temporary storage using temporary credentials. If your job runs for more than an hour, these credentials will expire causing the job to fail. To avoid this problem, you can assign a role to the Amazon Redshift cluster itself that grants the necessary permissions to jobs using temporary credentials. For more information, see "Moving Data to and from Amazon Redshift" in the *AWS Glue Developer Guide*.

If the job uses data sources or targets other than Amazon S3, then you must attach the necessary permissions to the IAM role used by the job to access these data sources and targets. For more information, see "Setting Up Your Environment to Access Data Stores" in the *AWS Glue Developer Guide*.

If you're using connectors and connections for your data store, you need additional permissions, as described in the section called “Permissions required for using connectors”.

**Permissions required for deleting jobs**

In AWS Glue Studio you can select multiple jobs in the console to delete. To perform this action, you must have the `glue:BatchDeleteJob` permission. This is different from the AWS Glue console, which requires the `glue:DeleteJob` permission for deleting jobs.

**AWS Key Management Service permissions**

If you plan to access Amazon S3 sources and targets that use server-side encryption with AWS Key Management Service (AWS KMS), then attach a policy to the AWS Glue Studio role used by the job that enables the job to decrypt the data. The job role needs the `kms:ReEncrypt`, `kms:GenerateDataKey`, and `kms:DescribeKey` permissions. Additionally, the job role needs the `kms:Decrypt` permission to upload or download an Amazon S3 object that is encrypted with an AWS KMS customer master key (CMK).

There are additional charges for using AWS KMS CMKs. For more information, see *AWS Key Management Service Concepts - Customer Master Keys (CMKs)* and *AWS Key Management Service Pricing* in the *AWS Key Management Service Developer Guide*.

**Permissions required for using connectors**

If you're using an AWS Glue Custom Connector and connection to access a data store, the role used to run the AWS Glue ETL job needs additional permissions attached:
• The AWS managed policy AmazonEC2ContainerRegistryReadOnly for accessing connectors purchased from AWS Marketplace.

• The glue:GetJob and glue:GetJobs permissions.

• AWS Secrets Manager permissions for accessing secrets that are used with connections. Refer to Example: Permission to retrieve secret values for example IAM policies.

If your AWS Glue ETL job runs within a VPC running Amazon VPC, then the VPC must be configured as described in the section called “Configure a VPC for your ETL job”.

Set up IAM permissions for AWS Glue Studio

You can create the roles and assign policies to users and job roles by using the AWS administrator user.

You can use the AWSGlueConsoleFullAccess AWS managed policy to provide the necessary permissions for using the AWS Glue Studio console.

To create your own policy, follow the steps documented in Create an IAM Policy for the AWS Glue Service in the AWS Glue Developer Guide. Include the IAM permissions described previously in Review IAM permissions needed for the AWS Glue Studio user.

Topics
• Attach policies to the AWS Glue Studio user
• Create an IAM policy for roles not named "AWSGlueServiceRole*"

Attach policies to the AWS Glue Studio user

Any AWS user that signs in to the AWS Glue Studio console must have permissions to access specific resources. You provide those permissions by using assigning IAM policies to the user.

To attach the AWSGlueConsoleFullAccess managed policy to a user

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose Policies.
3. In the list of policies, select the check box next to the AWSGlueConsoleFullAccess. You can use the Filter menu and the search box to filter the list of policies.
4. Choose **Policy actions**, and then choose **Attach**.

5. Choose the user to attach the policy to. You can use the **Filter** menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose **Attach policy**.

6. Repeat the previous steps to attach additional policies to the user, as needed.

**Create an IAM policy for roles not named "AWSGlueServiceRole"**

**To configure an IAM policy for roles used by AWS Glue Studio**

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).

2. Add a new IAM policy. You can add to an existing policy or create a new IAM inline policy. To create an IAM policy:

   1. Choose **Policies**, and then choose **Create Policy**. If a **Get Started** button appears, choose it, and then choose **Create Policy**.

   2. Next to **Create Your Own Policy**, choose **Select**.

   3. For **Policy Name**, type any value that is easy for you to refer to later. Optionally, type descriptive text in **Description**.

   4. For **Policy Document**, type a policy statement with the following format, and then choose **Create Policy**:

   ```json
   {
     "Action": [
       "iam:PassRole"
     ],
     "Effect": "Allow",
     "Resource": "arn:aws:iam::*:role/my-interactive-session-role-prefix*",
     "Condition": {
       "StringLike": {
         "iam:PassedToService": [
           "glue.amazonaws.com "
         ]
       }
     }
   }
   ```

   IAM permissions for using the visual ETL
Here is the full example with the Version and Statement arrays included in the policy

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "iam:PassRole"
      ],
      "Effect": "Allow",
      "Resource": "arn:aws:iam::*:role/my-interactive-session-role-prefix*",
      "Condition": {
        "StringLike": {
          "iam:PassedToService": [
            "glue.amazonaws.com ",
            "execute-api.amazonaws.com "
          ]
        }
      }
    }
  ]
}
```

4. To enable the policy for a user, choose **Users**.

5. Choose the user to whom you want to attach the policy.

**Configure a VPC for your ETL job**

You can use Amazon Virtual Private Cloud (Amazon VPC) to define a virtual network in your own logically isolated area within the AWS Cloud, known as a **virtual private cloud (VPC)**. You can launch your AWS resources, such as instances, into your VPC. Your VPC closely resembles a traditional network that you might operate in your own data center, with the benefits of using the scalable infrastructure of AWS. You can configure your VPC; you can select its IP address range, create subnets, and configure route tables, network gateways, and security settings. You can connect instances in your VPC to the internet. You can connect your VPC to your own corporate data center, making the AWS Cloud an extension of your data center. To protect the resources in each subnet, you can use multiple layers of security, including security groups and network access control lists. For more information, see the [Amazon VPC User Guide](https://docs.aws.amazon.com/vpc/latest/userguide/).
You can configure your AWS Glue ETL jobs to run within a VPC when using connectors. You must configure your VPC for the following, as needed:

- Public network access for data stores not in AWS. All data stores that are accessed by the job must be available from the VPC subnet.
- If your job needs to access both VPC resources and the public internet, the VPC needs to have a network address translation (NAT) gateway inside the VPC.

For more information, see Setting Up Your Environment to Access Data Stores in the AWS Glue Developer Guide.

**Getting started with notebooks in AWS Glue Studio**

When you start a notebook through AWS Glue Studio, all the configuration steps are done for you so that you can explore your data and start developing your job script after only a few seconds.

The following sections describe how to create a role and grant the appropriate permissions to use notebooks in AWS Glue Studio for ETL jobs.

**Topics**

- Granting permissions for the IAM role

**Granting permissions for the IAM role**

Setting up AWS Glue Studio is a pre-requisite to using notebooks.

To use notebooks in AWS Glue, your role requires the following:

- A trust relationship with AWS Glue for the sts:AssumeRole action and, if you want tagging then sts:TagSession.
- An IAM policy containing all the API operations for notebooks, AWS Glue, and interactive sessions.
- An IAM policy for a pass role since the role needs to be able to pass itself from the notebook to interactive sessions.
For example, when you create a new role, you can add a standard AWS managed policy like AWSGlueConsoleFullAccessRole to the role, and then add a new policy for the notebook operations and another for the IAM PassRole policy.

**Actions needed for a trust relationship with AWS Glue**

When starting a notebook session, you must add the `sts:AssumeRole` to the trust relationship of the role that is passed to the notebook. If your session includes tags, you must also pass the `sts:TagSession` action. Without these actions, the notebook session cannot start.

For example:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "glue.amazonaws.com"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

**Policies containing the API operations for notebooks**

The following sample policy describes the required AWS IAM permissions for notebooks. If you are creating a new role, create a policy that contains the following:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:StartNotebook",
                "glue:TerminateNotebook",
                "glue:GlueNotebookRefreshCredentials",
                "glue:DeregisterDataPreview"
            ]
        }
    ]
}
```
You can use the following IAM policies to allow access to specific resources:

- **AwsGlueSessionUserRestrictedNotebookServiceRole**: Provides full access to all AWS Glue resources except for sessions. Allows users to create and use only the notebook sessions that are associated with the user. This policy also includes other permissions needed by AWS Glue to manage AWS Glue resources in other AWS services.

- **AwsGlueSessionUserRestrictedNotebookPolicy**: Provides permissions that allows users to create and use only the notebook sessions that are associated with the user. This policy also includes permissions to explicitly allow users to pass a restricted AWS Glue session role.

**IAM policy to pass a role**

When you create a notebook with a role, that role is then passed to interactive sessions so that the same role can be used in both places. As such, the `iam:PassRole` permission needs to be part of the role's policy.

Create a new policy for your role using the following example. Replace the account number with your own and the role name.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "iam:PassRole",
            "Resource": "arn:aws:iam::090000000210:role/<role_name>"
        }
    ]
}
```
Getting started with the AWS Glue Data Catalog

The AWS Glue Data Catalog is your persistent technical metadata store. It is a managed service that you can use to store, annotate, and share metadata in the AWS Cloud. For more information, see AWS Glue Data Catalog.

The AWS Glue console was recently updated and some user interfaces have been updated.

Overview

You can use this tutorial to create your first AWS Glue Data Catalog, which uses an Amazon S3 bucket as your data source.

In this tutorial, you'll do the following using the AWS Glue console:

1. Create a database
2. Create a table
3. Use an Amazon S3 bucket as a data source

After completing these steps, you will have successfully used an Amazon S3 bucket as the data source to populate the AWS Glue Data Catalog.

Step 1: Create a database

To get started, sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue.html.

To create a database using the AWS Glue console:

1. In the AWS Glue console, choose Databases under Data catalog from the left-hand menu.
2. Choose Add database.
3. In the Create a database page, enter a name for the database. In the Location - optional section, set the URI location for use by clients of the Data Catalog. If you don't know this, you can continue with creating the database.
4. (Optional). Enter a description for the database.
5. Choose Create database.
Congratulations, you've just set up your first database using the AWS Glue console. Your new database will appear in the list of available databases. You can edit the database by choosing the database's name from the **Databases** dashboard.

**Next steps**

**Other ways to create a database:**

You just created a database using the AWS Glue console, but there are other ways to create a database:

- You can use crawlers to create a database and tables for you automatically. To set up a database using crawlers, see *Working with Crawlers in the AWS Glue Console*.
- You can use AWS CloudFormation templates. See *Creating AWS Glue Resources Using AWS Glue Data Catalog Templates*.
- You can also create a database using the AWS Glue Database API operations.

To create a database using the `create` operation, structure the request by including the `DatabaseInput` (required) parameters.

For example:

The following are examples of how you can use the CLI, Boto3, or DDL to define a table based on the same `flights_data.csv` file from the S3 bucket that you used in the tutorial.

**CLI**

```bash
aws glue create-database --database-input "{"Name":"clidb"}"
```

**Boto3**

```python
glueClient = boto3.client('glue')
response = glueClient.create_database(
    DatabaseInput={
        'Name': 'boto3db'
    }
)
```
For more information about the Database API data types, structure, and operations, see Database API.

Next Steps

In the next section, you'll create a table and add that table to your database.

You can also explore the settings and permissions for your Data Catalog. See Working with Data Catalog Settings in the AWS Glue Console.

Step 2. Create a table

In this step, you create a table using the AWS Glue console.

1. In the AWS Glue console, choose Tables in the left-hand menu.
2. Choose Create table.
3. Set your table's properties by entering a name for your table in Table details.
4. In the Databases section, choose the database that you created in Step 1 from the drop-down menu.
5. In Add a data store section, S3 will be selected by default as the type of source.
6. For Data is located in, choose Specified path in another account.
7. Copy and paste the path for the Include path input field:
   
   s3://crawler-public-us-west-2/flight/2016/csv/

8. In the section Data format, for Classification, choose CSV. and for Delimiter, choose comma (,). Choose Next.
9. You are asked to define a schema. A schema defines the structure and format of a data record. Choose Add column. (For more information, see See Schema registries).
10. Specify the column properties:
    a. Enter a column name.
    b. For Column type, 'string' is already selected by default.
    c. For Column number, '1' is already selected by default.
    d. Choose Add.
11. You are asked to add partition indexes. This is optional. To skip this step, choose Next.
12. A summary of the table properties is displayed. If everything looks as expected, choose Finish. Otherwise, choose Back and make edits as needed.
Congratulations, you've successfully created a table manually and associated it to a database. Your newly created table will appear in the Tables dashboard. From the dashboard, you can modify and manage all your tables.

For more information, see Working with Tables in the AWS Glue Console.

Next steps

Now that the Data Catalog is populated, you can begin authoring jobs in AWS Glue. See Authoring Jobs.

In addition to using the console, there are other ways to define tables in the Data Catalog including:

- Creating and running a crawler
- Using the AWS Glue Table API
- Using the AWS Glue Data Catalog template
- Migrating an Apache Hive metastore
- Using the AWS CLI, Boto3, or data definition language (DDL)

The following are examples of how you can use the CLI, Boto3, or DDL to define a table based on the same flights_data.csv file from the S3 bucket that you used in the tutorial.

See the documentation on how to structure an AWS CLI command. The CLI example contains the JSON syntax for the 'aws glue create-table --table-input' value.

CLI

```json
{
    "Name": "flights_data_cli",
    "StorageDescriptor": {
        "Columns": [
            {
                "Name": "year",
                "Type": "bigint"
            },
            {
                "Name": "quarter",
                "Type": "bigint"
            }
        ]
    }
}
```
"Location": "s3://crawler-public-us-west-2/flight/2016/csv",
"InputFormat": "org.apache.hadoop.mapred.TextInputFormat",
"OutputFormat": 
"org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat",
"Compressed": false,
"NumberOfBuckets": -1,
"SerdeInfo": {
   "SerializationLibrary": 
"org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe",
   "Parameters": {
      "field.delim": ",",
      "serialization.format": ",",
   }
},
"PartitionKeys": [
   {
      "Name": "mon",
      "Type": "string"
   }
],
"TableType": "EXTERNAL_TABLE",
"Parameters": {
   "EXTERNAL": "TRUE",
   "classification": "csv",
   "columnsOrdered": "true",
   "compressionType": "none",
   "delimiter": ",",
   "skip.header.line.count": "1",
   "typeOfData": "file"
}
}

Boto3

import boto3

glue_client = boto3.client("glue")

response = glue_client.create_table(
    DatabaseName='sampledb',
    TableInput={

Step 2. Create a table
Step 2. Create a table

```python

'Name': 'flights_data_manual',
'StorageDescriptor': {
    'Columns': [
        {'Name': 'year',
         'Type': 'bigint'},
        {'Name': 'quarter',
         'Type': 'bigint'}],
    'Location': 's3://crawler-public-us-west-2/flight/2016/csv',
    'InputFormat': 'org.apache.hadoop.mapred.TextInputFormat',
    'OutputFormat': 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat',
    'Compressed': False,
    'NumberOfBuckets': -1,
    'SerdeInfo': {
        'SerializationLibrary': 'org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe',
        'Parameters': {
            'field.delim': ',',
            'serialization.format': ','
        }
    },
    'PartitionKeys': [
        {'Name': 'mon',
         'Type': 'string'}],
    'TableType': 'EXTERNAL_TABLE',
    'Parameters': {
        'EXTERNAL': 'TRUE',
        'classification': 'csv',
        'columnsOrdered': 'true',
        'compressionType': 'none',
        'delimiter': ',',
        'skip.header.line.count': '1',
        'typeOfData': 'file'
    }
}
```
CREATE EXTERNAL TABLE `sampledb`.`flights_data` (  `year` bigint,  `quarter` bigint)  PARTITIONED BY (  `mon` string)  ROW FORMAT DELIMITED  FIELDS TERMINATED BY ','  STORED AS INPUTFORMAT  'org.apache.hadoop.mapred.TextInputFormat'  OUTPUTFORMAT  'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'  LOCATION  's3://crawler-public-us-west-2/flight/2016/csv/'  TBLPROPERTIES (  'classification'='csv',  'columnsOrdered'='true',  'compressionType'='none',  'delimiter'=',',  'skip.header.line.count'='1',  'typeOfData'='file')

### Setting up network access to data stores

To run your extract, transform, and load (ETL) jobs, AWS Glue must be able to access your data stores. If a job doesn't need to run in your virtual private cloud (VPC) subnet—for example, transforming data from Amazon S3 to Amazon S3—no additional configuration is needed.

If a job needs to run in your VPC subnet—for example, transforming data from a JDBC data store in a private subnet—AWS Glue sets up elastic network interfaces that enable your jobs to connect securely to other resources within your VPC. Each elastic network interface is assigned a private IP address from the IP address range within the subnet you specified. No public IP addresses are assigned. Security groups specified in the AWS Glue connection are applied on each of the elastic network interfaces. For more information, see [Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue](#)

All JDBC data stores that are accessed by the job must be available from the VPC subnet. To access Amazon S3 from within your VPC, a VPC endpoint is required. If your job needs to access both VPC
resources and the public internet, the VPC needs to have a Network Address Translation (NAT) gateway inside the VPC.

A job or development endpoint can only access one VPC (and subnet) at a time. If you need to access data stores in different VPCs, you have the following options:

- Use VPC peering to access the data stores. For more about VPC peering, see VPC Peering Basics.
- Use an Amazon S3 bucket as an intermediary storage location. Split the work into two jobs, with the Amazon S3 output of job 1 as the input to job 2.

For details on how to connect to a Amazon Redshift data store using Amazon VPC, see the section called “Configure Redshift”.

For details on how to connect to Amazon RDS data stores using Amazon VPC, see the section called “Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue”.

Once necessary rules are set in Amazon VPC, you create a connection in AWS Glue with the necessary properties to connect to your data stores. For more information about the connection, see Connecting to data.

Note

Make sure you set up your DNS environment for AWS Glue. For more information, see Setting up DNS in your VPC.

Topics

- Setting up a VPC to connect to PyPI for AWS Glue
- Setting up DNS in your VPC

Setting up a VPC to connect to PyPI for AWS Glue

The Python Package Index (PyPI) is a repository of software for the Python programming language. This topic addresses the details needed to support the use of pip installed packages (as specified by the session creator using the --additional-python-modules flag).
Using AWS Glue interactive sessions with a connector results in the use of VPC network via the subnet specified for the connector. Consequently AWS services and other network destinations are not available unless you set up a special configuration.

The resolutions to this issue include:

- Use of an internet gateway which is reachable by your session.
- Set up and use of an S3 bucket with a PyPI/simple repo containing the transitive closure of a package set's dependencies.
- Use of a CodeArtifact repository which is mirroring PyPI and attached to your VPC.

**Setting up an internet gateway**

The technical aspects are detailed in [NAT gateway use cases](#) but note these requirements for using `--additional-python-modules`. Specifically, `--additional-python-modules` requires access to pypi.org which is determined by the configuration of your VPC. Note the following requirements:

1. The requirement of installing additional python modules via pip install for a user's session. If the session uses a connector, your configuration may be affected.
2. When a connector is being used with `--additional-python-modules`, when the session is started the subnet associated with the connector's `PhysicalConnectionRequirements` has to provide a network path for reaching pypi.org.
3. You must determine whether or not your configuration is correct.

**Setting up an Amazon S3 bucket to host a targeted PyPI/simple repo**

This example sets up a PyPI mirror in Amazon S3 for a set of packages and their dependencies.

To set up the PyPI mirror for a set of packages:

```
# pip download all the dependencies
pip download -d s3pypi --only-binary :all: plotly gglplot
pip download -d s3pypi --platform manylinux_2_17_x86_64 --only-binary :all: psycopg2-binary
# create and upload the pypi/simple index and wheel files to the s3 bucket
s3pypi -b test-domain-name --put-root-index -v s3pypi/*
```
If you already have an existing artifact repository, it will have an index URL for pip's use that you can provide in place of the example URL for the Amazon S3 bucket as above.

To use the custom index-url, with some example packages:

```yaml
%configure
{
    "--additional-python-modules": "psycopg2_binary==2.9.5",
}
```

### Setting up a CodeArtifact mirror of pypi attached to your VPC

To set up a mirror:

1. Create a repository in the same region as the subnet used by the connector.
   
   Select Public upstream repositories and choose pypi-store.
2. Provide access to the repository from the VPC for the subnet.
3. Specify the correct `--index-url` using the `python-modules-installer-option`.

```yaml
%configure
{
    "--additional-python-modules": "psycopg2_binary==2.9.5",
}
```

For more information, see [Use CodeArtifact from a VPC](#).

### Setting up DNS in your VPC

Domain Name System (DNS) is a standard by which names used on the internet are resolved to their corresponding IP addresses. A DNS hostname uniquely names a computer and consists of a host name and a domain name. DNS servers resolve DNS hostnames to their corresponding IP addresses.

To set up DNS in your VPC, ensure that DNS hostnames and DNS resolution are both enabled in your VPC. The VPC network attributes `enableDnsHostnames` and `enableDnsSupport`
must be set to true. To view and modify these attributes, go to the VPC console at https://console.aws.amazon.com/vpc/.

For more information, see Using DNS with your VPC. Also, you can use the AWS CLI and call the modify-vpc-attribute command to configure the VPC network attributes.

Note
If you are using Route 53, confirm that your configuration does not override DNS network attributes.

Setting up encryption in AWS Glue

The following example workflow highlights the options to configure when you use encryption with AWS Glue. The example demonstrates the use of specific AWS Key Management Service (AWS KMS) keys, but you might choose other settings based on your particular needs. This workflow highlights only the options that pertain to encryption when setting up AWS Glue.

1. If the user of the AWS Glue console doesn't use a permissions policy that allows all AWS Glue API operations (for example, "glue:*"), confirm that the following actions are allowed:
   - "glue:GetDataCatalogEncryptionSettings"
   - "glue:PutDataCatalogEncryptionSettings"
   - "glue:CreateSecurityConfiguration"
   - "glue:GetSecurityConfiguration"
   - "glue:GetSecurityConfigurations"
   - "glue:DeleteSecurityConfiguration"

2. Any client that accesses or writes to an encrypted catalog—that is, any console user, crawler, job, or development endpoint—needs the following permissions.

```json
{
  "Version": "2012-10-17",
  "Statement": {
    "Effect": "Allow",
    "Action": [
      "kms:GenerateDataKey",
      "kms:Decrypt",
      "kms:Encrypt"
    ]
  }
}
```
3. Any user or role that accesses an encrypted connection password needs the following permissions.

```json
{
   "Version": "2012-10-17",
   "Statement": {
      "Effect": "Allow",
      "Action": [
         "kms:Decrypt"
      ],
      "Resource": "<key-arns-used-for-password-encryption>"
   }
}
```

4. The role of any extract, transform, and load (ETL) job that writes encrypted data to Amazon S3 needs the following permissions.

```json
{
   "Version": "2012-10-17",
   "Statement": {
      "Effect": "Allow",
      "Action": [
         "kms:Decrypt",
         "kms:Encrypt",
         "kms:GenerateDataKey"
      ],
      "Resource": "<key-arns-used-for-s3>"
   }
}
```

5. Any ETL job or crawler that writes encrypted Amazon CloudWatch Logs requires the following permissions in the key policy (not the IAM policy).

```json
{
   "Effect": "Allow",
   "Principal": {
      "Service": "logs.region.amazonaws.com"
   }
}
```
"Action": [
  "kms:Encrypt*",
  "kms:Decrypt*",
  "kms:ReEncrypt*",
  "kms:GenerateDataKey*",
  "kms:Describe*"
],
"Resource": "<arn of key used for ETL/crawler cloudwatch encryption>"
}

For more information about key policies, see Using Key Policies in AWS KMS in the AWS Key Management Service Developer Guide.

6. Any ETL job that uses an encrypted job bookmark needs the following permissions.

{
  "Version": "2012-10-17",
  "Statement": {
    "Effect": "Allow",
    "Action": [
      "kms:Decrypt",
      "kms:Encrypt"
    ],
    "Resource": "<key-arns-used-for-job-bookmark-encryption>"
  }
}

7. On the AWS Glue console, choose Settings in the navigation pane.

   a. On the Data catalog settings page, encrypt your Data Catalog by selecting Metadata encryption. This option encrypts all the objects in the Data Catalog with the AWS KMS key that you choose.

   b. For AWS KMS key, choose aws/glue. You can also choose a AWS KMS key that you created.

   **Important**

   AWS Glue supports only symmetric customer master keys (CMKs). The AWS KMS key list displays only symmetric keys. However, if you select Choose a AWS KMS key ARN, the console lets you enter an ARN for any key type. Ensure that you enter only ARNs for symmetric keys.
When encryption is enabled, the client that is accessing the Data Catalog must have AWS KMS permissions.

8. In the navigation pane, choose **Security configurations**. A security configuration is a set of security properties that can be used to configure AWS Glue processes. Then choose **Add security configuration**. In the configuration, choose any of the following options:

   a. Select **S3 encryption**. For **Encryption mode**, choose **SSE-KMS**. For the **AWS KMS key**, choose `aws/s3` (ensure that the user has permission to use this key). This enables data written by the job to Amazon S3 to use the AWS managed AWS Glue AWS KMS key.

   b. Select **CloudWatch logs encryption**, and choose a CMK. (Ensure that the user has permission to use this key). For more information, see [Encrypt Log Data in CloudWatch Logs Using AWS KMS](https://docs.aws.amazon.com/kms/latest/APIReference/Welcome.html) in the **AWS Key Management Service Developer Guide**.

   **Important**

   AWS Glue supports only symmetric customer master keys (CMKs). The **AWS KMS key** list displays only symmetric keys. However, if you select **Choose a AWS KMS key ARN**, the console lets you enter an ARN for any key type. Ensure that you enter only ARNs for symmetric keys.

   c. Choose **Advanced properties**, and select **Job bookmark encryption**. For the **AWS KMS key**, choose `aws/glue` (ensure that the user has permission to use this key). This enables encryption of job bookmarks written to Amazon S3 with the AWS Glue AWS KMS key.

9. In the navigation pane, choose **Connections**.

   a. Choose **Add connection** to create a connection to the Java Database Connectivity (JDBC) data store that is the target of your ETL job.

   b. To enforce that Secure Sockets Layer (SSL) encryption is used, select **Require SSL connection**, and test your connection.

10. In the navigation pane, choose **Jobs**.

    a. Choose **Add job** to create a job that transforms data.

    b. In the job definition, choose the security configuration that you created.

11. On the AWS Glue console, run your job on demand. Verify that any Amazon S3 data written by the job, the CloudWatch Logs written by the job, and the job bookmarks are all encrypted.
Setting up networking for development for AWS Glue

To run your extract, transform, and load (ETL) scripts with AWS Glue, you can develop and test your scripts using a development endpoint. Development endpoints are not supported for use with AWS Glue version 2.0 jobs. For versions 2.0 and later, the preferred development method is using Jupyter Notebook with one of the AWS Glue kernels. For more information, see the section called “Getting started with AWS Glue interactive sessions”.

Setting up your network for a development endpoint

When you set up a development endpoint, you specify a virtual private cloud (VPC), subnet, and security groups.

Note

Make sure you set up your DNS environment for AWS Glue. For more information, see Setting up DNS in your VPC.

To enable AWS Glue to access required resources, add a row in your subnet route table to associate a prefix list for Amazon S3 to the VPC endpoint. A prefix list ID is required for creating an outbound security group rule that allows traffic from a VPC to access an AWS service through a VPC endpoint. To ease connecting to a notebook server that is associated with this development endpoint, from your local machine, add a row to the route table to add an internet gateway ID. For more information, see VPC Endpoints. Update the subnet routes table to be similar to the following table:

<table>
<thead>
<tr>
<th>Destination</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0.0.0/16</td>
<td>local</td>
</tr>
<tr>
<td>pl-id for Amazon S3</td>
<td>vpce-id</td>
</tr>
<tr>
<td>0.0.0.0/0</td>
<td>igw-xxxx</td>
</tr>
</tbody>
</table>

To enable AWS Glue to communicate between its components, specify a security group with a self-referencing inbound rule for all TCP ports. By creating a self-referencing rule, you can restrict the
source to the same security group in the VPC, and it's not open to all networks. The default security group for your VPC might already have a self-referencing inbound rule for ALL Traffic.

To set up a security group

1. Sign in to the AWS Management Console and open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.
2. In the left navigation pane, choose Security Groups.
3. Either choose an existing security group from the list, or Create Security Group to use with the development endpoint.
4. In the security group pane, navigate to the Inbound tab.
5. Add a self-referencing rule to allow AWS Glue components to communicate. Specifically, add or confirm that there is a rule of Type All TCP, Protocol is TCP, Port Range includes all ports, and whose Source is the same security group name as the Group ID.

The inbound rule looks similar to this:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>security-group</td>
</tr>
</tbody>
</table>

The following shows an example of a self-referencing inbound rule:

Add a rule to for outbound traffic also. Either open outbound traffic to all ports, or create a self-referencing rule of Type All TCP, Protocol is TCP, Port Range includes all ports, and whose Source is the same security group name as the Group ID.
The outbound rule looks similar to one of these rules:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>security-group</td>
</tr>
<tr>
<td>All Traffic</td>
<td>ALL</td>
<td>ALL</td>
<td>0.0.0.0/0</td>
</tr>
</tbody>
</table>

**Setting up Amazon EC2 for a notebook server**

With a development endpoint, you can create a notebook server to test your ETL scripts with Jupyter notebooks. To enable communication to your notebook, specify a security group with inbound rules for both HTTPS (port 443) and SSH (port 22). Ensure that the rule's source is either 0.0.0.0/0 or the IP address of the machine that is connecting to the notebook.

**To set up a security group**

1. Sign in to the AWS Management Console and open the Amazon EC2 console at [https://console.aws.amazon.com/ec2/](https://console.aws.amazon.com/ec2/).
2. In the left navigation pane, choose Security Groups.
3. Either choose an existing security group from the list, or Create Security Group to use with your notebook server. The security group that is associated with your development endpoint is also used to create your notebook server.
4. In the security group pane, navigate to the Inbound tab.
5. Add inbound rules similar to this:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSH</td>
<td>TCP</td>
<td>22</td>
<td>0.0.0.0/0</td>
</tr>
<tr>
<td>HTTPS</td>
<td>TCP</td>
<td>443</td>
<td>0.0.0.0/0</td>
</tr>
</tbody>
</table>

The following shows an example of the inbound rules for the security group:
### Security Group: sg-19e1b768

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port Range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSH</td>
<td>TCP</td>
<td>22</td>
<td>0.0.0.0/0</td>
</tr>
<tr>
<td>HTTPS</td>
<td>TCP</td>
<td>443</td>
<td>0.0.0.0/0</td>
</tr>
</tbody>
</table>
Data Catalog and crawlers in AWS Glue

The AWS Glue Data Catalog contains references to data that is used as sources and targets of your extract, transform, and load (ETL) jobs in AWS Glue. To create your data warehouse or data lake, you must catalog this data. The AWS Glue Data Catalog is an index to the location, schema, and runtime metrics of your data. You use the information in the Data Catalog to create and monitor your ETL jobs. Information in the Data Catalog is stored as metadata tables, where each table specifies a single data store. Typically, you run a crawler to take inventory of the data in your data stores, but there are other ways to add metadata tables into your Data Catalog. For more information, see AWS Glue tables.

The following workflow diagram shows how AWS Glue crawlers interact with data stores and other elements to populate the Data Catalog.
The following is the general workflow for how a crawler populates the AWS Glue Data Catalog:

1. A crawler runs any custom classifiers that you choose to infer the format and schema of your data. You provide the code for custom classifiers, and they run in the order that you specify. The first custom classifier to successfully recognize the structure of your data is used to create a schema. Custom classifiers lower in the list are skipped.

2. If no custom classifier matches your data's schema, built-in classifiers try to recognize your data's schema. An example of a built-in classifier is one that recognizes JSON.

3. The crawler connects to the data store. Some data stores require connection properties for crawler access.

4. The inferred schema is created for your data.

5. The crawler writes metadata to the Data Catalog. A table definition contains metadata about the data in your data store. The table is written to a database, which is a container of tables in the Data Catalog. Attributes of a table include classification, which is a label created by the classifier that inferred the table schema.

Topics

- AWS Glue databases
- AWS Glue tables
- Working with Data Catalog settings on the AWS Glue console
- Creating tables, updating the schema, and adding new partitions in the Data Catalog from AWS Glue ETL jobs
- Defining crawlers in AWS Glue
- Adding classifiers to a crawler in AWS Glue
- AWS Glue Schema Registry
- Tutorial: Adding an AWS Glue crawler

AWS Glue databases

Databases are used to organize metadata tables in the AWS Glue. When you define a table in the AWS Glue Data Catalog, you add it to a database. A table can be in only one database.
Your database can contain tables that define data from many different data stores. This data can include objects in Amazon Simple Storage Service (Amazon S3) and relational tables in Amazon Relational Database Service.

**Note**

When you delete a database from the AWS Glue Data Catalog, all the tables in the database are also deleted.

For more information about defining a database using the AWS Glue console, see [Working with databases on the AWS Glue console](#).

### Database resource links

The AWS Glue console was recently updated. The current version of the console does not support Database Resource Links.

The Data Catalog can also contain *resource links* to databases. A database resource link is a link to a local or shared database. Currently, you can create resource links only in AWS Lake Formation. After you create a resource link to a database, you can use the resource link name wherever you would use the database name. Along with databases that you own or that are shared with you, database resource links are returned by `glue:GetDatabases()` and appear as entries on the **Databases** page of the AWS Glue console.

The Data Catalog can also contain table resource links.

For more information about resource links, see [Creating Resource Links](#) in the *AWS Lake Formation Developer Guide*.

### Working with databases on the AWS Glue console

A database in the AWS Glue Data Catalog is a container that holds tables. You use databases to organize your tables into separate categories. Databases are created when you run a crawler or add a table manually. The database list in the AWS Glue console displays descriptions for all your databases.
To view the list of databases, sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/. Choose Databases, and then choose a database name in the list to view the details.

From the Databases tab in the AWS Glue console, you can add, edit, and delete databases:

- To create a new database, choose Add database and provide a name and description. For compatibility with other metadata stores, such as Apache Hive, the name is folded to lowercase characters.

  **Note**
  If you plan to access the database from Amazon Athena, then provide a name with only alphanumeric and underscore characters. For more information, see Athena names.

- To edit the description for a database, select the check box next to the database name and choose Edit.

- To delete a database, select the check box next to the database name and choose Remove.

- To display the list of tables contained in the database, choose the database name and the database properties will display all tables in the database.

To change the database that a crawler writes to, you must change the crawler definition. For more information, see Defining crawlers in AWS Glue.

**AWS Glue tables**

You can add table definitions to the Data Catalog in the following ways:

- Run a crawler that connects to one or more data stores, determines the data structures, and writes tables into the Data Catalog. The crawler uses built-in or custom classifiers to recognize the structure of the data. You can run your crawler on a schedule. For more information, see Defining crawlers in AWS Glue.

- Use the AWS Glue console to manually create a table in the AWS Glue Data Catalog. For more information, see Working with tables on the AWS Glue console.

- Use the CreateTable operation in the AWS Glue API to create a table in the AWS Glue Data Catalog. For more information, see CreateTable action (Python: create_table).
Use AWS CloudFormation templates. For more information, see [AWS CloudFormation for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-enterprise-cloudformation.html).

Migrate an Apache Hive metastore. For more information, see [Migration between the Hive Metastore and the AWS Glue Data Catalog](https://github.com/aws/aws-glue-data-catalog) on GitHub.

When you define a table manually using the console or an API, you specify the table schema and the value of a classification field that indicates the type and format of the data in the data source. If a crawler creates the table, the data format and schema are determined by either a built-in classifier or a custom classifier. For more information about creating a table using the AWS Glue console, see [Working with tables on the AWS Glue console](https://docs.aws.amazon.com/glue/latest/dg/console-create-table.html).

Topics

- Table partitions
- Table resource links
- Updating manually created Data Catalog tables using crawlers
- Data Catalog table properties
- Working with tables on the AWS Glue console
- Working with partition indexes in AWS Glue
- Working with column statistics

Table partitions

An AWS Glue table definition of an Amazon Simple Storage Service (Amazon S3) folder can describe a partitioned table. For example, to improve query performance, a partitioned table might separate monthly data into different files using the name of the month as a key. In AWS Glue, table definitions include the partitioning key of a table. When AWS Glue evaluates the data in Amazon S3 folders to catalog a table, it determines whether an individual table or a partitioned table is added.

You can create partition indexes on a table to fetch a subset of the partitions instead of loading all the partitions in the table. For information about working with partition indexes, see [Working with partition indexes in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/partitionindex.html).

All the following conditions must be true for AWS Glue to create a partitioned table for an Amazon S3 folder:
The schemas of the files are similar, as determined by AWS Glue.

The data format of the files is the same.

The compression format of the files is the same.

For example, you might own an Amazon S3 bucket named `my-app-bucket`, where you store both iOS and Android app sales data. The data is partitioned by year, month, and day. The data files for iOS and Android sales have the same schema, data format, and compression format. In the AWS Glue Data Catalog, the AWS Glue crawler creates one table definition with partitioning keys for year, month, and day.

The following Amazon S3 listing of `my-app-bucket` shows some of the partitions. The `=` symbol is used to assign partition key values.

```plaintext
my-app-bucket/Sales/year=2010/month=feb/day=1/iOS.csv
my-app-bucket/Sales/year=2010/month=feb/day=1/Android.csv
my-app-bucket/Sales/year=2010/month=feb/day=2/iOS.csv
my-app-bucket/Sales/year=2010/month=feb/day=2/Android.csv
...  
my-app-bucket/Sales/year=2017/month=feb/day=4/iOS.csv
my-app-bucket/Sales/year=2017/month=feb/day=4/Android.csv
```

## Table resource links

The AWS Glue console was recently updated. The current version of the console does not support Table Resource Links.

The Data Catalog can also contain resource links to tables. A table resource link is a link to a local or shared table. Currently, you can create resource links only in AWS Lake Formation. After you create a resource link to a table, you can use the resource link name wherever you would use the table name. Along with tables that you own or that are shared with you, table resource links are returned by `glue:GetTables()` and appear as entries on the **Tables** page of the AWS Glue console.

The Data Catalog can also contain database resource links.

For more information about resource links, see [Creating Resource Links](#) in the *AWS Lake Formation Developer Guide*. 
Updating manually created Data Catalog tables using crawlers

You might want to create AWS Glue Data Catalog tables manually and then keep them updated with AWS Glue crawlers. Crawlers running on a schedule can add new partitions and update the tables with any schema changes. This also applies to tables migrated from an Apache Hive metastore.

To do this, when you define a crawler, instead of specifying one or more data stores as the source of a crawl, you specify one or more existing Data Catalog tables. The crawler then crawls the data stores specified by the catalog tables. In this case, no new tables are created; instead, your manually created tables are updated.

The following are other reasons why you might want to manually create catalog tables and specify catalog tables as the crawler source:

- You want to choose the catalog table name and not rely on the catalog table naming algorithm.
- You want to prevent new tables from being created in the case where files with a format that could disrupt partition detection are mistakenly saved in the data source path.

For more information, see [Crawler source type](#).

Data Catalog table properties

Table properties, or parameters, as they are known in the AWS CLI, are unvalidated key and value strings. You can set your own properties on the table to support uses of the Data Catalog outside of AWS Glue. Other services using the Data Catalog may do so as well. AWS Glue sets some table properties when running jobs or crawlers. Unless otherwise described, these properties are for internal use, we do not support that they will continue to exist in their current form, or support product behavior if these properties are manually changed.

For more information about table properties set by AWS Glue crawlers, see [the section called “Parameters set on Data Catalog tables by crawler”](#).

Working with tables on the AWS Glue console

A table in the AWS Glue Data Catalog is the metadata definition that represents the data in a data store. You create tables when you run a crawler, or you can create a table manually in the AWS Glue console. The **Tables** list in the AWS Glue console displays values of your table's metadata. You use
table definitions to specify sources and targets when you create ETL (extract, transform, and load) jobs.

Note

With recent changes to the AWS management console, you may need to modify your existing IAM roles to have the SearchTables permission. For new role creation, the SearchTables API permission has already been added as default.

To get started, sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/. Choose the Tables tab, and use the Add tables button to create tables either with a crawler or by manually typing attributes.

Adding tables on the console

To use a crawler to add tables, choose Add tables, Add tables using a crawler. Then follow the instructions in the Add crawler wizard. When the crawler runs, tables are added to the AWS Glue Data Catalog. For more information, see Defining crawlers in AWS Glue.

If you know the attributes that are required to create an Amazon Simple Storage Service (Amazon S3) table definition in your Data Catalog, you can create it with the table wizard. Choose Add tables, Add table manually, and follow the instructions in the Add table wizard.

When adding a table manually through the console, consider the following:

- If you plan to access the table from Amazon Athena, then provide a name with only alphanumeric and underscore characters. For more information, see Athena names.
- The location of your source data must be an Amazon S3 path.
- The data format of the data must match one of the listed formats in the wizard. The corresponding classification, SerDe, and other table properties are automatically populated based on the format chosen. You can define tables with the following formats:
  
  **Avro**
  
  Apache Avro JSON binary format.

  **CSV**
  
  Character separated values. You also specify the delimiter of either comma, pipe, semicolon, tab, or Ctrl-A.
JSON

JavaScript Object Notation.

XML

Extensible Markup Language format. Specify the XML tag that defines a row in the data. Columns are defined within row tags.

Parquet

Apache Parquet columnar storage.

ORC

Optimized Row Columnar (ORC) file format. A format designed to efficiently store Hive data.

- You can define a partition key for the table.
- Currently, partitioned tables that you create with the console cannot be used in ETL jobs.

Table attributes

The following are some important attributes of your table:

Name

The name is determined when the table is created, and you can't change it. You refer to a table name in many AWS Glue operations.

Database

The container object where your table resides. This object contains an organization of your tables that exists within the AWS Glue Data Catalog and might differ from an organization in your data store. When you delete a database, all tables contained in the database are also deleted from the Data Catalog.

Description

The description of the table. You can write a description to help you understand the contents of the table.

Table format

Specify creating a standard AWS Glue table, or a table in Apache Iceberg format.
Enable compaction

Choose Enable compaction to compact small Amazon S3 objects in the table into larger objects.

IAM role

To run compaction, the service assumes an IAM role on your behalf. You can choose an IAM role using the drop-down. Ensure that the role has the permissions required to enable compaction.

To learn more about the required permissions for the IAM role, see Table optimization prerequisites.

Location

The pointer to the location of the data in a data store that this table definition represents.

Classification

A categorization value provided when the table was created. Typically, this is written when a crawler runs and specifies the format of the source data.

Last updated

The time and date (UTC) that this table was updated in the Data Catalog.

Date added

The time and date (UTC) that this table was added to the Data Catalog.

Deprecated

If AWS Glue discovers that a table in the Data Catalog no longer exists in its original data store, it marks the table as deprecated in the data catalog. If you run a job that references a deprecated table, the job might fail. Edit jobs that reference deprecated tables to remove them as sources and targets. We recommend that you delete deprecated tables when they are no longer needed.

Connection

If AWS Glue requires a connection to your data store, the name of the connection is associated with the table.
Viewing and editing table details

To see the details of an existing table, choose the table name in the list, and then choose **Action, View details.**

The table details include properties of your table and its schema. This view displays the schema of the table, including column names in the order defined for the table, data types, and key columns for partitions. If a column is a complex type, you can choose **View properties** to display details of the structure of that field, as shown in the following example:

```json
{
    "StorageDescriptor": {
        "cols": {
            "FieldSchema": [
                {
                    "name": "primary-1",
                    "type": "CHAR",
                    "comment":"
                },
                {
                    "name": "second ",
                    "type": "STRING",
                    "comment":"
                }
            ]
        },
        "location": "s3://aws-logs-111122223333-us-east-1",
        "inputFormat": "",
        "outputFormat": "org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat",
        "compressed": "false",
        "numBuckets": "0",
        "SerDeInfo": {
            "name": "",
            "serializationLib": "org.apache.hadoop.hive.serde2.OpenCSVserde",
            "parameters": {
                "separatorChar": "|
            }
        },
        "bucketCols": [],
        "sortCols": [],
        "parameters": {},
        "SkewedInfo": {}
    }
}
```
For more information about the properties of a table, such as `StorageDescriptor`, see `StorageDescriptor` structure.

To change the schema of a table, choose **Edit schema** to add and remove columns, change column names, and change data types.

To compare different versions of a table, including its schema, choose **Compare versions** to see a side-by-side comparison of two versions of the schema for a table. For more information, see **Compare table schema versions**.

To display the files that make up an Amazon S3 partition, choose **View partition**. For Amazon S3 tables, the **Key** column displays the partition keys that are used to partition the table in the source data store. Partitioning is a way to divide a table into related parts based on the values of a key column, such as date, location, or department. For more information about partitions, search the internet for information about "hive partitioning."

**Note**

To get step-by-step guidance for viewing the details of a table, see the **Explore table** tutorial in the console.

**Compare table schema versions**

When you compare two versions of table schemas, you can compare nested row changes by expanding and collapsing nested rows, compare schemas of two versions side-by-side, and view table properties side-by-side.

To compare versions

1. From the AWS Glue console, choose **Tables**, then **Actions** and choose **Compare versions**.
2. Choose a version to compare by choosing the version drop-down menu. When comparing schemas, the Schema tab is highlighted in orange.

3. When you compare tables between two versions, the table schemas are presented to you on the left and right side of the screen. This enables you to determine changes visually by comparing the Column name, data type, key, and comment fields side-by-side. When there is a change, a colored icon displays the type of change that was made.

- Deleted – displayed by a red icon indicates where the column was removed from a previous version of the table schema.
- Edited or Moved – displayed by a blue icon indicates where the column was modified or moved in a newer version of the table schema.
- Added – displayed by a green icon indicates where the column was added to a newer version of the table schema.
• Nested changes – displayed by a yellow icon indicates where the nested column contains changes. Choose the column to expand and view the columns that have either been deleted, edited, moved, or added.

4. Use the filter fields search bar to display fields based on the characters you enter here. If you enter a column name in either table version, the filtered fields are displayed in both table versions to show you where the changes have occurred.

5. To compare properties, choose the **Properties tab**.

6. To stop comparing versions, choose **Stop comparing** to return to the list of tables.
Optimizing Iceberg tables

The Amazon S3 data lakes using open table formats such as Apache Iceberg store the data as Amazon S3 objects. Having thousands of small Amazon S3 objects in a data lake table increases metadata overhead on Iceberg tables and affects the read performance. For better read performance by AWS analytics services such as Amazon Athena and Amazon EMR, and AWS Glue ETL jobs, AWS Glue Data Catalog provides managed compaction (a process that compacts small Amazon S3 objects into larger objects) for Iceberg tables in Data Catalog. You can use AWS Glue console, Lake Formation console, AWS CLI, or AWS API to enable or disable compaction for individual Iceberg tables that are in the Data Catalog.

The table optimizer constantly monitors table partitions and kicks off the compaction process when the threshold is exceeded for the number of files and file sizes. In the Data Catalog, the default threshold value to initiate compaction is set to 384 MB whereas in the Iceberg library the threshold for compaction is ~75% of the target file size. Data Catalog performs compaction without interfering with concurrent queries. Data Catalog supports data compaction only for tables in the Parquet format.

Topics

- Table optimization prerequisites
- Enabling compaction
- Disabling compaction
- Viewing compaction details
- Viewing Amazon CloudWatch metrics
- Deleting an optimizer
- Considerations and limitations

Table optimization prerequisites

The table optimizer assumes the permissions of the AWS Identity and Access Management (IAM) role that you specify when you enable compaction for a table. The IAM role must have the permissions to read data and update metadata in the Data Catalog. You can create an IAM role and attach the following inline policies:

- Add the following inline policy that grants Amazon S3 read/write permissions on the location for data that is not registered with Lake Formation. This policy also includes permissions to update the table in the Data Catalog, and to permit AWS Glue to add logs in Amazon CloudWatch logs
and publish metrics. For source data in Amazon S3 that isn't registered with Lake Formation, access is determined by IAM permissions policies for Amazon S3 and AWS Glue actions.

In the following inline policies, replace bucket-name with your Amazon S3 bucket name, aws-account-id and region with a valid AWS account number and Region of the Data Catalog, database_name with the name of your database, and table_name with the name of the table.

```
{
   "Version": "2012-10-17",
   "Statement": [
   {
      "Effect": "Allow",
      "Action": [
      "s3:PutObject",
      "s3:GetObject",
      "s3:DeleteObject"
      ],
      "Resource": [
      "arn:aws:s3:::<bucket-name>/*"
      ]
   },
   {
      "Effect": "Allow",
      "Action": [
      "s3:ListBucket"
      ],
      "Resource": [
      "arn:aws:s3:::<bucket-name>"
      ]
   },
   {
      "Effect": "Allow",
      "Action": [
      "glue:UpdateTable",
      "glue:GetTable"
      ],
      "Resource": [
      "arn:aws:glue:<region>:<aws-account-id>:catalog"
      ]
   }
   ],
}
Use the following policy to enable compaction for data registered with Lake Formation.

For more information on registering an Amazon S3 bucket with Lake Formation, see Requirements for roles used to register locations.
Additionally, if the Amazon S3 data location is registered with Lake Formation, and the compaction role doesn't have IAM_ALLOWED_PRINCIPALS group permissions granted on the table, the role requires Lake Formation ALTER and DESCRIBE permissions on the table. The role used for registering the Amazon S3 bucket requires Lake Formation INSERT and DELETE permissions on the table. If the Amazon S3 data location not registered with Lake Formation, and the compaction role doesn't have IAM_ALLOWED_PRINCIPALS group permissions granted on the table, the role requires Lake Formation ALTER, DESCRIBE, INSERT and DELETE permissions on the table.

• (Optional) To compact Iceberg tables with data in Amazon S3 buckets encrypted using Server-side encryption, the compaction role requires permissions to decrypt Amazon S3 objects and generate a new data key to write objects to the encrypted buckets. Add the following policy to the desired AWS KMS key. We support only bucket-level encryption.

```json
{
  "Effect": "Allow",
  "Principal": {
    "AWS": "arn:aws:iam::<aws-account-id>:role/<compaction-role-name>"
  },
  "Action": [
    "kms:Decrypt",
    "kms:GenerateDataKey"
  ],
  "Resource": "*"
}
```

• (Optional) For data location registered with Lake Formation, the role used to register the location requires permissions to decrypt Amazon S3 objects and generate a new data key to write objects
to the encrypted buckets. For more information, see Registering an encrypted Amazon S3 location.

• (Optional) If the AWS KMS key is stored in a different AWS account, you need to include the following permissions to the compaction role.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "kms:Decrypt",
        "kms:GenerateDataKey"
      ],
      "Resource": ["arn:aws:kms:<REGION>:<KEY_OWNER_ACCOUNT_ID>:key/<KEY_ID>"]
    }
  ]
}
```

• The role you use to run compaction must have the `iam:PassRole` permission on the role.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iam:PassRole"],
      "Resource": ["arn:aws:iam::<account-id>:role/compaction-role-name"]
    }
  ]
}
```

• Add the following trust policy to the role for AWS Glue service to assume the IAM role to run the compaction process.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["sts:AssumeRole"],
      "Resource": ["arn:aws:iam::<account-id>:role/compaction-role-name"]
    }
  ]
}
```
Enabling compaction

You can use AWS Glue console, Lake Formation console, AWS CLI, or AWS API to enable compaction for your Apache Iceberg tables in the Data Catalog. For new tables, you can choose Apache Iceberg as table format and enable compaction when you create the table. Compaction is disabled by default for new tables.

Console

To enable compaction

1. Open the AWS Glue console at https://console.aws.amazon.com/glue/ and sign in as a data lake administrator, the table creator, or a user who has been granted the glue:UpdateTable and lakeformation:GetDataAccess permissions on the table.

2. In the navigation pane, under Data Catalog, choose Tables.

3. On the Tables page, choose a table in open table format that you want to enable compaction for, then under Actions menu, choose Enable compaction.

4. You can also enable compaction by selecting the table and opening the Table details page. Choose the Table optimization tab on the lower section of the page, and choose Enable compaction.

5. Next, select an existing IAM role from the drop down with the permissions shown in the Table optimization prerequisites section.

When you choose Create a new IAM role option, the service creates a custom role with the required permissions to run compaction.
Follow the steps below to update an existing IAM role:

a. To update the permissions policy for the IAM role, in the IAM console, go to the IAM role that is being used for running compaction.

b. In the Add permissions section, choose Create policy. In the newly opened browser window, create a new policy to use with your role.

c. On the Create policy page, choose the JSON tab. Copy the JSON code shown in the section called “Prerequisites” section into the policy editor field.

AWS CLI

The following example shows how to enable compaction. Replace the account ID with a valid AWS account ID. Replace the database name and table name with the actual Iceberg table name and the database name. Replace the roleArn with the AWS Resource Name (ARN) of the IAM role and name of the IAM role that has the required permissions to run compaction.

```
aws glue create-table-optimizer \
  --catalog-id 123456789012 \
  --database-name iceberg_db \
  --table-name iceberg_table \
  --table-optimizer-configuration \
  '{"roleArn":"arn:aws:iam::<123456789012>:role/<compaction_role>"},"enabled":"true'} \
  --type compaction
```

AWS API

Call CreateTableOptimizer operation to enable compaction for a table.

After you enable compaction, Table optimization tab shows the following compaction details (after approximately 15-20 minutes):

- **Start time** - The time at which the compaction process started within Lake Formation. The value is a timestamp in UTC time.
- **End time** - The time at which the compaction process ended in Lake Formation. The value is a timestamp in UTC time.
- **Status** - The status of the compaction run. Values are success or fail.
• Files compacted - Total number of files compacted.
• Bytes compacted - Total number of bytes compacted.

Disabling compaction

You can disable automatic compaction for a particular Apache Iceberg table using AWS Glue console or AWS CLI.

Console

1. Choose **Data Catalog** and choose **Tables**. From the tables list, choose the table in open table format that you want to disable compaction.

2. You can choose an Iceberg table, and choose **Disable compaction** under **Actions**.

   You can also disable compaction for the table by choosing **Disable compaction** on the lower section of the **Tables details** page.

3. Choose **Disable compaction** on the confirmation message. You can re-enable compaction at a later time.

   After the you confirm, compaction is disabled and the compaction status for the table turns back to **Off**.

AWS CLI

In the following example, replace the account ID with a valid AWS account ID. Replace the database name and table name with actual Iceberg table name and the database name. Replace the `roleArn` with the AWS Resource Name (ARN) of the IAM role and actual name of the IAM role that has the required permissions to run compaction.

```
aws glue update-table-optimizer \
   --catalog-id 123456789012 \
   --database-name iceberg_db \
   --table-name iceberg_table \
   --table-optimizer-configuration \
   '{"roleArn":"arn:aws:iam::123456789012:role/compaction_role", "enabled":"false"}'\n   --type compaction
```
AWS API

Call UpdateTableOptimizer operation to disable compaction for a specific table.

Viewing compaction details

You can view compaction status for Apache Iceberg using the AWS Glue console, AWS CLI, or using AWS API operations.

Console

To view compaction status for Iceberg tables

- You can view compaction status for Iceberg tables in the AWS Glue console by choosing Tables under Data Catalog. The Compaction status field shows the status of the compaction run. You can display table format and compaction status using the table preferences.
- To view the compaction run history for a specific table, choose Tables under AWS Glue Data Catalog, and choose a table to view the table details. The Table optimization tab shows the compaction history for the table.

AWS CLI

You can view the compaction details using AWS CLI.

In the following examples, replace the account ID with a valid AWS account ID, the database name, and table name with actual Iceberg table name.

- To get the last compaction run details for a table

```bash
aws get-table-optimizer \
--catalog-id 123456789012 \
--database-name iceberg_db \
--table-name iceberg_table \
--type compaction
```

- Use the following example to retrieve the history of an optimizer for a specific table.

```bash
aws list-table-optimizer-runs \
--catalog-id 123456789012 \
--database-name iceberg_db
```
The following example shows how to retrieve the compaction run and configuration details for multiple optimizers. You can specify a maximum of 20 optimizers.

```
aws glue batch-get-table-optimizer \
--entries '[["catalogId":"123456789012", "databaseName":"iceberg_db", "tableName":"iceberg_table", "type":"compaction"]]
```

AWS API

- Use `GetTableOptimizer` operation to retrieve the last run details of an optimizer.
- Use `ListTableOptimizerRuns` operation to retrieve history of a given optimizer on a specific table. You can specify 20 optimizers in a single API call.
- Use `BatchGetTableOptimizer` operation to retrieve configuration details for multiple optimizers in your account. This operation doesn't support cross account calls.

**Viewing Amazon CloudWatch metrics**

After running the compaction successfully, the service creates Amazon CloudWatch metrics on the compaction job performance. You can go to the CloudWatch console and choose Metrics, All metrics. You can filter metrics by the specific name space (for example AWS Glue), table name, or database name.

For more information, see View available metrics in the Amazon CloudWatch User Guide.

- Number of bytes compacted
- Number of files compacted
- Number of DPU allocated to jobs
- Duration of job (Hours)

**Deleting an optimizer**

You can delete an optimizer and associated metadata for the table using AWS CLI or AWS API operation.
Run the following AWS CLI command to delete compaction history for a table.

```
aws glue delete-table-optimizer \
   --catalog-id 123456789012 \
   --database-name iceberg_db \
   --table-name iceberg_table \
   --type compaction
```

Use `DeleteTableOptimizer` operation to delete an optimizer for a table.

**Considerations and limitations**

**Data compaction supports:**

- **Data types:** Boolean, Integer, Long, Float, Double, String, Decimal, Date, Time, Timestamp, String, UUID, Binary
- **Compression:** zstd, gzip, snappy, uncompressed
- **Encryption:** Data compaction only supports default Amazon S3 encryption (SSE-S3) and server-side KMS encryption (SSE-KMS).
- **Bin pack compaction**
- **Schema evolution**
- **Tables with target file size** (write.target-file-size-bytes property in iceberg configuration) within the inclusive range 128MB to 512 MB.

- **Regions**
  - ap-northeast-1
  - us-east-1
  - us-east-2
  - us-west-2
  - eu-west-1
- You can run compaction from the account where Data Catalog resides when the Amazon S3 bucket that stores the underlying data is in another account. To do this, the compaction role requires access to the Amazon S3 bucket.

**Data compaction currently doesn’t support:**

**Working with tables on the console**
• **Data types**: Fixed
• **Compression**: brotli, lz4
• Compaction of files while the partition spec evolves.
• **Regular sorting or z-order sorting**
• **Merge or delete files**: The compaction process skips data files that have delete files associated with them.
• **Compaction on cross-account tables**: You can't run compaction on cross-account tables.
• **Compaction on cross-Region tables**: You can't run compaction on cross-Region tables.
• **Enabling compaction on resource links**
• **VPC endpoints for Amazon S3 buckets**

**Working with partition indexes in AWS Glue**

Over time, hundreds of thousands of partitions get added to a table. The [GetPartitions API](https://docs.aws.amazon.com/glue/latest/dg/get-partitions-api.html) is used to fetch the partitions in the table. The API returns partitions which match the expression provided in the request.

Let's take a *sales_data* table as an example which is partitioned by the keys *Country*, *Category*, *Year*, and *Month*. If you want to obtain sales data for all the items sold for the *Books* category in the year 2020, you have to make a GetPartitions request with the expression "Category = Books and year = 2020" to the Data Catalog.

If no partition indexes are present on the table, AWS Glue loads all the partitions of the table, and then filters the loaded partitions using the query expression provided by the user in the GetPartitions request. The query takes more time to run as the number of partitions increase on a table with no indexes. With an index, the GetPartitions query will try to fetch a subset of the partitions instead of loading all the partitions in the table.

**Topics**

• [About partition indexes](#)
• [Creating a table with partition indexes](#)
• [Adding a partition index to an existing table](#)
• [Describing partition indexes on a table](#)
• [Limitations on using partition indexes](#)
• [Using indexes for an optimized GetPartitions call](#)
About partition indexes

When you create a partition index, you specify a list of partition keys that already exist on a given table. Partition index is a sub list of partition keys defined in the table. A partition index can be created on any permutation of partition keys defined on the table. For the above `sales_data` table, the possible indexes are (country, category, year, month), (country, category, year), (country, category), (country), (category, country, year, month), and so on.

The Data Catalog will concatenate the partition values in the order provided at the time of index creation. The index is built consistently as partitions are added to the table. Indexes can be created for String (string, char, and varchar) and Numeric (int, bigint, long, tinyint, and smallint) column types. For example, for a table with the partition keys `country` (String), `item` (String), `creationDate` (date), an index cannot be created on the partition key `creationDate`.

Indexes on Numeric and String data types support =, >, >=, <, <= and between operators. The indexing solution currently only supports the AND logical operator. Sub-expressions with the operators "LIKE", "IN", "OR", and "NOT" are ignored in the expression for filtering using an index. Filtering for the ignored sub-expression is done on the partitions fetched after applying index filtering.

For each partition added to a table, there is a corresponding index item created. For a table with ‘n’ partitions, 1 partition index will result in ‘n’ partition index items. ‘m’ partition index on same table will result into ‘m*n’ partition index items. Each partition index item will be charged according to the current AWS Glue pricing policy for data catalog storage. For details on storage object pricing, see AWS Glue pricing.

Creating a table with partition indexes

You can create a partition index during table creation. The CreateTable request takes a list of `PartitionIndex` objects as an input. A maximum of 3 partition indexes can be created on a given table. Each partition index requires a name and a list of partitionKeys defined for the table. Created indexes on a table can be fetched using the `GetPartitionIndexes` API.

Adding a partition index to an existing table

To add a partition index to an existing table, use the CreatePartitionIndex operation. You can create one `PartitionIndex` per CreatePartitionIndex operation. Adding an index does
not affect the availability of a table, as the table continues to be available while indexes are being created.

The index status for an added partition is set to CREATING and the creation of the index data is started. If the process for creating the indexes is successful, the indexStatus is updated to ACTIVE and for an unsuccessful process, the index status is updated to FAILED. Index creation can fail for multiple reasons, and you can use the GetPartitionIndexes operation to retrieve the failure details. The possible failures are:

- ENCRYPTED_PARTITION_ERROR — Index creation on a table with encrypted partitions is not supported.
- INVALID_PARTITION_TYPE_DATA_ERROR — Observed when the partitionKey value is not a valid value for the corresponding partitionKey data type. For example: a partitionKey with the 'int' datatype has a value 'foo'.
- MISSING_PARTITION_VALUE_ERROR — Observed when the partitionValue for an indexedKey is not present. This can happen when a table is not partitioned consistently.
- UNSUPPORTED_PARTITION_CHARACTER_ERROR — Observed when the value for an indexed partition key contains the characters \u0000, \u0001 or \u0002
- INTERNAL_ERROR — An internal error occurred while indexes were being created.

**Describing partition indexes on a table**

To fetch the partition indexes created on a table, use the GetPartitionIndexes operation. The response returns all the indexes on the table, along with the current status of each index (the IndexStatus).

The IndexStatus for a partition index will be one of the following:

- CREATING — The index is currently being created, and is not yet available for use.
- ACTIVE — The index is ready for use. Requests can use the index to perform an optimized query.
- DELETING — The index is currently being deleted, and can no longer be used. An index in the active state can be deleted using the DeletePartitionIndex request, which moves the status from ACTIVE to DELETING.
- FAILED — The index creation on an existing table failed. Each table stores the last 10 failed indexes.
The possible state transitions for indexes created on an existing table are:

- CREATING → ACTIVE → DELETING
- CREATING → FAILED

Limitations on using partition indexes

Once you have created a partition index, note these changes to table and partition functionality:

**New Partition Creation (after Index Addition)**

After a partition index is created on a table, all new partitions added to the table will be validated for the data type checks for indexed keys. The partition value of the indexed keys will be validated for data type format. If the data type check fails, the create partition operation will fail. For the `sales_data` table, if an index is created for keys `(category, year)` where the category is of type `string` and year of type `int`, the creation of the new partition with a value of YEAR as "foo" will fail.

After indexes are enabled, the addition of partitions with indexed key values having the characters U+0000, U+00001, and U+00002 will start to fail.

**Table Updates**

Once a partition index is created on a table, you cannot modify the partition key names for existing partition keys, and you cannot change the type, or order, of keys which are registered with the index.

**Using indexes for an optimized GetPartitions call**

When you call `GetPartitions` on a table with an index, you can include an expression, and if applicable the Data Catalog will use an index if possible. The first key of the index should be passed in the expression for the indexes to be used in filtering. Index optimization in filtering is applied as a best effort. The Data Catalog tries to use index optimization as much as possible, but in case of a missing index, or unsupported operator, it falls back to the existing implementation of loading all partitions.

For the `sales_data` table above, lets add the index `[Country, Category, Year]`. If "Country" is not passed in the expression, the registered index will not be able to filter partitions using indexes. You can add up to 3 indexes to support various query patterns.

Lets take some example expressions and see how indexes work on them:
<table>
<thead>
<tr>
<th>Expressions</th>
<th>How Index Will Be Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country = 'US'</td>
<td>Index will be used to filter partitions.</td>
</tr>
<tr>
<td>Country = 'US' and Category = 'Shoes'</td>
<td>Index will be used to filter partitions.</td>
</tr>
<tr>
<td>Category = 'Shoes'</td>
<td>Indexes will not be used as &quot;country&quot; is not provided in the expression. All partitions will be loaded to return a response.</td>
</tr>
<tr>
<td>Country = 'US' and Category = 'Shoes' and Year &gt; '2018'</td>
<td>Index will be used to filter partitions.</td>
</tr>
<tr>
<td>Country = 'US' and Category = 'Shoes' and Year &gt; '2018' and month = 2</td>
<td>Index will be used to fetch all partitions with country = &quot;US&quot; and category = &quot;shoes&quot; and year &gt; 2018. Then, filtering on the month expression will be performed.</td>
</tr>
<tr>
<td>Country = 'US' AND Category = 'Shoes' OR Year &gt; '2018'</td>
<td>Indexes will not be used as an OR operator is present in the expression.</td>
</tr>
<tr>
<td>Country = 'US' AND Category = 'Shoes' AND (Year = 2017 OR Year = '2018')</td>
<td>Index will be used to fetch all partitions with country = &quot;US&quot; and category = &quot;shoes&quot;, and then filtering on the year expression will be performed.</td>
</tr>
<tr>
<td>Country in ('US', 'UK') AND Category = 'Shoes'</td>
<td>Indexes will not be used for filtering as the IN operator is not supported currently.</td>
</tr>
<tr>
<td>Country = 'US' AND Category in ('Shoes', 'Books')</td>
<td>Index will be used to fetch all partitions with country = &quot;US&quot;, and then filtering on the Category expression will be performed.</td>
</tr>
</tbody>
</table>

**Integration with engines**

Redshift Spectrum, Amazon EMR and AWS Glue ETL Spark DataFrames are able to utilize indexes for fetching partitions after indexes are in an ACTIVE state in AWS Glue. Athena and AWS Glue ETL Dynamic frames require you to follow extra steps to utilize indexes for query improvement.
Working with column statistics

You can compute column-level statistics for AWS Glue Data Catalog tables in data formats such as Parquet, ORC, JSON, ION, CSV, and XML without setting up additional data pipelines. Column statistics help you to understand data profiles by getting insights about values within a column. Data Catalog supports generating statistics for column values such as minimum value, maximum value, total null values, total distinct values, average length of values, and total occurrences of true values.

AWS analytical services such as Amazon Redshift and Amazon Athena can use these column statistics to generate query execution plans, and choose the optimal plan that improves query performance.

You can configure to run column statistics generation task using AWS Glue console or AWS CLI. When you initiate the process, AWS Glue starts a Spark job in the background and updates the AWS Glue table metadata in the Data Catalog. You can view column statistics using AWS Glue console or AWS CLI or by calling the `GetColumnStatisticsForTable` API operation.

**Note**

If you're using Lake Formation permissions to control access to the table, the role assumed by the column statistics task requires full table access to generate statistics.

Topics

- Prerequisites for generating column statistics
- Generating column statistics
- Viewing column statistics
- Updating column statistics
- Deleting column statistics
- Viewing column statistics task runs
- Stopping column statistics task run
- Considerations and limitations
Prerequisites for generating column statistics

To generate or update column statistics, the statistics generation task assumes an AWS Identity and Access Management (IAM) role on your behalf. Based on the permissions granted to the role, the column statistics generation task can read the data from the Amazon S3 data store.

Note

To generate statistics for tables managed by Lake Formation, the IAM role used to generate statistics requires full table access.

To use role-based access control, you must create an IAM role with the permissions listed in the policy below, and add that role to the column statistics generation task.

To create an IAM role for generating column statistics

1. To create an IAM role, see Create an IAM role for AWS Glue.
2. To update an existing role, in the IAM console, go to the IAM role that is being used by the generate column statistics process.
3. In the Add permissions section, choose Attach policies. In the newly opened browser window, choose AWSGlueServiceRole AWS managed policy.
4. You also need to include permissions to read data from the Amazon S3 data location.

   In the Add permissions section, choose Create policy. In the newly opened browser window, create a new policy to use with your role.

5. In the Create policy page, choose the JSON tab. Copy the following JSON code into the policy editor field.

   In the following policies, replace accountId with a valid AWS account, and replace region with the Region of the table, and bucket with Amazon S3 bucket name.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": [
       
   ```
6. (Optional) If you're using Lake Formation permissions to provide access to your data, the IAM role requires `lakeformation:GetDataAccess` permissions.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "LakeFormationDataAccess",
            "Effect": "Allow",
            "Action": "lakeformation:GetDataAccess",
            "Resource": [
                "*"
            ]
        }
    ]
}
```

If the Amazon S3 data location is registered with Lake Formation, and the IAM role assumed by the column statistics generation task doesn't have `IAM_ALLOWED_PRINCIPALS` group permissions granted on the table, the role requires Lake Formation ALTER and DESCRIBE permissions on the table. The role used for registering the Amazon S3 bucket requires Lake Formation INSERT and DELETE permissions on the table.

If the Amazon S3 data location is not registered with Lake Formation, and the IAM role doesn't have `IAM_ALLOWED_PRINCIPALS` group permissions granted on the table, the role requires Lake Formation ALTER, DESCRIBE, INSERT and DELETE permissions on the table.
7. (Optional) The column statistics generation task that writes encrypted Amazon CloudWatch Logs requires the following permissions in the key policy.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CWLogsKmsPermissions",
            "Effect": "Allow",
            "Action": [
                "logs:CreateLogGroup",
                "logs:CreateLogStream",
                "logs:PutLogEvents",
                "logs:AssociateKmsKey"
            ],
            "Resource": [
                "arn:aws:logs:<region>:<accountId>:log-group:/aws-glue:*"
            ]
        },
        {
            "Sid": "KmsPermissions",
            "Effect": "Allow",
            "Action": [
                "kms:GenerateDataKey",
                "kms:Decrypt",
                "kms:Encrypt"
            ],
            "Resource": [
                "arn:aws:kms:<region>:<accountId>:key/arn of key used for ETL cloudwatch encryption"
            ],
            "Condition": {
                "StringEquals": {
                    "kms:ViaService": ["glue.<region>.amazonaws.com"]
                }
            }
        }
    ]
}
```

8. When you create an IAM role for generating column statistics, that role must also have the following trust policy that enables the service to assume the role.
Generating column statistics

Follow these steps to manage statistics generation in the Data Catalog using AWS Glue console or AWS CLI.

Console

To generate column statistics using the console

2. Choose Data Catalog tables.
3. Choose a table from the list.
4. Choose Generate statistics under Actions menu.
   
   You can also choose Generate statistics button under Column statistics tab in the lower section of the Tables page.
5. On the Generate statistics page, specify the following options:
Generate statistics
Generate column statistics for the table to improve query performance and potentially save costs. View pricing

---

**Choose columns**

- **Table (all columns)** – Choose this option to generate statistics for all columns in the table.
- **Selected columns** – Choose this option to generate statistics for specific columns. You can select the columns from the drop-down list.
- **All rows** – Choose all rows from the table to generate accurate statistics.
- **Sample rows** – Choose only a specific percent of rows from the table to generate statistics. The default is all rows. Use the up and down arrows to increase or decrease the percent value.

---

**Row sampling options**

We recommend to use all rows to compute accurate column statistics. You can use sampling when the dataset is potentially large and approximate results are acceptable.

- **All rows** – Generate column statistics on entire data.
- **Sample rows** – Generate approximate statistics using sample rows.

---

**IAM role**

To generate statistics, the IAM role assumed by the job should have necessary permissions. Learn more

Choose an existing IAM role

Choose an existing IAM role

12495-pentestRole

Create new IAM role

---

**Security configuration - optional**

Enable at-rest encryption with a security configuration.

---

**Note**

We recommend to include all rows in the table to compute accurate statistics. Use sample rows to generate column statistics only when approximate values are acceptable.

---

6. (Optional) Next, choose a security configuration to enable at-rest encryption for logs.

7. Choose **Generate statistics** to run the process.
AWS CLI

In the following example, replace values for DatabaseName, TableName, and ColumnNameList with actual database, table, and column names. Replace account ID with a valid AWS account, and role name with the name of the IAM role that you're using to generate statistics.

```bash
aws glue start-column-statistics-task-run --input-cli-json file://input.json
{
    "DatabaseName": "<test-db>",
    "TableName": "<test-table>",
    "ColumnNameList": ["<column1>",
                        "<column2>"],
    "Role": "arn:aws:iam::<123456789012>:role/<Stats-Role>",
    "SampleSize": 10.0
}
```

You can generate column statistics also by calling the `StartColumnStatisticsTaskRun` operation.

**Viewing column statistics**

After generating the statistics successfully, Data Catalog stores this information for the cost-based optimizers in Amazon Athena and Amazon Redshift to make optimal choices when running queries. The statistics varies based on the type of the column.

**AWS Management Console**

**To view column statistics for a table**

- After running column statistics task, the Column statistics tab on the Table details page shows the statistics for the table.
The following statistics are available:

- **Column name**: Column name used to generate statistics
- **Last updated**: Data and time when the statistics were generated
- **Average length**: Average length of values in the column
- **Distinct values**: Total number of distinct values in the column. We estimate the number of distinct values in a column with 5% relative error.
- **Max value**: The largest value in the column.
- **Min value**: The smallest value in the column.
- **Max length**: The length of the highest value in the column.
- **Null values**: The total number of null values in the column.
- **True values**: The total number of true values in the column.
- **False values**: The total number of false values in the column.

AWS CLI

The following example shows how to retrieve column statistics using AWS CLI.

```
aws glue get-column-statistics-for-table 
```
--database-name <test_db> \
--table-name <test_tble> \
--column-names <col1>

You can also view the column statistics using the [GetColumnStatisticsForTable](#) API operation.

**Updating column statistics**

Keeping statistics current improves query performance by enabling the query planner to choose optimal plans. You need to explicitly run the **Generate statistics** task from the AWS Glue console to refresh the column statistics. Data Catalog doesn't automatically refresh the statistics.

If you are not using AWS Glue's statistics generation feature in the console, you can manually update column statistics using the [UpdateColumnStatisticsForTable](#) API operation or AWS CLI. The following example shows how to update column statistics using AWS CLI.

```
aws glue update-column-statistics-for-table --cli-input-json:
{
    "CatalogId": "111122223333",
    "DatabaseName": "test_db",
    "TableName": "test_table",
    "ColumnStatisticsList": [
        {
            "ColumnName": "col1",
            "ColumnType": "Boolean",
            "AnalyzedTime": "1970-01-01T00:00:00",
            "StatisticsData": {
                "Type": "BOOLEAN",
                "BooleanColumnStatisticsData": {
                    "NumberOfTrues": 5,
                    "NumberOfFalses": 5,
                    "NumberOfNulls": 0
                }
            }
        }
    ]
}
```

Working with column statistics
Deleting column statistics

You can delete column statistics using the `DeleteColumnStatisticsForTable` API operation or AWS CLI. The following example shows how to delete column statistics using AWS Command Line Interface (AWS CLI).

```bash
aws glue delete-column-statistics-for-table \
  --database-name test_db \
  --table-name test_table \
  --column-name col1
```

Viewing column statistics task runs

After you run a column statistics task, you can explore the task run details for a table using AWS Glue console, AWS CLI or using `GetColumnStatisticsTaskRuns` operation.

Console

**To view column statistics task run details**

1. On AWS Glue console, choose **Tables** under Data Catalog.
2. Select a table with column statistics.
3. On the **Table details** page, choose **Column statistics**.
4. Choose **View runs**.

You can see information about all runs associated with the specified table.

AWS CLI

In the following example, replace values for `DatabaseName` and `TableName` with the actual database and table name.
aws glue get-column-statistics-task-runs --input-cli-json file://input.json
{
   "DatabaseName": "<test-db>",
   "TableName": "<test-table>"
}

Stopping column statistics task run

You can stop a column statistics task run for a table using AWS Glue console, AWS CLI or using `StopColumnStatisticsTaskRun` operation.

Console

To stop a column statistics task run

1. On AWS Glue console, choose Tables under Data Catalog.
2. Select the table with the column statistics task run is in progress.
3. On the Table details page, choose Column statistics.
4. Choose Stop.

   If you stop the task before the run is complete, column statistics won't be generated for the table.

AWS CLI

In the following example, replace values for DatabaseName and TableName with the actual database and table name.

aws glue stop-column-statistics-task-run --input-cli-json file://input.json
{
   "DatabaseName": "<test-db>",
   "TableName": "<test-table>"
}
Considerations and limitations

The following considerations and limitations apply to generating column statistics.

Considerations

• Using sampling to generate statistics reduces run time, but can generate inaccurate statistics.
• Each column statistics run requires processing the entire dataset.
• Data Catalog doesn't store different versions of the statistics.
• You can only run one statistics generation task at a time per table.
• If a table is encrypted using customer AWS KMS key registered with Data Catalog, AWS Glue uses the same key to encrypt statistics.

Column statistics task supports generating statistics:

• When the IAM role has full table permissions (IAM or Lake Formation).
• When the IAM role has permissions on the table using Lake Formation hybrid access mode.

Column statistics task doesn’t support generating statistics for:

• Tables with Lake Formation cell-based access control.
• Transactional data lakes - Linux foundation Delta Lake, Apache Iceberg, Apache Hudi.
• Tables in federated databases - Hive metastore, Amazon Redshift datashares
• Nested columns, arrays, and struct data types.
• Table that is shared with you from another account.

Working with Data Catalog settings on the AWS Glue console

The Data Catalog settings page contains options to set properties for the Data Catalog in your account.
Data catalog settings
Choose encryption and permission options for your account's data catalog.

Encryption options

- **Metadata encryption**
  Enable at-rest encryption for metadata stored in the data catalog.

- **Encrypt connection passwords**
  When enabled, the password you provide when you create a connection is encrypted with the given KMS key.

Permissions
Add a policy to define fine-grained access control of the data catalog.
To change the fine-grained access control of the Data Catalog

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.

2. Choose an encryption option.

   - **Metadata encryption** – Select this check box to encrypt the metadata in your Data Catalog. Metadata is encrypted at rest using the AWS Key Management Service (AWS KMS) key that you specify. For more information, see Encrypting your Data Catalog.

   - **Encrypt connection passwords** – Select this check box to encrypt passwords in the AWS Glue connection object when the connection is created or updated. Passwords are encrypted using the AWS KMS key that you specify. When passwords are returned, they are encrypted. This option is a global setting for all AWS Glue connections in the Data Catalog. If you clear this check box, previously encrypted passwords remain encrypted using the key that was used when they were created or updated. For more information about AWS Glue connections, see Connecting to data.

     When you enable this option, choose an AWS KMS key, or choose Enter a key ARN and provide the Amazon Resource Name (ARN) for the key. Enter the ARN in the form arn:aws:kms:region:account-id:key/key-id. You can also provide the ARN as a key alias, such as arn:aws:kms:region:account-id:alias/alias-name.

     ! Important

     If this option is selected, any user or role that creates or updates a connection must have kms:Encrypt permission on the specified KMS key.

     For more information, see Encrypting connection passwords.

3. Choose Settings, and then in the Permissions editor, add the policy statement to change fine-grained access control of the Data Catalog for your account. Only one policy at a time can be attached to a Data Catalog. You can paste a JSON resource policy into this control. For more information, see Resource-based policies within AWS Glue.

4. Choose Save to update your Data Catalog with any changes you made.

You can also use AWS Glue API operations to put, get, and delete resource policies. For more information, see Security APIs in AWS Glue.
Creating tables, updating the schema, and adding new partitions in the Data Catalog from AWS Glue ETL jobs

Your extract, transform, and load (ETL) job might create new table partitions in the target data store. Your dataset schema can evolve and diverge from the AWS Glue Data Catalog schema over time. AWS Glue ETL jobs now provide several features that you can use within your ETL script to update your schema and partitions in the Data Catalog. These features allow you to see the results of your ETL work in the Data Catalog, without having to rerun the crawler.

New partitions

If you want to view the new partitions in the AWS Glue Data Catalog, you can do one of the following:

- When the job finishes, rerun the crawler, and view the new partitions on the console when the crawler finishes.
- When the job finishes, view the new partitions on the console right away, without having to rerun the crawler. You can enable this feature by adding a few lines of code to your ETL script, as shown in the following examples. The code uses the `enableUpdateCatalog` argument to indicate that the Data Catalog is to be updated during the job run as the new partitions are created.

Method 1

Pass `enableUpdateCatalog` and `partitionKeys` in an options argument.

Python

```python
additionalOptions = {"enableUpdateCatalog": True}
additionalOptions["partitionKeys"] = ["region", "year", "month", "day"]

sink = glueContext.write_dynamic_frame_from_catalog(frame=last_transform,
database=<target_db_name>,
table_name=<target_table_name>, transformation_ctx="write_sink",
additional_options=additionalOptions)
```
Scala

```scala
val options = JsonOptions(Map(
    "path" -> <S3_output_path>,
    "partitionKeys" -> Seq("region", "year", "month", "day"),
    "enableUpdateCatalog" -> true))
val sink = glueContext.getCatalogSink(
    database = <target_db_name>,
    tableName = <target_table_name>,
    additionalOptions = options)
sink.writeDynamicFrame(df)
```

Method 2

Pass `enableUpdateCatalog` and `partitionKeys` in `getSink()`, and call `setCatalogInfo()` on the `DataSink` object.

Python

```python
sink = glueContext.getSink(
    connection_type="s3",
    path="<S3_output_path>",
    enableUpdateCatalog=True,
    partitionKeys=["region", "year", "month", "day"])
sink.setFormat("json")
sink.setCatalogInfo(catalogDatabase=<target_db_name>,
    catalogTableName=<target_table_name>)
sink.writeFrame(last_transform)
```

Scala

```scala
val options = JsonOptions(
    Map("path" -> <S3_output_path>,
        "partitionKeys" -> Seq("region", "year", "month", "day"),
        "enableUpdateCatalog" -> true))
val sink = glueContext.getSink("s3", options).withFormat("json")
sink.setCatalogInfo(<target_db_name>, <target_table_name>)
sink.writeDynamicFrame(df)
```

Now, you can create new catalog tables, update existing tables with modified schema, and add new table partitions in the Data Catalog using an AWS Glue ETL job itself, without the need to re-run crawlers.
Updating table schema

If you want to overwrite the Data Catalog table's schema you can do one of the following:

- When the job finishes, rerun the crawler and make sure your crawler is configured to update the table definition as well. View the new partitions on the console along with any schema updates, when the crawler finishes. For more information, see Configuring a Crawler Using the API.

- When the job finishes, view the modified schema on the console right away, without having to rerun the crawler. You can enable this feature by adding a few lines of code to your ETL script, as shown in the following examples. The code uses enableUpdateCatalog set to true, and also updateBehavior set to UPDATE_IN_DATABASE, which indicates to overwrite the schema and add new partitions in the Data Catalog during the job run.

Python

```python
additionalOptions = {
    "enableUpdateCatalog": True,
    "updateBehavior": "UPDATE_IN_DATABASE"
}
additionalOptions["partitionKeys"] = ["partition_key0", "partition_key1"]

sink = glueContext.write_dynamic_frame_from_catalog(frame=last_transform, 
database=<dst_db_name>,
    table_name=<dst_tbl_name>, transformation_ctx="write_sink",
    additional_options=additionalOptions)
job.commit()
```

Scala

```scala
val options = JsonOptions(Map(
    "path" -> outputPath,
    "partitionKeys" -> Seq("partition_0", "partition_1"),
    "enableUpdateCatalog" -> true))
val sink = glueContext.getCatalogSink(database = nameSpace, tableName = tableName, 
    additionalOptions = options)
sink.writeDynamicFrame(df)
```

You can also set the updateBehavior value to LOG if you want to prevent your table schema from being overwritten, but still want to add the new partitions. The default value of updateBehavior
is UPDATE_IN_DATABASE, so if you don’t explicitly define it, then the table schema will be overwritten.

If enableUpdateCatalog is not set to true, regardless of whichever option selected for updateBehavior, the ETL job will not update the table in the Data Catalog.

Creating new tables

You can also use the same options to create a new table in the Data Catalog. You can specify the database and new table name using setCatalogInfo.

Python

```python
sink = glueContext.getSink(connection_type="s3", path="s3://path/to/data",
   enableUpdateCatalog=True, updateBehavior="UPDATE_IN_DATABASE",
   partitionKeys=["partition_key0", "partition_key1"]
sink.setFormat("<format>")
sink.setCatalogInfo(catalogDatabase=<dst_db_name>, catalogTableName=<dst_tbl_name>)
sink.writeFrame(last_transform)
```

Scala

```scala
val options = JsonOptions(Map(  "path" -> outputPath,  "partitionKeys" -> Seq("<partition_1>", "<partition_2>"),  "enableUpdateCatalog" -> true,  "updateBehavior" -> "UPDATE_IN_DATABASE"))
val sink = glueContext.getSink(connectionType = "s3", connectionOptions = options).withFormat("<format>")
sink.setCatalogInfo(catalogDatabase = "<dst_db_name>", catalogTableName = "<dst_tbl_name>"
sink.writeDynamicFrame(df)
```

Restrictions

Take note of the following restrictions:

• Only Amazon Simple Storage Service (Amazon S3) targets are supported.
• The enableUpdateCatalog feature is not supported for governed tables.
Only the following formats are supported: json, csv, avro, and parquet.

To create or update tables with the parquet classification, you must utilize the AWS Glue optimized parquet writer for DynamicFrames. This can be achieved with one of the following:

If you're updating an existing table in the catalog with parquet classification, the table must have the "useGlueParquetWriter" table property set to true before you update it. You can set this property via the AWS Glue APIs/SDK, via the console or via an Athena DDL statement.

Once the catalog table property is set, you can use the following snippet of code to update the catalog table with the new data:

```python
glueContext.write_dynamic_frame.from_catalog(
    frame=frameToWrite,
    database="dbName",
    table_name="tableName",
    additional_options={
        "enableUpdateCatalog": True,
    }
)```
If the table doesn't already exist within catalog, you can utilize the `getSink()` method in your script with `connection_type="s3"` to add the table and its partitions to the catalog, along with writing the data to Amazon S3. Provide the appropriate `partitionKeys` and `compression` for your workflow.

```python
s3sink = glueContext.getSink(
    path="s3://bucket/folder/",
    connection_type="s3",
    updateBehavior="UPDATE_IN_DATABASE",
    partitionKeys=[],
    compression="snappy",
    enableUpdateCatalog=True
)

s3sink.setCatalogInfo(
    catalogDatabase="dbName",
    catalogTableName="tableName"
)

s3sink.setFormat("parquet", useGlueParquetWriter=True)

s3sink.writeFrame(frameToWrite)
```

- The `glueparquet` format value is a legacy method of enabling the AWS Glue parquet writer.
- When the `updateBehavior` is set to `LOG`, new partitions will be added only if the `DynamicFrame` schema is equivalent to or contains a subset of the columns defined in the Data Catalog table's schema.
- Schema updates are not supported for non-partitioned tables (not using the "partitionKeys" option).
- Your `partitionKeys` must be equivalent, and in the same order, between your parameter passed in your ETL script and the `partitionKeys` in your Data Catalog table schema.
- This feature currently does not yet support updating/creating tables in which the updating schemas are nested (for example, arrays inside of structs).

For more information, see the section called “AWS Glue for Spark”.
Working with MongoDB connections in ETL jobs

You can create a connection for MongoDB and then use that connection in your AWS Glue job. For more information, see the section called “MongoDB connections” in the AWS Glue programming guide. The connection url, username and password are stored in the MongoDB connection. Other options can be specified in your ETL job script using the additionalOptions parameter of glueContext.getCatalogSource. The other options can include:

- database: (Required) The MongoDB database to read from.
- collection: (Required) The MongoDB collection to read from.

By placing the database and collection information inside the ETL job script, you can use the same connection for in multiple jobs.

1. Create an AWS Glue Data Catalog connection for the MongoDB data source. See "connectionType": "mongodb" for a description of the connection parameters. You can create the connection using the console, APIs or CLI.

2. Create a database in the AWS Glue Data Catalog to store the table definitions for your MongoDB data. See AWS Glue databases for more information.

3. Create a crawler that crawls the data in the MongoDB using the information in the connection to connect to the MongoDB. The crawler creates the tables in the AWS Glue Data Catalog that describe the tables in the MongoDB database that you use in your job. See Defining crawlers in AWS Glue for more information.

4. Create a job with a custom script. You can create the job using the console, APIs or CLI. For more information, see Adding Jobs in AWS Glue.

5. Choose the data targets for your job. The tables that represent the data target can be defined in your Data Catalog, or your job can create the target tables when it runs. You choose a target location when you author the job. If the target requires a connection, the connection is also referenced in your job. If your job requires multiple data targets, you can add them later by editing the script.

6. Customize the job-processing environment by providing arguments for your job and generated script.

Here is an example of creating a DynamicFrame from the MongoDB database based on the table structure defined in the Data Catalog. The code uses additionalOptions to provide the additional data source information:
Scala

```scala
val resultFrame: DynamicFrame = glueContext.getCatalogSource(
    database = catalogDB,
    tableName = catalogTable,
    additionalOptions = JsonOptions(Map("database" -> DATABASE_NAME,
                                         "collection" -> COLLECTION_NAME))
).getDynamicFrame()
```

Python

```python
glue_context.create_dynamic_frame_from_catalog(
    database = catalogDB,
    table_name = catalogTable,
    additional_options = {"database":"database_name",
                          "collection":"collection_name"})
```

7. Run the job, either on-demand or through a trigger.

**Defining crawlers in AWS Glue**

You can use a crawler to populate the AWS Glue Data Catalog with tables. This is the primary method used by most AWS Glue users. A crawler can crawl multiple data stores in a single run. Upon completion, the crawler creates or updates one or more tables in your Data Catalog. Extract, transform, and load (ETL) jobs that you define in AWS Glue use these Data Catalog tables as sources and targets. The ETL job reads from and writes to the data stores that are specified in the source and target Data Catalog tables.

For more information about using the AWS Glue console to add a crawler, see [Working with crawlers on the AWS Glue console](#).

**Topics**

- [Which data stores can I crawl?](#)
- [How crawlers work](#)
- [Crawler prerequisites](#)
- [Crawler properties](#)
- [Setting crawler configuration options](#)
## Which data stores can I crawl?

Crawlers can crawl the following file-based and table-based data stores.

<table>
<thead>
<tr>
<th>Access type that crawler uses</th>
<th>Data stores</th>
</tr>
</thead>
</table>
| Native client                 | - Amazon Simple Storage Service (Amazon S3)  
|                               | - Amazon DynamoDB  
|                               | - Delta Lake 2.0.x  
|                               | - Apache Iceberg 1.3  
|                               | - Apache Hudi 0.14  
| JDBC                          | Amazon Redshift  
|                               | Snowflake  
|                               | Within Amazon Relational Database Service (Amazon RDS) or external to Amazon RDS:  
|                               | - Amazon Aurora  
|                               | - MariaDB  
|                               | - Microsoft SQL Server  
|                               | - MySQL  
|                               | - Oracle  
|                               | - PostgreSQL  
| MongoDB client                | - MongoDB  
|                               | - MongoDB Atlas  
|                               | - Amazon DocumentDB (with MongoDB compatibility)  

Which data stores can I crawl?
For JDBC, MongoDB, MongoDB Atlas, and Amazon DocumentDB (with MongoDB compatibility) data stores, you must specify an AWS Glue connection that the crawler can use to connect to the data store. For Amazon S3, you can optionally specify a connection of type Network. A connection is a Data Catalog object that stores connection information, such as credentials, URL, Amazon Virtual Private Cloud information, and more. For more information, see Connecting to data.

The following are notes about the various data stores.

**Amazon S3**

You can choose to crawl a path in your account or in another account. If all the Amazon S3 files in a folder have the same schema, the crawler creates one table. Also, if the Amazon S3 object is partitioned, only one metadata table is created and partition information is added to the Data Catalog for that table.

**Amazon S3 and Amazon DynamoDB**

Crawlers use an AWS Identity and Access Management (IAM) role for permission to access your data stores. The role you pass to the crawler must have permission to access Amazon S3 paths and Amazon DynamoDB tables that are crawled.

**Amazon DynamoDB**

When defining a crawler using the AWS Glue console, you specify one DynamoDB table. If you're using the AWS Glue API, you can specify a list of tables. You can choose to crawl only a small sample of the data to reduce crawler run times.

**Delta Lake**

For each Delta Lake data store, you specify how to create the Delta tables:

- **Create Native tables**: Allow integration with query engines that support querying of the Delta transaction log directly. For more information, see Querying Delta Lake tables.

- **Create Symlink tables**: Create a _symlink_manifest folder with manifest files partitioned by the partition keys, based on the specified configuration parameters.

```
Which data stores can I crawl?
```
Iceberg

For each Iceberg data store, you specify an Amazon S3 path that contains the metadata for your Iceberg tables. If crawler discovers Iceberg table metadata, it registers it in the Data Catalog. You can set a schedule for the crawler to keep the tables updated.

You can define these parameters for the data store:

- **Exclusions**: Allows you to skip certain folders.
- **Maximum Traversal Depth**: Sets the depth limit the crawler can crawl in your Amazon S3 bucket. The default maximum traversal depth is 10 and the maximum depth you can set is 20.

Hudi

For each Hudi data store, you specify an Amazon S3 path that contains the metadata for your Hudi tables. If crawler discovers Hudi table metadata, it registers it in the Data Catalog. You can set a schedule for the crawler to keep the tables updated.

You can define these parameters for the data store:

- **Exclusions**: Allows you to skip certain folders.
- **Maximum Traversal Depth**: Sets the depth limit the crawler can crawl in your Amazon S3 bucket. The default maximum traversal depth is 10 and the maximum depth you can set is 20.

**Note**

Timestamp columns with `millis` as logical types will be interpreted as `bigint`, due to an incompatibility with Hudi 0.13.1 and timestamp types. A resolution may be provided in the upcoming Hudi release.

Hudi tables are categorized as follows, with specific implications for each:

- **Copy on Write (CoW)**: Data is stored in a columnar format (Parquet), and each update creates a new version of files during a write.
- **Merge on Read (MoR)**: Data is stored using a combination of columnar (Parquet) and row-based (Avro) formats. Updates are logged to row-based delta files and are compacted as needed to create new versions of the columnar files.

With CoW datasets, each time there is an update to a record, the file that contains the record is rewritten with the updated values. With a MoR dataset, each time there is an update, Hudi writes only the row for the changed record. MoR is better suited for write- or change-heavy
workloads with fewer reads. CoW is better suited for read-heavy workloads on data that change less frequently.

Hudi provides three query types for accessing the data:

- **Snapshot queries**: Queries that see the latest snapshot of the table as of a given commit or compaction action. For MoR tables, snapshot queries expose the most recent state of the table by merging the base and delta files of the latest file slice at the time of the query.
- **Incremental queries**: Queries only see new data written to the table, since a given commit/compaction. This effectively provides change streams to enable incremental data pipelines.
- **Read optimized queries**: For MoR tables, queries see the latest data compacted. For CoW tables, queries see the latest data committed.

For Copy-On-Write tables, the crawlers creates a single table in the Data Catalog with the ReadOptimized serde `org.apache.hudi.hadoop.HoodieParquetInputFormat`.

For Merge-On-Read tables, the crawler creates two tables in the Data Catalog for the same table location:

- A table with suffix `_ro` which uses the ReadOptimized serde `org.apache.hudi.hadoop.HoodieParquetInputFormat`.

**MongoDB and Amazon DocumentDB (with MongoDB compatibility)**

MongoDB versions 3.2 and later are supported. You can choose to crawl only a small sample of the data to reduce crawler run times.

**Relational database**

Authentication is with a database user name and password. Depending on the type of database engine, you can choose which objects are crawled, such as databases, schemas, and tables.

**Snowflake**

The Snowflake JDBC crawler supports crawling the Table, External Table, View, and Materialized View. The Materialized View Definition will not be populated.

For Snowflake external tables, the crawler only will crawl if it points to an Amazon S3 location. In addition to the the table schema, the crawler will also crawl the Amazon S3 location, file format and output as table parameters in the Data Catalog table. Note that the partition information of the partitioned external table is not populated.
ETL is currently not supported for Data Catalog tables created using the Snowflake crawler.

How crawlers work

When a crawler runs, it takes the following actions to interrogate a data store:

- **Classifies data to determine the format, schema, and associated properties of the raw data** – You can configure the results of classification by creating a custom classifier.
- **Groups data into tables or partitions** – Data is grouped based on crawler heuristics.
- **Writes metadata to the Data Catalog** – You can configure how the crawler adds, updates, and deletes tables and partitions.

When you define a crawler, you choose one or more classifiers that evaluate the format of your data to infer a schema. When the crawler runs, the first classifier in your list to successfully recognize your data store is used to create a schema for your table. You can use built-in classifiers or define your own. You define your custom classifiers in a separate operation, before you define the crawlers. AWS Glue provides built-in classifiers to infer schemas from common files with formats that include JSON, CSV, and Apache Avro. For the current list of built-in classifiers in AWS Glue, see [Built-in classifiers in AWS Glue](#).

The metadata tables that a crawler creates are contained in a database when you define a crawler. If your crawler does not specify a database, your tables are placed in the default database. In addition, each table has a classification column that is filled in by the classifier that first successfully recognized the data store.

If the file that is crawled is compressed, the crawler must download it to process it. When a crawler runs, it interrogates files to determine their format and compression type and writes these properties into the Data Catalog. Some file formats (for example, Apache Parquet) enable you to compress parts of the file as it is written. For these files, the compressed data is an internal component of the file, and AWS Glue does not populate the `compressionType` property when it writes tables into the Data Catalog. In contrast, if an **entire file** is compressed by a compression algorithm (for example, gzip), then the `compressionType` property is populated when tables are written into the Data Catalog.

The crawler generates the names for the tables that it creates. The names of the tables that are stored in the AWS Glue Data Catalog follow these rules:

- Only alphanumeric characters and underscore (_) are allowed.
• Any custom prefix cannot be longer than 64 characters.
• The maximum length of the name cannot be longer than 128 characters. The crawler truncates generated names to fit within the limit.
• If duplicate table names are encountered, the crawler adds a hash string suffix to the name.

If your crawler runs more than once, perhaps on a schedule, it looks for new or changed files or tables in your data store. The output of the crawler includes new tables and partitions found since a previous run.

Topics
• How does a crawler determine when to create partitions?
• Incremental crawls for adding new partitions in AWS Glue

How does a crawler determine when to create partitions?

When an AWS Glue crawler scans Amazon S3 and detects multiple folders in a bucket, it determines the root of a table in the folder structure and which folders are partitions of a table. The name of the table is based on the Amazon S3 prefix or folder name. You provide an include path that points to the folder level to crawl. When the majority of schemas at a folder level are similar, the crawler creates partitions of a table instead of separate tables. To influence the crawler to create separate tables, add each table's root folder as a separate data store when you define the crawler.

For example, consider the following Amazon S3 folder structure.

```
sales
    year=2010
        month=Jan
            day=1
            day=2
        month=Feb
            day=1
            day=2
```
The paths to the four lowest level folders are the following:

S3://sales/year=2019/month=Jan/day=1
S3://sales/year=2019/month=Jan/day=2
S3://sales/year=2019/month=Feb/day=1
S3://sales/year=2019/month=Feb/day=2

Assume that the crawler target is set at Sales, and that all files in the day=n folders have the same format (for example, JSON, not encrypted), and have the same or very similar schemas. The crawler will create a single table with four partitions, with partition keys year, month, and day.

In the next example, consider the following Amazon S3 structure:

s3://bucket01/folder1/table1/partition1/file.txt
s3://bucket01/folder1/table1/partition2/file.txt
s3://bucket01/folder1/table1/partition3/file.txt
s3://bucket01/folder1/table2/partition4/file.txt
s3://bucket01/folder1/table2/partition5/file.txt

If the schemas for files under table1 and table2 are similar, and a single data store is defined in the crawler with **Include path** s3://bucket01/folder1/, the crawler creates a single table with two partition key columns. The first partition key column contains table1 and table2, and the second partition key column contains partition1 through partition3 for the table1 partition and partition4 and partition5 for the table2 partition. To create two separate tables, define the crawler with two data stores. In this example, define the first **Include path** as s3://bucket01/folder1/table1/ and the second as s3://bucket01/folder1/table2.

**Note**

In Amazon Athena, each table corresponds to an Amazon S3 prefix with all the objects in it. If objects have different schemas, Athena does not recognize different objects within the same prefix as separate tables. This can happen if a crawler creates multiple tables from the same Amazon S3 prefix. This might lead to queries in Athena that return zero results. For Athena to properly recognize and query tables, create the crawler with a separate **Include path** for each different table schema in the Amazon S3 folder structure. For more information, see [Best Practices When Using Athena with AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/best-practices-athena.html) and this AWS Knowledge Center article.
Incremental crawls for adding new partitions in AWS Glue

The crawler provides an option for adding new partitions resulting in faster crawls for incremental datasets with a stable table schema. The typical use case is for scheduled crawlers, where during each crawl, new partitions are added. When this option is turned on, it will first run a complete crawl on the target dataset to allow the crawler to record the initial schema and partition structure. During a recrawl, new partitions will be added to existing tables only when the schemas are compatible. No schema changes are made or no new tables will be added to the Data Catalog after the first crawl run.

You can use this option when setting up an Amazon S3 data source. You can set the RecrawlPolicy with RecrawlBehavior as "Crawl_New_Folders" in the CreateCrawler API or Subsequent crawler runs as Crawl new sub-folders only in the console.

Continuing with the example in the section called “How does a crawler determine when to create partitions?”, the following diagram shows that files for the month of March have been added.

![Diagram showing file addition]

If you set the RecrawlBehavior as the "Crawl_New_Folders" option, only the new folder, month=Mar is crawled.

Notes and restrictions

When this option is turned on, you can't change the Amazon S3 target data stores when editing the crawler. This option affects certain crawler configuration settings. When turned on, it forces the update behavior and delete behavior of the crawler to LOG. This means that:

- If it discovers objects where schemas are not compatible, the crawler will not add the objects in the Data Catalog, and adds this detail as a log in CloudWatch Logs.
• It will not update deleted objects in the Data Catalog.

For more information, see the section called “Setting crawler configuration options”.

**Crawler prerequisites**

The crawler assumes the permissions of the AWS Identity and Access Management (IAM) role that you specify when you define it. This IAM role must have permissions to extract data from your data store and write to the Data Catalog. The AWS Glue console lists only IAM roles that have attached a trust policy for the AWS Glue principal service. From the console, you can also create an IAM role with an IAM policy to access Amazon S3 data stores accessed by the crawler. For more information about providing roles for AWS Glue, see Identity-based policies for AWS Glue.

⚠️ **Note**

When crawling a Delta Lake data store, you must have Read/Write permissions to the Amazon S3 location.

For your crawler, you can create a role and attach the following policies:

• The AWSGlueServiceRole AWS managed policy, which grants the required permissions on the Data Catalog
• An inline policy that grants permissions on the data source.

A quicker approach is to let the AWS Glue console crawler wizard create a role for you. The role that it creates is specifically for the crawler, and includes the AWSGlueServiceRole AWS managed policy plus the required inline policy for the specified data source.

If you specify an existing role for a crawler, ensure that it includes the AWSGlueServiceRole policy or equivalent (or a scoped down version of this policy), plus the required inline policies. For example, for an Amazon S3 data store, the inline policy would at a minimum be the following:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
```

Crawler prerequisites
For an Amazon DynamoDB data store, the policy would at a minimum be the following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb:DescribeTable",
                "dynamodb:Scan"
            ],
            "Resource": [
                "arn:aws:dynamodb:region:account-id:table/table-name*"
            ]
        }
    ]
}
```

In addition, if the crawler reads AWS Key Management Service (AWS KMS) encrypted Amazon S3 data, then the IAM role must have decrypt permission on the AWS KMS key. For more information, see [Step 2: Create an IAM role for AWS Glue](#).

## Crawler properties

When defining a crawler using the AWS Glue console or the AWS Glue API, you specify the following information:
Step 1: Set crawler properties

Name

Name may contain letters (A-Z), numbers (0-9), hyphens (-), or underscores (_), and can be up to 255 characters long.

Description

Descriptions can be up to 2048 characters long.

Tags

Use tags to organize and identify your resources. For more information, see the following:

- AWS tags in AWS Glue

Step 2: Choose data sources and classifiers

Data source configuration

Select the appropriate option for Is your data already mapped to AWS Glue tables?

The crawler can access data stores directly as the source of the crawl, or it can use existing tables in the Data Catalog as the source. If the crawler uses existing catalog tables, it crawls the data stores that are specified by those catalog tables. For more information, see Crawler source type.

- Not yet: Select one or more data sources to be crawled. A crawler can crawl multiple data stores of different types (Amazon S3, JDBC, and so on).

  You can configure only one data store at a time. After you have provided the connection information and include paths and exclude patterns, you then have the option of adding another data store.

  For more information, see Crawler source type.

- Yes: Select existing tables from your AWS Glue Data Catalog. The catalog tables specify the data stores to crawl. The crawler can crawl only catalog tables in a single run; it can't mix in other source types.

Data sources

Select or add the list of data sources to be scanned by the crawler.
Include path

For an Amazon S3 data store

Choose whether to specify a path in this account or in a different account, and then browse to choose an Amazon S3 path.

For a Delta Lake data store

Specify one or more Amazon S3 paths to Delta tables as s3://bucket/prefix/object.

For an Iceberg or Hudi data store

Specify one or more Amazon S3 paths that contain folders with Iceberg or Hudi table metadata as s3://bucket/prefix.

For a Hudi data store, the Hudi folder may be located in a child folder of the root folder. The crawler will scan all folders underneath a path for a Hudi folder.

For a JDBC data store

Enter <database>/<schema>/<table> or <database>/<table>, depending on the database product. Oracle Database and MySQL don't support schema in the path. You can substitute the percent (%) character for <schema> or <table>. For example, for an Oracle database with a system identifier (SID) of orcl, enter orcl/% to import all tables to which the user named in the connection has access.

⚠️ Important

This field is case-sensitive.

For a MongoDB, MongoDB Atlas, or Amazon DocumentDB data store

Enter database/collection.

For more information, see Include and exclude patterns.

Maximum transversal depth (for Iceberg or Hudi data stores only)

Defines the maximum depth of the Amazon S3 path that the crawler can traverse to discover the Iceberg or Hudi metadata folder in your Amazon S3 path. The purpose of this parameter is to limit the crawler run time. The default value is 10 and the maximum is 20.
Exclude patterns

These enable you to exclude certain files or tables from the crawl. For more information, see Include and exclude patterns.

Additional crawler source parameters

Each source type requires a different set of additional parameters. The following is an incomplete list:

Connection

Select or add an AWS Glue connection. For information about connections, see Connecting to data.

Additional metadata - optional (for JDBC data stores)

Select additional metadata properties for the crawler to crawl.

- Comments: Crawl associated table level and column level comments.
- Raw types: Persist the raw datatypes of the table columns in additional metadata. As a default behavior, the crawler translates the raw datatypes to Hive-compatible types.

JDBC Driver Class name - optional (for JDBC data stores)

Type a custom JDBC driver class name for the crawler to connect to the data source:

- Postgres: org.postgresql.Driver
- Oracle: oracle.jdbc.driver.OracleDriver
- SQL Server: com.microsoft.sqlserver.jdbc.SQLServerDriver

JDBC Driver S3 Path - optional (for JDBC data stores)

Choose an existing Amazon S3 path to a .jar file. This is where the .jar file will be stored when using a custom JDBC driver for the crawler to connect to the data source.

Enable data sampling (for Amazon DynamoDB, MongoDB, MongoDB Atlas, and Amazon DocumentDB data stores only)

Select whether to crawl a data sample only. If not selected the entire table is crawled. Scanning all the records can take a long time when the table is not a high throughput table.
Create tables for querying (for Delta Lake data stores only)

Select how you want to create the Delta Lake tables:

- Create Native tables: Allow integration with query engines that support querying of the Delta transaction log directly.
- Create Symlink tables: Create a symlink manifest folder with manifest files partitioned by the partition keys, based on the specified configuration parameters.

Scanning rate - optional (for DynamoDB data stores only)

Specify the percentage of the DynamoDB table Read Capacity Units to use by the crawler. Read capacity units is a term defined by DynamoDB, and is a numeric value that acts as rate limiter for the number of reads that can be performed on that table per second. Enter a value between 0.1 and 1.5. If not specified, defaults to 0.5% for provisioned tables and 1/4 of maximum configured capacity for on-demand tables. Note that only provisioned capacity mode should be used with AWS Glue crawlers.

Note

For DynamoDB data stores, set the provisioned capacity mode for processing reads and writes on your tables. The AWS Glue crawler should not be used with the on-demand capacity mode.

Network connection - optional (for Amazon S3 data stores only)

Optionally include a Network connection to use with this Amazon S3 target. Note that each crawler is limited to one Network connection so any other Amazon S3 targets will also use the same connection (or none, if left blank).

For information about connections, see Connecting to data.

Sample only a subset of files and Sample size (for Amazon S3 data stores only)

Specify the number of files in each leaf folder to be crawled when crawling sample files in a dataset. When this feature is turned on, instead of crawling all the files in this dataset, the crawler randomly selects some files in each leaf folder to crawl.

The sampling crawler is best suited for customers who have previous knowledge about their data formats and know that schemas in their folders do not change. Turning on this feature will significantly reduce crawler runtime.
A valid value is an integer between 1 and 249. If not specified, all the files are crawled.

Subsequent crawler runs

This field is a global field that affects all Amazon S3 data sources.

- Crawl all sub-folders: Crawl all folders again with every subsequent crawl.
- Crawl new sub-folders only: Only Amazon S3 folders that were added since the last crawl will be crawled. If the schemas are compatible, new partitions will be added to existing tables. For more information, see the section called “Incremental crawls for adding new partitions in AWS Glue”.
- Crawl based on events: Rely on Amazon S3 events to control what folders to crawl. For more information, see the section called “Accelerating crawls using Amazon S3 event notifications”.

Custom classifiers - optional

Define custom classifiers before defining crawlers. A classifier checks whether a given file is in a format the crawler can handle. If it is, the classifier creates a schema in the form of a StructType object that matches that data format.

For more information, see Adding classifiers to a crawler in AWS Glue.

Step 3: Configure security settings

IAM role

The crawler assumes this role. It must have permissions similar to the AWS managed policy AWSGlueServiceRole. For Amazon S3 and DynamoDB sources, it must also have permissions to access the data store. If the crawler reads Amazon S3 data encrypted with AWS Key Management Service (AWS KMS), then the role must have decrypt permissions on the AWS KMS key.

For an Amazon S3 data store, additional permissions attached to the role would be similar to the following:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
```
"Action": [
    "s3:GetObject",
    "s3:PutObject"
],
"Resource": [
    "arn:aws:s3:::bucket/object*"
]
]}

For an Amazon DynamoDB data store, additional permissions attached to the role would be similar to the following:

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb:DescribeTable",
                "dynamodb:Scan"
            ],
            "Resource": [
                "arn:aws:dynamodb:region:account-id:table/table-name*"
            ]
        }
    ]
}

For more information, see Step 2: Create an IAM role for AWS Glue and Identity and access management for AWS Glue.

**Lake Formation configuration - optional**

Allow the crawler to use Lake Formation credentials for crawling the data source.

Checking **Use Lake Formation credentials for crawling S3 data source** will allow the crawler to use Lake Formation credentials for crawling the data source. If the data source belongs to another account, you must provide the registered account ID. Otherwise, the crawler will crawl only those data sources associated to the account. Only applicable to Amazon S3 and Data Catalog data sources.
Security configuration - optional

Settings include security configurations. For more information, see the following:

- Encrypting data written by AWS Glue

Step 4: Set output and scheduling

Output configuration

Options include how the crawler should handle detected schema changes, deleted objects in the data store, and more. For more information, see Setting crawler configuration options

Crawler schedule

You can run a crawler on demand or define a time-based schedule for your crawlers and jobs in AWS Glue. The definition of these schedules uses the Unix-like cron syntax. For more information, see Scheduling an AWS Glue crawler.

Step 5: Review and create

Review the crawler settings you configured, and create the crawler.

Crawler source type

A crawler can access data stores directly as the source of the crawl or use existing catalog tables as the source. If the crawler uses existing catalog tables, it crawls the data stores specified by those catalog tables.

A common reason to specify a catalog table as the source is when you create the table manually (because you already know the structure of the data store) and you want a crawler to keep the table updated, including adding new partitions. For a discussion of other reasons, see Updating manually created Data Catalog tables using crawlers.

When you specify existing tables as the crawler source type, the following conditions apply:

- Database name is optional.
- Only catalog tables that specify Amazon S3 or Amazon DynamoDB data stores are permitted.
- No new catalog tables are created when the crawler runs. Existing tables are updated as needed, including adding new partitions.
• Deleted objects found in the data stores are ignored; no catalog tables are deleted. Instead, the crawler writes a log message. (SchemaChangePolicy.DeleteBehavior=LOG)

• The crawler configuration option to create a single schema for each Amazon S3 path is enabled by default and cannot be disabled. (TableGroupingPolicy=CombineCompatibleSchemas)

For more information, see [How to create a single schema for each Amazon S3 include path](#).

• You can't mix catalog tables as a source with any other source types (for example Amazon S3 or Amazon DynamoDB).

### Include and exclude patterns

When evaluating what to include or exclude in a crawl, a crawler starts by evaluating the required include path. For Amazon S3, MongoDB, MongoDB Atlas, Amazon DocumentDB (with MongoDB compatibility), and relational data stores, you must specify an include path.

For Amazon S3 data stores, include path syntax is `bucket-name/folder-name/file-name.ext`. To crawl all objects in a bucket, you specify just the bucket name in the include path. The exclude pattern is relative to the include path.

For MongoDB, MongoDB Atlas, and Amazon DocumentDB (with MongoDB compatibility), the syntax is `database/collection`.

For JDBC data stores, the syntax is either `database-name/schema-name/table-name` or `database-name/table-name`. The syntax depends on whether the database engine supports schemas within a database. For example, for database engines such as MySQL or Oracle, don't specify a schema-name in your include path. You can substitute the percent sign (%) for a schema or table in the include path to represent all schemas or all tables in a database. You cannot substitute the percent sign (%) for database in the include path. The exclude path is relative to the include path. For example, to exclude a table in your JDBC data store, type the table name in the exclude path.

A crawler connects to a JDBC data store using an AWS Glue connection that contains a JDBC URI connection string. The crawler only has access to objects in the database engine using the JDBC user name and password in the AWS Glue connection. The crawler can only create tables that it can access through the JDBC connection. After the crawler accesses the database engine with the JDBC URI, the include path is used to determine which tables in the database engine are created in the Data Catalog. For example, with MySQL, if you specify an include path of `MyDatabase/%`, then all tables within `MyDatabase` are created in the Data Catalog. When accessing Amazon Redshift,
if you specify an include path of MyDatabase/%, then all tables within all schemas for database MyDatabase are created in the Data Catalog. If you specify an include path of MyDatabase/MySchema/%, then all tables in database MyDatabase and schema MySchema are created.

After you specify an include path, you can then exclude objects from the crawl that your include path would otherwise include by specifying one or more Unix-style glob exclude patterns. These patterns are applied to your include path to determine which objects are excluded. These patterns are also stored as a property of tables created by the crawler. AWS Glue PySpark extensions, such as create_dynamic_frame.from_catalog, read the table properties and exclude objects defined by the exclude pattern.

AWS Glue supports the following kinds of glob patterns in the exclude pattern.

<table>
<thead>
<tr>
<th>Exclude pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>*.csv</td>
<td>Matches an Amazon S3 path that represents an object name in the current folder ending in .csv</td>
</tr>
<tr>
<td><em>.</em></td>
<td>Matches all object names that contain a dot</td>
</tr>
<tr>
<td>*.{csv,avro}</td>
<td>Matches object names ending with .csv or .avro</td>
</tr>
<tr>
<td>foo.?</td>
<td>Matches object names starting with foo. that are followed by a single character extension</td>
</tr>
<tr>
<td>myfolder/*</td>
<td>Matches objects in one level of subfolder from myfolder, such as /myfolder/mysource</td>
</tr>
<tr>
<td>myfolder/**</td>
<td>Matches objects in two levels of subfolders from myfolder, such as /myfolder/mysource/data</td>
</tr>
<tr>
<td>myfolder/**</td>
<td>Matches objects in all subfolders of myfolder, such as /myfolder/mysource/mydata and /myfolder/mysource/data</td>
</tr>
</tbody>
</table>
AWS Glue interprets `glob` exclude patterns as follows:

- The slash (/) character is the delimiter to separate Amazon S3 keys into a folder hierarchy.
- The asterisk (*) character matches zero or more characters of a name component without crossing folder boundaries.
- A double asterisk (**) matches zero or more characters crossing folder or schema boundaries.
- The question mark (?) character matches exactly one character of a name component.
- The backslash (\) character is used to escape characters that otherwise can be interpreted as special characters. The expression `\` matches a single backslash, and `{` matches a left brace.
- Brackets `[ ]` create a bracket expression that matches a single character of a name component out of a set of characters. For example, `[abc]` matches `a`, `b`, or `c`. The hyphen (-) can be used to specify a range, so `[a-z]` specifies a range that matches from `a` through `z` (inclusive). These forms can be mixed, so `[abce-g]` matches `a`, `b`, `c`, `e`, `f`, or `g`. If the character after the bracket (`]`) is an exclamation point (!), the bracket expression is negated. For example, `[^a-c]` matches any character except `a`, `b`, or `c`.

Within a bracket expression, the *, ?, and \ characters match themselves. The hyphen (-) character matches itself if it is the first character within the brackets, or if it's the first character after the ! when you are negating.

- Braces (`{ }`) enclose a group of subpatterns, where the group matches if any subpattern in the group matches. A comma (,) character is used to separate the subpatterns. Groups cannot be nested.
- Leading period or dot characters in file names are treated as normal characters in match operations. For example, the * exclude pattern matches the file name `.hidden`.

### Exclude Pattern Table

<table>
<thead>
<tr>
<th>Exclude Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>myfolder**</td>
<td>Matches subfolder <code>myfolder</code> as well as files below <code>myfolder</code>, such as <code>/myfolder</code> and <code>/myfolder/mydata.txt</code></td>
</tr>
<tr>
<td>Market*</td>
<td>Matches tables in a JDBC database with names that begin with <code>Market</code>, such as <code>Market_us</code> and <code>Market_fr</code></td>
</tr>
</tbody>
</table>
Example Amazon S3 exclude patterns

Each exclude pattern is evaluated against the include path. For example, suppose that you have the following Amazon S3 directory structure:

/mybucket/myfolder/
  departments/
    finance.json
    market-us.json
    market-emea.json
    market-ap.json
  employees/
    hr.json
    john.csv
    jane.csv
    juan.txt

Given the include path s3://mybucket/myfolder/, the following are some sample results for exclude patterns:

<table>
<thead>
<tr>
<th>Exclude pattern</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>departments/**</td>
<td>Excludes all files and folders below departments and includes the employees folder and its files</td>
</tr>
<tr>
<td>departments/market*</td>
<td>Excludes market-us.json, market-emea.json, and market-ap.json</td>
</tr>
<tr>
<td>**.csv</td>
<td>Excludes all objects below myfolder that have a name ending with .csv</td>
</tr>
<tr>
<td>employees/*.csv</td>
<td>Excludes all .csv files in the employees folder</td>
</tr>
</tbody>
</table>

Example Excluding a subset of Amazon S3 partitions

Suppose that your data is partitioned by day, so that each day in a year is in a separate Amazon S3 partition. For January 2015, there are 31 partitions. Now, to crawl data for only the first week of January, you must exclude all partitions except days 1 through 7:
Take a look at the parts of this glob pattern. The first part, `2015/01/{[!0],0[8-9]}**`, excludes all days that don't begin with a "0" in addition to day 08 and day 09 from month 01 in year 2015. Notice that "**" is used as the suffix to the day number pattern and crosses folder boundaries to lower-level folders. If "*" is used, lower folder levels are not excluded.

The second part, `2015/0[2-9]**`, excludes days in months 02 to 09, in year 2015.

The third part, `2015/1[0-2]**`, excludes days in months 10, 11, and 12, in year 2015.

**Example JDBC exclude patterns**

Suppose that you are crawling a JDBC database with the following schema structure:

```
MyDatabase/MySchema/
    HR_us
    HR_fr
    Employees_Table
    Finance
    Market_US_Table
    Market_EMEA_Table
    Market_AP_Table
```

Given the include path `MyDatabase/MySchema/%`, the following are some sample results for exclude patterns:

<table>
<thead>
<tr>
<th>Exclude pattern</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR*</td>
<td>Excludes the tables with names that begin with HR</td>
</tr>
<tr>
<td>Market_*</td>
<td>Excludes the tables with names that begin with Market_</td>
</tr>
<tr>
<td>**_Table</td>
<td>Excludes all tables with names that end with _Table</td>
</tr>
</tbody>
</table>
Setting crawler configuration options

When a crawler runs, it might encounter changes to your data store that result in a schema or partition that is different from a previous crawl. You can use the AWS Management Console or the AWS Glue API to configure how your crawler processes certain types of changes.

Topics

• Setting crawler configuration options on the AWS Glue console
• Setting the partition index crawler configuration option
• Setting crawler configuration options using the API
• How to prevent the crawler from changing an existing schema
• How to create a single schema for each Amazon S3 include path
• How to specify the table location and partitioning level
• How to specify the maximum number of tables the crawler is allowed to create
• How to specify configuration options for a Delta Lake data store
• How to configure a crawler to use Lake Formation credentials

Setting crawler configuration options on the AWS Glue console

When you define a crawler using the AWS Glue console, you have several options for configuring the behavior of your crawler. For more information about using the AWS Glue console to add a crawler, see Working with crawlers on the AWS Glue console.

When a crawler runs against a previously crawled data store, it might discover that a schema has changed or that some objects in the data store have been deleted. The crawler logs changes to a schema. Depending on the source type for the crawler, new tables and partitions might be created regardless of the schema change policy.

To specify what the crawler does when it finds changes in the schema, you can choose one of the following actions on the console:

• **Update the table definition in the Data Catalog** – Add new columns, remove missing columns, and modify the definitions of existing columns in the AWS Glue Data Catalog. Remove any metadata that is not set by the crawler. This is the default setting.

• **Add new columns only** – For tables that map to an Amazon S3 data store, add new columns as they are discovered, but don't remove or change the type of existing columns in the DataCatalog.
Catalog. Choose this option when the current columns in the Data Catalog are correct and you don't want the crawler to remove or change the type of the existing columns. If a fundamental Amazon S3 table attribute changes, such as classification, compression type, or CSV delimiter, mark the table as deprecated. Maintain input format and output format as they exist in the Data Catalog. Update SerDe parameters only if the parameter is one that is set by the crawler. For all other data stores, modify existing column definitions.

- **Ignore the change and don't update the table in the Data Catalog** – Only new tables and partitions are created.

  This is the default setting for incremental crawls.

A crawler might also discover new or changed partitions. By default, new partitions are added and existing partitions are updated if they have changed. In addition, you can set a crawler configuration option to **Update all new and existing partitions with metadata from the table** on the AWS Glue console. When this option is set, partitions inherit metadata properties—such as their classification, input format, output format, SerDe information, and schema—from their parent table. Any changes to these properties in a table are propagated to its partitions. When this configuration option is set on an existing crawler, existing partitions are updated to match the properties of their parent table the next time the crawler runs.

To specify what the crawler does when it finds a deleted object in the data store, choose one of the following actions:

- **Delete tables and partitions from the Data Catalog**
- **Ignore the change and don't update the table in the Data Catalog**

  This is the default setting for incremental crawls.

- **Mark the table as deprecated in the Data Catalog** – This is the default setting.

### Setting the partition index crawler configuration option

The Data Catalog supports partition indexes to provide efficient lookup for specific partitions. For more information, see [Working with partition indexes in AWS Glue](#).

Currently, the AWS Glue crawler supports creating partition indexes for Amazon S3 and Delta Lake targets.
To specify the crawler create a separate partition index for every Data Catalog table, choose the following option in the console from the **Set output and scheduling** page's **Advanced options**:

- **Create partition indexes automatically**

To specify this behavior using the crawler API, set the `CreatePartitionIndex` in the `Configuration`. The default value is true.

**Usage notes for partition indexes**

- Tables created by the crawler do not have the variable `partition_filtering.enabled` by default. For more information, see [AWS Glue partition indexing and filtering](https://docs.aws.amazon.com/glue/latest/dg/partition-indexing-and-filtering.html).
- Creating partition indexes for encrypted partitions is not supported.

**Setting crawler configuration options using the API**

When you define a crawler using the AWS Glue API, you can choose from several fields to configure your crawler. The `SchemaChangePolicy` in the crawler API determines what the crawler does when it discovers a changed schema or a deleted object. The crawler logs schema changes as it runs.

When a crawler runs, new tables and partitions are always created regardless of the schema change policy. You can choose one of the following actions in the `UpdateBehavior` field in the `SchemaChangePolicy` structure to determine what the crawler does when it finds a changed table schema:

- **UPDATE_IN_DATABASE** – Update the table in the AWS Glue Data Catalog. Add new columns, remove missing columns, and modify the definitions of existing columns. Remove any metadata that is not set by the crawler.
- **LOG** – Ignore the changes, and don't update the table in the Data Catalog.

  This is the default setting for incremental crawls.

You can also override the `SchemaChangePolicy` structure using a JSON object supplied in the crawler API `Configuration` field. This JSON object can contain a key-value pair to set the policy to not update existing columns and only add new columns. For example, provide the following JSON object as a string:
This option corresponds to the **Add new columns only** option on the AWS Glue console. It overrides the SchemaChangePolicy structure for tables that result from crawling Amazon S3 data stores only. Choose this option if you want to maintain the metadata as it exists in the Data Catalog (the source of truth). New columns are added as they are encountered, including nested data types. But existing columns are not removed, and their type is not changed. If an Amazon S3 table attribute changes significantly, mark the table as deprecated, and log a warning that an incompatible attribute needs to be resolved. This option is not applicable for incremental crawler.

When a crawler runs against a previously crawled data store, it might discover new or changed partitions. By default, new partitions are added and existing partitions are updated if they have changed. In addition, you can set a crawler configuration option to `InheritFromTable` (corresponding to the **Update all new and existing partitions with metadata from the table** option on the AWS Glue console). When this option is set, partitions inherit metadata properties from their parent table, such as their classification, input format, output format, SerDe information, and schema. Any property changes to the parent table are propagated to its partitions.

When this configuration option is set on an existing crawler, existing partitions are updated to match the properties of their parent table the next time the crawler runs. This behavior is set crawler API Configuration field. For example, provide the following JSON object as a string:

```
{
  "Version": 1.0,
  "CrawlerOutput": {
    "Partitions": { "AddOrUpdateBehavior": "InheritFromTable" }
  }
}
```

The crawler API Configuration field can set multiple configuration options. For example, to configure the crawler output for both partitions and tables, you can provide a string representation of the following JSON object:
You can choose one of the following actions to determine what the crawler does when it finds a deleted object in the data store. The DeleteBehavior field in the SchemaChangePolicy structure in the crawler API sets the behavior of the crawler when it discovers a deleted object.

- **DELETE_FROM_DATABASE** – Delete tables and partitions from the Data Catalog.
- **LOG** – Ignore the change. Don't update the Data Catalog. Write a log message instead.
- **DEPRECATE_IN_DATABASE** – Mark the table as deprecated in the Data Catalog. This is the default setting.

**How to prevent the crawler from changing an existing schema**

If you don't want a crawler to overwrite updates you made to existing fields in an Amazon S3 table definition, choose the option on the console to **Add new columns only** or set the configuration option **MergeNewColumns**. This applies to tables and partitions, unless `Partitions.AddOrUpdateBehavior` is overridden to `InheritFromTable`.

If you don't want a table schema to change at all when a crawler runs, set the schema change policy to **LOG**. You can also set a configuration option that sets partition schemas to inherit from the table.

If you are configuring the crawler on the console, you can choose the following actions:

- **Ignore the change and don't update the table in the Data Catalog**
- **Update all new and existing partitions with metadata from the table**

When you configure the crawler using the API, set the following parameters:

- Set the **UpdateBehavior** field in SchemaChangePolicy structure to **LOG**.
• Set the Configuration field with a string representation of the following JSON object in the crawler API; for example:

```
{
   "Version": 1.0,
   "CrawlerOutput": {
      "Partitions": { "AddOrUpdateBehavior": "InheritFromTable" }  
   }
}
```

**How to create a single schema for each Amazon S3 include path**

By default, when a crawler defines tables for data stored in Amazon S3, it considers both data compatibility and schema similarity. Data compatibility factors that it considers include whether the data is of the same format (for example, JSON), the same compression type (for example, GZIP), the structure of the Amazon S3 path, and other data attributes. Schema similarity is a measure of how closely the schemas of separate Amazon S3 objects are similar.

You can configure a crawler to CombineCompatibleSchemas into a common table definition when possible. With this option, the crawler still considers data compatibility, but ignores the similarity of the specific schemas when evaluating Amazon S3 objects in the specified include path.

If you are configuring the crawler on the console, to combine schemas, select the crawler option **Create a single schema for each S3 path**.

When you configure the crawler using the API, set the following configuration option:

• Set the Configuration field with a string representation of the following JSON object in the crawler API; for example:

```
{
   "Version": 1.0,
   "Grouping": {
      "TableGroupingPolicy": "CombineCompatibleSchemas" }  
}
```

To help illustrate this option, suppose that you define a crawler with an include path s3://bucket/table1/. When the crawler runs, it finds two JSON files with the following characteristics:
- **File 1** – S3://bucket/table1/year=2017/data1.json
  - **File content** – {“A”: 1, “B”: 2}
  - **Schema** – A:int, B:int

- **File 2** – S3://bucket/table1/year=2018/data2.json
  - **File content** – {“C”: 3, “D”: 4}
  - **Schema** – C: int, D: int

By default, the crawler creates two tables, named `year_2017` and `year_2018` because the schemas are not sufficiently similar. However, if the option **Create a single schema for each S3 path** is selected, and if the data is compatible, the crawler creates one table. The table has the schema A:int, B:int, C:int, D:int and partitionKey year:string.

### How to specify the table location and partitioning level

By default, when a crawler defines tables for data stored in Amazon S3 the crawler attempts to merge schemas together and create top-level tables (year=2019). In some cases, you may expect the crawler to create a table for the folder month=Jan but instead the crawler creates a partition since a sibling folder (month=Mar) was merged into the same table.

The table level crawler option provides you the flexibility to tell the crawler where the tables are located, and how you want partitions created. When you specify a **Table level**, the table is created at that absolute level from the Amazon S3 bucket.

![Diagram](image)

When configuring the crawler on the console, you can specify a value for the **Table level** crawler option. The value must be a positive integer that indicates the table location (the absolute level in
the dataset). The level for the top level folder is 1. For example, for the path mydataset/a/b, if the level is set to 3, the table is created at location mydataset/a/b.

Console

Set output and scheduling

Output configuration

Target database

0-test-catalog

Table name prefix - optional

Type a prefix added to table names

Maximum table threshold - optional

This field sets the maximum number of tables the crawler is allowed to generate. In the event that this number is surpassed, the crawl will fail with an error. If not set, the crawler will automatically generate the number of tables depending on the data schema.

API

When you configure the crawler using the API, set the Configuration field with a string representation of the following JSON object; for example:

configuration = jsonencode(

{
   "Version": 1.0,
   "Grouping": {
      "TableLevelConfiguration": 2
   }
})

CloudFormation

In this example, you set the Table level option available in the console within your CloudFormation template:
How to specify the maximum number of tables the crawler is allowed to create

You can optionally specify the maximum number of tables the crawler is allowed to create by specifying a `TableThreshold` via the AWS Glue console or CLI. If the tables detected by the crawler during its crawl is greater that this input value, the crawl fails and no data is written to the Data Catalog.

This parameter is useful when the tables that would be detected and created by the crawler are much greater more than what you expect. There can be multiple reasons for this, such as:

- When using an AWS Glue job to populate your Amazon S3 locations you can end up with empty files at the same level as a folder. In such cases when you run a crawler on this Amazon S3 location, the crawler creates multiple tables due to files and folders present at the same level.
- If you do not configure "TableGroupingPolicy": "CombineCompatibleSchemas" you may end up with more tables than expected.

You specify the `TableThreshold` as an integer value greater than 0. This value is configured on a per crawler basis. That is, for every crawl this value is considered. For example: a crawler has the `TableThreshold` value set as 5. In each crawl AWS Glue compares the number of tables detected with this table threshold value (5) and if the number of tables detected is less than 5, AWS Glue writes the tables to the Data Catalog and if not, the crawl fails without writing to the Data Catalog.

Console

To set `TableThreshold` using the AWS console:

Set output and scheduling

- Output configuration
  - Target database
    - Choose a database
  - Table name prefix - optional
    - Type prefix added to table name
  - Maximum table threshold - optional
    - Type a number greater than 0
To set TableThreshold using the AWS CLI:

```
{"Version":1.0,
"CrawlerOutput":
{"Tables":{"AddOrUpdateBehavior":"MergeNewColumns",
"TableThreshold":5}}}
```

Error messages are logged to help you identify table paths and clean-up your data. Example log in your account if the crawler fails because the table count was greater than table threshold value provided:

Table Threshold value = 28, Tables detected - 29

In CloudWatch, we log all table locations detected as an INFO message. An error is logged as the reason for the failure.

```
ERROR com.amazonaws.services.glue.customerLogs.CustomerLogService - CustomerLogService received CustomerFacingException with message
The number of tables detected by crawler: 29 is greater than the table threshold value provided: 28. Failing crawler without writing to Data Catalog.
com.amazonaws.services.glue.exceptions.CustomerFacingInternalException: The number of tables detected by crawler: 29 is greater than the table threshold value provided: 28.
Failing crawler without writing to Data Catalog.
```

**How to specify configuration options for a Delta Lake data store**

When you configure a crawler for a Delta Lake data store, you specify these configuration parameters:

**Connection**

 Optionally select or add a Network connection to use with this Amazon S3 target. For information about connections, see [Connecting to data](#).

**Create tables for querying**

 Select how you want to create the Delta Lake tables:
• Create Native tables: Allow integration with query engines that support querying of the Delta transaction log directly.

• Create Symlink tables: Create a symlink manifest folder with manifest files partitioned by the partition keys, based on the specified configuration parameters.

Enable write manifest (configurable only if you've selected to Create Symlink tables for a Delta Lake source)

Select whether to detect table metadata or schema changes in the Delta Lake transaction log; it regenerates the manifest file. You should not choose this option if you configured an automatic manifest update with Delta Lake SET TBLPROPERTIES.

Include delta lake table path(s)

Specify one or more Amazon S3 paths to Delta tables as s3://bucket/prefix/object.
How to configure a crawler to use Lake Formation credentials

You can configure a crawler to use AWS Lake Formation credentials to access an Amazon S3 data store or a Data Catalog table with an underlying Amazon S3 location within the same AWS account or another AWS account. You can configure an existing Data Catalog table as a crawler’s target, if
the crawler and the Data Catalog table reside in the same account. Currently, only a single catalog target with a single catalog table is allowed when using a Data Catalog table as a crawler's target.

### Note
When you are defining a Data Catalog table as a crawler target, make sure that the underlying location of the Data Catalog table is an Amazon S3 location. Crawlers that use Lake Formation credentials only support Data Catalog targets with underlying Amazon S3 locations.

---

**Setup required when the crawler and registered Amazon S3 location or Data Catalog table reside in the same account (in-account crawling)**

To allow the crawler to access a data store or Data Catalog table by using Lake Formation credentials, you need to register the data location with Lake Formation. Also, the crawler's IAM role must have permissions to read the data from the destination where the Amazon S3 bucket is registered.

You can complete the following configuration steps using the AWS Management Console or AWS Command Line Interface (AWS CLI).

**AWS Management Console**

1. Before configuring a crawler to access the crawler source, register the data location of the data store or the Data Catalog with Lake Formation. In the Lake Formation console (https://console.aws.amazon.com/lakeformation/), register an Amazon S3 location as the root location of your data lake in the AWS account where the crawler is defined. For more information, see [Registering an Amazon S3 location](https://console.aws.amazon.com/lakeformation/).

2. Grant **Data location** permissions to the IAM role that's used for the crawler run so that the crawler can read the data from the destination in Lake Formation. For more information, see [Granting data location permissions (same account)](https://console.aws.amazon.com/lakeformation/).

3. Grant the crawler role access permissions (Create) to the database, which is specified as the output database. For more information, see [Granting database permissions using the Lake Formation console and the named resource method](https://console.aws.amazon.com/lakeformation/).

4. In the IAM console (https://console.aws.amazon.com/iam/), create an IAM role for the crawler. Add the `lakeformation:GetDataAccess` policy to the role.
5. In the AWS Glue console (https://console.aws.amazon.com/glue/), while configuring the crawler, select the option **Use Lake Formation credentials for crawling Amazon S3 data source.**

![Note]

The accountId field is optional for in-account crawling.

**AWS CLI**

```bash
aws glue --profile demo create-crawler --debug --cli-input-json '{
    "Name": "prod-test-crawler",
    "Role": "arn:aws:iam::111122223333:role/service-role/AWSGlueServiceRole-prod-test-run-role",
    "DatabaseName": "prod-run-db",
    "Description": "",
    "Targets": {
        "S3Targets": [
            {
                "Path": "s3://crawl-testbucket"
            }
        ]
    },
    "SchemaChangePolicy": {
        "UpdateBehavior": "LOG",
        "DeleteBehavior": "LOG"
    },
    "RecrawlPolicy": {
        "RecrawlBehavior": "CRAWL_EVERYTHING"
    },
    "LineageConfiguration": {
        "CrawlerLineageSettings": "DISABLE"
    },
    "LakeFormationConfiguration": {
        "UseLakeFormationCredentials": true,
        "AccountId": "111122223333"
    },
    "Configuration": {
        "Version": 1.0,
        "CrawlerOutput": {
            "Partitions": {
                "AddOrUpdateBehavior": "InheritFromTable"
            }
        }
    }
}'
```
Setup required when the crawler and registered Amazon S3 location reside in different accounts (cross-account crawling)

To allow the crawler to access a data store in a different account using Lake Formation credentials, you must first register the Amazon S3 data location with Lake Formation. Then, you grant data location permissions to the crawler's account by taking the following steps.

You can complete the following steps using the AWS Management Console or AWS CLI.

AWS Management Console

1. In the account where the Amazon S3 location is registered (account B):
   a. Register an Amazon S3 path with Lake Formation. For more information, see Registering Amazon S3 location.
   b.Grant Data location permissions to the account (account A) where the crawler will be run. For more information, see Grant data location permissions.
   c. Create an empty database in Lake Formation with the underlying location as the target Amazon S3 location. For more information, see Creating a database.
   d. Grant account A (the account where the crawler will be run) access to the database that you created in the previous step. For more information, see Granting database permissions.

2. In the account where the crawler is created and will be run (account A):
   a. Using the AWS RAM console, accept the database that was shared from the external account (account B). For more information, see Accepting a resource share invitation from AWS Resource Access Manager.
   b. Create an IAM role for the crawler. Add lakeformation:GetDataAccess policy to the role.
c. In the Lake Formation console (https://console.aws.amazon.com/lakeformation/), grant **Data location** permissions on the target Amazon S3 location to the IAM role used for the crawler run so that the crawler can read the data from the destination in Lake Formation. For more information, see [Granting data location permissions](#).

d. Create a resource link on the shared database. For more information, see [Create a resource link](#).

e. Grant the crawler role access permissions (Create) on the shared database and (Describe) the resource link. The resource link is specified in the output for the crawler.

f. In the AWS Glue console (https://console.aws.amazon.com/glue/), while configuring the crawler, select the option **Use Lake Formation credentials for crawling Amazon S3 data source**.

For cross-account crawling, specify the AWS account ID where the target Amazon S3 location is registered with Lake Formation. For in-account crawling, the accountID field is optional.

```bash
aws glue --profile demo create-crawler --debug --cli-input-json '{
  "Name": "prod-test-crawler",
}"
```
"Role": "arn:aws:iam::111122223333:role/service-role/AWSGlueServiceRole-prod-test-run-role",
"DatabaseName": "prod-run-db",
"Description": "",
"Targets": {
  "S3Targets": [
    {
      "Path": "s3://crawl-testbucket"
    }
  ]
},
"SchemaChangePolicy": {
  "UpdateBehavior": "LOG",
  "DeleteBehavior": "LOG"
},
"RecrawlPolicy": {
  "RecrawlBehavior": "CRAWL_EVERYTHING"
},
"LineageConfiguration": {
  "CrawlerLineageSettings": "DISABLE"
},
"LakeFormationConfiguration": {
  "UseLakeFormationCredentials": true,
  "AccountId": "111111111111"
},
"Configuration": {
  "Version": 1.0,
  "CrawlerOutput": {
    "Partitions": { "AddOrUpdateBehavior": "InheritFromTable" },
    "Tables": { "AddOrUpdateBehavior": "MergeNewColumns" }
  },
  "Grouping": { "TableGroupingPolicy": "CombineCompatibleSchemas" }
},
"CrawlerSecurityConfiguration": "",
"Tags": {
  "KeyName": ""
}'}
Scheduling an AWS Glue crawler

You can run an AWS Glue crawler on demand or on a regular schedule. Crawler schedules can be expressed in `cron` format. For more information, see `cron` in Wikipedia.

When you create a crawler based on a schedule, you can specify certain constraints, such as the frequency the crawler runs, which days of the week it runs, and at what time. These constraints are based on cron. When setting up a crawler schedule, you should consider the features and limitations of cron. For example, if you choose to run your crawler on day 31 each month, keep in mind that some months don't have 31 days.

Crawls for each crawler is valid only for up to 12 months

For more information about using cron to schedule jobs and crawlers, see Time-based schedules for jobs and crawlers.

Working with crawlers on the AWS Glue console

A crawler accesses your data store, extracts metadata, and creates table definitions in the AWS Glue Data Catalog. The Crawlers pane in the AWS Glue console lists all the crawlers that you create. The list displays status and metrics from the last run of your crawler.
Note

If you choose to bring in your own JDBC driver versions, AWS Glue crawlers will consume resources in AWS Glue jobs and Amazon S3 buckets to ensure your provided driver are run in your environment. The additional usage of resources will be reflected in your account. Additionally, providing your own JDBC driver does not mean that the crawler is able to leverage all of the driver's features. Drivers are limited to the properties described in Adding an AWS Glue connection.

To add a crawler using the console

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/. Choose Crawlers in the navigation pane.
2. Choose Create crawler, and follow the instructions in the Add crawler wizard. The wizard will guide you through the following steps.

1. Set crawler properties. Enter a name for your crawler and description (optional).
   
   Optionally, you can tag your crawler with a Tag key and optional Tag value. Once created, tag keys are read-only. Use tags on some resources to help you organize and identify them. For more information, see AWS tags in AWS Glue.

2. Choose data sources and classifiers. In Data source configuration, choose 'Not yet' or 'Yes' to answer the question 'Is your data mapped to AWS Glue tables? By default, 'Not yet' is selected.

   If your data is already mapped to AWS Glue tables, choose Add a data source. For more information, see Adding an AWS Glue connection.

   In the Add data source window, choose your data source and choose the appropriate options for your data source.

   (Optional) If you choose JDBC as the data source, you can use your own JDBC drivers when specifying the Connection access where the driver info is stored.

3. Configure security settings. Choose an existing IAM role or create a new IAM role.
Note

In order to add your own JDBC driver, additional permissions need to be added. For more information, see

- Grant permissions for the following job actions: CreateJob, DeleteJob, GetJob, GetJobRun, StartJobRun.
- Grant permissions for Amazon S3 actions: s3:DeleteObjects, s3:GetObject, s3:ListBucket, s3:PutObject.

Note

The s3:ListBucket is not needed if the Amazon S3 bucket policy is disabled.

- Grant service principal access to bucket/folder in the Amazon S3 policy.

Example Amazon S3 policy:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "VisualEditor0",
         "Effect": "Allow",
         "Action": [
            "s3:PutObject",
            "s3:GetObject",
            "s3:ListBucket",
            "s3:DeleteObject"
         ],
         "Resource": [
            "arn:aws:s3:::bucket-name/driver-parent-folder/driver.jar",
            "arn:aws:s3:::bucket-name"
         ]
      }
   ]
}
```
AWS Glue creates the following folders (_crawler and _glue_job_crawler at the same level as the JDBC driver in your Amazon S3 bucket. For example, if the driver path is <s3-path/driver_folder/driver.jar>, then the following folders will be created if they do not already exist:

- <s3-path/driver_folder/_crawler>
- <s3-path/driver_folder/_glue_job_crawler>

Optionally, you can add a security configuration to a crawler to specify at-rest encryption options.

4. Set output and scheduling. You can choose the target database, add a prefix to add to table names, and set a maximum table threshold (optional).

When selecting a crawler schedule, choose the frequency.

5. Review and create. Choose Edit to make changes to any of the steps in the wizard. When done, choose Create crawler.

When you crawl DynamoDB tables, you can choose one table name from the list of DynamoDB tables in your account.

Tip
For more information about configuring crawlers, see the section called “Crawler properties”.

Viewing Crawler Results and Details

After the crawler runs successfully, it creates table definitions in the Data Catalog. Choose Tables in the navigation pane to see the tables that were created by your crawler in the database that you specified.

You can view information related to the crawler itself as follows:

- The Crawlers page on the AWS Glue console displays the following properties for a crawler:
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>When you create a crawler, you must give it a unique name.</td>
</tr>
<tr>
<td>Status</td>
<td>A crawler can be ready, starting, stopping, scheduled, or schedule paused. A running crawler progresses from starting to stopping. You can resume or pause a schedule attached to a crawler.</td>
</tr>
<tr>
<td>Schedule</td>
<td>You can choose to run your crawler on demand or choose a frequency with a schedule. For more information about scheduling a crawler, see <a href="#">Scheduling a crawler</a>.</td>
</tr>
<tr>
<td>Last run</td>
<td>The date and time of the last time the crawler was run.</td>
</tr>
<tr>
<td>Log</td>
<td>Links to any available logs from the last run of the crawler.</td>
</tr>
<tr>
<td>Tables changes from last run</td>
<td>The number of tables in the AWS Glue Data Catalog that were updated by the latest run of the crawler.</td>
</tr>
</tbody>
</table>

- To view the history of a crawler, choose **Crawlers** in the navigation pane to see the crawlers you created. Choose a crawler from the list of available crawlers. You can view the crawler properties and view the crawler history in the **Crawler runs** tab.

  The Crawler runs tab displays information about each time the crawler ran, including **Start time (UTC)**, **End time (UTC)**, **Duration**, **Status**, **DPU hours**, and **Table changes**.

- To see additional information, choose a tab in the crawler details page. Each tab will display information related to the crawler.
  - **Schedule**: Any schedules created for the crawler will be visible here.
  - **Data sources**: All data sources scanned by the crawler will be visible here.
• **Classifiers**: All classifiers assigned to the crawler will be visible here.

• **Tags**: Any tags created and assigned to an AWS resource will be visible here.

## Accelerating crawls using Amazon S3 event notifications

Instead of listing the objects from an Amazon S3 or Data Catalog target, you can configure the crawler to use Amazon S3 events to find any changes. This feature improves the recrawl time by using Amazon S3 events to identify the changes between two crawls by listing all the files from the subfolder which triggered the event instead of listing the full Amazon S3 or Data Catalog target.

The first crawl lists all Amazon S3 objects from the target. After the first successful crawl, you can choose to recrawl manually or on a set schedule. The crawler will list only the objects from those events instead of listing all objects.

The advantages of moving to an Amazon S3 event based crawler are:

• A faster recrawl as the listing of all the objects from the target is not required, instead the listing of specific folders is done where objects are added or deleted.

• A reduction in the overall crawl cost as the listing of specific folders is done where objects are added or deleted.

The Amazon S3 event crawl runs by consuming Amazon S3 events from the SQS queue based on the crawler schedule. There will be no cost if there are no events in the queue. Amazon S3 events can be configured to go directly to the SQS queue or in cases where multiple consumers need the same event, a combination of SNS and SQS. For more information, see the section called “Setting up your Account for Amazon S3 event notifications”.

After creating and configuring the crawler in event mode, the first crawl runs in listing mode by performing full a listing of the Amazon S3 or Data Catalog target. The following log confirms the operation of the crawl by consuming Amazon S3 events after the first successful crawl: "The crawl is running by consuming Amazon S3 events."

After creating the Amazon S3 event crawl and updating the crawler properties which may impact the crawl, the crawl operates in list mode and the following log is added: "Crawl is not running in S3 event mode".
Catalog target

When the target is the Data Catalog the crawler updates the existing tables in the Data Catalog with changes (for example, extra partitions in a table).

Topics

• Setting up your Account for Amazon S3 event notifications

Setting up your Account for Amazon S3 event notifications

This section describes how to set up your account for Amazon S3 event notifications, and provides instructions for doing so using a script, or the AWS Glue console.

Prerequisites

Complete the following setup tasks. Note the values in parenthesis reference the configurable settings from the script.

1. Create an Amazon S3 bucket (s3_bucket_name).
2. Identify a crawler target (folder_name, such as "test1") which is a path in the identified bucket.
3. Prepare a crawler name (crawler_name)
4. Prepare an SNS Topic name (sns_topic_name) which could be the same as the crawler name.
5. Prepare the AWS Region where the crawler is to run and the S3 bucket exists (region).
6. Optionally prepare an email address if email is used to get the Amazon S3 events (subscribing_email).

You can also use the CloudFormation stack to create your resources. Complete the following steps:

1. [Launch](#) your CloudFormation stack in US East (N. Virginia):
2. Under Parameters, enter a name for your Amazon S3 bucket (include your account number).
3. Select I acknowledge that AWS CloudFormation might create IAM resources with custom names.
4. Choose Create stack.

Limitations:
• Only a single target is supported by the crawler, whether for Amazon S3 or Data Catalog targets.
• SQS on private VPC is not supported.
• Amazon S3 sampling is not supported.
• The crawler target should be a folder for an Amazon S3 target, or one or more AWS Glue Data Catalog tables for a Data Catalog target.
• The 'everything' path wildcard is not supported: s3://%
• For a Data Catalog target, all catalog tables should point to same Amazon S3 bucket for Amazon S3 event mode.
• For a Data Catalog target, a catalog table should not point to an Amazon S3 location in the Delta Lake format (containing _symlink folders, or checking the catalog table's InputFormat).

To use the Amazon S3 event based crawler, you should enable event notification on the S3 bucket with events filtered from the prefix which is the same as the S3 target and store in SQS. You can set up SQS and event notification through the console by following the steps in Walkthrough: Configuring a bucket for notifications or using the the section called “Script to generate SQS and configure Amazon S3 events from the target”.

**SQS policy**

Add the following SQS policy which is required to be attached to the role used by the crawler.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "sqs:DeleteMessage",
                "sqs:GetQueueUrl",
                "sqs:ListDeadLetterSourceQueues",
                "sqs:ReceiveMessage",
                "sqs:GetQueueAttributes",
                "sqs:ListQueueTags",
                "sqs:SetQueueAttributes",
                "sqs:PurgeQueue"
            ],
            "Resource": "arn:aws:sqs:{region}:{accountID}:cfn-sqs-queue"
        }
    ]
}
```
Script to generate SQS and configure Amazon S3 events from the target

After ensuring the prerequisites are met, you can run the following Python script to create the SQS. Replace the Configurable settings with the names prepared from the prerequisites.

⚠️ Note
After running the script, login to the SQS console to find the ARN of the SQS created.

Amazon SQS sets a visibility timeout, a period of time during which Amazon SQS prevents other consumers from receiving and processing the message. Set the visibility timeout approximately equal to the crawl run time.

```python
#!/venv/bin/python
import boto3
import botocore

#---------Start : READ ME FIRST ----------------------#
# 1. Purpose of this script is to create the SQS, SNS and enable S3 bucket notification.
#     The following are the operations performed by the scripts:
#     a. Enable S3 bucket notification to trigger 's3:ObjectCreated:' and 's3:ObjectRemoved:' events.
#     b. Create SNS topic for fan out.
#     c. Create SQS queue for saving events which will be consumed by the crawler.
#     SQS Event Queue ARN will be used to create the crawler after running the script.
# 2. This script does not create the crawler.
# 3. SNS topic is created to support FAN out of S3 events. If S3 event is also used by another
#     purpose, SNS topic created by the script can be used.
# 1. Creation of bucket is an optional step.
#     To create a bucket set create_bucket variable to true.
# 2. The purpose of crawler_name is to easily locate the SQS/SNS.
#     crawler_name is used to create SQS and SNS with the same name as crawler.
# 3. 'folder_name' is the target of crawl inside the specified bucket 's3_bucket_name'
# #---------End : READ ME FIRST ------------------------#
```
#--------------------------------#
# Start : Configurable settings #
#--------------------------------#

#Create
region = 'us-west-2'
s3_bucket_name = 's3eventtestuswest2'
folder_name = "test"
crawler_name = "test33S3Event"
sns_topic_name = crawler_name
sqs_queue_name = sns_topic_name
create_bucket = False

#-------------------------------#
# End : Configurable settings   #
#-------------------------------#

# Define aws clients
dev = boto3.session.Session(profile_name='myprofile')
boto3.setup_default_session(profile_name='myprofile')
s3 = boto3.resource('s3', region_name=region)
sns = boto3.client('sns', region_name=region)
sqs = boto3.client('sqs', region_name=region)
client = boto3.client("sts")
account_id = client.get_caller_identity()['Account']
queue_arn = ""

def print_error(e):
    print(e.message + ' RequestId: ' + e.response['ResponseMetadata']['RequestId'])

def create_s3_bucket(bucket_name, client):
    bucket = client.Bucket(bucket_name)
    try:
        if not create_bucket:
            return True
        response = bucket.create(
            ACL='private',
            CreateBucketConfiguration={
                'LocationConstraint': region
            },
        )
    }
return True
except botocore.exceptions.ClientError as e:
    print_error(e)
    if 'BucketAlreadyOwnedByYou' in e.message:  # we own this bucket so continue
        print('We own the bucket already. Lets continue...')
        return True
    return False

def create_s3_bucket_folder(bucket_name, client, directory_name):
    s3.put_object(Bucket=bucket_name, Key=(directory_name + '/'))

def set_s3_notification_sns(bucket_name, client, topic_arn):
    bucket_notification = client.BucketNotification(bucket_name)
    try:
        response = bucket_notification.put(
            NotificationConfiguration={
                'TopicConfigurations': [
                    {
                        'Id' : crawler_name,
                        'TopicArn': topic_arn,
                        'Events': [  
                            's3:ObjectCreated:*',
                            's3:ObjectRemoved:*',
                        ],
                        'Filter': {'Key': {'FilterRules': [{  
                            'Name': 'prefix',
                            'Value': folder_name
                        }]}},
                    },
                ],
            }
        )
        return True
    except botocore.exceptions.ClientError as e:
        print_error(e)
    return False

def create_sns_topic(topic_name, client):
    try:
        response = client.create_topic(  
            Name=topic_name
        )
        return response['TopicArn']
except botocore.exceptions.ClientError as e:
    print_error(e)
return None

def set_sns_topic_policy(topic_arn, client, bucket_name):
    try:
        response = client.set_topic_attributes(
            TopicArn=topic_arn,
            AttributeName='Policy',
            AttributeValue='''{
                "Version": "2008-10-17",
                "Id": "s3-publish-to-sns",
                "Statement": [{
                    "Effect": "Allow",
                    "Principal": { "AWS" : "*" },
                    "Action": [ "SNS:Publish" ],
                    "Resource": "%s",
                    "Condition": {
                        "StringEquals": {
                            "AWS:SourceAccount": "%s"
                        },
                        "ArnLike": {
                            "aws:SourceArn": "arn:aws:s3:*::*:%s"
                        }
                    }
                }]
            }''' % (topic_arn, account_id, bucket_name)
        )
        return True
    except botocore.exceptions.ClientError as e:
        print_error(e)
        return False

def subscribe_to_sns_topic(topic_arn, client, protocol, endpoint):
    try:
        response = client.subscribe(
            TopicArn=topic_arn,
            Protocol=protocol,
            Endpoint=endpoint
        )
        return response['SubscriptionArn']
    except botocore.exceptions.ClientError as e:
        print_error(e)
        return False
print_error(e)
return None

def create_sqs_queue(queue_name, client):
    try:
        response = client.create_queue(
            QueueName=queue_name,
        )
        return response['QueueUrl']
    except botocore.exceptions.ClientError as e:
        print_error(e)
    return None

def get_sqs_queue_arn(queue_url, client):
    try:
        response = client.get_queue_attributes(
            QueueUrl=queue_url,
            AttributeNames=[
                'QueueArn',
            ]
        )
        return response['Attributes']['QueueArn']
    except botocore.exceptions.ClientError as e:
        print_error(e)
    return None

def set_sqs_policy(queue_url, queue_arn, client, topic_arn):
    try:
        response = client.set_queue_attributes(
            QueueUrl=queue_url,
            Attributes={
                'Policy': '''{
                "Version": "2012-10-17",
                "Id": "AllowSNSPublish",
                "Statement": [
                    {
                        "Sid": "AllowSNSPublish01",
                        "Effect": "Allow",
                        "Principal": "*",
                        "Action": "SQS:SendMessage",
                        "Resource": "%s",
                        "Condition": {
```
"ArnEquals": {
    "aws:SourceArn": "%s"
}
}"

'''

if __name__ == "__main__":
    print('Creating S3 bucket %s.' % s3_bucket_name)
    if create_s3_bucket(s3_bucket_name, s3):
        print('
Creating SNS topic %s.' % sns_topic_name)
        topic_arn = create_sns_topic(sns_topic_name, sns)
        if topic_arn:
            print('SNS topic created successfully: %s' % topic_arn)

            print('Creating SQS queue %s' % sqs_queue_name)
            queue_url = create_sqs_queue(sqs_queue_name, sqs)
            if queue_url is not None:
                print('Subscribing sqs queue with sns.')
                queue_arn = get_sqs_queue_arn(queue_url, sqs)
                if queue_arn is not None:
                    if set_sqs_policy(queue_url, queue_arn, sqs, topic_arn):
                        print('Successfully configured queue policy.')
                        subscription_arn = subscribe_to_sns_topic(topic_arn, sns, 'sqs', queue_arn)
                        if subscription_arn is not None:
                            if 'pending confirmation' in subscription_arn:
                                print('Please confirm SNS subscription by visiting the subscribe URL.')
                            else:
                                print('Successfully subscribed SQS queue: ' + queue_arn)
                            else:
                                print('Failed to subscribe SNS')
                    else:
                        print('Failed to set queue policy.')
Setting up a crawler for Amazon S3 event notifications using the console (Amazon S3 target)

To set up a crawler for Amazon S3 event notifications using the AWS Glue console for an Amazon S3 target:

1. Set your crawler properties. For more information, see Setting Crawler Configuration Options on the AWS Glue console.

2. In the section Data source configuration, you are asked Is your data already mapped to AWS Glue tables?

   By default Not yet is already selected. Leave this as the default as you are using an Amazon S3 data source and the data is not already mapped to AWS Glue tables.

3. In the section Data sources, choose Add a data source.
4. In the **Add data source** modal, configure the Amazon S3 data source:

   - **Data source**: By default, Amazon S3 is selected.
   - **Network connection** (Optional): Choose **Add new connection**.
   - **Location of Amazon S3 data**: By default, **In this account** is selected.
   - **Amazon S3 path**: Specify the Amazon S3 path where folders and files are crawled.
   - **Subsequent crawler runs**: Choose **Crawl based on events** to use Amazon S3 event notifications for your crawler.
   - **Include SQS ARN**: Specify the data store parameters including the a valid SQS ARN. (For example, `arn:aws:sqs:region:account:sqs`).
   - **Include dead-letter SQS ARN** (Optional): Specify a valid Amazon dead-letter SQS ARN. (For example, `arn:aws:sqs:region:account:deadLetterQueue`).
   - Choose **Add an Amazon S3 data source**.
Setting up a crawler for Amazon S3 event notifications using the AWS CLI

The following is an example Amazon S3 AWS CLI call to create SQS queues and setup event notifications on Amazon S3 target bucket.

```
aws sqs create-queue --queue-name MyQueue --attributes file://create-queue.json
```

```
```
Accelerating crawls using Amazon S3 event notifications

```
aws s3api put-bucket-notification-configuration --bucket customer-data-pdx --notification-configuration file://s3-event-config.json
```

```
{  
  "QueueConfigurations": [  
    {  
      "Id": "s3event-sqs-queue",  
      "QueueArn": "arn:aws:sqs:{region}:{account}:queuename",  
      "Events": [  
        "s3:ObjectCreated:*",  
        "s3:ObjectRemoved:*"  
      ],  
      "Filter": {  
        "Key": {  
          "FilterRules": [  
            {  
              "Name": "Prefix",  
              "buckets": [  
                "example-ID"  
              ]  
            }  
          ]  
        }  
      }  
    }  
  ]
}
```
Setting up a crawler for Amazon S3 event notifications using the console (Data Catalog target)

When you have a catalog target, set up a crawler for Amazon S3 event notifications using the AWS Glue console:

1. Set your crawler properties. For more information, see Setting Crawler Configuration Options on the AWS Glue console.

2. In the section Data source configuration, you are asked Is your data already mapped to AWS Glue tables?

   Select Yes to select existing tables from your Data Catalog as your data source.

3. In the section Glue tables, choose Add tables.
4. In the **Add table** modal, configure the database and tables:

- **Network connection** (Optional): Choose **Add new connection**.
- **Database**: Select a database in the Data Catalog.
- **Tables**: Select one or more tables from that database in the Data Catalog.
- **Subsequent crawler runs**: Choose **Crawl based on events** to use Amazon S3 event notifications for your crawler.
- **Include SQS ARN**: Specify the data store parameters including the a valid SQS ARN. (For example, `arn:aws:sqs:region:account:sqs`).
- **Include dead-letter SQS ARN** (Optional): Specify a valid Amazon dead-letter SQS ARN. (For example, `arn:aws:sqs:region:account:deadLetterQueue`).
- Choose **Confirm**.
Using encryption with the Amazon S3 event crawler

This section describes using encryption on SQS only or on both SQS and Amazon S3.

Topics

- Enabling encryption on SQS only
- Enabling encryption on both SQS and Amazon S3
- FAQ
Enabling encryption on SQS only

Amazon SQS provides encryption in-transit by default. To add optional Server-Side Encryption (SSE) to your queue you can attach a customer master key (CMK) in the edit panel. This means that SQS encrypts all customer data at-rest on SQS servers.

Create a Customer Master Key (CMK)

1. Choose Key Management Service (KMS) > Customer Managed Keys > Create key.
2. Follow the steps to add your own alias and description.
3. Add the respective IAM roles you would like to be able to use this key.
4. In the key policy, add another statement to the "Statement" list so that your custom key policy gives the Amazon SNS sufficient key usage permissions.

```
"Statement": [
    {
        "Effect": "Allow",
        "Principal": {
            "Service": "sns.amazonaws.com"
        },
        "Action": [
            "kms:GenerateDataKey",
            "kms:Decrypt"
        ],
        "Resource": "*"
    }
]
```

Enable Server-Side Encryption (SSE) on your queue

1. Choose Amazon SQS > Queues > sqs_queue_name > Encryption tab.
2. Choose Edit, and scroll down to the Encryption drop down.
3. Select Enabled to add SSE.
4. Select the CMK you created earlier, and not the default key with the name alias/aws/sqs.
After adding this, your Encryption tab is updated with the key you added.

Note
Amazon SQS automatically deletes messages that have been in a queue for more than the maximum message retention period. The default message retention period is 4 days. To avoid missing events change the SQS `MessageRetentionPeriod` to the maximum of 14 days.

Enabling encryption on both SQS and Amazon S3

Enable Server-Side Encryption (SSE) on SQS

1. Follow the steps in the section called “Enabling encryption on SQS only”.
2. In the last step of the CMK setup, give Amazon S3 sufficient key usage permissions.

Paste the following in to the "Statement" list:

```
"Statement": [
    {
        "Effect": "Allow",
        "Principal": {
```
Enable Server-Side Encryption (SSE) on your Amazon S3 bucket

1. Follow the steps in the section called “Enabling encryption on SQS only”.

2. Do one of the following:
   - To enable SSE for your entire S3 bucket, navigate to the Properties tab in your target bucket.

Here you can enable SSE and choose the encryption type you would like to use. Amazon S3 provides an encryption key that Amazon S3 creates, manages, and uses for you, or you can choose a key from KMS as well.

Edit default encryption

Default encryption
Automatically encrypt new objects stored in this bucket. Learn more

Server-side encryption
- Disable
- Enable

Encryption key type
To upload an object with a customer-provided encryption key (SSE-C), use the AWS CLI, AWS SDK, or Amazon S3 REST API.
- Amazon S3 key (SSE-S3)
  - An encryption key that Amazon S3 creates, manages, and uses for you. Learn more
- AWS Key Management Service key (SSE-KMS)
  - An encryption key protected by AWS Key Management Service (AWS KMS). Learn more

Cancel  Save changes
To enable SSE on a specific folder, click the checkbox beside your target folder and choose **Edit server-side encryption** under the **Actions** drop down.
**FAQ**

Why aren't messages that I publish to my Amazon SNS topic getting delivered to my subscribed Amazon SQS queue that has server-side encryption (SSE) enabled?

Double check that your Amazon SQS queue is using:

1. A [customer master key (CMK)](#) that is customer managed. Not the default one provided by SQS.
2. Your CMK from (1) includes a [custom key policy](#) that gives the Amazon SNS sufficient key usage permissions.

For more information, [see this article](#) in the knowledge center.

I've subscribed to email notifications, but I don't receive any email updates when I edit my Amazon S3 bucket.

Make sure that you have confirmed your email address by clicking the "Confirm Subscription" link in your email. You can verify the status of your confirmation by checking the **Subscriptions** table under your SNS topic.

Choose **Amazon SNS > Topics > sns_topic_name > Subscriptions table**.

If you followed our prerequisite script, you will find that the `sns_topic_name` is equal to your `sqs_queue_name`. It should look similar to the following:

<table>
<thead>
<tr>
<th>ID</th>
<th>Endpoint</th>
<th>Status</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>13fa3254-a252-4621-8d5a-05b1bb9245c6</td>
<td><a href="mailto:chengies@amazon.com">chengies@amazon.com</a></td>
<td>Confirmed</td>
<td>EMAIL</td>
</tr>
<tr>
<td>fba36c7b-3ec2-4890-bbe6-6503f11a9577</td>
<td>arn:aws:sqs:us-east-2:804918391416:s3-sqs-both-encrypted</td>
<td>Confirmed</td>
<td>SQS</td>
</tr>
</tbody>
</table>

Only some of the folders I added are showing up in my table after enabling server-side encryption on my SQS queue. Why am I missing some parquets?

If the Amazon S3 bucket changes were made before enabling SSE on your SQS queue, they may not be picked up by the crawler. To ensure that you have crawled all the updates to your S3 bucket, run the crawler again in listing mode ("Crawl All Folders"). Another option is to start fresh by creating a new crawler with S3 events enabled.
Parameters set on Data Catalog tables by crawler

These table properties are set by AWS Glue crawlers. We expect users to consume the classification and compressionType properties. Other properties, including table size estimates, are used for internal calculations, and we do not guarantee their accuracy or applicability to customer use cases. Changing these parameters may alter the behavior of the crawler, we do not support this workflow.

<table>
<thead>
<tr>
<th>Property key</th>
<th>Property value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPDATED_BY_CRAWLER</td>
<td>Name of crawler performing update.</td>
</tr>
<tr>
<td>connectionName</td>
<td>The name of the connection in the Data Catalog for the crawler used to connect to the data store.</td>
</tr>
<tr>
<td>recordCount</td>
<td>Estimate count of records in table, based on file sizes and headers.</td>
</tr>
<tr>
<td>skip.header.line.count</td>
<td>Rows skipped to skip header. Set on tables classified as CSV.</td>
</tr>
<tr>
<td>CrawlerSchemaSerializerVersion</td>
<td>For internal use</td>
</tr>
<tr>
<td>classification</td>
<td>Format of data, inferred by crawler. For more information about data formats supported by AWS Glue crawlers see the section called “Built-in classifiers in AWS Glue”.</td>
</tr>
<tr>
<td>CrawlerSchemaDeserializerVersion</td>
<td>For internal use</td>
</tr>
<tr>
<td>sizeKey</td>
<td>Combined size of files in table crawled.</td>
</tr>
<tr>
<td>averageRecordSize</td>
<td>Average size of row in table, in bytes.</td>
</tr>
<tr>
<td>Property key</td>
<td>Property value</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>compressionType</td>
<td>Type of compression used on data in the table. For more information about compression types supported by AWS Glue crawlers see the section called “Built-in classifiers in AWS Glue”.</td>
</tr>
<tr>
<td>typeofData</td>
<td>file, table or view.</td>
</tr>
<tr>
<td>objectCount</td>
<td>Number of objects under Amazon S3 path for table.</td>
</tr>
</tbody>
</table>

These additional table properties are set by AWS Glue crawlers for Snowflake data stores.

<table>
<thead>
<tr>
<th>Property key</th>
<th>Property value</th>
</tr>
</thead>
<tbody>
<tr>
<td>aws:RawTableLastAltered</td>
<td>Records the last altered timestamp of the Snowflake table.</td>
</tr>
<tr>
<td>ViewOriginalText</td>
<td>View SQL statement.</td>
</tr>
<tr>
<td>ViewExpandedText</td>
<td>View SQL statement encoded in Base64 format.</td>
</tr>
<tr>
<td>ExternalTable:S3Location</td>
<td>Amazon S3 location of the Snowflake external table.</td>
</tr>
<tr>
<td>ExternalTable:FileFormat</td>
<td>Amazon S3 file format of the Snowflake external table.</td>
</tr>
</tbody>
</table>

These additional table properties are set by AWS Glue crawlers for JDBC-type data stores such as Amazon Redshift, Microsoft SQL Server, MySQL, PostgreSQL, and Oracle.
### Property key | Property value
--- | ---
aws:RawType | When a crawler stores the data in the Data Catalog, it translates the datatypes to Hive-compatible types, which many times causes the information on the native datatype to be lost. The crawler outputs the `aws:RawType` parameter to provide the native-level datatype.

aws:RawColumnComment | If a comment is associated with a column in the database, the crawler outputs the corresponding comment in the catalog table. The comment string is truncated to 255 bytes. Comments are not supported for Microsoft SQL Server.

aws:RawTableComment | If a comment is associated with a table in the database, the crawler outputs the corresponding comment in the catalog table. The comment string is truncated to 255 bytes. Comments are not supported for Microsoft SQL Server.

---

**Adding classifiers to a crawler in AWS Glue**

A classifier reads the data in a data store. If it recognizes the format of the data, it generates a schema. The classifier also returns a certainty number to indicate how certain the format recognition was.

AWS Glue provides a set of built-in classifiers, but you can also create custom classifiers. AWS Glue invokes custom classifiers first, in the order that you specify in your crawler definition. Depending on the results that are returned from custom classifiers, AWS Glue might also invoke built-in classifiers. If a classifier returns `certainty=1.0` during processing, it indicates that it's 100 percent certain that it can create the correct schema. AWS Glue then uses the output of that classifier.

If no classifier returns `certainty=1.0`, AWS Glue uses the output of the classifier that has the highest certainty. If no classifier returns a certainty greater than `0.0`, AWS Glue returns the default classification string of `UNKNOWN`. 

---

*Adding classifiers to a crawler*
When do I use a classifier?

You use classifiers when you crawl a data store to define metadata tables in the AWS Glue Data Catalog. You can set up your crawler with an ordered set of classifiers. When the crawler invokes a classifier, the classifier determines whether the data is recognized. If the classifier can't recognize the data or is not 100 percent certain, the crawler invokes the next classifier in the list to determine whether it can recognize the data.

For more information about creating a classifier using the AWS Glue console, see Working with classifiers on the AWS Glue console.

Custom classifiers

The output of a classifier includes a string that indicates the file's classification or format (for example, json) and the schema of the file. For custom classifiers, you define the logic for creating the schema based on the type of classifier. Classifier types include defining schemas based on grok patterns, XML tags, and JSON paths.

If you change a classifier definition, any data that was previously crawled using the classifier is not reclassified. A crawler keeps track of previously crawled data. New data is classified with the updated classifier, which might result in an updated schema. If the schema of your data has evolved, update the classifier to account for any schema changes when your crawler runs. To reclassify data to correct an incorrect classifier, create a new crawler with the updated classifier.

For more information about creating custom classifiers in AWS Glue, see Writing custom classifiers.

蹑 Note

If your data format is recognized by one of the built-in classifiers, you don't need to create a custom classifier.

Built-in classifiers in AWS Glue

AWS Glue provides built-in classifiers for various formats, including JSON, CSV, web logs, and many database systems.

If AWS Glue doesn't find a custom classifier that fits the input data format with 100 percent certainty, it invokes the built-in classifiers in the order shown in the following table. The built-in
Classifiers return a result to indicate whether the format matches (certainty=1.0) or does not match (certainty=0.0). The first classifier that has certainty=1.0 provides the classification string and schema for a metadata table in your Data Catalog.

<table>
<thead>
<tr>
<th>Classifier type</th>
<th>Classification string</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Avro</td>
<td>avro</td>
<td>Reads the schema at the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Apache ORC</td>
<td>orc</td>
<td>Reads the file metadata to determine format.</td>
</tr>
<tr>
<td>Apache Parquet</td>
<td>parquet</td>
<td>Reads the schema at the end of the file to determine format.</td>
</tr>
<tr>
<td>JSON</td>
<td>json</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Binary JSON</td>
<td>bson</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>XML</td>
<td>xml</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AWS Glue determines the table schema based on XML tags in the document.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For information about creating a custom XML classifier to specify rows in the document, see Writing XML custom classifiers.</td>
</tr>
<tr>
<td>Amazon Ion</td>
<td>ion</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Combined Apache log</td>
<td>combined_apache</td>
<td>Determines log formats through a grok pattern.</td>
</tr>
<tr>
<td>Apache log</td>
<td>apache</td>
<td>Determines log formats through a grok pattern.</td>
</tr>
<tr>
<td>Linux kernel log</td>
<td>linux_kernel</td>
<td>Determines log formats through a grok pattern.</td>
</tr>
<tr>
<td>Microsoft log</td>
<td>microsoft_log</td>
<td>Determines log formats through a grok pattern.</td>
</tr>
</tbody>
</table>
### Built-in classifiers in AWS Glue

<table>
<thead>
<tr>
<th>Classifier type</th>
<th>Classification string</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruby log</td>
<td>ruby_logger</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Squid 3.x log</td>
<td>squid</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Redis monitor log</td>
<td>redismonlog</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>Redis log</td>
<td>redislog</td>
<td>Reads the beginning of the file to determine format.</td>
</tr>
<tr>
<td>CSV</td>
<td>csv</td>
<td>Checks for the following delimiters: comma (,), pipe (</td>
</tr>
<tr>
<td>Amazon Redshift</td>
<td>redshift</td>
<td>Uses JDBC connection to import metadata.</td>
</tr>
<tr>
<td>MySQL</td>
<td>mysql</td>
<td>Uses JDBC connection to import metadata.</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>postgresql</td>
<td>Uses JDBC connection to import metadata.</td>
</tr>
<tr>
<td>Oracle database</td>
<td>oracle</td>
<td>Uses JDBC connection to import metadata.</td>
</tr>
<tr>
<td>Microsoft SQL Server</td>
<td>sqlserver</td>
<td>Uses JDBC connection to import metadata.</td>
</tr>
<tr>
<td>Amazon DynamoDB</td>
<td>dynamodb</td>
<td>Reads data from the DynamoDB table.</td>
</tr>
</tbody>
</table>

Files in the following compressed formats can be classified:

- ZIP (supported for archives containing only a single file). Note that Zip is not well-supported in other services (because of the archive).
- BZIP
Built-in CSV classifier

The built-in CSV classifier parses CSV file contents to determine the schema for an AWS Glue table. This classifier checks for the following delimiters:

- Comma (,)
- Pipe (|)
- Tab (\t)
- Semicolon (;)
- Ctrl-A (\u0001)

Ctrl-A is the Unicode control character for Start Of Heading.

To be classified as CSV, the table schema must have at least two columns and two rows of data. The CSV classifier uses a number of heuristics to determine whether a header is present in a given file. If the classifier can’t determine a header from the first row of data, column headers are displayed as col1, col2, col3, and so on. The built-in CSV classifier determines whether to infer a header by evaluating the following characteristics of the file:

- Every column in a potential header parses as a STRING data type.
- Except for the last column, every column in a potential header has content that is fewer than 150 characters. To allow for a trailing delimiter, the last column can be empty throughout the file.
- Every column in a potential header must meet the AWS Glue regex requirements for a column name.
- The header row must be sufficiently different from the data rows. To determine this, one or more of the rows must parse as other than STRING type. If all columns are of type STRING, then the first row of data is not sufficiently different from subsequent rows to be used as the header.
Note

If the built-in CSV classifier does not create your AWS Glue table as you want, you might be able to use one of the following alternatives:

- Change the column names in the Data Catalog, set the SchemaChangePolicy to LOG, and set the partition output configuration to InheritFromTable for future crawler runs.

- Create a custom grok classifier to parse the data and assign the columns that you want.

- The built-in CSV classifier creates tables referencing the LazySimpleSerDe as the serialization library, which is a good choice for type inference. However, if the CSV data contains quoted strings, edit the table definition and change the SerDe library to OpenCSVSerDe. Adjust any inferred types to STRING, set the SchemaChangePolicy to LOG, and set the partitions output configuration to InheritFromTable for future crawler runs. For more information about SerDe libraries, see SerDe Reference in the Amazon Athena User Guide.

Writing custom classifiers

You can provide a custom classifier to classify your data in AWS Glue. You can create a custom classifier using a grok pattern, an XML tag, JavaScript Object Notation (JSON), or comma-separated values (CSV). An AWS Glue crawler calls a custom classifier. If the classifier recognizes the data, it returns the classification and schema of the data to the crawler. You might need to define a custom classifier if your data doesn't match any built-in classifiers, or if you want to customize the tables that are created by the crawler.

For more information about creating a classifier using the AWS Glue console, see Working with classifiers on the AWS Glue console.

AWS Glue runs custom classifiers before built-in classifiers, in the order you specify. When a crawler finds a classifier that matches the data, the classification string and schema are used in the definition of tables that are written to your AWS Glue Data Catalog.

Topics

- Writing grok custom classifiers
- Writing XML custom classifiers
Writing grok custom classifiers

Grok is a tool that is used to parse textual data given a matching pattern. A grok pattern is a named set of regular expressions (regex) that are used to match data one line at a time. AWS Glue uses grok patterns to infer the schema of your data. When a grok pattern matches your data, AWS Glue uses the pattern to determine the structure of your data and map it into fields.

AWS Glue provides many built-in patterns, or you can define your own. You can create a grok pattern using built-in patterns and custom patterns in your custom classifier definition. You can tailor a grok pattern to classify custom text file formats.

Note

AWS Glue grok custom classifiers use the GrokSerDe serialization library for tables created in the AWS Glue Data Catalog. If you are using the AWS Glue Data Catalog with Amazon Athena, Amazon EMR, or Redshift Spectrum, check the documentation about those services for information about support of the GrokSerDe. Currently, you might encounter problems querying tables created with the GrokSerDe from Amazon EMR and Redshift Spectrum.

The following is the basic syntax for the components of a grok pattern:

%{PATTERN:field-name}

Data that matches the named PATTERN is mapped to the field-name column in the schema, with a default data type of string. Optionally, the data type for the field can be cast to byte, boolean, double, short, int, long, or float in the resulting schema.

%{PATTERN:field-name:data-type}

For example, to cast a num field to an int data type, you can use this pattern:

%{NUMBER:num:int}
Patterns can be composed of other patterns. For example, you can have a pattern for a SYSLOG timestamp that is defined by patterns for month, day of the month, and time (for example, Feb 1 06:25:43). For this data, you might define the following pattern:

SYSLOGTIMESTAMP %{MONTH} +{MONTHDAY} %{TIME}

Note

Grok patterns can process only one line at a time. Multiple-line patterns are not supported. Also, line breaks within a pattern are not supported.

Custom classifier values in AWS Glue

When you define a grok classifier, you supply the following values to AWS Glue to create the custom classifier.

Name

Name of the classifier.

Classification

The text string that is written to describe the format of the data that is classified; for example, special-logs.

Grok pattern

The set of patterns that are applied to the data store to determine whether there is a match. These patterns are from AWS Glue built-in patterns and any custom patterns that you define.

The following is an example of a grok pattern:

{%TIMESTAMP_ISO8601:timestamp} \[%{MESSAGEPREFIX:message_prefix}\]
{%CRAWLERLOGLEVEL:loglevel} : %{GREEDYDATA:message}

When the data matches TIMESTAMP_ISO8601, a schema column timestamp is created. The behavior is similar for the other named patterns in the example.
Custom patterns

Optional custom patterns that you define. These patterns are referenced by the grok pattern that classifies your data. You can reference these custom patterns in the grok pattern that is applied to your data. Each custom component pattern must be on a separate line. Regular expression (regex) syntax is used to define the pattern.

The following is an example of using custom patterns:

```
CRAWLERLOGLEVEL (BENCHMARK|ERROR|WARN|INFO|TRACE)
MESSAGEPREFIX .*-..*-..*-.*. *
```

The first custom named pattern, CRAWLERLOGLEVEL, is a match when the data matches one of the enumerated strings. The second custom pattern, MESSAGEPREFIX, tries to match a message prefix string.

AWS Glue keeps track of the creation time, last update time, and version of your classifier.

AWS Glue built-in patterns

AWS Glue provides many common patterns that you can use to build a custom classifier. You add a named pattern to the grok pattern in a classifier definition.

The following list consists of a line for each pattern. In each line, the pattern name is followed its definition. Regular expression (regex) syntax is used in defining the pattern.

```bash
#<noloc>&GLU;</noloc> Built-in patterns
USERNAME [a-zA-Z0-9_.-]+  
USER %{USERNAME:UNWANTED}  
INT (?:[-+]?(?:[0-9]+))  
NUMBER (?:%{BASE10NUM:UNWANTED})  
BASE16NUM (?<![0-9A-Fa-f])(?:[-+]?(?:0x)?(?:[0-9A-Fa-f]+))  
BASE16FLOAT \b(?<![0-9A-Fa-f.\[])(?:[-+]?(?:0x)?(?:[0-9A-Fa-f]+(?:\.[0-9A-Fa-f]*))|  
(?!\.[0-9A-Fa-f]+))\b  
BOOLEAN (?i)(true|false)  
POSINT \b(?:[1-9][0-9]*)\b  
NONNEGINT \b(?:[0-9]+)\b  
WORD \b\w+\b  
NOTSPACE \S+  
```
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URIHOST %{IPORHOST}(?::%{POSINT:port})?
# uripath comes loosely from RFC1738, but mostly from what Firefox
# doesn't turn into %XX
URIPATH (?.?/[A-Za-z0-9.]+*()(?),~;@=%#\-]*)+
#URIPARAM \(?:([A-Za-z0-9-]+)(?:=(?:[^&]*))?(?:&(&([A-Za-z0-9-]+)(?:=(?:[^&]*))*)?)??
URIPARAM \[A-Za-z0-9.]+*'(())~;@=%#\-]*\[\]?
URIPATHPARAM %{URIPATH}(?:%{URIPARAM})?
URI %{URIPROTO}(?:%{USER}(?:%[^@]*%)?)?(?:%{URIHOST})?(?:%{URIPATHPARAM})?

# Months: January, Feb, 3, 03, 12, December
MONTH \b(?:Jan(?:uary)?|Feb(?:ruary)?|Mar(?:ch)?|Apr(?:il)?|May|Jun(?:e)?|Jul(?:y)?|Aug(?:ust)?|Sep(?:tember)?|Oct(?:ober)?|Nov(?:ember)?|Dec(?:ember)?)\b
MONTHNUM (?:0?[1-9]|1[0-2])
MONTHNUM2 (?:0[1-9]|1[0-2])
MONTHDAY (?:0[1-9]|1[0-9])

# Days: Monday, Tue, Thu, etc...
DAY (?:Mon(?:day)?|Tue(?:sday)?|Wed(?:nesday)?|Thu(?:rsday)?|Fri(?:day)?|Sat(?:urday)?|Sun(?:day)?)

# Years?
YEAR (?>\d\d){1,2}

# Time: HH:MM:SS
#TIME \d(\d(\d(\d|\d)))?
# TIME %{POSINT<24}:%{POSINT<60}(?:%{POSINT<60}(?:%\.%{POSINT})?)?
HOUR (?:2[0123]|1[0-9])
MINUTE (?:[0-5]\d)
SECOND (?:[0-5]\d|60)
TIME (?!<\d(\d(\d|\d)))%{HOUR}:%{MINUTE}(?!<\d(\d(\d|\d)))

'60' is a leap second in most time standards and thus is valid.
SECOND (?:[0-9-0-9][0-960](?:[0-9-0-9][0-9-0-9]))
TIME (?!<\d(\d(\d|\d)))%{HOUR}:%{MINUTE}(?!<\d(\d(\d|\d)))

# datestamp is YYYY/MM/DD-HH:MM:SS.UUUU (or something like it)
DATE_US %{MONTHNUM}[-/-%{MONTHDAY}][--%{YEAR}]
DATE_EU %{MONTHDAY}[--%{MONTHNUM}][--%{YEAR}]
DATESTAMP_US %{DATE_US}[--%{TIME}]
DATESTAMP_EU %{DATE_EU}[--%{TIME}]
ISO8601_TIMEZONE (?:Z|[-%-%{HOUR}]%{MINUTE}))
ISO8601_SECOND (?:%{SECOND}|60)
TIMESTAMP_ISO8601 %{YEAR}-%{MONTHNUM}-%{MONTHDAY}[T] %{HOUR}:%{MINUTE}(?:%{SECOND})%{ISO8601_TIMEZONE}?

TZ (?:[PMCE][SD]T|UTC)
DATESTAMP RFC822 %{DAY} %{MONTH} %{MONTHDAY} %{YEAR} %{TIME} %{TZ}
DATESTAMP RFC2822 %{DAY}, %{MONTHDAY} %{MONTH} %{YEAR} %{TIME} %{ISO8601_TIMEZONE}
DATESTAMP OTHER %{DAY} %{MONTH} %{MONTHDAY} %{TIME} %{TZ} %{YEAR}
DATESTAMP_EVENTLOG %{YEAR} %{MONTHNUM2} %{MONTHDAY} %{HOUR} %{MINUTE} %{SECOND}
Writing XML custom classifiers

XML defines the structure of a document with the use of tags in the file. With an XML custom classifier, you can specify the tag name used to define a row.
Custom classifier values in AWS Glue

When you define an XML classifier, you supply the following values to AWS Glue to create the classifier. The classification field of this classifier is set to xml.

Name

Name of the classifier.

Row tag

The XML tag name that defines a table row in the XML document, without angle brackets < >. The name must comply with XML rules for a tag.

Note

The element containing the row data cannot be a self-closing empty element. For example, this empty element is not parsed by AWS Glue:

```
<row att1="xx" att2="yy" />
```

Empty elements can be written as follows:

```
<row att1="xx" att2="yy"> </row>
```

AWS Glue keeps track of the creation time, last update time, and version of your classifier.

For example, suppose that you have the following XML file. To create an AWS Glue table that only contains columns for author and title, create a classifier in the AWS Glue console with Row tag as AnyCompany. Then add and run a crawler that uses this custom classifier.

```
<?xml version="1.0"?>
<catalog>
  <book id="bk101">
    <AnyCompany>
```

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Writing JSON custom classifiers

JSON is a data-interchange format. It defines data structures with name-value pairs or an ordered list of values. With a JSON custom classifier, you can specify the JSON path to a data structure that is used to define the schema for your table.

Custom classifier values in AWS Glue

When you define a JSON classifier, you supply the following values to AWS Glue to create the classifier. The classification field of this classifier is set to `json`.

**Name**

Name of the classifier.

**JSON path**

A JSON path that points to an object that is used to define a table schema. The JSON path can be written in dot notation or bracket notation. The following operators are supported:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$.</td>
<td>Root element of a JSON object. This starts all path expressions</td>
</tr>
<tr>
<td>*</td>
<td>Wildcard character. Available anywhere a name or numeric are required in the JSON path.</td>
</tr>
<tr>
<td>.&lt;name&gt;</td>
<td>Dot-notated child. Specifies a child field in a JSON object.</td>
</tr>
<tr>
<td>['&lt;name&gt;']</td>
<td>Bracket-notated child. Specifies child field in a JSON object. Only a single child field can be specified.</td>
</tr>
</tbody>
</table>
Array index. Specifies the value of an array by index.

AWS Glue keeps track of the creation time, last update time, and version of your classifier.

Example Using a JSON classifier to pull records from an array

Suppose that your JSON data is an array of records. For example, the first few lines of your file might look like the following:

```json
[
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:ak",
    "name": "Alaska"
  },
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:al\cd:1",
    "name": "Alabama's 1st congressional district"
  },
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:al\cd:2",
    "name": "Alabama's 2nd congressional district"
  },
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:al\cd:3",
    "name": "Alabama's 3rd congressional district"
  },
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:al\cd:4",
    "name": "Alabama's 4th congressional district"
  },
  {
    "type": "constituency",
    "id": "ocd-division\country:us\state:al\cd:5",
    "name": "Alabama's 5th congressional district"
  }
]
```
When you run a crawler using the built-in JSON classifier, the entire file is used to define the schema. Because you don’t specify a JSON path, the crawler treats the data as one object, that is, just an array. For example, the schema might look like the following:

```
root
|-- record: array
```

However, to create a schema that is based on each record in the JSON array, create a custom JSON classifier and specify the JSON path as $[*]$. When you specify this JSON path, the classifier interrogates all 12 records in the array to determine the schema. The resulting schema contains separate fields for each object, similar to the following example:

```
root
 | -- type: string
 | -- id: string
 | -- name: string
```

**Example Using a JSON classifier to examine only parts of a file**

Suppose that your JSON data follows the pattern of the example JSON file s3://awsglue-datasets/examples/us-legislators/all/areas.json drawn from [http://everypolitician.org/](http://everypolitician.org/). Example objects in the JSON file look like the following:

```json
{
   "type": "constituency",
   "id": "ocd-division\country:us\state:ak",
   "name": "Alaska"
}
{
   "type": "constituency",
   "identifiers": [
   { 
      "scheme": "dmoz",
      "identifier": "Regional\North_America\United_States\Alaska\"
   },
   { 
      "scheme": "freebase",
      "identifier": "\m\0hjy"
   },
   { 
      "scheme": "fips",
      "identifier": "US02"
   },
   { 
      "scheme": "quora",
      "identifier": "Alaska-state"
   }
   ]
}
```
When you run a crawler using the built-in JSON classifier, the entire file is used to create the schema. You might end up with a schema like this:

```json
{
    "scheme": "britannica",
    "identifier": "place\Alaska"
},
{
    "scheme": "wikidata",
    "identifier": "Q797"
},
"other_names": [
    {
        "lang": "en",
        "note": "multilingual",
        "name": "Alaska"
    },
    {
        "lang": "fr",
        "note": "multilingual",
        "name": "Alaska"
    },
    {
        "lang": "nov",
        "note": "multilingual",
        "name": "Alaska"
    }
],
"id": "ocd-division\country:us\state:ak",
"name": "Alaska"
}
```

Writing custom classifiers
However, to create a schema using just the "id" object, create a custom JSON classifier and specify the JSON path as $.id. Then the schema is based on only the "id" field:

```plaintext
root
|-- record: string
```

The first few lines of data extracted with this schema look like this:

```json
{"record": "ocd-division/country:us/state:ak"}
{"record": "ocd-division/country:us/state:al/cd:1"}
{"record": "ocd-division/country:us/state:al/cd:2"}
{"record": "ocd-division/country:us/state:al/cd:3"}
{"record": "ocd-division/country:us/state:al/cd:4"}
{"record": "ocd-division/country:us/state:al/cd:5"}
{"record": "ocd-division/country:us/state:al/cd:6"}
{"record": "ocd-division/country:us/state:al/cd:7"}
{"record": "ocd-division/country:us/state:ar/cd:1"}
{"record": "ocd-division/country:us/state:ar/cd:2"}
{"record": "ocd-division/country:us/state:ar/cd:3"}
{"record": "ocd-division/country:us/state:ar/cd:4"}
{"record": "ocd-division/country:us/state:as"}
{"record": "ocd-division/country:us/state:az/cd:1"}
{"record": "ocd-division/country:us/state:az/cd:2"}
{"record": "ocd-division/country:us/state:az/cd:3"}
{"record": "ocd-division/country:us/state:az/cd:4"}
{"record": "ocd-division/country:us/state:az/cd:5"}
{"record": "ocd-division/country:us/state:az/cd:6"}
{"record": "ocd-division/country:us/state:az/cd:7"}
```

To create a schema based on a deeply nested object, such as "identifier," in the JSON file, you can create a custom JSON classifier and specify the JSON path as $.identifiers[*].identifier. Although the schema is similar to the previous example, it is based on a different object in the JSON file.
The schema looks like the following:

```
root
|-- record: string
```

Listing the first few lines of data from the table shows that the schema is based on the data in the "identifier" object:

```
{"record": "Regional/North_America/United_States/Alaska/"}
{"record": "/m/0hjy"}
{"record": "US02"}
{"record": "5879092"}
{"record": "4001016-8"}
{"record": "destination/alaska"}
{"record": "1116270"}
{"record": "139487266"}
{"record": "n79018447"}
{"record": "01490999-8dec-4129-8254-eef6e80fadc3"}
{"record": "Alaska-state"}
{"record": "place/Alaska"}
{"record": "Q797"}
{"record": "Regional/North_America/United_States/Alabama/"}
{"record": "/m/0gyh"}
{"record": "US01"}
{"record": "4829764"}
{"record": "4084839-5"}
{"record": "161950"}
{"record": "131885589"}
```

To create a table based on another deeply nested object, such as the "name" field in the "other_names" array in the JSON file, you can create a custom JSON classifier and specify the JSON path as $.other_names[*].name. Although the schema is similar to the previous example, it is based on a different object in the JSON file. The schema looks like the following:

```
root
|-- record: string
```
Listing the first few lines of data in the table shows that it is based on the data in the "name" object in the "other_names" array:

```json
["record": "Alaska"],
["record": "Alaska"],
["record": "Аляска"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Аляска"],
["record": "Alaska"],
["record": "Alyaska"],
["record": "Alaska"],
["record": "Alaska"],
["record": "Штат Аляска"],
["record": "Аляска"],
["record": "Alaska"],
["record": "####"]
```

**Writing CSV custom classifiers**

Custom CSV classifiers allows you to specify datatypes for each column in the custom csv classifier field. You can specify each column’s datatype separated by a comma. By specifying datatypes, you can override the crawlers inferred datatypes and ensure data will be classified appropriately.

You can set the SerDe for processing CSV in the classifier, which will be applied in the Data Catalog.

When you create a custom classifier, you can also re-use the classifier for different crawlers.

- For csv files with only headers (no data), these files will be classified as UNKNOWN since not enough information is provided. If you specify that the CSV 'Has headings' in the Column headings option, and provide the datatypes, we can classify these files correctly.
You can use a custom CSV classifier to infer the schema of various types of CSV data. The custom attributes that you can provide for your classifier include delimiters, a CSV SerDe option, options about the header, and whether to perform certain validations on the data.

**Custom classifier values in AWS Glue**

When you define a CSV classifier, you provide the following values to AWS Glue to create the classifier. The classification field of this classifier is set to `csv`.

**Classifier name**

Name of the classifier.

**CSV Serde**

Sets the SerDe for processing CSV in the classifier, which will be applied in the Data Catalog. Options are Open CSV SerDe, Lazy Simple SerDe, and None. You can specify the None value when you want the crawler to do the detection.

**Column delimiter**

A custom symbol to denote what separates each column entry in the row. Provide a unicode character. If you cannot type your delimiter, you can copy and paste it. This works for printable characters, including those your system does not support (typically shown as □).

**Quote symbol**

A custom symbol to denote what combines content into a single column value. Must be different from the column delimiter. Provide a unicode character. If you cannot type your delimiter, you can copy and paste it. This works for printable characters, including those your system does not support (typically shown as □).

**Column headings**

Indicates the behavior for how column headings should be detected in the CSV file. If your custom CSV file has column headings, enter a comma-delimited list of the column headings.

**Processing options: Allow files with single column**

Enables the processing of files that contain only one column.

**Processing options: Trim white space before identifying column values**

Specifies whether to trim values before identifying the type of column values.
Custom datatypes - *optional*


Working with classifiers on the AWS Glue console

A classifier determines the schema of your data. You can write a custom classifier and point to it from AWS Glue.

Viewing classifiers

To see a list of all the classifiers that you have created, open the AWS Glue console at [https://console.aws.amazon.com/glue/](https://console.aws.amazon.com/glue/), and choose the **Classifiers** tab.

The list displays the following properties about each classifier:

- **Classifier** – The classifier name. When you create a classifier, you must provide a name for it.
- **Classification** – The classification type of tables inferred by this classifier.
- **Last updated** – The last time this classifier was updated.

Managing classifiers

From the **Classifiers** list in the AWS Glue console, you can add, edit, and delete classifiers. To see more details for a classifier, choose the classifier name in the list. Details include the information you defined when you created the classifier.

Creating classifiers

To add a classifier in the AWS Glue console, choose **Add classifier**. When you define a classifier, you supply values for the following:

- **Classifier name** – Provide a unique name for your classifier.
- **Classifier type** – The classification type of tables inferred by this classifier.
- **Last updated** – The last time this classifier was updated.
Classifier name

Provide a unique name for your classifier.

Classifier type

Choose the type of classifier to create.

Depending on the type of classifier you choose, configure the following properties for your classifier:

Grok

- **Classification**

  Describe the format or type of data that is classified or provide a custom label.

- **Grok pattern**

  This is used to parse your data into a structured schema. The grok pattern is composed of named patterns that describe the format of your data store. You write this grok pattern using the named built-in patterns provided by AWS Glue and custom patterns you write and include in the **Custom patterns** field. Although grok debugger results might not match the results from AWS Glue exactly, we suggest that you try your pattern using some sample data with a grok debugger. You can find grok debuggers on the web. The named built-in patterns provided by AWS Glue are generally compatible with grok patterns that are available on the web.

  Build your grok pattern by iteratively adding named patterns and check your results in a debugger. This activity gives you confidence that when the AWS Glue crawler runs your grok pattern, your data can be parsed.

- **Custom patterns**

  For grok classifiers, these are optional building blocks for the **Grok pattern** that you write. When built-in patterns cannot parse your data, you might need to write a custom pattern. These custom patterns are defined in this field and referenced in the **Grok pattern** field. Each custom pattern is defined on a separate line. Just like the built-in patterns, it consists of a named pattern definition that uses regular expression (regex) syntax.

  For example, the following has the name MESSAGEPREFIX followed by a regular expression definition to apply to your data to determine whether it follows the pattern.
XML

- **Row tag**

For XML classifiers, this is the name of the XML tag that defines a table row in the XML document. Type the name without angle brackets `< >`. The name must comply with XML rules for a tag.

For more information, see [Writing XML custom classifiers](#).

JSON

- **JSON path**

For JSON classifiers, this is the JSON path to the object, array, or value that defines a row of the table being created. Type the name in either dot or bracket JSON syntax using AWS Glue supported operators.

For more information, see the list of operators in [Writing JSON custom classifiers](#).

CSV

- **Column delimiter**

A single character or symbol to denote what separates each column entry in the row. Choose the delimiter from the list, or choose Other to enter a custom delimiter.

- **Quote symbol**

A single character or symbol to denote what combines content into a single column value. Must be different from the column delimiter. Choose the quote symbol from the list, or choose Other to enter a custom quote character.

- **Column headings**
Indicates the behavior for how column headings should be detected in the CSV file. You can choose Has headings, No headings, or Detect headings. If your custom CSV file has column headings, enter a comma-delimited list of the column headings.

- **Allow files with single column**

To be classified as CSV, the data must have at least two columns and two rows of data. Use this option to allow the processing of files that contain only one column.

- **Trim whitespace before identifying column values**

This option specifies whether to trim values before identifying the type of column values.

- **Custom datatype**

(Optional) - Enter custom datatypes in a comma-delimited list. The supported datatypes are: “BINARY”, “BOOLEAN”, “DATE”, “DECIMAL”, “DOUBLE”, “FLOAT”, “INT”, “LONG”, “SHORT”, “STRING”, “TIMESTAMP”.

- **CSV Serde**

(Optional) - A SerDe for processing CSV in the classifier, which will be applied in the Data Catalog. Choose from Open CSV SerDe, Lazy Simple SerDe, or None. You can specify the None value when you want the crawler to do the detection.

For more information, see [Writing custom classifiers](#).

**AWS Glue Schema Registry**

**Note**

AWS Glue Schema Registry is not supported in the following Regions in the AWS Glue console: Asia Pacific (Jakarta) and Middle East (UAE).

The AWS Glue Schema Registry is a new feature that allows you to centrally discover, control, and evolve data stream schemas. A schema defines the structure and format of a data record. With AWS Glue Schema Registry, you can manage and enforce schemas on your data streaming applications using convenient integrations with Apache Kafka, Amazon Managed Streaming for Apache Kafka,
Amazon Kinesis Data Streams, Amazon Managed Service for Apache Flink for Apache Flink, and AWS Lambda.

The AWS Glue Schema Registry supports AVRO (v1.10.2) data format, JSON Data format with JSON Schema format for the schema (specifications Draft-04, Draft-06, and Draft-07) with JSON schema validation using the Everit library, Protocol Buffers (Protobuf) versions proto2 and proto3 without support for extensions or groups, and Java language support, with other data formats and languages to come. Supported features include compatibility, schema sourcing via metadata, auto-registration of schemas, IAM compatibility, and optional ZLIB compression to reduce storage and data transfer. AWS Glue Schema Registry is serverless and free to use.

Using a schema as a data format contract between producers and consumers leads to improved data governance, higher quality data, and enables data consumers to be resilient to compatible upstream changes.

The Schema Registry allows disparate systems to share a schema for serialization and deserialization. For example, assume you have a producer and consumer of data. The producer knows the schema when it publishes the data. The Schema Registry supplies a serializer and deserializer for certain systems such as Amazon MSK or Apache Kafka.

For more information, see How the Schema Registry works.

Topics

• Schemas
• Registries
• Schema versioning and compatibility
• Open source Serde libraries
• Quotas of the Schema Registry
• How the Schema Registry works
• Getting started with Schema Registry
• Integrating with AWS Glue Schema Registry
• Migration from a third-party schema registry to AWS Glue Schema Registry

Schemas

A schema defines the structure and format of a data record. A schema is a versioned specification for reliable data publication, consumption, or storage.
In this example schema for Avro, the format and structure are defined by the layout and field names, and the format of the field names is defined by the data types (e.g., string, int).

```json
{
   "type": "record",
   "namespace": "ABC_Organization",
   "name": "Employee",
   "fields": [
      {
         "name": "Name",
         "type": "string"
      },
      {
         "name": "Age",
         "type": "int"
      },
      {
         "name": "address",
         "type": {
            "type": "record",
            "name": "addressRecord",
            "fields": [
               {
                  "name": "street",
                  "type": "string"
               },
               {
                  "name": "zipcode",
                  "type": "int"
               }
            ]
         }
      }
   ]
}
```

In this example JSON Schema Draft-07 for JSON, the format is defined by the JSON Schema organization.

```json
{
   "$id": "https://example.com/person.schema.json",
   "$schema": "http://json-schema.org/draft-07/schema#",
   "title": "Person",
}```
In this example for Protobuf, the format is defined by the version 2 of the Protocol Buffers language (proto2).

```protobuf
syntax = "proto2";

package tutorial;

option java_multiple_files = true;
option java_package = "com.example.tutorial.protos";
option java_outer_classname = "AddressBookProtos";

message Person {
  optional string name = 1;
  optional int32 id = 2;
  optional string email = 3;

  enum PhoneType {
    MOBILE = 0;
    HOME = 1;
    WORK = 2;
  }

  message PhoneNumber {
    optional string number = 1;
    optional PhoneType type = 2 [default = HOME];
  }
}
```
Registries

A registry is a logical container of schemas. Registries allow you to organize your schemas, as well as manage access control for your applications. A registry has an Amazon Resource Name (ARN) to allow you to organize and set different access permissions to schema operations within the registry.

You may use the default registry or create as many new registries as necessary.

AWS Glue Schema Registry Hierarchy

- RegistryName: [string]
  - RegistryArn: [AWS ARN]
  - CreatedTime: [timestamp]
  - UpdatedTime: [timestamp]

- SchemaName: [string]
  - SchemaArn: [AWS ARN]
  - DataFormat: [Avro, Json, or Protobuf]
  - Compatibility: [eg. BACKWARD, BACKWARD_ALL, FORWARD, FORWARD_ALL, FULL, FULL_ALL, NONE, DISABLED]
  - Status: [eg. PENDING, AVAILABLE, DELETING]
  - SchemaCheckpoint: [integer]
  - CreatedTime: [timestamp]
  - UpdatedTime: [timestamp]

- SchemaVersion: [string]
  - SchemaVersionNumber: [integer]
  - Status: [eg. PENDING, AVAILABLE, DELETING, FAILURE]
Schema versioning and compatibility

Each schema can have multiple versions. Versioning is governed by a compatibility rule that is applied on a schema. Requests to register new schema versions are checked against this rule by the Schema Registry before they can succeed.

A schema version that is marked as a checkpoint is used to determine the compatibility of registering new versions of a schema. When a schema first gets created the default checkpoint will be the first version. As the schema evolves with more versions, you can use the CLI/SDK to change the checkpoint to a version of a schema using the `UpdateSchema` API that adheres to a set of constraints. In the console, editing the schema definition or compatibility mode will change the checkpoint to the latest version by default.

Compatibility modes allow you to control how schemas can or cannot evolve over time. These modes form the contract between applications producing and consuming data. When a new version of a schema is submitted to the registry, the compatibility rule applied to the schema name is used to determine if the new version can be accepted. There are 8 compatibility modes: NONE, DISABLED, BACKWARD, BACKWARD_ALL, FORWARD, FORWARD_ALL, FULL, FULL_ALL.

In the Avro data format, fields may be optional or required. An optional field is one in which the Type includes null. Required fields do not have null as the Type.

In the Protobuf data format, fields can be optional (including repeated) or required in proto2 syntax, while all fields are optional (including repeated) in proto3 syntax. All compatibility rules are determined based on the understanding of the Protocol Buffers specifications as well as the guidance from the [Google Protocol Buffers documentation](https://developers.google.com/protocol-buffers).
• **NONE**: No compatibility mode applies. You can use this choice in development scenarios or if you do not know the compatibility modes that you want to apply to schemas. Any new version added will be accepted without undergoing a compatibility check.

• **DISABLED**: This compatibility choice prevents versioning for a particular schema. No new versions can be added.

• **BACKWARD**: This compatibility choice is recommended because it allows consumers to read both the current and the previous schema version. You can use this choice to check compatibility against the previous schema version when you delete fields or add optional fields. A typical use case for BACKWARD is when your application has been created for the most recent schema.

**AVRO**

For example, assume you have a schema defined by first name (required), last name (required), email (required), and phone number (optional).

If your next schema version removes the required email field, this would successfully register. BACKWARD compatibility requires consumers to be able to read the current and previous schema version. Your consumers will be able to read the new schema as the extra email field from old messages is ignored.

If you have a proposed new schema version that adds a required field, for example, zip code, this would not successfully register with BACKWARD compatibility. Your consumers on the new version would not be able to read old messages before the schema change, as they are missing the required zip code field. However, if the zip code field was set as optional in the new schema, then the proposed version would successfully register as consumers can read the old schema without the optional zip code field.

**JSON**

For example, assume you have a schema version defined by first name (optional), last name (optional), email (optional) and phone number (optional).

If your next schema version adds the optional phone number property, this would successfully register as long as the original schema version does not allow any additional properties by setting the `additionalProperties` field to false. BACKWARD compatibility requires consumers to be able to read the current and previous schema version. Your consumers will be able to read data produced with the original schema where phone number property does not exist.
If you have a proposed new schema version that adds the optional phone number property, this would not successfully register with BACKWARD compatibility when the original schema version sets the additionalProperties field to true, namely allowing any additional property. Your consumers on the new version would not be able to read old messages before the schema change, as they cannot read data with phone number property in a different type, for example string instead of number.

**PROTOBUF**

For example, assume you have a schema version defined by a Message Person with **first name** (required), **last name** (required), **email** (required), and **phone number** (optional) fields under proto2 syntax.

Similar to AVRO scenarios, if your next schema version removes the required **email** field, this would successfully register. BACKWARD compatibility requires consumers to be able to read the current and previous schema version. Your consumers will be able to read the new schema as the extra **email** field from old messages is ignored.

If you have a proposed new schema version that adds a required field, for example, **zip code**, this would not successfully register with BACKWARD compatibility. Your consumers on the new version would not be able to read old messages before the schema change, as they are missing the required **zip code** field. However, if the **zip code** field was set as optional in the new schema, then the proposed version would successfully register as consumers can read the old schema without the optional **zip code** field.

In case of a gRPC use case, adding new RPC service or RPC method is a backward compatible change. For example, assume you have a schema version defined by an RPC service MyService with two RPC methods **Foo** and **Bar**.

If your next schema version adds a new RPC method called **Baz**, this would successfully register. Your consumers will be able to read data produced with the original schema according to BACKWARD compatibility since the newly added RPC method **Baz** is optional.

If you have a proposed new schema version that removes the existing RPC method **Foo**, this would not successfully register with BACKWARD compatibility. Your consumers on the new version would not be able to read old messages before the schema change, as they cannot understand and read data with the non-existent RPC method **Foo** in a gRPC application.
• **BACKWARD_ALL**: This compatibility choice allows consumers to read both the current and all previous schema versions. You can use this choice to check compatibility against all previous schema versions when you delete fields or add optional fields.

• **FORWARD**: This compatibility choice allows consumers to read both the current and the subsequent schema versions, but not necessarily later versions. You can use this choice to check compatibility against the last schema version when you add fields or delete optional fields. A typical use case for FORWARD is when your application has been created for a previous schema and should be able to process a more recent schema.

**AVRO**

For example, assume you have a schema version defined by first name (required), last name (required), email (optional).

If you have a new schema version that adds a required field, e.g. phone number, this would successfully register. FORWARD compatibility requires consumers to be able to read data produced with the new schema by using the previous version.

If you have a proposed schema version that deletes the required first name field, this would not successfully register with FORWARD compatibility. Your consumers on the prior version would not be able to read the proposed schemas as they are missing the required first name field. However, if the first name field was originally optional, then the proposed new schema would successfully register as the consumers can read data based on the new schema that doesn't have the optional first name field.

**JSON**

For example, assume you have a schema version defined by first name (optional), last name (optional), email (optional) and phone number (optional).

If you have a new schema version that removes the optional phone number property, this would successfully register as long as the new schema version does not allow any additional properties by setting the `additionalProperties` field to false. FORWARD compatibility requires consumers to be able to read data produced with the new schema by using the previous version.

If you have a proposed schema version that deletes the optional phone number property, this would not successfully register with FORWARD compatibility when the new schema version sets the `additionalProperties` field to true, namely allowing any additional property. Your
consumers on the prior version would not be able to read the proposed schemas as they could have phone number property in a different type, for example string instead of number.

**PROTOBUF**

For example, assume you have a schema version defined by a Message Person with `first name` (required), `last name` (required), `email` (optional) fields under proto2 syntax.

Similar to AVRO scenarios, if you have a new schema version that adds a required field, e.g. `phone number`, this would successfully register. FORWARD compatibility requires consumers to be able to read data produced with the new schema by using the previous version.

If you have a proposed schema version that deletes the required `first name` field, this would not successfully register with FORWARD compatibility. Your consumers on the prior version would not be able to read the proposed schemas as they are missing the required `first name` field. However, if the `first name` field was originally optional, then the proposed new schema would successfully register as the consumers can read data based on the new schema that doesn't have the optional `first name` field.

In case of a gRPC use case, removing an RPC service or RPC method is a forward-compatible change. For example, assume you have a schema version defined by an RPC service `MyService` with two RPC methods `Foo` and `Bar`.

If your next schema version deletes the existing RPC method named `Foo`, this would successfully register according to FORWARD compatibility as the consumers can read data produced with the new schema by using the previous version. If you have a proposed new schema version that adds an RPC method `Baz`, this would not successfully register with FORWARD compatibility. Your consumers on the prior version would not be able to read the proposed schemas as they are missing the RPC method `Baz`.

- **FORWARD_ALL**: This compatibility choice allows consumers to read data written by producers of any new registered schema. You can use this choice when you need to add fields or delete optional fields, and check compatibility against all previous schema versions.

- **FULL**: This compatibility choice allows consumers to read data written by producers using the previous or next version of the schema, but not earlier or later versions. You can use this choice to check compatibility against the last schema version when you add or remove optional fields.

- **FULL_ALL**: This compatibility choice allows consumers to read data written by producers using all previous schema versions. You can use this choice to check compatibility against all previous schema versions when you add or remove optional fields.
Open source Serde libraries

AWS provides open-source Serde libraries as a framework for serializing and deserializing data. The open source design of these libraries allows common open-source applications and frameworks to support these libraries in their projects.

For more details on how the Serde libraries work, see How the Schema Registry works.

Quotas of the Schema Registry

Quotas, also referred to as limits in AWS, are the maximum values for the resources, actions, and items in your AWS account. The following are soft limits for the Schema Registry in AWS Glue.

Registries

You can have up to 10 registries per AWS account per AWS Region.

SchemaVersion

You can have up to 1000 schema versions per AWS account per AWS Region.

Each new schema creates a new schema version, so you can theoretically have up to 1000 schemas per account per region, if each schema has only one version.

Schema version metadata key-value pairs

You can have up to 10 key-value pairs per SchemaVersion per AWS Region.

You can view or set the key-value metadata pairs using the QuerySchemaVersionMetadata action (Python: query_schema_version_metadata) or PutSchemaVersionMetadata action (Python: put_schema_version_metadata) APIs.

The following are hard limits for the Schema Registry in AWS Glue.

Schema payloads

There is a size limit of 170KB for schema payloads.

How the Schema Registry works

This section describes how the serialization and deserialization processes in Schema Registry work.

1. Register a schema: If the schema doesn’t already exist in the registry, the schema can be registered with a schema name equal to the name of the destination (e.g., test_topic,
test_stream, prod_firehose) or the producer can provide a custom name for the schema. Producers can also add key-value pairs to the schema as metadata, such as source: msk_kafka_topic_A, or apply AWS tags to schemas on schema creation. Once a schema is registered the Schema Registry returns the schema version ID to the serializer. If the schema exists but the serializer is using a new version that doesn’t exist, the Schema Registry will check the schema reference a compatibility rule to ensure the new version is compatible before registering it as a new version.

There are two methods of registering a schema: manual registration and auto-registration. You can register a schema manually via the AWS Glue console or CLI/SDK.

When auto-registration is turned on in the serializer settings, automatic registration of the schema will be performed. If REGISTRY_NAME is not provided in the producer configurations, then auto-registration will register the new schema version under the default registry (default-registry). See Installing SerDe Libraries for information on specifying the auto-registration property.

2. Serializer validates data records against the schema: When the application producing data has registered its schema, the Schema Registry serializer validates the record being produced by the application is structured with the fields and data types matching a registered schema. If the schema of the record does not match a registered schema, the serializer will return an exception and the application will fail to deliver the record to the destination.

If no schema exists and if the schema name is not provided via the producer configurations, then the schema is created with the same name as the topic name (if Apache Kafka or Amazon MSK) or stream name (if Kinesis Data Streams).

Every record has a schema definition and data. The schema definition is queried against the existing schemas and versions in the Schema Registry.

By default, producers cache schema definitions and schema version IDs of registered schemas. If a record’s schema version definition does not match what’s available in cache, the producer will attempt to validate the schema with the Schema Registry. If the schema version is valid, then its version ID and definition will be cached locally on the producer.

You can adjust the default cache period (24 hours) within the optional producer properties in step #3 of Installing SerDe Libraries.

3. Serialize and deliver records: If the record complies with the schema, the serializer decorates each record with the schema version ID, serializes the record based on the data format selected
(AVRO, JSON, Protobuf, or other formats coming soon), compresses the record (optional producer configuration), and delivers it to the destination.

4. Consumers deserialize the data: Consumers reading this data use the Schema Registry deserializer library that parses the schema version ID from the record payload.

5. Deserializer may request the schema from the Schema Registry: If this is the first time the deserializer has seen records with a particular schema version ID, using the schema version ID the deserializer will request the schema from the Schema Registry and cache the schema locally on the consumer. If the Schema Registry cannot deserialize the record, the consumer can log the data from the record and move on, or halt the application.

6. The deserializer uses the schema to deserialize the record: When the deserializer retrieves the schema version ID from the Schema Registry, the deserializer decompresses the record (if record sent by producer is compressed) and uses the schema to deserialize the record. The application now processes the record.

Note

Encryption: Your clients communicate with the Schema Registry via API calls which encrypt data in-transit using TLS encryption over HTTPS. Schemas stored in the Schema Registry are always encrypted at rest using a service-managed AWS Key Management Service (AWS KMS) key.

Note

User Authorization: The Schema Registry supports identity-based IAM policies.

Getting started with Schema Registry

The following sections provide an overview and walk you through setting up and using Schema Registry. For information about Schema Registry concepts and components, see AWS Glue Schema Registry.

Topics

- Installing SerDe Libraries
- Using AWS CLI for the AWS Glue Schema Registry APIs
The SerDe libraries provide a framework for serializing and deserializing data.

You will install the open source serializer for your applications producing data (collectively the "serializers"). The serializer handles serialization, compression, and the interaction with the Schema Registry. The serializer automatically extracts the schema from a record being written to a Schema Registry compatible destination, such as Amazon MSK. Likewise, you will install the open source deserializer on your applications consuming data.

To install the libraries on producers and consumers:

1. Inside both the producers' and consumers' pom.xml files, add this dependency via the code below:

   ```xml
   <dependency>
     <groupId>software.amazon.glue</groupId>
   ```
Alternatively, you can clone the AWS Glue Schema Registry Github repository.

2. Setup your producers with these required properties:

```java
props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, 
    StringSerializer.class.getName()); // Can replace StringSerializer.class.getName()
with any other key serializer that you may use
props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, 
    GlueSchemaRegistryKafkaSerializer.class.getName());
props.put(AWSSchemaRegistryConstants.AWS_REGION, "us-east-2");
properties.put(AWSSchemaRegistryConstants.DATA_FORMAT, "JSON"); // OR "AVRO"
```

If there are no existing schemas, then auto-registration needs to be turned on (next step). If you do have a schema that you would like to apply, then replace "my-schema" with your schema name. Also the "registry-name" has to be provided if schema auto-registration is off. If the schema is created under the "default-registry" then registry name can be omitted.

3. (Optional) Set any of these optional producer properties. For detailed property descriptions, see the ReadMe file.

```java
props.put(AWSSchemaRegistryConstants.SCHEMA_AUTO_REGISTRATION_SETTING, "true"); // If not passed, uses "false"
props.put(AWSSchemaRegistryConstants.SCHEMA_NAME, "my-schema"); // If not passed, uses transport name (topic name in case of Kafka, or stream name in case of Kinesis Data Streams)
props.put(AWSSchemaRegistryConstants.REGISTRY_NAME, "my-registry"); // If not passed, uses "default-registry"
props.put(AWSSchemaRegistryConstants.CACHE_TIME_TO_LIVE_MILLIS, "86400000"); // If not passed, uses 86400000 (24 Hours)
props.put(AWSSchemaRegistryConstants.CACHE_SIZE, "10"); // default value is 200
props.put(AWSSchemaRegistryConstants.COMpatibility_SETTING, Compatibility.FULL); // Pass a compatibility mode. If not passed, uses Compatibility.BACKWARD
props.put(AWSSchemaRegistryConstants.DESCRIPTION, "This registry is used for several purposes."); // If not passed, constructs a description
props.put(AWSSchemaRegistryConstants.COMPRESSION_TYPE, 
    AWSSchemaRegistryConstants.COMPRESSION.ZLIB); // If not passed, records are sent uncompressed
```
Auto-registration registers the schema version under the default registry ("default-registry"). If a SCHEMA_NAME is not specified in the previous step, then the topic name is inferred as SCHEMA_NAME.

See Schema versioning and compatibility for more information on compatibility modes.

4. Setup your consumers with these required properties:

```java
props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, StringDeserializer.class.getName());
props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, GlueSchemaRegistryKafkaDeserializer.class.getName());
props.put(AWSSchemaRegistryConstants.AWS_REGION, "us-east-2"); // Pass an AWS Region
props.put(AWSSchemaRegistryConstants.AVRO_RECORD_TYPE, AvroRecordType.GENERIC_RECORD.getName()); // Only required for AVRO data format
```

5. (Optional) Set these optional consumer properties. For detailed property descriptions, see the ReadMe file.

```java
properties.put(AWSSchemaRegistryConstants.CACHE_TIME_TO_LIVE_MILLIS, "86400000"); // If not passed, uses 86400000
props.put(AWSSchemaRegistryConstants.CACHE_SIZE, "10"); // default value is 200
props.put(AWSSchemaRegistryConstants.SECONDARY_DESERIALIZER, "com.amazonaws.services.schemaregistry.deserializers.external.ThirdPartyDeserializer"); // For migration fall back scenario
```

### Using AWS CLI for the AWS Glue Schema Registry APIs

To use the AWS CLI for the AWS Glue Schema Registry APIs, make sure to update your AWS CLI to the latest version.

#### Creating a registry

You may use the default registry or create as many new registries as necessary using the AWS Glue APIs or AWS Glue console.

#### AWS Glue APIs

You can use these steps to perform this task using the AWS Glue APIs.
To add a new registry, use the CreateRegistry action (Python: create_registry) API. Specify RegistryName as the name of the registry to be created, with a max length of 255, containing only letters, numbers, hyphens, underscores, dollar signs, or hash marks.

Specify a Description as a string not more than 2048 bytes long, matching the URI address multi-line string pattern.

Optionally, specify one or more Tags for your registry, as a map array of key-value pairs.

```
aws glue create-registry --registry-name registryName1 --description description
```

When your registry is created it is assigned an Amazon Resource Name (ARN), which you can view in the RegistryArn of the API response. Now that you've created a registry, create one or more schemas for that registry.

**AWS Glue console**

To add a new registry in the AWS Glue console:

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under Data catalog, choose Schema registries.
3. Choose Add registry.
4. Enter a Registry name for the registry, consisting of letters, numbers, hyphens, or underscores. This name cannot be changed.
5. Enter a Description (optional) for the registry.
6. Optionally, apply one or more tags to your registry. Choose Add new tag and specify a Tag key and optionally a Tag value.
7. Choose Add registry.
When your registry is created it is assigned an Amazon Resource Name (ARN), which you can view by choosing the registry from the list in Schema registries. Now that you've created a registry, create one or more schemas for that registry.

**Dealing with a specific record (JAVA POJO) for JSON**

You can use a plain old Java object (POJO) and pass the object as a record. This is similar to the notion of a specific record in AVRO. The [mbknor-jackson-jsonschema](https://mbknor.github.io/jackson-jsonschema/) can generate a JSON schema for the POJO passed. This library can also inject additional information in the JSON schema.

The AWS Glue Schema Registry library uses the injected "className" field in schema to provide a fully classified class name. The "className" field is used by the deserializer to deserialize into an object of that class.

Example class:

```java
@JsonSchemaDescription("This is a car")
@JsonSchemaTitle("Simple Car Schema")
```
```java
@Builder
@AllArgsConstructor
@EqualsAndHashCode
// Fully qualified class name to be added to an additionally injected property
// called className for deserializer to determine which class to deserialize
// the bytes into
@JsonSchemaInject(
    strings = {@JsonSchemaString(path = "className",
        value =
        "com.amazonaws.services.schemaregistry.integrationtests.generators.Car")}
)
// List of annotations to help infer JSON Schema are defined by https://github.com/
mbknor/mbknor-jackson-jsonSchema
public class Car {
    @JsonProperty(required = true)
    private String make;

    @JsonProperty(required = true)
    private String model;

    @JsonSchemaDefault("true")
    @JsonProperty
    public boolean used;

    @JsonSchemaInject(ints = {@JsonSchemaInt(path = "multipleOf", value = 1000)})
    @Max(200000)
    @JsonProperty
    private int miles;

    @Min(2000)
    @JsonProperty
    private int year;

    @JsonProperty
    private Date purchaseDate;

    @JsonProperty
    @JsonFormat(shape = JsonFormat.Shape.NUMBER)
    private Date listedDate;

    @JsonProperty
    private String[] owners;

    @JsonProperty
```
Creating a schema

You can create a schema using the AWS Glue APIs or the AWS Glue console.

AWS Glue APIs

You can use these steps to perform this task using the AWS Glue APIs.

To add a new schema, use the `CreateSchema` action (Python: `create_schema`) API.

Specify a `RegistryId` structure to indicate a registry for the schema. Or, omit the `RegistryId` to use the default registry.

Specify a `SchemaName` consisting of letters, numbers, hyphens, or underscores, and `DataFormat` as **AVRO** or **JSON**. `DataFormat` once set on a schema is not changeable.

Specify a `Compatibility` mode:

- `Backward (recommended)` — Consumer can read both current and previous version.
- `Backward all` — Consumer can read current and all previous versions.
- `Forward` — Consumer can read both current and subsequent version.
- `Forward all` — Consumer can read both current and all subsequent versions.
- `Full` — Combination of Backward and Forward.
- `Full all` — Combination of Backward all and Forward all.
- `None` — No compatibility checks are performed.
- `Disabled` — Prevent any versioning for this schema.

Optionally, specify Tags for your schema.

Specify a `SchemaDefinition` to define the schema in Avro, JSON, or Protobuf data format. See the examples.
For Avro data format:

```
aws glue create-schema --registry-id RegistryName="registryName1" --schema-name testschema --compatibility NONE --data-format AVRO --schema-definition "{"type": "record", "name": "r1", "fields": [ {"name": "f1", "type": "int"}, {"name": "f2", "type": "string"} ]}"  
aws glue create-schema --registry-id RegistryArn="arn:aws:glue:us-east-2:901234567890:registry/registryName1" --schema-name testschema --compatibility NONE --data-format AVRO --schema-definition "{"type": "record", "name": "r1", "fields": [ {"name": "f1", "type": "int"}, {"name": "f2", "type": "string"} ]}"
```

For JSON data format:

```
aws glue create-schema --registry-id RegistryName="registryName" --schema-name testSchemaJson --compatibility NONE --data-format JSON --schema-definition "{"$schema": "http://json-schema.org/draft-07/schema#","type":"object","properties": {"f1":{"type":"string"}}}"  
```

For Protobuf data format:

```
aws glue create-schema --registry-id RegistryName="registryName" --schema-name testSchemaProtobuf --compatibility NONE --data-format PROTOBUF --schema-definition "syntax = "proto2";package org.test;message Basic { optional int32 basic = 1;}"  
aws glue create-schema --registry-id RegistryArn="arn:aws:glue:us-east-2:901234567890:registry/registryName" --schema-name testSchemaProtobuf --compatibility NONE --data-format PROTOBUF --schema-definition "syntax = "proto2";package org.test;message Basic { optional int32 basic = 1;}"  
```

**AWS Glue console**

To add a new schema using the AWS Glue console:
1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.

2. In the navigation pane, under Data catalog, choose Schemas.

3. Choose Add schema.

4. Enter a Schema name, consisting of letters, numbers, hyphens, underscores, dollar signs, or hashmarks. This name cannot be changed.

5. Choose the Registry where the schema will be stored from the drop-down menu. The parent registry cannot be changed post-creation.

6. Leave the Data format as Apache Avro or JSON. This format applies to all versions of this schema.

7. Choose a Compatibility mode.
   - Backward (recommended) — receiver can read both current and previous versions.
   - Backward All — receiver can read current and all previous versions.
   - Forward — sender can write both current and previous versions.
   - Forward All — sender can write current and all previous versions.
   - Full — combination of Backward and Forward.
   - Full All — combination of Backward All and Forward All.
   - None — no compatibility checks performed.
   - Disabled — prevent any versioning for this schema.

8. Enter an optional Description for the registry of up to 250 characters.
9. Optionally, apply one or more tags to your schema. Choose **Add new tag** and specify a **Tag key** and optionally a **Tag value**.

10. In the **First schema version** box, enter or paste your initial schema.

   For Avro format, see [Working with Avro data format](#)

   For JSON format, see [Working with JSON data format](#)
11. Optionally, choose **Add metadata** to add version metadata to annotate or classify your schema version.

12. Choose **Create schema and version**.

The schema is created and appears in the list under **Schemas**.
Working with Avro data format

Avro provides data serialization and data exchange services. Avro stores the data definition in JSON format making it easy to read and interpret. The data itself is stored in binary format.

For information on defining an Apache Avro schema, see the [Apache Avro specification](#).

Working with JSON data format

Data can be serialized with JSON format. [JSON Schema format](#) defines the standard for JSON Schema format.

Updating a schema or registry

Once created you can edit your schemas, schema versions, or registry.

Updating a registry

You can update a registry using the AWS Glue APIs or the AWS Glue console. The name of an existing registry cannot be edited. You can edit the description for a registry.

AWS Glue APIs

To update an existing registry, use the [UpdateRegistry action (Python: update_registry)](#) API.

Specify a RegistryId structure to indicate the registry that you want to update. Pass a Description to change the description for a registry.

```
aws glue update-registry --description updatedDescription --registry-id RegistryArn="arn:aws:glue:us-east-2:901234567890:registry/registryName1"
```

AWS Glue console

To update a registry using the AWS Glue console:

2. In the navigation pane, under **Data catalog**, choose **Schema registries**.
3. Choose a registry from the the list of registries, by checking its box.
4. In the **Action** menu, choose **Edit registry**.
Updating a schema

You can update the description or compatibility setting for a schema.

To update an existing schema, use the UpdateSchema action (Python: update_schema) API.

Specify a SchemaId structure to indicate the schema that you want to update. One of VersionNumber or Compatibility has to be provided.

Code example 11:

```
aws glue update-schema --description testDescription --schema-id
  SchemaName="testSchema1",RegistryName="registryName1" --schema-version-number
  LatestVersion=true --compatibility NONE
```

```
aws glue update-schema --description testDescription --schema-id
  schema-version-number LatestVersion=true --compatibility NONE
```

Adding a schema version

When you add a schema version, you will need to compare the versions to make sure the new schema will be accepted.

To add a new version to an existing schema, use the RegisterSchemaVersion action (Python: register_schema_version) API.

Specify a SchemaId structure to indicate the schema for which you want to add a version, and a SchemaDefinition to define the schema.

Code example 12:

```
aws glue register-schema-version --schema-definition 
  "{"type": "record", "name": "r1", "fields": [ {"name": "f1", "type": "int"}, {"name": "f2", "type": "string\"} ]}" --schema-id
  SchemaArn="arn:aws:glue:us-east-1:901234567890:schema/registryName/testschema"
```

```
aws glue register-schema-version --schema-definition 
  "{"type": "record", "name": "r1", "fields": [ {"name": "f1", "type": "int"}, {"name": "f2", "type": "string\"} ]}" --schema-id
  SchemaName="testschema",RegistryName="testregistry"
```
1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under Data catalog, choose Schemas.
3. Choose the schema from the the list of schemas, by checking its box.
4. Choose one or more schemas from the list, by checking the boxes.
5. In the Action menu, choose Register new version.
6. In the New version box, enter or paste your new schema.
7. Choose Compare with previous version to see differences with the previous schema version.
8. Optionally, choose Add metadata to add version metadata to annotate or classify your schema version. Enter Key and optional Value.
9. Choose Register version.
The schema(s) version appears in the list of versions. If the version changed the compatibility mode, the version will be marked as a checkpoint.

**Example of a schema version comparison**

When you choose to **Compare with previous version**, you will see the previous and new versions displayed together. Changed information will be highlighted as follows:

- **Yellow**: indicates changed information.
Deleting a schema or registry

Deleting a schema, a schema version, or a registry are permanent actions that cannot be undone.

Deleting a schema

You may want to delete a schema when it will no longer be used within a registry, using the AWS Management Console, or the DeleteSchema action (Python: delete_schema) API.

Deleting one or more schemas is a permanent action that cannot be undone. Make sure that the schema or schemas are no longer needed.

To delete a schema from the registry, call the DeleteSchema action (Python: delete_schema) API, specifying the SchemaId structure to identify the schema.
For example:

```
```

```
aws glue delete-schema --schema-id SchemaName="TestSchema6-deleteschemabyname",RegistryName="default-registry"
```

**AWS Glue console**

To delete a schema from the AWS Glue console:

2. In the navigation pane, under **Data catalog**, choose **Schema registries**.
3. Choose the registry that contains your schema from the list of registries.
4. Choose one or more schemas from the list, by checking the boxes.
5. In the **Action** menu, choose **Delete schema**.
6. Enter the text **Delete** in the field to confirm deletion.
7. Choose **Delete**.

The schema(s) you specified are deleted from the registry.

**Deleting a schema version**

As schemas accumulate in the registry, you may want to delete unwanted schema versions using the AWS Management Console, or the [DeleteSchemaVersions action](https://boto3.amazonaws.com/v1/documentation/api/latest/reference/services/glue.html#Glue.Client.delete_schema_versions) API. Deleting one or more schema versions is a permanent action that cannot be undone. Make sure that the schema versions are no longer needed.

When deleting schema versions, take note of the following constraints:

- You cannot delete a check-pointed version.
- The range of contiguous versions cannot be more than 25.
- The latest schema version must not be in a pending state.
Specify the SchemaId structure to identify the schema, and specify Versions as a range of versions to delete. For more information on specifying a version or range of versions, see `DeleteRegistry action (Python: delete_registry)`. The schema versions you specified are deleted from the registry.

Calling the `ListSchemaVersions action (Python: list_schema_versions)` API after this call will list the status of the deleted versions.

For example:

```bash
aws glue delete-schema-versions --schema-id
  SchemaName="TestSchema6",RegistryName="default-registry" --versions "1-1"
```

```bash
```

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under Data catalog, choose Schema registries.
3. Choose the registry that contains your schema from the the list of registries.
4. Choose one or more schemas from the list, by checking the boxes.
5. In the Action menu, choose Delete schema.
6. Enter the text Delete in the field to confirm deletion.
7. Choose Delete.

The schema versions you specified are deleted from the registry.

**Deleting a registry**

You may want to delete a registry when the schemas it contains should no longer be organized under that registry. You will need to reassign those schemas to another registry.

Deleting one or more registries is a permanent action that cannot be undone. Make sure that the registry or registries no longer needed.

The default registry can be deleted using the AWS CLI.

**AWS Glue API**
To delete the entire registry including the schema and all of its versions, call the `DeleteRegistry` action (Python: `delete_registry`) API. Specify a `RegistryId` structure to identify the registry.

For example:

```
aws glue delete-registry --registry-id RegistryArn="arn:aws:glue:us-east-2:901234567890:registry/registryName1"
```

```
aws glue delete-registry --registry-id RegistryName="TestRegistry-deletebyname"
```

To get the status of the delete operation, you can call the `GetRegistry` API after the asynchronous call.

**AWS Glue console**

To delete a registry from the AWS Glue console:

2. In the navigation pane, under **Data catalog**, choose **Schema registries**.
3. Choose a registry from the list, by checking a box.
4. In the **Action** menu, choose **Delete registry**.
5. Enter the text **Delete** in the field to confirm deletion.
6. Choose **Delete**.

The registries you selected are deleted from AWS Glue.

**IAM examples for serializers**

**Note**

AWS managed policies grant necessary permissions for common use cases. For information on using managed policies to manage the schema registry, see [AWS managed (predefined) policies for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/how-to-collaborate.html).

For serializers, you should create a minimal policy similar to that below to give you the ability to find the `schemaVersionId` for a given schema definition. Note, you should have read permissions...
on the registry in order to read the schemas in the registry. You can limit the registries that can be read by using the Resource clause.

**Code example 13:**

```json
{
    "Sid" : "GetSchemaByDefinition",
    "Effect" : "Allow",
    "Action" : [
        "glue:GetSchemaByDefinition"
    ],
                   schemaname-1",
                   schemaname-2"
    ]
}
```

Further, you can also allow producers to create new schemas and versions by including the following extra methods. Note, you should be able to inspect the registry in order to add/remove/evolve the schemas inside it. You can limit the registries that can be inspected by using the Resource clause.

**Code example 14:**

```json
{
    "Sid" : "RegisterSchemaWithMetadata",
    "Effect" : "Allow",
    "Action" : [
        "glue:GetSchemaByDefinition",
        "glue:CreateSchema",
        "glue:RegisterSchemaVersion",
        "glue:PutSchemaVersionMetadata",
    ],
                   schemaname-1",
                   schemaname-2"
    ]
}
```
IAM examples for deserializers

For deserializers (consumer side), you should create a policy similar to that below to allow the deserializer to fetch the schema from the Schema Registry for deserialization. Note, you should be able to inspect the registry in order to fetch the schemas inside it.

Code example 15:

```json
{
   "Sid" : "GetSchemaVersion",
   "Effect" : "Allow",
   "Action" :
   [        
      "glue:GetSchemaVersion"
   ],
   "Resource" : ["*"]
}
```

Private connectivity using AWS PrivateLink

You can use AWS PrivateLink to connect your data producer's VPC to AWS Glue by defining an interface VPC endpoint for AWS Glue. When you use a VPC interface endpoint, communication between your VPC and AWS Glue is conducted entirely within the AWS network. For more information, see [Using AWS Glue with VPC Endpoints](#).

Accessing Amazon CloudWatch metrics

Amazon CloudWatch metrics are available as part of CloudWatch's free tier. You can access these metrics in the CloudWatch Console. API-Level metrics include CreateSchema (Success and Latency), GetSchemaByDefinition, (Success and Latency), GetSchemaVersion (Success and Latency), RegisterSchemaVersion (Success and Latency), PutSchemaVersionMetadata (Success and Latency). Resource-level metrics include Registry.ThrottledByLimit, SchemaVersion.ThrottledByLimit, SchemaVersion.Size.

Sample AWS CloudFormation template for Schema Registry

The following is a sample template for creating Schema Registry resources in AWS CloudFormation. To create this stack in your account, copy the above template into a file SampleTemplate.yaml, and run the following command:
This example uses AWS::Glue::Registry to create a registry, AWS::Glue::Schema to create a schema, AWS::Glue::SchemaVersion to create a schema version, and AWS::Glue::SchemaVersionMetadata to populate schema version metadata.

Description: "A sample CloudFormation template for creating Schema Registry resources."

Resources:

ABCRegistry:
  Type: "AWS::Glue::Registry"
  Properties:
    Name: "ABCSchemaRegistry"
    Description: "ABC Corp. Schema Registry"
    Tags:
      - Key: "Project"
        Value: "Foo"

ABCSchema:
  Type: "AWS::Glue::Schema"
  Properties:
    Registry:
      Arn: !Ref ABCRegistry
      Name: "TestSchema"
      Compatibility: "NONE"
      DataFormat: "AVRO"
      SchemaDefinition: >
        {"namespace":"foo.avro","type":"record","name":"user","fields":
          [{"name":"name","type":"string"},{"name":"favorite_number","type":"int"}]
        }
    Tags:
      - Key: "Project"
        Value: "Foo"

SecondSchemaVersion:
  Type: "AWS::Glue::SchemaVersion"
  Properties:
    Schema:
      SchemaArn: !Ref ABCSchema
      SchemaDefinition: >
        {"namespace":"foo.avro","type":"record","name":"user","fields":
          [{"name":"status","type":"string", "default":"ON"}, {"name":"name","type":"string"},
          {"name":"favorite_number","type":"int"}]
        }

FirstSchemaVersionMetadata:
  Type: "AWS::Glue::SchemaVersionMetadata"
Integrating with AWS Glue Schema Registry

These sections describe integrations with AWS Glue Schema Registry. The examples in these section show a schema with AVRO data format. For more examples, including schemas with JSON data format, see the integration tests and ReadMe information in the AWS Glue Schema Registry open source repository.

Topics

- Use case: Connecting Schema Registry to Amazon MSK or Apache Kafka
- Use case: Integrating Amazon Kinesis Data Streams with the AWS Glue Schema Registry
- Use case: Amazon Managed Service for Apache Flink for Apache Flink
- Use Case: Integration with AWS Lambda
- Use case: AWS Glue Data Catalog
- Use case: AWS Glue streaming
- Use case: Apache Kafka Streams
- Use case: Apache Kafka Connect

Use case: Connecting Schema Registry to Amazon MSK or Apache Kafka

Let's assume you are writing data to an Apache Kafka topic, and you can follow these steps to get started.

1. Create an Amazon Managed Streaming for Apache Kafka (Amazon MSK) or Apache Kafka cluster with at least one topic. If creating an Amazon MSK cluster, you can use the AWS Management
Console. Follow these instructions: [Getting Started Using Amazon MSK](#) in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

2. Follow the [Installing SerDe Libraries](#) step above.

3. To create schema registries, schemas, or schema versions, follow the instructions under the [Getting started with Schema Registry](#) section of this document.

4. Start your producers and consumers to use the Schema Registry to write and read records to/from the Amazon MSK or Apache Kafka topic. Example producer and consumer code can be found in [the ReadMe file](#) from the Serde libraries. The Schema Registry library on the producer will automatically serialize the record and decorate the record with a schema version ID.

5. If the schema of this record has been inputted, or if auto-registration is turned on, then the schema will have been registered in the Schema Registry.

6. The consumer reading from the Amazon MSK or Apache Kafka topic, using the AWS Glue Schema Registry library, will automatically lookup the schema from the Schema Registry.

**Use case: Integrating Amazon Kinesis Data Streams with the AWS Glue Schema Registry**

This integration requires that you have an existing Amazon Kinesis data stream. For more information, see [Getting Started with Amazon Kinesis Data Streams](#) in the *Amazon Kinesis Data Streams Developer Guide*.

There are two ways that you can interact with data in a Kinesis data stream.

- Through the Kinesis Producer Library (KPL) and Kinesis Client Library (KCL) libraries in Java. Multi-language support is not provided.

- Through the `PutRecords`, `PutRecord`, and `GetRecords` Kinesis Data Streams APIs available in the AWS SDK for Java.

If you currently use the KPL/KCL libraries, we recommend continuing to use that method. There are updated KCL and KPL versions with Schema Registry integrated, as shown in the examples. Otherwise, you can use the sample code to leverage the AWS Glue Schema Registry if using the KDS APIs directly.

Schema Registry integration is only available with KPL v0.14.2 or later and with KCL v2.3 or later. Schema Registry integration with JSON data format is available with KPL v0.14.8 or later and with KCL v2.3.6 or later.
// Example JSON Record, you can construct a AVRO record also
private static final JsonDataWithSchema record =
        JsonDataWithSchema.builder(schemaString, payloadString);
private static final DataFormat dataFormat = DataFormat.JSON;

//Configurations for Schema Registry
GlueSchemaRegistryConfiguration gsrConfig = new GlueSchemaRegistryConfiguration("us-
        east-1");

GlueSchemaRegistrySerializer glueSchemaRegistrySerializer =
        new GlueSchemaRegistrySerializerImpl(awsCredentialsProvider, gsrConfig);
GlueSchemaRegistryDataFormatSerializer dataFormatSerializer =
        new GlueSchemaRegistrySerializerFactory().getInstance(dataFormat, gsrConfig);

Schema gsrSchema =
        new Schema(dataFormatSerializer.getSchemaDefinition(record), dataFormat.name(),
                "MySchema");

byte[] serializedBytes = dataFormatSerializer.serialize(record);

byte[] gsrEncodedBytes = glueSchemaRegistrySerializer.encode(streamName, gsrSchema,
        serializedBytes);

PutRecordRequest putRecordRequest = PutRecordRequest.builder()
        .streamName(streamName)
        .partitionKey("partitionKey")
        .data(SdkBytes.fromByteArray(gsrEncodedBytes))
        .build();
shardId = kinesisClient.putRecord(putRecordRequest)
        .get()
        .shardId();

GlueSchemaRegistryDeserializer glueSchemaRegistryDeserializer = new
        GlueSchemaRegistryDeserializerImpl(awsCredentialsProvider, gsrConfig);

GlueSchemaRegistryDataFormatDeserializer gsrDataFormatDeserializer =
        glueSchemaRegistryDeserializerFactory.getInstance(dataFormat, gsrConfig);

GetShardIteratorRequest getShardIteratorRequest = GetShardIteratorRequest.builder()
        .streamName(streamName)
String shardIterator = kinesisClient.getShardIterator(getShardIteratorRequest)
    .get()
    .shardIterator();

GetRecordsRequest getRecordRequest = GetRecordsRequest.builder()
    .shardIterator(shardIterator)
    .build();
GetRecordsResponse recordsResponse = kinesisClient.getRecords(getRecordRequest)
    .get();

List<Object> consumerRecords = new ArrayList<>();
List<Record> recordsFromKinesis = recordsResponse.records();

for (int i = 0; i < recordsFromKinesis.size(); i++) {
    byte[] consumedBytes = recordsFromKinesis.get(i)
        .data()
        .asByteArray();

    Schema gsrSchema = glueSchemaRegistryDeserializer.getSchema(consumedBytes);
    Object decodedRecord = gsrDataFormatDeserializer.deserialize(ByteBuffer.wrap(consumedBytes),
        gsrSchema.getSchemaDefinition());
    consumerRecords.add(decodedRecord);
}

**Interacting with data using the KPL/KCL libraries**

This section describes integrating Kinesis Data Streams with Schema Registry using the KPL/KCL libraries. For more information on using KPL/KCL, see [Developing Producers Using the Amazon Kinesis Producer Library](https://docs.aws.amazon.com/kinesis/latest/deployguide/kinesis-producer-library.html) in the *Amazon Kinesis Data Streams Developer Guide*.

**Setting up the Schema Registry in KPL**

1. Define the schema definition for the data, data format and schema name authored in the AWS Glue Schema Registry.
2. Optionally configure the GlueSchemaRegistryConfiguration object.
3. Pass the schema object to the addUserRecord API.
private static final String SCHEMA_DEFINITION = "{namespace": "example.avro",
+ "  "type": "record",
+  "name": "User",
+  "fields": [
+    {"name": "name", "type": "string"},
+    {"name": "favorite_number", "type": ["int", "null"]},
+    {"name": "favorite_color", "type": ["string", "null"]}
+  ]"
+}"

KinesisProducerConfiguration config = new KinesisProducerConfiguration();
config.setRegion("us-west-1")

//[Optional] configuration for Schema Registry.

GlueSchemaRegistryConfiguration schemaRegistryConfig =
new GlueSchemaRegistryConfiguration("us-west-1");

schemaRegistryConfig.setCompression(true);

config.setGlueSchemaRegistryConfiguration(schemaRegistryConfig);

//Optional configuration ends.

final KinesisProducer producer =
    new KinesisProducer(config);

final ByteBuffer data = getDataToSend();

com.amazonaws.services.schemaregistry.common.Schema gsrSchema =
    new Schema(SCHEMA_DEFINITION, DataFormat.AVRO.toString(), "demoSchema");

ListenableFuture<UserRecordResult> f = producer.addUserRecord(
    config.getStreamName(), TIMESTAMP, Utils.randomExplicitHashKey(), data, gsrSchema);

private static ByteBuffer getDataToSend() {
  org.apache.avro.Schema avroSchema =
    new org.apache.avro.Schema.Parser().parse(SCHEMA_DEFINITION);

  GenericRecord user = new GenericData.Record(avroSchema);
  user.put("name", "Emily");
  user.put("favorite_number", 32);
  user.put("favorite_color", "green");

  return ByteBuffer.wrap(user.toData());
}
ByteArrayOutputStream outBytes = new ByteArrayOutputStream();
Encoder encoder = EncoderFactory.get().directBinaryEncoder(outBytes, null);
new GenericDatumWriter<>(avroSchema).write(user, encoder);
encoder.flush();
return ByteBuffer.wrap(outBytes.toByteArray());

Setting up the Kinesis client library

You will develop your Kinesis Client Library consumer in Java. For more information, see Developing a Kinesis Client Library Consumer in Java in the Amazon Kinesis Data Streams Developer Guide.

2. Pass the GlueSchemaRegistryDeserializer to retrievalConfig.glueSchemaRegistryDeserializer.
3. Access the schema of incoming messages by calling kinesisClientRecord.getSchema().

GlueSchemaRegistryConfiguration schemaRegistryConfig =
    new GlueSchemaRegistryConfiguration(this.region.toString());

GlueSchemaRegistryDeserializer glueSchemaRegistryDeserializer =
    new GlueSchemaRegistryDeserializerImpl(DefaultCredentialsProvider.builder().build(),
    schemaRegistryConfig);

RetrievalConfig retrievalConfig =
cfgsBuilder.retrievalConfig().retrievalSpecificConfig(new
PollingConfig(streamName, kinesisClient));
retrievalConfig.glueSchemaRegistryDeserializer(glueSchemaRegistryDeserializer);

Scheduler scheduler = new Scheduler(
    cfgsBuilder.checkpointConfig(),
    cfgsBuilder.coordinatorConfig(),
    cfgsBuilder.leaseManagementConfig(),
    cfgsBuilder.lifecycleConfig(),
    cfgsBuilder.metricsConfig(),
    cfgsBuilder.processorConfig(),
    retrievalConfig)
public void processRecords(ProcessRecordsInput processRecordsInput) {
    MDC.put(SHARD_ID_MDC_KEY, shardId);
    try {
        log.info("Processing {} record(s)",
            processRecordsInput.records().size());
        processRecordsInput.records().
            forEach(
                r ->
                    log.info("Processed record pk: {} -- Seq: {} : data {} with
                        schema: {}",
                        r.partitionKey(),
                        r.sequenceNumber(),
                        recordToAvroObj(r).toString(),
                        r.getSchema()));
    } catch (Throwable t) {
        log.error("Caught throwable while processing records. Aborting.");
        Runtime.getRuntime().halt(1);
    } finally {
        MDC.remove(SHARD_ID_MDC_KEY);
    }
}

private GenericRecord recordToAvroObj(KinesisClientRecord r) {
    byte[] data = new byte[r.data().remaining()];
    r.data().get(data, 0, data.length);
    org.apache.avro.Schema schema = new
        org.apache.avro.Schema.Parser().parse(r.schema().getSchemaDefinition());
    DatumReader datumReader = new GenericDatumReader<>(schema);
    BinaryDecoder binaryDecoder = DecoderFactory.get().binaryDecoder(data, 0,
        data.length, null);
    return (GenericRecord) datumReader.read(null, binaryDecoder);
}

### Interacting with data using the Kinesis Data Streams APIs

This section describes integrating Kinesis Data Streams with Schema Registry using the Kinesis Data Streams APIs.

1. Update these Maven dependencies:

```xml
<dependencyManagement>
```
2. In the producer, add schema header information using the PutRecords or PutRecord API in Kinesis Data Streams.

```java
//The following lines add a Schema Header to the record
com.amazonaws.services.schemaregistry.common.Schema awsSchema =
    new com.amazonaws.services.schemaregistry.common.Schema(schemaDefinition,
        DataFormat.AVRO.name(),
        schemaName);
GlueSchemaRegistrySerializerImpl glueSchemaRegistrySerializer =
    new GlueSchemaRegistrySerializerImpl(DefaultCredentialsProvider.builder().build(), new
    GlueSchemaRegistryConfiguration(getConfigs()));
byte[] recordWithSchemaHeader =
```
3. In the producer, use the PutRecords or PutRecord API to put the record into the data stream.
4. In the consumer, remove the schema record from the header, and serialize an Avro schema record.

```java
//The following lines remove Schema Header from record
GlueSchemaRegistryDeserializerImpl glueSchemaRegistryDeserializer =
    new GlueSchemaRegistryDeserializerImpl(DefaultCredentialsProvider.builder().build(),
    getconfigs());
byte[] recordWithSchemaHeaderBytes = new
byte[recordWithSchemaHeader.remaining()];
    recordWithSchemaHeader.get(recordWithSchemaHeaderBytes, 0,
    recordWithSchemaHeaderBytes.length);
com.amazonaws.services.schemaregistry.common.Schema awsSchema =
    glueSchemaRegistryDeserializer.getSchema(recordWithSchemaHeaderBytes);
byte[] record =
    glueSchemaRegistryDeserializer.getData(recordWithSchemaHeaderBytes);

//The following lines serialize an AVRO schema record
if (DataFormat.AVRO.name().equals(awsSchema.getDataFormat())) {
    Schema avroSchema = new
    Object genericRecord = convertBytesToRecord(avroSchema, record);
    System.out.println(genericRecord);
}
```

**Interacting with data using the Kinesis Data Streams APIs**

The following is example code for using the PutRecords and GetRecords APIs.

```java
//Full sample code
import
    com.amazonaws.services.schemaregistry.deserializers.GlueSchemaRegistryDeserializerImpl;
import
    com.amazonaws.services.schemaregistry.serializers.GlueSchemaRegistrySerializerImpl;
import com.amazonaws.services.schemaregistry.utils.AVROUtils;
import com.amazonaws.services.schemaregistry.utils.AWSSchemaRegistryConstants;
import org.apache.avro.Schema;
import org.apache.avro.generic.GenericData;
```
import org.apache.avro.generic.GenericDatumReader;
import org.apache.avro.generic.GenericDatumWriter;
import org.apache.avro.generic.GenericRecord;
import org.apache.avro.io.Decoder;
import org.apache.avro.io.DecoderFactory;
import org.apache.avro.io.Encoder;
import org.apache.avro.io.EncoderFactory;
import software.amazon.awssdk.auth.credentials.DefaultCredentialsProvider;
import software.amazon.awssdk.services.glue.model.DataFormat;
import java.io.ByteArrayOutputStream;
import java.io.File;
import java.io.IOException;
import java.nio.ByteBuffer;
import java.util.Collections;
import java.util.HashMap;
import java.util.Map;

public class PutAndGetExampleWithEncodedData {
    static final String regionName = "us-east-2";
    static final String streamName = "testStream1";
    static final String schemaName = "User-Topic";
    static final String AVRO_USER_SCHEMA_FILE = "src/main/resources/user.avsc";
    KinesisApi kinesisApi = new KinesisApi();

    void runSampleForPutRecord() throws IOException {
        Object testRecord = getTestRecord();
        byte[] recordAsBytes = convertRecordToBytes(testRecord);
        String schemaDefinition = AVROUtils.getInstance().getSchemaDefinition(testRecord);

        //The following lines add a Schema Header to a record
        com.amazonaws.services.schemaregistry.common.Schema awsSchema =
            new com.amazonaws.services.schemaregistry.common.Schema(schemaDefinition,
                DataFormat.AVRO.name(),
                schemaName);

        GlueSchemaRegistrySerializerImpl glueSchemaRegistrySerializer =
            new GlueSchemaRegistrySerializerImpl(DefaultCredentialsProvider.builder().build(), new
                GlueSchemaRegistryConfiguration(regionName));

        byte[] recordWithSchemaHeader =
            glueSchemaRegistrySerializer.encode(streamName, awsSchema, recordAsBytes);
    
}
//Use PutRecords api to pass a list of records
kinesisApi.putRecords(Collections.singletonList(recordWithSchemaHeader),
streamName, regionName);

//OR
//Use PutRecord api to pass single record
//kinesisApi.putRecord(recordWithSchemaHeader, streamName, regionName);
}

byte[] runSampleForGetRecord() throws IOException {
    ByteBuffer recordWithSchemaHeader = kinesisApi.getRecords(streamName,
    regionName);

    //The following lines remove the schema registry header
    GlueSchemaRegistryDeserializerImpl glueSchemaRegistryDeserializer =
    new
    GlueSchemaRegistryDeserializerImpl(DefaultCredentialsProvider.builder().build(), new
    GlueSchemaRegistryConfiguration(regionName));
    byte[] recordWithSchemaHeaderBytes = new
    byte[recordWithSchemaHeader.remaining()];
    recordWithSchemaHeader.get(recordWithSchemaHeaderBytes, 0,
    recordWithSchemaHeaderBytes.length);

    com.amazonaws.services.schemaregistry.common.Schema awsSchema =
    glueSchemaRegistryDeserializer.getSchema(recordWithSchemaHeaderBytes);

    byte[] record =
    glueSchemaRegistryDeserializer.getData(recordWithSchemaHeaderBytes);

    //The following lines serialize an AVRO schema record
    if (DataFormat.AVRO.name().equals(awsSchema.getDataFormat())) {
        Schema avroSchema = new
        Object genericRecord = convertBytesToRecord(avroSchema, record);
        System.out.println(genericRecord);
    }

    return record;
}

private byte[] convertRecordToBytes(final Object record) throws IOException {
    ByteArrayOutputStream recordAsBytes = new ByteArrayOutputStream();
    Encoder encoder = EncoderFactory.get().directBinaryEncoder(recordAsBytes,
    null);
GenericDatumWriter datumWriter = new GenericDatumWriter<>(AVROUtils.getInstance().getSchema(record));
    datumWriter.write(record, encoder);
    encoder.flush();
    return recordAsBytes.toByteArray();
}

private GenericRecord convertBytesToRecord(Schema avroSchema, byte[] record) throws IOException {
    final GenericDatumReader<GenericRecord> datumReader = new GenericDatumReader<>(avroSchema);
    Decoder decoder = DecoderFactory.get().binaryDecoder(record, null);
    GenericRecord genericRecord = datumReader.read(null, decoder);
    return genericRecord;
}

private Map<String, String> getMetadata() {
    Map<String, String> metadata = new HashMap<>();
    metadata.put("event-source-1", "topic1");
    metadata.put("event-source-2", "topic2");
    metadata.put("event-source-3", "topic3");
    metadata.put("event-source-4", "topic4");
    metadata.put("event-source-5", "topic5");
    return metadata;
}

private GlueSchemaRegistryConfiguration getConfigs() {
    GlueSchemaRegistryConfiguration configs = new GlueSchemaRegistryConfiguration(regionName);
    configs.setSchemaName(schemaName);
    configs.setAutoRegistration(true);
    configs.setMetadata(getMetadata());
    return configs;
}

private Object getTestRecord() throws IOException {
    GenericRecord genericRecord;
    Schema avroSchema = parser.parse(new File(AVRO_USER_SCHEMA_FILE));

    genericRecord = new GenericData.Record(avroSchema);
    genericRecord.put("name", "testName");
    genericRecord.put("favorite_number", 99);
    genericRecord.put("favorite_color", "red");
Use case: Amazon Managed Service for Apache Flink for Apache Flink

Apache Flink is a popular open source framework and distributed processing engine for stateful computations over unbounded and bounded data streams. Amazon Managed Service for Apache Flink for Apache Flink is a fully managed AWS service that enables you to build and manage Apache Flink applications to process streaming data.

Open source Apache Flink provides a number of sources and sinks. For example, predefined data sources include reading from files, directories, and sockets, and ingesting data from collections and iterators. Apache Flink DataStream Connectors provide code for Apache Flink to interface with various third-party systems, such as Apache Kafka or Kinesis as sources and/or sinks.

For more information, see Amazon Kinesis Data Analytics Developer Guide.

Apache Flink Kafka connector

Apache Flink provides an Apache Kafka data stream connector for reading data from and writing data to Kafka topics with exactly-once guarantees. Flink's Kafka consumer, FlinkKafkaConsumer, provides access to read from one or more Kafka topics. Apache Flink's Kafka Producer, FlinkKafkaProducer, allows writing a stream of records to one or more Kafka topics. For more information, see Apache Kafka Connector.

Apache Flink Kinesis streams Connector

The Kinesis data stream connector provides access to Amazon Kinesis Data Streams. The FlinkKinesisConsumer is an exactly-once parallel streaming data source that subscribes to multiple Kinesis streams within the same AWS service region, and can transparently handle re-sharding of streams while the job is running. Each subtask of the consumer is responsible for fetching data records from multiple Kinesis shards. The number of shards fetched by each subtask will change as shards are closed and created by Kinesis. The FlinkKinesisProducer uses Kinesis Producer Library (KPL) to put data from an Apache Flink stream into a Kinesis stream. For more information, see Amazon Kinesis Streams Connector.

For more information, see the AWS Glue Schema Github repository.
Integrating with Apache Flink

The SerDes library provided with Schema Registry integrates with Apache Flink. To work with Apache Flink, you are required to implement `SerializationSchema` and `DeserializationSchema` interfaces called `GlueSchemaRegistryAvroSerializationSchema` and `GlueSchemaRegistryAvroDeserializationSchema`, which you can plug into Apache Flink connectors.

Adding an AWS Glue Schema Registry dependency into the Apache Flink application

To set up the integration dependencies to AWS Glue Schema Registry in the Apache Flink application:

1. Add the dependency to the `pom.xml` file.

```xml
<dependency>
    <groupId>software.amazon.glue</groupId>
    <artifactId>schema-registry-flink-serde</artifactId>
    <version>1.0.0</version>
</dependency>
```

Integrating Kafka or Amazon MSK with Apache Flink

You can use Managed Service for Apache Flink for Apache Flink, with Kafka as a source or Kafka as a sink.

Kafka as a source

The following diagram shows integrating Kinesis Data Streams with Managed Service for Apache Flink for Apache Flink, with Kafka as a source.
Kafka as a sink

The following diagram shows integrating Kinesis Data Streams with Managed Service for Apache Flink for Apache Flink, with Kafka as a sink.

To integrate Kafka (or Amazon MSK) with Managed Service for Apache Flink for Apache Flink, with Kafka as a source or Kafka as a sink, make the code changes below. Add the bolded code blocks to your respective code in the analogous sections.

If Kafka is the source, then use the deserializer code (block 2). If Kafka is the sink, use the serializer code (block 3).

```java
StreamExecutionEnvironment env = StreamExecutionEnvironment.getExecutionEnvironment();
```
String topic = "topic";
Properties properties = new Properties();
properties.setProperty("bootstrap.servers", "localhost:9092");
properties.setProperty("group.id", "test");

// block 1
Map<String, Object> configs = new HashMap<>();
configs.put(AWSSchemaRegistryConstants.AWS_REGION, "aws-region");
configs.put(AWSSchemaRegistryConstants.SCHEMA_AUTO_REGISTRATION_SETTING, true);
configs.put(AWSSchemaRegistryConstants.AVRO_RECORD_TYPE, AvroRecordType.GENERIC_RECORD.getName());

FlinkKafkaConsumer<GenericRecord> consumer = new FlinkKafkaConsumer<>(
    topic,
    // block 2
    GlueSchemaRegistryAvroDeserializationSchema.forGeneric(schema, configs),
    properties);

FlinkKafkaProducer<GenericRecord> producer = new FlinkKafkaProducer<>(
    topic,
    // block 3
    GlueSchemaRegistryAvroSerializationSchema.forGeneric(schema, topic, configs),
    properties);

DataStream<GenericRecord> stream = env.addSource(consumer);
stream.addSink(producer);
env.execute();

**Integrating Kinesis Data Streams with Apache Flink**

You can use Managed Service for Apache Flink for Apache Flink with Kinesis Data Streams as a source or a sink.

**Kinesis Data Streams as a source**

The following diagram shows integrating Kinesis Data Streams with Managed Service for Apache Flink for Apache Flink, with Kinesis Data Streams as a source.
Kinesis Data Streams as a sink

The following diagram shows integrating Kinesis Data Streams with Managed Service for Apache Flink for Apache Flink, with Kinesis Data Streams as a sink.

To integrate Kinesis Data Streams with Managed Service for Apache Flink for Apache Flink, with Kinesis Data Streams as a source or Kinesis Data Streams as a sink, make the code changes below. Add the bolded code blocks to your respective code in the analogous sections.

If Kinesis Data Streams is the source, use the deserializer code (block 2). If Kinesis Data Streams is the sink, use the serializer code (block 3).

```java
StreamExecutionEnvironment env = StreamExecutionEnvironment.getExecutionEnvironment();
```
String streamName = "stream";
Properties consumerConfig = new Properties();
consumerConfig.put(AWSConfigConstants.AWS_REGION, "aws-region");
consumerConfig.put(AWSConfigConstants.AWS_ACCESS_KEY_ID, "aws_access_key_id");
consumerConfig.put(AWSConfigConstants.AWS_SECRET_ACCESS_KEY, "aws_secret_access_key");
consumerConfig.put(ConsumerConfigConstants.STREAM_INITIAL_POSITION, "LATEST");

// block 1
Map<String, Object> configs = new HashMap<>();
configs.put(AWSSchemaRegistryConstants.AWS_REGION, "aws-region");
configs.put(AWSSchemaRegistryConstants.SCHEMA_AUTO_REGISTRATION_SETTING, true);
configs.put(AWSSchemaRegistryConstants.AVRO_RECORD_TYPE, AvroRecordType.GENERIC_RECORD.getName());

FlinkKinesisConsumer<GenericRecord> consumer = new FlinkKinesisConsumer<>(
    streamName,
    // block 2
    GlueSchemaRegistryAvroDeserializationSchema.forGeneric(schema, configs),
    properties);

FlinkKinesisProducer<GenericRecord> producer = new FlinkKinesisProducer<>(
    // block 3
    GlueSchemaRegistryAvroSerializationSchema.forGeneric(schema, topic, configs),
    properties);
producer.setDefaultStream(streamName);
producer.setDefaultPartition("0");

DataStream<GenericRecord> stream = env.addSource(consumer);
stream.addSink(producer);
env.execute();

Use Case: Integration with AWS Lambda

To use an AWS Lambda function as an Apache Kafka/Amazon MSK consumer and deserialize Avro-encoded messages using AWS Glue Schema Registry, visit the [MSK Labs page](https://aws.amazon.com/marketplace/product/2216).

Use case: AWS Glue Data Catalog

AWS Glue tables support schemas that you can specify manually or by reference to the AWS Glue Schema Registry. The Schema Registry integrates with the Data Catalog to allow you to optionally use schemas stored in the Schema Registry when creating or updating AWS Glue tables or partitions in the Data Catalog. To identify a schema definition in the Schema Registry, at a minimum, you need to know the ARN of the schema it is part of. A schema version of a schema,
which contains a schema definition, can be referenced by its UUID or version number. There is always one schema version, the "latest" version, that can be looked up without knowing its version number or UUID.

When calling the CreateTable or UpdateTable operations, you will pass a TableInput structure that contains a StorageDescriptor, which may have a SchemaReference to an existing schema in the Schema Registry. Similarly, when you call the GetTable or GetPartition APIs, the response may contain the schema and the SchemaReference. When a table or partition was created using a schema references, the Data Catalog will try to fetch the schema for this schema reference. In case it is unable to find the schema in the Schema Registry, it returns an empty schema in the GetTable response; otherwise the response will have both the schema and schema reference.

You can also perform the actions from the AWS Glue console.

To perform these operations and create, update, or view the schema information, you must give an IAM role to the calling user that provides permissions for the GetSchemaVersion API.

**Adding a table or updating the schema for a table**

Adding a new table from an existing schema binds the table to a specific schema version. Once new schema versions get registered, you can update this table definition from the View table page in the AWS Glue console or using the UpdateTable action (Python: update_table) API.

**Adding a table from an existing schema**

You can create an AWS Glue table from a schema version in the registry using the AWS Glue console or CreateTable API.

**AWS Glue API**

When calling the CreateTable API, you will pass a TableInput that contains a StorageDescriptor which has a SchemaReference to an existing schema in the Schema Registry.

**AWS Glue console**

To create a table from the AWS Glue console:

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under Data catalog, choose Tables.
3. In the **Add Tables** menu, choose **Add table from existing schema**.

4. Configure the table properties and data store per the AWS Glue Developer Guide.

5. In the **Choose a Glue schema** page, select the **Registry** where the schema resides.

6. Choose the **Schema name** and select the **Version** of the schema to apply.

7. Review the schema preview, and choose **Next**.

8. Review and create the table.

The schema and version applied to the table appears in the **Glue schema** column in the list of tables. You can view the table to see more details.

### Updating the schema for a table

When a new schema version becomes available, you may want to update a table's schema using the **UpdateTable action (Python: update_table)** API or the AWS Glue console.

⚠️ **Important**

When updating the schema for an existing table that has an AWS Glue schema specified manually, the new schema referenced in the Schema Registry may be incompatible. This can result in your jobs failing.

### AWS Glue API

When calling the `UpdateTable` API, you will pass a `TableInput` that contains a `StorageDescriptor` which has a `SchemaReference` to an existing schema in the Schema Registry.

### AWS Glue console

To update the schema for a table from the AWS Glue console:

2. In the navigation pane, under **Data catalog**, choose **Tables**.
3. View the table from the list of tables.
4. Click **Update schema** in the box that informs you about a new version.
5. Review the differences between the current and new schema.
6. Choose **Show all schema differences** to see more details.

7. Choose **Save table** to accept the new version.

**Use case: AWS Glue streaming**

AWS Glue streaming consumes data from streaming sources and perform ETL operations before writing to an output sink. Input streaming source can be specified using a Data Table or directly by specifying the source configuration.

AWS Glue streaming supports a Data Catalog table for the streaming source created with the schema present in the AWS Glue Schema Registry. You can create a schema in the AWS Glue Schema Registry and create an AWS Glue table with a streaming source using this schema. This AWS Glue table can be used as an input to an AWS Glue streaming job for deserializing data in the input stream.

One point to note here is when the schema in the AWS Glue Schema Registry changes, you need to restart the AWS Glue streaming job needs to reflect the changes in the schema.

**Use case: Apache Kafka Streams**

The Apache Kafka Streams API is a client library for processing and analyzing data stored in Apache Kafka. This section describes the integration of Apache Kafka Streams with AWS Glue Schema Registry, which allows you to manage and enforce schemas on your data streaming applications. For more information on Apache Kafka Streams, see [Apache Kafka Streams](https://kafka.apache.org/).

**Integrating with the SerDes Libraries**

There is a `GlueSchemaRegistryKafkaStreamsSerde` class that you can configure a Streams application with.

**Kafka Streams application example code**

To use the AWS Glue Schema Registry within an Apache Kafka Streams application:

1. Configure the Kafka Streams application.

```java
final Properties props = new Properties();
    props.put(StreamsConfig.APPLICATION_ID_CONFIG, "avro-streams");
    props.put(StreamsConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    props.put(StreamsConfig.CACHE_MAX_BYTES_BUFFERING_CONFIG, 0);
```
2. Create a stream from the topic avro-input.

```java
StreamsBuilder builder = new StreamsBuilder();
final KStream<String, GenericRecord> source = builder.stream("avro-input");
```

3. Process the data records (the example filters out those records whose value of favorite_color is pink or where the value of amount is 15).

```java
final KStream<String, GenericRecord> result = source
    .filter((key, value) -> !"pink".equals(String.valueOf(value.get("favorite_color"))));
    .filter((key, value) -> !"15.0".equals(String.valueOf(value.get("amount"))));
```

4. Write the results back to the topic avro-output.

```java
result.to("avro-output");
```

5. Start the Apache Kafka Streams application.

```java
KafkaStreams streams = new KafkaStreams(builder.build(), props);
streams.start();
```
Implementation results

These results show the filtering process of records that were filtered out in step 3 as a favorite_color of "pink" or value of "15.0".

Records before filtering:

```json
{"name": "Sansa", "favorite_number": 99, "favorite_color": "white"}
{"name": "Harry", "favorite_number": 10, "favorite_color": "black"}
{"name": "Hermione", "favorite_number": 1, "favorite_color": "red"}
{"name": "Ron", "favorite_number": 0, "favorite_color": "pink"}
{"name": "Jay", "favorite_number": 0, "favorite_color": "pink"}

{"id": "commute_1","amount": 3.5}
{"id": "grocery_1","amount": 25.5}
{"id": "entertainment_1","amount": 19.2}
{"id": "entertainment_2","amount": 105}
{"id": "commute_1","amount": 15}
```

Records after filtering:

```json
{"name": "Sansa", "favorite_number": 99, "favorite_color": "white"}
{"name": "Harry", "favorite_number": 10, "favorite_color": "black"}
{"name": "Hermione", "favorite_number": 1, "favorite_color": "red"}
{"name": "Ron", "favorite_number": 0, "favorite_color": "pink"}

{"id": "commute_1","amount": 3.5}
{"id": "grocery_1","amount": 25.5}
{"id": "entertainment_1","amount": 19.2}
{"id": "entertainment_2","amount": 105}
```

Use case: Apache Kafka Connect

The integration of Apache Kafka Connect with the AWS Glue Schema Registry enables you to get schema information from connectors. The Apache Kafka converters specify the format of data within Apache Kafka and how to translate it into Apache Kafka Connect data. Every Apache Kafka Connect user will need to configure these converters based on the format they want their data in when loaded from or stored into Apache Kafka. In this way, you can define your own converters to translate Apache Kafka Connect data into the type used in the AWS Glue Schema Registry (for...
example: Avro) and utilize our serializer to register its schema and do serialization. Then converters are also able to use our deserializer to deserialize data received from Apache Kafka and convert it back into Apache Kafka Connect data. An example workflow diagram is given below.

1. Install the `aws-glue-schema-registry` project by cloning the Github repository for the AWS Glue Schema Registry.

   ```bash
git clone git@github.com:awslabs/aws-glue-schema-registry.git
cd aws-glue-schema-registry
mvn clean install
mvn dependency:copy-dependencies
```

2. If you plan on using Apache Kafka Connect in Standalone mode, update `connect-standalone.properties` using the instructions below for this step. If you plan on using Apache Kafka Connect in Distributed mode, update `connect-avro-distributed.properties` using the same instructions.

   a. Add these properties also to the Apache Kafka connect properties file:

   ```properties
   key.converter.region=aws-region
   value.converter.region=aws-region
   key.converter.schemaAutoRegistrationEnabled=true
   value.converter.schemaAutoRegistrationEnabled=true
   key.converter.avroRecordType=GENERIC_RECORD
   ```
value.converter.avroRecordType=GENERIC_RECORD

b. Add the command below to the **Launch mode** section under *kafka-run-class.sh*:

```bash
-cp $CLASSPATH:"<your AWS GlueSchema Registry base directory>/target/dependency/**"
```

3. Add the command below to the **Launch mode** section under *kafka-run-class.sh*

```bash
-cp $CLASSPATH:"<your AWS GlueSchema Registry base directory>/target/dependency/**"
```

It should look like this:

```bash
# Launch mode
if [ "x$DAEMON_MODE" = "xtrue" ]; then
  nohup "$JAVA" $KAFKA_HEAP_OPTS $KAFKA_JVM_PERFORMANCE_OPTS $KAFKA_GC_LOG_OPTS
  $KAFKA_JMX_OPTS $KAFKA_LOG4J_OPTS -cp $CLASSPATH:"/Users/johndoe/aws-glue-schema-
  registry/target/dependency/**" $KAFKA_OPTS "$@" > "$CONSOLE_OUTPUT_FILE" 2>&1 < /dev/null &
else
  exec "$JAVA" $KAFKA_HEAP_OPTS $KAFKA_JVM_PERFORMANCE_OPTS $KAFKA_GC_LOG_OPTS
  $KAFKA_JMX_OPTS $KAFKA_LOG4J_OPTS -cp $CLASSPATH:"/Users/johndoe/aws-glue-schema-
  registry/target/dependency/**" $KAFKA_OPTS "$@"
fi
```

4. If using bash, run the below commands to set-up your CLASSPATH in your bash_profile. For any
other shell, update the environment accordingly.

```bash
echo 'export GSR_LIB_BASE_DIR=<>' >>~/.bash_profile
echo 'export GSR_LIB_VERSION=1.0.0' >>~/.bash_profile
echo 'export KAFKA_HOME=<your Apache Kafka installation directory>' >>~/.bash_profile
echo 'export CLASSPATH=$CLASSPATH:$GSR_LIB_BASE_DIR/avro-kafkaconnect-converter/
target/schema-registry-kafkaconnect-converter-$GSR_LIB_VERSION.jar:$GSR_LIB_BASE_DIR/
common/target/schema-registry-common-$GSR_LIB_VERSION.jar:$GSR_LIB_BASE_DIR/
avro-serializer-deserializer/target/schema-registry-serde-$GSR_LIB_VERSION.jar'
>>~/.bash_profile
source ~/.bash_profile
```

5. (Optional) If you want to test with a simple file source, then clone the file source connector.

```bash
git clone https://github.com/mmolimar/kafka-connect-fs.git
cd kafka-connect-fs/
```
a. Under the source connector configuration, edit the data format to Avro, file reader to AvroFileReader and update an example Avro object from the file path you are reading from. For example:

```bash
vim config/kafka-connect-fs.properties

fs.uris=<path to a sample avro object>
policy.regexp=^\.*\Avro$
file_reader.class=com.github.mmolimar.kafka.connect.fs.file.reader.AvroFileReader
```

b. Install the source connector.

```bash
mvn clean package
echo "export CLASSPATH="$CLASSPATH:"$(find target/ -type f -name '*.-jar' | grep '\-package' | tr 'n' ' ' | grep "AvroFileReader")" >> ~/.bash_profile
source ~/.bash_profile
```

c. Update the sink properties under `<your Apache Kafka installation directory>/config/connect-file-sink.properties` update the topic name and output file name.

```bash
file=<output file full path>
topics=<my topic>
```

6. Start the Source Connector (in this example it is a file source connector).

```bash
$KAFKA_HOME/bin/connect-standalone.sh $KAFKA_HOME/config/connect-standalone.properties config/kafka-connect-fs.properties
```

7. Run the Sink Connector (in this example it is a file sink connector).

```bash
$KAFKA_HOME/bin/connect-standalone.sh $KAFKA_HOME/config/connect-standalone.properties $KAFKA_HOME/config/connect-file-sink.properties
```

For an example Kafka Connect usage, look at the run-local-tests.sh script under integration-tests folder in the Github repository for the AWS Glue Schema Registry.
Migration from a third-party schema registry to AWS Glue Schema Registry

The migration from a third-party schema registry to the AWS Glue Schema Registry has a dependency on the existing, current third-party schema registry. If there are records in an Apache Kafka topic which were sent using a third-party schema registry, consumers need the third-party schema registry to deserialize those records. The AWSKafkaAvroDeserializer provides the ability to specify a secondary deserializer class which points to the third-party deserializer and is used to deserialize those records.

There are two criteria for retirement of a third-party schema. First, retirement can occur only after records in Apache Kafka topics using the 3rd party schema registry are either no longer required by and for any consumers. Second, retirement can occur by aging out of the Apache Kafka topics, depending on the retention period specified for those topics. Note that if you have topics which have infinite retention, you can still migrate to the AWS Glue Schema Registry but you will not be able to retire the third-party schema registry. As a workaround, you can use an application or Mirror Maker 2 to read from the current topic and produce to a new topic with the AWS Glue Schema Registry.

To migrate from a third-party schema registry to the AWS Glue Schema Registry:

1. Create a registry in the AWS Glue Schema Registry, or use the default registry.
2. Stop the consumer. Modify it to include AWS Glue Schema Registry as the primary deserializer, and the third-party schema registry as the secondary.

   - Set the consumer properties. In this example, the secondary_deserializer is set to a different deserializer. The behavior is as follows: the consumer retrieves records from Amazon MSK and first tries to use the AWSKafkaAvroDeserializer. If it is unable to read the magic byte that contains the Avro Schema ID for the AWS Glue Schema Registry schema, the AWSKafkaAvroDeserializer then tries to use the deserializer class provided in the secondary_deserializer. The properties specific to the secondary deserializer also need to be provided in the consumer properties, such as the schema_registry_url_config and specific_avro_reader_config, as shown below.

```java
consumerProps.setProperty(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, StringDeserializer.class.getName());
consumerProps.setProperty(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, AWSKafkaAvroDeserializer.class.getName());
```
3. Restart the consumer.

4. Stop the producer and point the producer to the AWS Glue Schema Registry.
   a. Set the producer properties. In this example, the producer will use the default-registry and auto register schema versions.

   ```java
   producerProps.setProperty(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, 
   StringSerializer.class.getName());
   producerProps.setProperty(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, 
   AWSKafkaAvroSerializer.class.getName());
   producerProps.setProperty(AWSSchemaRegistryConstants.AWS_REGION, "us-east-2");
   producerProps.setProperty(AWSSchemaRegistryConstants.AvroRecordType.SPECIFIC_RECORD.getName());
   producerProps.setProperty(AWSSchemaRegistryConstants.SCHEMA_AUTO_REGISTRATION_SETTING, "true");
   ```

5. (Optional) Manually move existing schemas and schema versions from the current third-party schema registry to the AWS Glue Schema Registry, either to the default-registry in AWS Glue Schema Registry or to a specific non-default registry in AWS Glue Schema Registry. This can be done by exporting schemas from the third-party schema registries in JSON format and creating new schemas in AWS Glue Schema Registry using the AWS Management Console or the AWS CLI.

   This step may be important if you need to enable compatibility checks with previous schema versions for newly created schema versions using the AWS CLI and the AWS Management Console, or when producers send messages with a new schema with auto-registration of schema versions turned on.

6. Start the producer.
Tutorial: Adding an AWS Glue crawler

For this AWS Glue scenario, you're asked to analyze arrival data for major air carriers to calculate the popularity of departure airports month over month. You have flights data for the year 2016 in CSV format stored in Amazon S3. Before you transform and analyze your data, you catalog its metadata in the AWS Glue Data Catalog.

In this tutorial, let's add a crawler that infers metadata from these flight logs in Amazon S3 and creates a table in your Data Catalog.

Topics

• Prerequisites
• Step 1: Add a crawler
• Step 2: Run the crawler
• Step 3: View AWS Glue Data Catalog objects

Prerequisites

This tutorial assumes that you have an AWS account and access to AWS Glue.

Step 1: Add a crawler

Use these steps to configure and run a crawler that extracts the metadata from a CSV file stored in Amazon S3.

To create a crawler that reads files stored on Amazon S3

1. On the AWS Glue service console, on the left-side menu, choose Crawlers.
2. On the Crawlers page, choose Create crawler. This starts a series of pages that prompt you for the crawler details.
3. In the Crawler name field, enter **Flights Data Crawler**, and choose **Next**.

   Crawlers invoke classifiers to infer the schema of your data. This tutorial uses the built-in classifier for CSV by default.

4. For the crawler source type, choose **Data stores** and choose **Next**.

5. Now let's point the crawler to your data. On the **Add a data store** page, choose the Amazon S3 data store. This tutorial doesn't use a connection, so leave the **Connection** field blank if it's visible.

   For the option **Crawl data in**, choose **Specified path in another account**. Then, for the **Include path**, enter the path where the crawler can find the flights data, which is `s3://crawler-public-us-east-1/flight/2016/csv`. After you enter the path, the title of this field changes to **Include path**. Choose **Next**.

6. You can crawl multiple data stores with a single crawler. However, in this tutorial, we're using only a single data store, so choose **No**, and then choose **Next**.

7. The crawler needs permissions to access the data store and create objects in the AWS Glue Data Catalog. To configure these permissions, choose **Create an IAM role**. The IAM role name starts with AWSGlueServiceRole-, and in the field, you enter the last part of the role name. Enter **CrawlerTutorial**, and then choose **Next**.

   **Note**

   To create an IAM role, your AWS user must have CreateRole, CreatePolicy, and AttachRolePolicy permissions.
The wizard creates an IAM role named AWSGlueServiceRole-CrawlerTutorial, attaches the AWS managed policy AWSGlueServiceRole to this role, and adds an inline policy that allows read access to the Amazon S3 location s3://crawler-public-us-east-1/flight/2016/csv.

8. Create a schedule for the crawler. For **Frequency**, choose **Run on demand**, and then choose **Next**.

9. Crawlers create tables in your Data Catalog. Tables are contained in a database in the Data Catalog. First, choose **Add database** to create a database. In the pop-up window, enter **test-flights-db** for the database name, and then choose **Create**.

   Next, enter **flights** for **Prefix added to tables**. Use the default values for the rest of the options, and choose **Next**.

10. Verify the choices you made in the **Add crawler** wizard. If you see any mistakes, you can choose **Back** to return to previous pages and make changes.

   After you have reviewed the information, choose **Finish** to create the crawler.

**Step 2: Run the crawler**

After creating a crawler, the wizard sends you to the Crawlers view page. Because you create the crawler with an on-demand schedule, you're given the option to run the crawler.

To run the crawler

1. The banner near the top of this page lets you know that the crawler was created, and asks if you want to run it now. Choose **Run it now?** to run the crawler.

   The banner changes to show "Attempting to run" and Running" messages for your crawler. After the crawler starts running, the banner disappears, and the crawler display is updated to show a status of Starting for your crawler. After a minute, you can click the Refresh icon to update the status of the crawler that is displayed in the table.

2. When the crawler completes, a new banner appears that describes the changes made by the crawler. You can choose the **test-flights-db** link to view the Data Catalog objects.
Step 3: View AWS Glue Data Catalog objects

The crawler reads data at the source location and creates tables in the Data Catalog. A table is the metadata definition that represents your data, including its schema. The tables in the Data Catalog do not contain data. Instead, you use these tables as a source or target in a job definition.

To view the Data Catalog objects created by the crawler

1. In the left-side navigation, under **Data catalog**, choose **Databases**. Here you can view the flights-db database that is created by the crawler.

2. In the left-side navigation, under **Data catalog** and below **Databases**, choose **Tables**. Here you can view the flightscsv table created by the crawler. If you choose the table name, then you can view the table settings, parameters, and properties.Scrolling down in this view, you can view the schema, which is information about the columns and data types of the table.

3. If you choose **View partitions** on the table view page, you can see the partitions created for the data. The first column is the partition key.
Connecting to data

An AWS Glue connection is a Data Catalog object that stores login credentials, URI strings, virtual private cloud (VPC) information, and more for a particular data store. AWS Glue crawlers, jobs, and development endpoints use connections in order to access certain types of data stores. You can use connections for both sources and targets, and reuse the same connection across multiple crawler or extract, transform, and load (ETL) jobs.

AWS Glue supports the following connection types:

- Amazon DocumentDB
- Amazon OpenSearch Service, for use with AWS Glue for Spark.
- Amazon Redshift
- Kafka
- Azure Cosmos, for use of Azure Cosmos DB for NoSQL with AWS Glue ETL jobs
- Azure SQL, for use with AWS Glue for Spark.
- Google BigQuery, for use with AWS Glue for Spark.
- JDBC
- MongoDB
- MongoDB Atlas
- SAP HANA, for use with AWS Glue for Spark.
- Snowflake, for use with AWS Glue for Spark.
- Teradata Vantage, when using AWS Glue for Spark.
- Vertica, for use with AWS Glue for Spark.
- Various Amazon Relational Database Service (Amazon RDS) offerings.
- Network (designates a connection to a data source that is in an Amazon Virtual Private Cloud (Amazon VPC))
- Aurora (supported if the native JDBC driver is being used. Not all driver features can be leveraged)

With AWS Glue Studio, you can also create a connection for a connector. A connector is an optional code package that assists with accessing data stores in AWS Glue Studio. For more information, see Using connectors and connections with AWS Glue Studio
For information about how to connect to on-premises databases, see [How to access and analyze on-premises data stores using AWS Glue](https://aws.amazon.com/bigdatablog) at the AWS Big Data Blog website.

This section includes the following topics to help you use AWS Glue connections:

- AWS Glue connection properties
- Storing connection credentials in AWS Secrets Manager
- Adding an AWS Glue connection
- Testing an AWS Glue connection
- Configuring AWS calls to go through your VPC
- Connecting to a JDBC data store in a VPC
- Using a MongoDB or MongoDB Atlas connection
- Crawling an Amazon S3 data store using a VPC endpoint
- Troubleshooting connection issues in AWS Glue
- Tutorial: Using the AWS Glue Connector for Elasticsearch

### AWS Glue connection properties

This topic includes information about properties for AWS Glue connections.

**Topics**

- Required connection properties
- AWS Glue JDBC connection properties
- AWS Glue MongoDB and MongoDB Atlas connection properties
- Snowflake connection
- Vertica connection
- SAP HANA connection
- Azure SQL connection
- Teradata Vantage connection
- OpenSearch Service connection
- Azure Cosmos connection
- AWS Glue SSL connection properties
- Apache Kafka connection properties for client authentication
- **Google BigQuery connection**
- **Vertica connection**

**Required connection properties**

When you define a connection on the AWS Glue console, you must provide values for the following properties:

**Connection name**

Enter a unique name for your connection.

**Connection type**

Choose **JDBC** or one of the specific connection types.

For details about the JDBC connection type, see the section called “JDBC connection properties”.

Choose **Network** to connect to a data source within an Amazon Virtual Private Cloud environment (Amazon VPC).

Depending on the type that you choose, the AWS Glue console displays other required fields. For example, if you choose **Amazon RDS**, you must then choose the database engine.

**Require SSL connection**

When you select this option, AWS Glue must verify that the connection to the data store is connected over a trusted Secure Sockets Layer (SSL).

For more information, including additional options that are available when you select this option, see the section called “SSL connection properties”.

**Select MSK cluster (Amazon managed streaming for Apache Kafka (MSK) only)**

Specifies an MSK cluster from another AWS account.

**Kafka bootstrap server URLs (Kafka only)**

Specifies a comma-separated list of bootstrap server URLs. Include the port number. For example: b-1.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094, b-2.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094, b-3.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094
AWS Glue JDBC connection properties

AWS Glue can connect to the following data stores through a JDBC connection:

- Amazon Redshift
- Amazon Aurora
- Microsoft SQL Server
- MySQL
- Oracle
- PostgreSQL
- Snowflake, when using AWS Glue crawlers.
- Aurora (supported if the native JDBC driver is being used. Not all driver features can be leveraged)
- Amazon RDS for MariaDB

**Important**

Currently, an ETL job can use JDBC connections within only one subnet. If you have multiple data stores in a job, they must be on the same subnet, or accessible from the subnet.

If you choose to bring in your own JDBC driver versions for AWS Glue crawlers, your crawlers will consume resources in AWS Glue jobs and Amazon S3 to ensure your provided drivers are run in your environment. The additional usage of resources will be reflected in your account. Additionally, providing your own JDBC driver does not mean that the crawler is able to leverage all of the driver’s features. Drivers are limited to the properties described in [Defining connections in the Data Catalog](#).

The following are additional properties for the JDBC connection type.

**JDBC URL**

Enter the URL for your JDBC data store. For most database engines, this field is in the following format. In this format, replace `protocol, host, port,` and `db_name` with your own information.
jdbc:protocol://host:port/db_name

Depending on the database engine, a different JDBC URL format might be required. This format can have slightly different use of the colon (:) and slash (/) or different keywords to specify databases.

For JDBC to connect to the data store, a db_name in the data store is required. The db_name is used to establish a network connection with the supplied username and password. When connected, AWS Glue can access other databases in the data store to run a crawler or run an ETL job.

The following JDBC URL examples show the syntax for several database engines.

- To connect to an Amazon Redshift cluster data store with a dev database:

  jdbc:redshift://xxx.us-east-1.redshift.amazonaws.com:8192/dev

- To connect to an Amazon RDS for MySQL data store with an employee database:

  jdbc:mysql://xxx-cluster.cluster-xxx.us-east-1.rds.amazonaws.com:3306/employee

- To connect to an Amazon RDS for PostgreSQL data store with an employee database:

  jdbc:postgresql://xxx-cluster.cluster-xxx.us-east-1.rds.amazonaws.com:5432/employee

- To connect to an Amazon RDS for Oracle data store with an employee service name:

  jdbc:oracle:thin://@xxx-cluster.cluster-xxx.us-east-1.rds.amazonaws.com:1521/employee

  The syntax for Amazon RDS for Oracle can follow the following patterns. In these patterns, replace host, port, service_name, and SID with your own information.

  - jdbc:oracle:thin://@host:port/service_name
  - jdbc:oracle:thin://@host:port:SID

- To connect to an Amazon RDS for Microsoft SQL Server data store with an employee database:

  jdbc:sqlserver://xxx-cluster.cluster-xxx.us-east-1.rds.amazonaws.com:1433;databaseName=employee
The syntax for Amazon RDS for SQL Server can follow the following patterns. In these patterns, replace server_name, port, and db_name with your own information.

- jdbc:sqlserver://server_name:port;database=db_name
- jdbc:sqlserver://server_name:port;databaseName=db_name

To connect to an Amazon Aurora PostgreSQL instance of the employee database, specify the endpoint for the database instance, the port, and the database name:

jdbc:postgresql://employee_instance_1.xxxxxxxxxxxxxx.us-east-2.rds.amazonaws.com:5432/employee

To connect to an Amazon RDS for MariaDB data store with an employee database, specify the endpoint for the database instance, the port, and the database name:


⚠️ Warning
Snowflake JDBC connections are supported only by AWS Glue crawlers. When using the Snowflake connector in AWS Glue jobs, use the Snowflake connection type.

To connect to a Snowflake instance of the sample database, specify the endpoint for the snowflake instance, the user, the database name, and the role name. You can optionally add the warehouse parameter.

jdbc:snowflake://account_name.snowflakecomputing.com/?user=user_name&db=sample&role=role_name&warehouse=warehouse_name

⚠️ Important
For Snowflake connections over JDBC, the order of parameters in the URL is enforced and must be ordered as user, db, role_name, and warehouse.

- To connect to a Snowflake instance of the sample database with AWS private link, specify the snowflake JDBC URL as follows:
jdbc:snowflake://account_name.region.privatelink.snowflakecomputing.com/?user=user_name&db=sample&role=role_name&warehouse=warehouse_name

**Username**

- **Note**
  - We recommend that you use an AWS secret to store connection credentials instead of supplying your user name and password directly. For more information, see [Storing connection credentials in AWS Secrets Manager](#).

  Provide a user name that has permission to access the JDBC data store.

**Password**

- Enter the password for the user name that has access permission to the JDBC data store.

**Port**

- Enter the port used in the JDBC URL to connect to an Amazon RDS Oracle instance. This field is only shown when **Require SSL connection** is selected for an Amazon RDS Oracle instance.

**VPC**

- Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

- **Important**
  - When working over a JDBC connection which is hosted off of AWS, such as with data from Snowflake, your VPC should have a NAT gateway which splits traffic into public and private subnets. The public subnet is used for connection to the external source, and the internal subnet is used for processing by AWS Glue. For information on configuring your Amazon VPC for external connections, read [Connect to the internet or other networks using NAT devices](#) and [Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue](#).
Subnet

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

Security groups

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.

JDBC Driver Class name - optional

Provide the custom JDBC driver class name:

- Postgres – org.postgresql.Driver
- Oracle – oracle.jdbc.driver.OracleDriver
- SQL Server – com.microsoft.sqlserver.jdbc.SQLServerDriver

JDBC Driver S3 Path - optional

Provide the Amazon S3 location to the custom JDBC driver. This is an absolute path to a .jar file. If you want to provide your own JDBC drivers to connect to your data sources for your crawler-supported databases, you can specify values for parameters customJdbcDriverS3Path and customJdbcDriverClassName. Using a JDBC driver supplied by a customer is limited to the required Required connection properties.

AWS Glue MongoDB and MongoDB Atlas connection properties

The following are additional properties for the MongoDB or MongoDB Atlas connection type.
MongoDB URL

Enter the URL for your MongoDB or MongoDB Atlas data store:

- For MongoDB: mongodb://host:port/database. The host can be a hostname, IP address, or UNIX domain socket. If the connection string doesn't specify a port, it uses the default MongoDB port, 27017.

- For MongoDB Atlas: mongodb+srv://server.example.com/database. The host can be a hostname that follows corresponds to a DNS SRV record. The SRV format does not require a port and will use the default MongoDB port, 27017.

Username

Note

We recommend that you use an AWS secret to store connection credentials instead of supplying your user name and password directly. For more information, see Storing connection credentials in AWS Secrets Manager.

Provide a user name that has permission to access the JDBC data store.

Password

Enter the password for the user name that has access permission to the MongoDB or MongoDB Atlas data store.

Snowflake connection

The following properties are used to set up a Snowflake connection used in AWS Glue ETL jobs. When crawling Snowflake, use a JDBC connection.

Snowflake URL

The URL of your Snowflake endpoint. For more information about Snowflake endpoint URLs, see Connecting to Your Accounts in the Snowflake documentation.

AWS Secret

The Secret name of a secret in AWS Secrets Manager. AWS Glue will connect to Snowflake using the sfUser and sfPassword keys of your secret.
**Snowflake role (optional)**

A Snowflake security role AWS Glue will use when connecting.

Use the following properties when configuring a connection to a Snowflake endpoint hosted in Amazon VPC using AWS PrivateLink.

**VPC**

Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

**Subnet**

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

**Security groups**

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.

**Vertica connection**

Use the following properties to set up a Vertica connection for AWS Glue ETL jobs.

**Vertica Host**

The hostname of your Vertica installation.

**Vertica Port**

The port your Vertica installation is available through.

**AWS Secret**

The **Secret name** of a secret in AWS Secrets Manager. AWS Glue will connect to Vertica using the keys of your secret.
Use the following properties when configuring a connection to a Vertica endpoint hosted in Amazon VPC.

**VPC**

Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

**Subnet**

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

**Security groups**

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.

**SAP HANA connection**

Use the following properties to set up a SAP HANA connection for AWS Glue ETL jobs.

**SAP HANA URL**

A SAP JDBC URL.

SAP HANA JDBC URLs are in the form

```
jdbc:sap://saphanaHostname:saphanaPort/?databaseName=saphanaDBname,ParameterName=ParameterValue
```

AWS Glue requires the following JDBC URL parameters:

- `databaseName` – A default database in SAP HANA to connect to.

**AWS Secret**

The **Secret name** of a secret in AWS Secrets Manager. AWS Glue will connect to SAP HANA using the keys of your secret.

Use the following properties when configuring a connection to a SAP HANA endpoint hosted in Amazon VPC:
VPC

Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

Subnet

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

Security groups

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.

Azure SQL connection

Use the following properties to set up a Azure SQL connection for AWS Glue ETL jobs.

Azure SQL URL

The JDBC URL of an Azure SQL endpoint.

The URL must be in the following format:
jdbc:sqlserver://databaseServerName:databasePort;databaseName=azuresqldbname;

AWS Glue requires the following URL properties:

• databaseName – A default database in Azure SQL to connect to.

For more information about JDBC URLs for Azure SQL Managed Instances, see the Microsoft documentation.

AWS Secret

The Secret name of a secret in AWS Secrets Manager. AWS Glue will connect to Azure SQL using the keys of your secret.
Teradata Vantage connection

Use the following properties to set up a Teradata Vantage connection for AWS Glue ETL jobs.

Teradata URL

To connect to a Teradata instance specify the hostname for the database instance and relevant Teradata parameters:

`jdbc:teradata://teradataHostname/ParameterName=ParameterValue,ParameterName=ParameterValue`

AWS Glue supports the following JDBC URL parameters:

- `DATABASE_NAME` – A default database in Teradata to connect to.
- `DBS_PORT` – Specifies the Teradata port, if nonstandard.

AWS Secret

The **Secret name** of a secret in AWS Secrets Manager. AWS Glue will connect to Teradata Vantage using the keys of your secret.

Use the following properties when configuring a connection to a Teradata Vantage endpoint hosted in Amazon VPC:

VPC

Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

Subnet

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

Security groups

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.
OpenSearch Service connection

Use the following properties to set up a OpenSearch Service connection for AWS Glue ETL jobs.

Domain endpoint

An Amazon OpenSearch Service domain endpoint will have the following default form, https://search-domainName-unstructuredIdContent.region.es.amazonaws.com. For more information on identifying your domain endpoint, see Creating and managing Amazon OpenSearch Service domains in the Amazon OpenSearch Service documentation.

Port

The port open on the endpoint.

AWS Secret

The Secret name of a secret in AWS Secrets Manager. AWS Glue will connect to OpenSearch Service using the keys of your secret.

Use the following properties when configuring a connection to a OpenSearch Service endpoint hosted in Amazon VPC:

VPC

Choose the name of the virtual private cloud (VPC) that contains your data store. The AWS Glue console lists all VPCs for the current Region.

Subnet

Choose the subnet within the VPC that contains your data store. The AWS Glue console lists all subnets for the data store in your VPC.

Security groups

Choose the security groups that are associated with your data store. AWS Glue requires one or more security groups with an inbound source rule that allows AWS Glue to connect. The AWS Glue console lists all security groups that are granted inbound access to your VPC. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet.
Azure Cosmos connection

Use the following properties to set up a Azure Cosmos connection for AWS Glue ETL jobs.

**Azure Cosmos DB Account Endpoint URI**

The endpoint used to connect to Azure Cosmos. For more information, see [the Azure documentation](#).  

**AWS Secret**

The *Secret name* of a secret in AWS Secrets Manager. AWS Glue will connect to Azure Cosmos using the keys of your secret.

**AWS Glue SSL connection properties**

The following are details about the **Require SSL connection** property.

If you do not require SSL connection, AWS Glue ignores failures when it uses SSL to encrypt a connection to the data store. See the documentation for your data store for configuration instructions. When you select this option, the job run, crawler, or ETL statements in a development endpoint fail when AWS Glue cannot connect.

> **Note**
> Snowflake supports an SSL connection by default, so this property is not applicable for Snowflake.

This option is validated on the AWS Glue client side. For JDBC connections, AWS Glue only connects over SSL with certificate and host name validation. SSL connection support is available for:

- Oracle Database
- Microsoft SQL Server
- PostgreSQL
- Amazon Redshift
- MySQL (Amazon RDS instances only)
- Amazon Aurora MySQL (Amazon RDS instances only)
- Amazon Aurora PostgreSQL (Amazon RDS instances only)
- Kafka, which includes Amazon Managed Streaming for Apache Kafka
- MongoDB

### Note

To enable an Amazon RDS Oracle data store to use **Require SSL connection**, you must create and attach an option group to the Oracle instance.

1. Sign in to the AWS Management Console and open the Amazon RDS console at [https://console.aws.amazon.com/rds/](https://console.aws.amazon.com/rds/).
2. Add an **Option group** to the Amazon RDS Oracle instance. For more information about how to add an option group on the Amazon RDS console, see [Creating an Option Group](#).
3. Add an **Option** to the option group for **SSL**. The **Port** you specify for SSL is later used when you create an AWS Glue JDBC connection URL for the Amazon RDS Oracle instance. For more information about how to add an option on the Amazon RDS console, see [Adding an Option to an Option Group](#) in the [Amazon RDS User Guide](#). For more information about the Oracle SSL option, see [Oracle SSL](#) in the [Amazon RDS User Guide](#).
4. On the AWS Glue console, create a connection to the Amazon RDS Oracle instance. In the connection definition, select **Require SSL connection**. When requested, enter the **Port** that you used in the Amazon RDS Oracle SSL option.

The following additional optional properties are available when **Require SSL connection** is selected for a connection:

**Custom JDBC certificate in S3**

If you have a certificate that you are currently using for SSL communication with your on-premises or cloud databases, you can use that certificate for SSL connections to AWS Glue data sources or targets. Enter an Amazon Simple Storage Service (Amazon S3) location that contains a custom root certificate. AWS Glue uses this certificate to establish an SSL connection to the database. AWS Glue handles only X.509 certificates. The certificate must be DER-encoded and supplied in base64 encoding PEM format.

If this field is left blank, the default certificate is used.
Custom JDBC certificate string

Enter certificate information specific to your JDBC database. This string is used for domain matching or distinguished name (DN) matching. For Oracle Database, this string maps to the SSL_SERVER_CERT_DN parameter in the security section of the tnsnames.ora file. For Microsoft SQL Server, this string is used as hostNameInCertificate.

The following is an example for the Oracle Database SSL_SERVER_CERT_DN parameter.

cn=sales,cn=OracleContext,dc=us,dc=example,dc=com

Kafka private CA certificate location

If you have a certificate that you are currently using for SSL communication with your Kafka data store, you can use that certificate with your AWS Glue connection. This option is required for Kafka data stores, and optional for Amazon Managed Streaming for Apache Kafka data stores. Enter an Amazon Simple Storage Service (Amazon S3) location that contains a custom root certificate. AWS Glue uses this certificate to establish an SSL connection to the Kafka data store. AWS Glue handles only X.509 certificates. The certificate must be DER-encoded and supplied in base64 encoding PEM format.

Skip certificate validation

Select the Skip certificate validation check box to skip validation of the custom certificate by AWS Glue. If you choose to validate, AWS Glue validates the signature algorithm and subject public key algorithm for the certificate. If the certificate fails validation, any ETL job or crawler that uses the connection fails.

The only permitted signature algorithms are SHA256withRSA, SHA384withRSA, or SHA512withRSA. For the subject public key algorithm, the key length must be at least 2048.

Kafka client keystore location

The Amazon S3 location of the client keystore file for Kafka client side authentication. Path must be in the form s3://bucket/prefix/filename.jks. It must end with the file name and .jks extension.

Kafka client keystore password (optional)

The password to access the provided keystore.
Kafka client key password (optional)

A keystore can consist of multiple keys, so this is the password to access the client key to be used with the Kafka server side key.

Apache Kafka connection properties for client authentication

AWS Glue supports the Simple Authentication and Security Layer (SASL) framework for authentication when you create an Apache Kafka connection. The SASL framework supports various mechanisms of authentication, and AWS Glue offers both the SCRAM protocol (user name and password) and GSSAPI (Kerberos protocol).

Use AWS Glue Studio to configure one of the following client authentication methods. For more information, see Creating connections for connectors in the AWS Glue Studio user guide.

- None - No authentication. This is useful if creating a connection for testing purposes.
- SASL/SCRAM-SHA-512 - Choosing this authentication method will allow you to specify authentication credentials. There are two options available:
  - Use AWS Secrets Manager (recommended) - if you select this option, you can store your user name and password in AWS Secrets Manager and let AWS Glue access them when needed. Specify the secret that stores the SSL or SASL authentication credentials. For more information, see Storing connection credentials in AWS Secrets Manager.
  - Provide a user name and password directly.
- SASL/GSSAPI (Kerberos) - if you select this option, you can select the location of the keytab file, krb5.conf file and enter the Kerberos principal name and Kerberos service name. The locations for the keytab file and krb5.conf file must be in an Amazon S3 location. Since MSK does not yet support SASL/GSSAPI, this option is only available for customer managed Apache Kafka clusters. For more information, see MIT Kerberos Documentation: Keytab.
- SSL Client Authentication - if you select this option, you can you can select the location of the Kafka client keystore by browsing Amazon S3. Optionally, you can enter the Kafka client keystore password and Kafka client key password.

Google BigQuery connection

The following properties are used to set up a Google BigQuery connection used in AWS Glue ETL jobs. For more information, see the section called “BigQuery connections”.

Kafka connection properties for authentication
AWS Secret

The **Secret name** of a secret in AWS Secrets Manager. AWS Glue ETL jobs will connect to Google BigQuery using the credentials key of your secret.

**Vertica connection**

The following properties are used to set up a Vertica connection used in AWS Glue ETL jobs. For more information, see the section called “Vertica connections”.

**Storing connection credentials in AWS Secrets Manager**

We recommend that you use AWS Secrets Manager to supply connection credentials for your data store. Using Secrets Manager this way lets AWS Glue access your secret at runtime for ETL jobs and crawler runs, and helps keep your credentials secure.

**Prerequisites**

To use Secrets Manager with AWS Glue, you must grant your IAM role for AWS Glue permission to retrieve secret values. The AWS managed policy AWSGlueServiceRole doesn't include AWS Secrets Manager permissions. For example IAM policies, see Example: Permission to retrieve secret values in the AWS Secrets Manager User Guide.

Depending on your network setup, you might also need to create a VPC endpoint to establish a private connection between your VPC and Secrets Manager. For more information, see Using an AWS Secrets Manager VPC endpoint.

**To create a secret for AWS Glue**

1. Follow the instructions in Create and manage secrets in the AWS Secrets Manager User Guide. The following example JSON shows how to specify your credentials in the Plaintext tab when you create a secret for AWS Glue.

   ```json
   {
     "username": "EXAMPLE-USERNAME",
     "password": "EXAMPLE-PASSWORD"
   }
   ```

2. Associate your secret with a connection using the AWS Glue Studio interface. For detailed instructions, see Creating connections for connectors in the AWS Glue Studio User Guide.
Adding an AWS Glue connection

You can connect to data sources in AWS Glue for Spark programmatically. For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).

You can also use the AWS Glue console to add, edit, delete, and test connections. For information about AWS Glue connections, see [Connecting to data](#).

To add an AWS Glue connection

2. In the navigation pane, under **Data catalog**, choose **Connections**.
3. Choose **Add connection** and then complete the wizard, entering connection properties as described in the section called “AWS Glue connection properties”.

Connecting to Redshift in AWS Glue Studio

**Note**

You can use AWS Glue for Spark to read from and write to tables in Amazon Redshift databases outside of AWS Glue Studio. To configure Amazon Redshift with AWS Glue jobs programmatically, see [Redshift connections](#).

AWS Glue provides built-in support for Amazon Redshift. AWS Glue Studio provides a visual interface to connect to Amazon Redshift, author data integration jobs, and run them on AWS Glue Studio serverless Spark runtime.

**Topics**

- [Creating an Amazon Redshift connection](#)
- [Creating a Amazon Redshift source node](#)
- [Creating an Amazon Redshift target node](#)
- [Advanced options](#)
Creating an Amazon Redshift connection

Permissions needed

Additional permissions are needed to use Amazon Redshift clusters and Amazon Redshift serverless environments. For more information on how to add permissions to ETL jobs, see Review IAM permissions needed for ETL jobs.

- redshift:DescribeClusters
- redshift-serverless:ListWorkgroups
- redshift-serverless:ListNamespaces

Overview

When adding an Amazon Redshift connection, you can choose an existing Amazon Redshift connection or create a new connection when adding a Data source - Redshift node in AWS Glue Studio.

AWS Glue supports both Amazon Redshift clusters and Amazon Redshift serverless environments. When you create a connection, Amazon Redshift serverless environments display the serverless label next to the connection option.

For more information on how to create an Amazon Redshift connection, see Moving data to and from Amazon Redshift.

Creating a Amazon Redshift source node

Permissions needed

AWS Glue Studio jobs using Amazon Redshift data sources require additional permissions. For more information on how to add permissions to ETL jobs, see Review IAM permissions needed for ETL jobs.

The following permissions are needed in order to use an Amazon Redshift connection.

- redshift-data:ListSchemas
- redshift-data:ListTables
- redshift-data:DescribeTable
- redshift-data:ExecuteStatement
Adding an Amazon Redshift data source

To add a Data Source – Amazon Redshift node:

1. Choose the Amazon Redshift access type:
   
   - Direct data connection (recommended) – choose this option if you want to access your Amazon Redshift data directly. This is the recommended option and also the default.
   - Data Catalog tables – choose this option if you have Data Catalog tables that you want to use.

2. If you choose Direct data connection, choose the connection for your Amazon Redshift data source. This assumes that the connection already exists and you can select from existing connections. If you need to create a connection, choose Create Redshift connection. For more information, see Overview of using connectors and connections.

   Once you have chosen a connection, you can view the connection properties by clicking View properties. Information about the connection are visible, including URL, security groups, subnet, availability zone, description, and created (UTC) and last updated (UTC) timestamps.

3. Choose a Amazon Redshift source option:

   - Choose a single table – this is the table that contains the data you want to access from a single Amazon Redshift table.
   - Enter custom query – allows you to access a dataset from multiple Amazon Redshift tables based on your custom query.

4. If you chose a single table, choose the Amazon Redshift schema. The list of available schema to choose from is determined by the selected table.

   Or, choose Enter custom query. Choose this option to access a custom dataset from multiple Amazon Redshift tables. When you choose this option, enter the Amazon Redshift query.

   When connecting to an Amazon Redshift serverless environment, add the following permission to the custom query:

   ```
   GRANT SELECT ON ALL TABLES IN <schema> TO PUBLIC
   ```
You can choose **Infer schema** to read the schema based on the query that you entered. You can also choose **Open Redshift query editor** to enter an Amazon Redshift query. For more information, see [Querying a database using the query editor](#).

5. In **Performance and security**, choose the Amazon S3 staging directory and IAM role.
   - **Amazon S3 staging directory** – choose the Amazon S3 location for temporarily staging data.
   - **IAM role** – choose the IAM role that can write to the Amazon S3 location you selected.

6. In **Custom Redshift parameters - optional**, enter the parameter and value.

### Creating an Amazon Redshift target node

#### Permissions needed

AWS Glue Studio jobs using Amazon Redshift data target require additional permissions. For more information on how to add permissions to ETL jobs, see [Review IAM permissions needed for ETL jobs](#).

The following permissions are needed in order to use an Amazon Redshift connection.

- redshift-data:ListSchemas
- redshift-data:ListTables

#### Adding an Amazon Redshift target node

**To create a a Amazon Redshift target node:**

1. Choose an existing Amazon Redshift table as the target, or enter a new table name.
2. When you use the **Data target - Redshift** target node, you can choose from the following options:
   - **APPEND** – If a table already exists, dump all the new data into the table as an insert. If the table doesn't exist, create it and then insert all new data.

   Additionally, check the box if you want to update (UPSERT) existing records in the target table. The table must exist first, otherwise the operation will fail.
• **MERGE** – AWS Glue will update or append data to your target table based on the conditions you specify.

**Note**
To use the merge action in AWS Glue, you must enable Amazon Redshift merge functionality. For instructions on how to enable merge for your Amazon Redshift instance, see [MERGE (preview)](mergetable).

Choose options:

• **Choose keys and simple actions** – choose the columns to be used as matching keys between the source data and your target data set.

Specify the following options when matched:

• Update record in your target data set with data from source.

• Delete record in your target data set.

Specify the following options when not matched:

• Insert source data as a new row into your target data set.

• Do nothing.

• **Enter custom MERGE statement** – You can then choose [Validate Merge statement](validate) to verify that the statement is valid or invalid.

• **TRUNCATE** – If a table already exists, truncate the table data by first clearing the contents of the target table. If truncate is successful, then insert all data. If the table doesn't exist, create the table and insert all data. If truncate is not successful, the operation will fail.

• **DROP** – If a table already exists, delete the table metadata and data. If deletion is successful, then insert all data. If the table doesn't exist, create the table and insert all data. If drop is not successful, the operation will fail.

• **CREATE** – Create a new table with the default name. If table name already exist, create a new table with a name postfix of `job_datetime` to the name for uniqueness. This will insert all the data into the new table. If the table exists, the final table name will have the postfix appended. If the table doesn't exist, a table will be created. In either case, a new table will be created.
Advanced options

See [Using the Amazon Redshift Spark connector on AWS Glue](#).

Connecting to Snowflake in AWS Glue Studio

**Note**

You can use AWS Glue for Spark to read from and write to tables in Snowflake in AWS Glue 4.0 and later versions. To configure a Snowflake connection with AWS Glue jobs programatically, see [Redshift connections](#).

AWS Glue provides built-in support for Snowflake. AWS Glue Studio provides a visual interface to connect to Snowflake, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

**Topics**

- Creating a Snowflake connection
- Creating a Snowflake source node
- Creating a Snowflake target node
- Advanced options

Creating a Snowflake connection

When adding a **Data source - Snowflake** node in AWS Glue Studio, you can choose an existing AWS Glue Snowflake connection or create a new connection. You must choose a SNOWFLAKE type connection and not a JDBC type connection configured to connect to Snowflake. Follow the following procedure to create a AWS Glue Snowflake connection:

**To create a Snowflake connection**

1. In Snowflake, generate a user, `snowflakeUser` and password, `snowflakePassword`.
2. Determine which Snowflake warehouse this user will interact with, `snowflakeWarehouse`. Either set it as the DEFAULT_WAREHOUSE for `snowflakeUser` in Snowflake or remember it for the next step.
3. In AWS Secrets Manager, create a secret using your Snowflake credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for `snowflakeUser` with the key `sfUser`.
   - When selecting **Key/value pairs**, create a pair for `snowflakePassword` with the key `sfPassword`.
   - When selecting **Key/value pairs**, create a pair for `snowflakeWarehouse` with the key `sfWarehouse`. This is not needed if a default is set in Snowflake.

4. In the AWS Glue Data Catalog, create a connection by following the steps in [Adding an AWS Glue connection](#). After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select Snowflake.
   - When selecting **Snowflake URL**, provide the hostname of your Snowflake instance. The URL will use a hostname in the form `account_identifier.snowflakecomputing.com`.
   - When selecting an **AWS Secret**, provide `secretName`.

### Creating a Snowflake source node

#### Permissions needed

AWS Glue Studio jobs using Snowflake data sources require additional permissions. For more information on how to add permissions to ETL jobs, see [Review IAM permissions needed for ETL jobs](#).

SNOWFLAKE AWS Glue connections use an AWS Secrets Manager secret to provide credential information. Your job and data preview roles in AWS Glue Studio must have permission to read this secret.

#### Adding a Snowflake data source

**Prerequisites:**

- An AWS Secrets Manager secret for your Snowflake credentials
- A Snowflake type AWS Glue Data Catalog connection
To add a Data Source – Snowflake node:

1. Choose the connection for your Snowflake data source. This assumes that the connection already exists and you can select from existing connections. If you need to create a connection, choose Create Snowflake connection. For more information, see Overview of using connectors and connections.

   Once you have chosen a connection, you can view the connection properties by clicking View properties. Information about the connection are visible, including URL, security groups, subnet, availability zone, description, and created (UTC) and last updated (UTC) timestamps.

2. Choose a Snowflake source option:

   - Choose a single table – this is the table that contains the data you want to access from a single Snowflake table.
   - Enter custom query – allows you to access a dataset from multiple Snowflake tables based on your custom query.

3. If you chose a single table, enter the name of a Snowflake schema.

   Or, choose Enter custom query. Choose this option to access a custom dataset from multiple Snowflake tables. When you choose this option, enter the Snowflake query.

4. In Performance and security options (optional),

   - Enable query pushdown – choose if you want to offload work to the Snowflake instance.

5. In Custom Snowflake properties (optional), enter parameters and values as needed.

Creating a Snowflake target node

Permissions needed

AWS Glue Studio jobs using Snowflake data sources require additional permissions. For more information on how to add permissions to ETL jobs, see Review IAM permissions needed for ETL jobs.

SNOWFLAKE AWS Glue connections use an AWS Secrets Manager secret to provide credential information. Your job and data preview roles in AWS Glue Studio must have permission to read this secret.
Adding a Snowflake data target

To create a Snowflake target node:

1. Choose an existing Snowflake table as the target, or enter a new table name.

2. When you use the **Data target - Snowflake** target node, you can choose from the following options:

   - **APPEND** – If a table already exists, dump all the new data into the table as an insert. If the table doesn't exist, create it and then insert all new data.
   - **MERGE** – AWS Glue will update or append data to your target table based on the conditions you specify.

Choose options:

   - **Choose keys and simple actions** – choose the columns to be used as matching keys between the source data and your target data set.

      Specify the following options when matched:
      - Update record in your target data set with data from source.
      - Delete record in your target data set.

      Specify the following options when not matched:
      - Insert source data as a new row into your target data set.
      - Do nothing.

   - **Enter custom MERGE statement** – You can then choose **Validate Merge statement** to verify that the statement is valid or invalid.

   - **TRUNCATE** – If a table already exists, truncate the table data by first clearing the contents of the target table. If truncate is successful, then insert all data. If the table doesn't exist, create the table and insert all data. If truncate is not successful, the operation will fail.

   - **DROP** – If a table already exists, delete the table metadata and data. If deletion is successful, then insert all data. If the table doesn't exist, create the table and insert all data. If drop is not successful, the operation will fail.

Advanced options

See **Snowflake connections** in the AWS Glue developer guide.
Connecting to BigQuery in AWS Glue Studio

Note

You can use AWS Glue for Spark to read from and write to tables in Google BigQuery in AWS Glue 4.0 and later versions. To configure Google BigQuery with AWS Glue jobs programmatically, see BigQuery connections.

AWS Glue Studio provides a visual interface to connect to BigQuery, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

Topics

• Creating a BigQuery connection
• Creating a BigQuery source node
• Creating a BigQuery target node
• Advanced options

Creating a BigQuery connection

To connect to Google BigQuery from AWS Glue, you will need to create and store your Google Cloud Platform credentials in a AWS Secrets Manager secret, then associate that secret with a Google BigQuery AWS Glue connection.

To configure a connection to BigQuery:

1. In Google Cloud Platform, create and identify relevant resources:
   • Create or identify a GCP project containing BigQuery tables you would like to connect to.
   • Enable the BigQuery API. For more information, see Use the BigQuery Storage Read API to read table data.
2. In Google Cloud Platform, create and export service account credentials:
   You can use the BigQuery credentials wizard to expedite this step: Create credentials.
   To create a service account in GCP, follow the tutorial available in Create service accounts.
• When selecting **project**, select the project containing your BigQuery table.

• When selecting GCP IAM roles for your service account, add or create a role that would grant appropriate permissions to run BigQuery jobs to read, write or create BigQuery tables.

To create credentials for your service account, follow the tutorial available in [Create a service account key](#).

• When selecting key type, select **JSON**.

You should now have downloaded a JSON file with credentials for your service account. It should look similar to the following:

```json
{
    "type": "service_account",
    "project_id": "*****",
    "private_key_id": "*****",
    "private_key": "*****",
    "client_email": "*****",
    "client_id": "*****",
    "auth_uri": "https://accounts.google.com/o/oauth2/auth",
    "token_uri": "https://oauth2.googleapis.com/token",
    "auth_provider_x509_cert_url": "https://www.googleapis.com/oauth2/v1/certs",
    "client_x509_cert_url": "*****",
    "universe_domain": "googleapis.com"
}
```

3. base64 encode your downloaded credentials file. On an AWS CloudShell session or similar, you can do this from the command line by running `cat credentialsFile.json | base64 -w 0`. Retain the output of this command, `credentialString`.

4. In AWS Secrets Manager, create a secret using your Google Cloud Platform credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

• When selecting **Key/value pairs**, create a pair for the key `credentials` with the value `credentialString`. 
5. In the AWS Glue Data Catalog, create a connection by following the steps in https://docs.aws.amazon.com/glue/latest/dg/console-connections.html. After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select Google BigQuery.
   - When selecting an **AWS Secret**, provide `secretName`.

6. Grant the IAM role associated with your AWS Glue job permission to read `secretName`.

7. In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

### Creating a BigQuery source node

**Prerequisites needed**

- A BigQuery type AWS Glue Data Catalog connection
- An AWS Secrets Manager secret for your Google BigQuery credentials, used by the connection.
- Appropriate permissions on your job to read the secret used by the connection.
- The name and dataset of the table and corresponding Google Cloud project you would like to read.

### Adding a BigQuery data source

**To add a Data source – BigQuery node:**

1. Choose the connection for your BigQuery data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose **Create BigQuery connection**. For more information, see [Overview of using connectors and connections](https://docs.aws.amazon.com/glue/latest/dg/using-connections.html).

   Once you have chosen a connection, you can view the connection properties by clicking **View properties**.

2. Identify what BigQuery data you would like to read, then choose a **BigQuery Source option**
   - Choose a single table – allows you to pull all data from a table.
   - Enter a custom query – allows you to customize which data is retrieved by providing a query.

3. Describe the data you would like to read
(Required) set Parent Project to the project containing your table, or a billing parent project, if relevant.

If you chose a single table, set Table to the name of a Google BigQuery table in the following format: [dataset].[table]

If you chose a query, provide it to Query. In your query, refer to tables with their fully qualified table name, in the format: [project].[dataset].[tableName].

4. Provide BigQuery properties

If you chose a single table, you do not need to provide additional properties.

If you chose a query, you must provide the following Custom Google BigQuery properties:

- Set viewsEnabled to true.
- Set materializationDataset to a dataset. The GCP principal authenticated by the credentials provided through the AWS Glue connection must be able to create tables in this dataset.

Creating a BigQuery target node

Prerequisites needed

- A BigQuery type AWS Glue Data Catalog connection
- An AWS Secrets Manager secret for your Google BigQuery credentials, used by the connection.
- Appropriate permissions on your job to read the secret used by the connection.
- The name and dataset of the table and corresponding Google Cloud project you would like to write to.

Adding a BigQuery data target

To add a Data target – BigQuery node:

1. Choose the connection for your BigQuery data target. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create BigQuery connection. For more information, see Overview of using connectors and connections.
Once you have chosen a connection, you can view the connection properties by clicking **View properties**.

2. Identify what BigQuery table you would like to write to, then choose a **Write method**.
   - Direct – writes to BigQuery directly using the BigQuery Storage Write API.
   - Indirect – writes to Google Cloud Storage, then copies to BigQuery.

If you would like to write indirectly, provide a destination GCS location with **Temporary GCS bucket**. You will need to provide additional configuration in your AWS Glue connection. For more information, see [Using indirect write with Google BigQuery](#).

3. Describe the data you would like to read

   *(Required)* set **Parent Project** to the project containing your table, or a billing parent project, if relevant.

   If you chose a single table, set **Table** to the name of a Google BigQuery table in the following format: `[dataset].[table]`

### Advanced options

You can provide advanced options when creating a BigQuery node. These options are the same as those available when programming AWS Glue for Spark scripts.

See [BigQuery connection option reference](#) in the AWS Glue developer guide.

### Connecting to Vertica in AWS Glue Studio

AWS Glue provides built-in support for Vertica. AWS Glue Studio provides a visual interface to connect to Vertica, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

### Topics

- [Creating a Vertica connection](#)
- [Creating a Vertica source node](#)
- [Creating a Vertica target node](#)
- [Advanced options](#)
Creating a Vertica connection

Prerequisites:

- An Amazon S3 bucket or folder to use for temporary storage when reading from and writing to the database, referred to by `tempS3Path`.

  **Note**

  When using Vertica in AWS Glue job data previews, temporary files may not be automatically removed from `tempS3Path`. To ensure the removal of temporary files, directly end the data preview session by choosing **End session** in the **Data preview** pane. If you cannot guarantee the data preview session is ended directly, consider setting Amazon S3 Lifecycle configuration to remove old data. We recommend removing data older than 49 hours, based on maximum job runtime plus a margin. For more information about configuring Amazon S3 Lifecycle, see [Managing your storage lifecycle](#) in the Amazon S3 documentation.

- An IAM policy with appropriate permissions to your Amazon S3 path you can associate with your AWS Glue job role.

- If your Vertica instance is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the Vertica instance without traffic traversing the public internet.

  In Amazon VPC, identify or create a **VPC**, **Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your Vertica instance and this location. Your job will need to establish a TCP connection with your Vertica client port, (default 5433). Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

To configure a connection to Vertica:

1. In AWS Secrets Manager, create a secret using your Vertica credentials, `verticaUsername` and `verticaPassword`. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.
• When selecting Key/value pairs, create a pair for the key user with the value verticaUsername.

• When selecting Key/value pairs, create a pair for the key password with the value verticaPassword.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for the next step.

   • When selecting a Connection type, select Vertica.
   • When selecting Vertica Host, provide the hostname of your Vertica installation.
   • When selecting Vertica Port, the port your Vertica installation is available through.
   • When selecting an AWS Secret, provide secretName.

3. In the following situations, you may require additional configuration:

   • For Vertica instances hosted on AWS in an Amazon VPC
     • Provide Amazon VPC connection information to the AWS Glue connection that defines your Vertica security credentials. When creating or updating your connection, set VPC, Subnet and Security groups in Network options.

You will need to perform the following steps before running your AWS Glue job:

• Grant the IAM role associated with your AWS Glue job permissions to tempS3Path.

• Grant the IAM role associated with your AWS Glue job permission to read secretName.

Creating a Vertica source node

Prerequisites needed

• A Vertica type AWS Glue Data Catalog connection, connectionName and a temporary Amazon S3 location, tempS3Path, as described in the previous section, the section called “Creating a Vertica connection”.

• A Vertica table you would like to read from, tableName, or query targetQuery.
Adding a Vertica data source

To add a Data source – Vertica node:

1. Choose the connection for your Vertica data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create Vertica connection. For more information see the previous section, the section called “Creating a Vertica connection”.

Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose the Database containing your table.

3. Choose the Staging area in Amazon S3, enter an S3A URI to tempS3Path.

4. Choose the Vertica Source.
   - Choose a single table – access all data from a single table.
   - Enter custom query – access a dataset from multiple tables based on your custom query.

5. If you chose a single table, enter tableName and optionally select a Schema.
   
   If you chose Enter custom query, enter a SQL SELECT query and optionally select a Schema.

6. In Custom Vertica properties, enter parameters and values as needed.

Creating a Vertica target node

Prerequisites needed

- A Vertica type AWS Glue Data Catalog connection, connectionName and a temporary Amazon S3 location, tempS3Path, as described in the previous section, the section called “Creating a Vertica connection”.

Adding a Vertica data target

To add a Data target – Vertica node:

1. Choose the connection for your Vertica data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create Vertica connection. For more information see the previous section, the section called “Creating a Vertica connection”.

Connecting to Vertica
Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose the **Database** containing your table.

3. Choose the **Staging area in Amazon S3**, enter an S3A URI to `tempS3Path`.

4. Enter `tableName` and optionally select a **Schema**.

5. In **Custom Vertica properties**, enter parameters and values as needed.

**Advanced options**

You can provide advanced options when creating a Vertica node. These options are the same as those available when programming AWS Glue for Spark scripts.

See [the section called “Vertica connections”](#).

**Connecting to SAP HANA in AWS Glue Studio**

AWS Glue provides built-in support for SAP HANA. AWS Glue Studio provides a visual interface to connect to SAP HANA, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

**Topics**

- [Creating a SAP HANA connection](#)
- [Creating a SAP HANA source node](#)
- [Creating a SAP HANA target node](#)
- [Advanced options](#)

**Creating a SAP HANA connection**

To connect to SAP HANA from AWS Glue, you will need to create and store your SAP HANA credentials in a AWS Secrets Manager secret, then associate that secret with a SAP HANA AWS Glue connection. You will need to configure network connectivity between your SAP HANA service and AWS Glue.

**Prerequisites:**
If your SAP HANA service is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the SAP HANA service without traffic traversing the public internet.

In Amazon VPC, identify or create a **VPC, Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your SAP HANA endpoint and this location. Your job will need to establish a TCP connection with your SAP HANA JDBC port. For more information about SAP HANA ports, see the [SAP HANA documentation](https://help.sap.com/SAP_HANA). Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

**To configure a connection to SAP HANA:**

1. In AWS Secrets Manager, create a secret using your SAP HANA credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](https://aws.amazon.com/getting-started/projects/create-aws-secrets-manager-secret/) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `user` with the value `saphanaUsername`.
   - When selecting **Key/value pairs**, create a pair for the key `password` with the value `saphanaPassword`.

2. In the AWS Glue console, create a connection by following the steps in [the section called “Adding an AWS Glue connection”](https://docs.aws.amazon.com/glue/latest/dg/add-connection.html). After creating the connection, keep the connection name, `connectionName`, for future use in AWS Glue.

   - When selecting a **Connection type**, select SAP HANA.
   - When providing **SAP HANA URL**, provide the URL for your instance.

   SAP HANA JDBC URLs are in the form
   ```
jdbc:sap://saphanaHostname:saphanaPort/?databaseName=saphanaDBname,ParameterName=ParameterValue
```

   AWS Glue requires the following JDBC URL parameters:
   - `databaseName` – A default database in SAP HANA to connect to.
   - When selecting an **AWS Secret**, provide `secretName`.

After creating a AWS Glue SAP HANA connection, you will need to perform the following steps before running your AWS Glue job:
Creating a SAP HANA source node

Prerequisites needed

- An AWS Glue SAP HANA connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a SAP HANA connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A SAP HANA table you would like to read from, tableName, or query targetQuery.

A table can be specified with a SAP HANA table name and schema name, in the form schemaName.tableName. The schema name and "." separator are not required if the table is in the default schema, "public". Call this tableIdentifier. Note that the database is provided as a JDBC URL parameter in connectionName.

Adding a SAP HANA data source

To add a Data source – SAP HANA node:

1. Choose the connection for your SAP HANA data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create SAP HANA connection. For more information see the previous section, the section called “Creating a SAP HANA connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose a SAP HANA Source option:
   - Choose a single table – access all data from a single table.
   - Enter custom query – access a dataset from multiple tables based on your custom query.

3. If you chose a single table, enter tableName.
   - If you chose Enter custom query, enter a SQL SELECT query.

4. In Custom SAP HANA properties, enter parameters and values as needed.
Creating a SAP HANA target node

Prerequisites needed

- A AWS Glue SAP HANA connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a SAP HANA connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A SAP HANA table you would like to write to, `tableName`.

A table can be specified with a SAP HANA table name and schema name, in the form `schemaName.tableName`. The schema name and "." separator are not required if the table is in the default schema, "public". Call this `tableIdentifier`. Note that the database is provided as a JDBC URL parameter in `connectionName`.

Adding a SAP HANA data target

To add a Data target – SAP HANA node:

1. Choose the connection for your SAP HANA data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create SAP HANA connection. For more information see the previous section, the section called “Creating a SAP HANA connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Configure Table name by providing `tableName`.

3. In Custom Teradata properties, enter parameters and values as needed.

Advanced options

You can provide advanced options when creating a SAP HANA node. These options are the same as those available when programming AWS Glue for Spark scripts.

See the section called “SAP HANA connections”.

Connecting to SAP HANA
Connecting to Azure SQL in AWS Glue Studio

AWS Glue provides built-in support for Azure SQL. AWS Glue Studio provides a visual interface to connect to Azure SQL, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

Topics
- Creating a Azure SQL connection
- Creating a Azure SQL source node
- Creating a Azure SQL target node
- Advanced options

Creating a Azure SQL connection

To connect to Azure SQL from AWS Glue, you will need to create and store your Azure SQL credentials in a AWS Secrets Manager secret, then associate that secret with a Azure SQL AWS Glue connection.

To configure a connection to Azure SQL:

1. In AWS Secrets Manager, create a secret using your Azure SQL credentials. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.
   - When selecting Key/value pairs, create a pair for the key user with the value azuresqlUsername.
   - When selecting Key/value pairs, create a pair for the key password with the value azuresqlPassword.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for future use in AWS Glue.
   - When selecting a Connection type, select Azure SQL.
   - When providing Azure SQL URL, provide a JDBC endpoint URL.
The URL must be in the following format:
jdbc:sqlserver://databaseServerName:databasePort;databaseName=azuresqlDBname

AWS Glue requires the following URL properties:

• databaseName – A default database in Azure SQL to connect to.

For more information about JDBC URLs for Azure SQL Managed Instances, see the Microsoft documentation.

• When selecting an AWS Secret, provide secretName.

Creating a Azure SQL source node

Prerequisites needed

• A AWS Glue Azure SQL connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a Azure SQL connection”.

• Appropriate permissions on your job to read the secret used by the connection.

• A Azure SQL table you would like to read from, tableName.

An Azure SQL table is identified by its database, schema and table name. You must provide the database name and table name when connecting to Azure SQL. You also must provide the schema if it is not the default, "public". Database is provided through a URL property in connectionName, schema and table name through the dbtable.

Adding a Azure SQL data source

To add a Data source – Azure SQL node:

1. Choose the connection for your Azure SQL data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create Azure SQL connection. For more information see the previous section, the section called “Creating a Azure SQL connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose a Azure SQL Source option:
• **Choose a single table** – access all data from a single table.

• **Enter custom query** – access a dataset from multiple tables based on your custom query.

3. If you chose a single table, enter `tableName`.

   If you chose **Enter custom query**, enter a TransactSQL SELECT query.

4. In **Custom Azure SQL properties**, enter parameters and values as needed.

### Creating a Azure SQL target node

#### Prerequisites needed

- A AWS Glue Azure SQL connection, configured with an AWS Secrets Manager secret, as described in the previous section, *the section called “Creating a Azure SQL connection”*. 
- Appropriate permissions on your job to read the secret used by the connection.
- A Azure SQL table you would like to write to, `tableName`.

An Azure SQL table is identified by its database, schema and table name. You must provide the database name and table name when connecting to Azure SQL. You also must provide the schema if it is not the default, "public". Database is provided through a URL property in `connectionName`, schema and table name through the `dbtable`.

### Adding a Azure SQL data target

#### To add a Data target – Azure SQL node:

1. Choose the connection for your Azure SQL data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose **Create Azure SQL connection**. For more information see the previous section, *the section called “Creating a Azure SQL connection”*.

   Once you have chosen a connection, you can view the connection properties by clicking **View properties**.

2. Configure **Table name** by providing `tableName`.

3. In **Custom Azure SQL properties**, enter parameters and values as needed.
Advanced options

You can provide advanced options when creating a Azure SQL node. These options are the same as those available when programming AWS Glue for Spark scripts.

See the section called “Azure SQL connections”.

Connecting to MongoDB in AWS Glue Studio

AWS Glue provides built-in support for MongoDB. AWS Glue Studio provides a visual interface to connect to MongoDB, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

Topics

- Creating a MongoDB connection
- Creating a MongoDB source node
- Creating a MongoDB target node
- Advanced options

Creating a MongoDB connection

Prerequisites:

- If your MongoDB instance is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the MongoDB instance without traffic traversing the public internet.

In Amazon VPC, identify or create a VPC, Subnet and Security group that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your MongoDB instance and this location. Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

To configure a connection to MongoDB:

1. Option ally, in AWS Secrets Manager, create a secret using your MongoDB credentials. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.
When selecting **Key/value pairs**, create a pair for the key `username` with the value `mongodbUser`.

When selecting **Key/value pairs**, create a pair for the key `password` with the value `mongodbPass`.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for future use in AWS Glue.

   - When selecting a **Connection type**, select **MongoDB** or **MongoDB Atlas**.
   - When selecting **MongoDB URL** or **MongoDB Atlas URL**, provide the hostname of your MongoDB instance.

     A MongoDB URL is provided in the format `mongodb://mongoHost:mongoPort/mongoDBname`.

     A MongoDB Atlas URL is provided in the format `mongodb+srv://mongoHost:mongoPort/mongoDBname`.

     Providing the default database for the connection, `mongoDBname` is optional.

   - If you chose to create an Secrets Manager secret, choose the AWS Secrets Manager **Credential type**.

     Then, in **AWS Secret** provide `secretName`.

   - If you choose to provide **Username and password**, provide `mongodbUser` and `mongodbPass`.

3. In the following situations, you may require additional configuration:

   - For MongoDB instances hosted on AWS in an Amazon VPC
     
       - You will need to provide Amazon VPC connection information to the AWS Glue connection that defines your MongoDB security credentials. When creating or updating your connection, set **VPC**, **Subnet** and **Security groups** in **Network options**.

After creating a AWS Glue MongoDB connection, you will need to perform the following steps before running your AWS Glue job:
• When working with AWS Glue jobs in the visual editor, you must provide Amazon VPC connection information for your job to connect to MongoDB. Identify a suitable location in Amazon VPC and provide it to your AWS Glue MongoDB connection.

• If you chose to create an Secrets Manager secret, grant the IAM role associated with your AWS Glue job permission to read `secretName`.

Creating a MongoDB source node

Prerequisites needed

• A AWS Glue MongoDB connection, as described in the previous section, the section called “Creating a MongoDB connection”.

• If you chose to create an Secrets Manager secret, appropriate permissions on your job to read the secret used by the connection.

• A MongoDB collection you would like to read from. You will need identification information for the collection.

A MongoDB collection is identified by a database name and a collection name, `mongodbName`, `mongodbCollection`.

Adding a MongoDB data source

To add a Data source – MongoDB node:

1. Choose the connection for your MongoDB data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create MongoDB connection. For more information see the previous section, the section called “Creating a MongoDB connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose a Database. Enter `mongodbName`.

3. Choose a Collection. Enter `mongodbCollection`.

4. Choose your Partitioner, Partition size (MB) and Partition key. For more information about partition parameters, see the section called "connectionType": "mongodb" as source".

5. In Custom MongoDB properties, enter parameters and values as needed.
Creating a MongoDB target node

Prerequisites needed

• A AWS Glue MongoDB connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a MongoDB connection”.

• Appropriate permissions on your job to read the secret used by the connection.

• A MongoDB table you would like to write to, tableName.

Adding a MongoDB data target

To add a Data target – MongoDB node:

1. Choose the connection for your MongoDB data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create MongoDB connection. For more information see the previous section, the section called “Creating a MongoDB connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose a Database. Enter mongodbName.

3. Choose a Collection. Enter mongodbCollection.

4. Choose your Partitioner, Partition size (MB) and Partition key. For more information about partition parameters, see the section called “"connectionType": "mongodb" as source”.

5. Choose Retry Writes if desired.

6. In Custom MongoDB properties, enter parameters and values as needed.

Advanced options

You can provide advanced options when creating a MongoDB node. These options are the same as those available when programming AWS Glue for Spark scripts.

See the section called “MongoDB connection”.
Connecting to Azure Cosmos DB in AWS Glue Studio

AWS Glue provides built-in support for Azure Cosmos DB. AWS Glue Studio provides a visual interface to connect to Azure Cosmos DB for NoSQL, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

Topics

- Creating a Azure Cosmos DB connection
- Creating a Azure Cosmos DB source node
- Creating a Azure Cosmos DB target node
- Advanced options

Creating a Azure Cosmos DB connection

Prerequisites:

- In Azure, you will need to identify or generate an Azure Cosmos DB Key for use by AWS Glue, cosmosKey. For more information, see Secure access to data in Azure Cosmos DB in the Azure documentation.

To configure a connection to Azure Cosmos DB:

1. In AWS Secrets Manager, create a secret using your Azure Cosmos DB Key for use by AWS Glue, cosmosKey. For more information, see Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.

   - When selecting Key/value pairs, create a pair for the key spark.cosmos.accountKey with the value cosmosKey.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for future use in AWS Glue.

   - When selecting a Connection type, select Azure Cosmos DB.
   - When selecting an AWS Secret, provide secretName.
Creating a Azure Cosmos DB source node

Prerequisites needed

- A AWS Glue Azure Cosmos DB connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a Azure Cosmos DB connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A Azure Cosmos DB for NoSQL container you would like to read from. You will need identification information for the container.

An Azure Cosmos for NoSQL container is identified by its database and container. You must provide the database, `cosmosDBName`, and container, `cosmosContainerName`, names when connecting to the Azure Cosmos for NoSQL API.

Adding a Azure Cosmos DB data source

To add a Data source – Azure Cosmos DB node:

1. Choose the connection for your Azure Cosmos DB data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create Azure Cosmos DB connection. For more information see the previous section, the section called “Creating a Azure Cosmos DB connection”.

Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose Cosmos DB Database Name – provide the name of the database you want to read from, `cosmosDBName`.

3. Choose Azure Cosmos DB Container – provide the name of the container you want to read from, `cosmosContainerName`.

4. Optionally, choose Azure Cosmos DB Custom Query – provide a SQL SELECT query to retrieve specific information from Azure Cosmos DB.

5. In Custom Azure Cosmos properties, enter parameters and values as needed.
Creating a Azure Cosmos DB target node

Prerequisites needed

- A AWS Glue Azure Cosmos DB connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a Azure Cosmos DB connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A Azure Cosmos DB table you would like to write to. You will need identification information for the container. You must create the container before calling the connection method.

An Azure Cosmos for NoSQL container is identified by its database and container. You must provide the database, `cosmosDBName`, and container, `cosmosContainerName`, names when connecting to the Azure Cosmos for NoSQL API.

Adding a Azure Cosmos DB data target

To add a Data target – Azure Cosmos DB node:

1. Choose the connection for your Azure Cosmos DB data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create Azure Cosmos DB connection. For more information see the previous section, the section called “Creating a Azure Cosmos DB connection”.

Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose Cosmos DB Database Name – provide the name of the database you want to read from, `cosmosDBName`.

3. Choose Azure Cosmos DB Container – provide the name of the container you want to read from, `cosmosContainerName`.

4. In Custom Azure Cosmos properties, enter parameters and values as needed.

Advanced options

You can provide advanced options when creating a Azure Cosmos DB node. These options are the same as those available when programming AWS Glue for Spark scripts.

See the section called “Azure Cosmos DB connections”.

Connecting to Azure Cosmos DB
Connecting to Teradata Vantage in AWS Glue Studio

AWS Glue provides built-in support for Teradata Vantage. AWS Glue Studio provides a visual interface to connect to Teradata, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime.

Topics

- Creating a Teradata Vantage connection
- Creating a Teradata source node
- Creating a Teradata target node
- Advanced options

Creating a Teradata Vantage connection

To connect to Teradata Vantage from AWS Glue, you will need to create and store your Teradata credentials in an AWS Secrets Manager secret, then associate that secret with a AWS Glue Teradata connection.

Prerequisites:

- If you are accessing your Teradata environment through Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the Teradata environment. We discourage accessing the Teradata environment over the public internet.

In Amazon VPC, identify or create a VPC, Subnet and Security group that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your Teradata instance and this location. Your job will need to establish a TCP connection with your Teradata client port. For more information about Teradata ports, see the Teradata documentation.

Based on your network layout, secure VPC connectivity may require changes in Amazon VPC and other networking services. For more information about AWS connectivity, consult AWS Connectivity Options in the Teradata documentation.
To configure a AWS Glue Teradata connection:

1. In your Teradata configuration, identify or create a user and password AWS Glue will connect
   with, `teradataUser` and `teradataPassword`. For more information, consult [Vantage Security Overview](#) in the Teradata documentation.

2. In AWS Secrets Manager, create a secret using your Teradata credentials. To create a secret in
   Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `user` with the value `teradataUsername`.
   - When selecting **Key/value pairs**, create a pair for the key `password` with the value `teradataPassword`.

3. In the AWS Glue console, create a connection by following the steps in the section called
   “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select Teradata.
   - When providing **JDBC URL**, provide the URL for your instance. You can also hardcode certain comma separated connection parameters in your JDBC URL. The URL must conform to the following format:
     `jdbc:teradata://teradataHostname/ParameterName=ParameterValue,ParameterName=

     Supported URL parameters include:

     - DATABASE_NAME—name of database on host to access by default.
     - DBS_PORT—the database port, used when running on a nonstandard port.

   - When selecting a **Credential type**, select AWS Secrets Manager, then set **AWS Secret** to `secretName`.

4. In the following situations, you may require additional configuration:

   - For Teradata instances hosted on AWS in an Amazon VPC
     - You will need to provide Amazon VPC connection information to the AWS Glue connection that defines your Teradata security credentials. When creating or updating your connection, set **VPC**, **Subnet** and **Security groups** in **Network options**.
Creating a Teradata source node

Prerequisites needed

- An AWS Glue Teradata Vantage connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a Teradata Vantage connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A Teradata table you would like to read from, tableName, or query targetQuery.

Adding a Teradata data source

To add a Data source – Teradata node:

1. Choose the connection for your Teradata data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create a new connection. For more information see the previous section, the section called “Creating a Teradata Vantage connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Choose a Teradata Source option:

   - Choose a single table – access all data from a single table.
   - Enter custom query – access a dataset from multiple tables based on your custom query.

3. If you chose a single table, enter tableName.

   If you chose Enter custom query, enter a SQL SELECT query.

4. In Custom Teradata properties, enter parameters and values as needed.

Creating a Teradata target node

Prerequisites needed

- A AWS Glue Teradata Vantage connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a Teradata Vantage connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A Teradata table you would like to write to, tableName.
Adding a Teradata data target

To add a Data target – Teradata node:

1. Choose the connection for your Teradata data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose **Create Teradata connection**. For more information, see [Overview of using connectors and connections](#).

   Once you have chosen a connection, you can view the connection properties by clicking **View properties**.

2. Configure **Table name** by providing `tableName`.

3. In **Custom Teradata properties**, enter parameters and values as needed.

Advanced options

You can provide advanced options when creating a Teradata node. These options are the same as those available when programming AWS Glue for Spark scripts.

See [the section called “Teradata Vantage connections”](#).

Connecting to OpenSearch Service in AWS Glue Studio

AWS Glue provides built-in support for Amazon OpenSearch Service. **AWS Glue Studio** provides a visual interface to connect to Amazon OpenSearch Service, author data integration jobs, and run them on the AWS Glue Studio serverless Spark runtime. This feature is not compatible with OpenSearch Service serverless.

Topics

- [Creating a OpenSearch Service connection](#)
- [Creating a OpenSearch Service source node](#)
- [Creating a OpenSearch Service target node](#)
- [Advanced options](#)

Creating a OpenSearch Service connection

Prerequisites:
• Identify the domain endpoint, `aosEndpoint` and port, `aosPort` you would like to read from, or create the resource by following instructions in the Amazon OpenSearch Service documentation. For more information on creating a domain, see Creating and managing Amazon OpenSearch Service domains in the Amazon OpenSearch Service documentation.

An Amazon OpenSearch Service domain endpoint will have the following default form, https://search-domainName-unstructuredIdContent.region.es.amazonaws.com. For more information on identifying your domain endpoint, see Creating and managing Amazon OpenSearch Service domains in the Amazon OpenSearch Service documentation.

Identify or generate HTTP basic authentication credentials, `aosUser` and `aosPassword` for your domain.

To configure a connection to OpenSearch Service:

1. In AWS Secrets Manager, create a secret using your OpenSearch Service credentials. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   • When selecting Key/value pairs, create a pair for the key `opensearch.net.http.auth.user` with the value `aosUser`.

   • When selecting Key/value pairs, create a pair for the key `opensearch.net.http.auth.user` with the value `aosPassword`.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for future use in AWS Glue.

   • When selecting a Connection type, select OpenSearch Service.

   • When selecting a Domain endpoint, provide `aosEndpoint`.

   • When selecting a port, provide `aosPort`.

   • When selecting an AWS Secret, provide `secretName`. 
Creating a OpenSearch Service source node

Prerequisites needed

- A AWS Glue OpenSearch Service connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a OpenSearch Service connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A OpenSearch Service index you would like to read from, aosIndex.

Adding a OpenSearch Service data source

To add a Data source – OpenSearch Service node:

1. Choose the connection for your OpenSearch Service data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose Create OpenSearch Service connection. For more information see the previous section, the section called “Creating a OpenSearch Service connection”.

   Once you have chosen a connection, you can view the connection properties by clicking View properties.

2. Provide Index, the index you would like to read.

3. Optionally, provide Query, an OpenSearch query to deliver more specific results. For more information about writing OpenSearch queries, consult the section called “Read from OpenSearch Service”.

4. In Custom OpenSearch Service properties, enter parameters and values as needed.

Creating a OpenSearch Service target node

Prerequisites needed

- A AWS Glue OpenSearch Service connection, configured with an AWS Secrets Manager secret, as described in the previous section, the section called “Creating a OpenSearch Service connection”.
- Appropriate permissions on your job to read the secret used by the connection.
- A OpenSearch Service index you would like to write to, aosIndex.
Adding a OpenSearch Service data target

To add a Data target – OpenSearch Service node:

1. Choose the connection for your OpenSearch Service data source. Since you have created it, it should be available in the dropdown. If you need to create a connection, choose **Create OpenSearch Service connection**. For more information see the previous section, the section called “Creating a OpenSearch Service connection”.

   Once you have chosen a connection, you can view the connection properties by clicking **View properties**.

2. Provide **Index**, the index you would like to read.

3. In **Custom OpenSearch Service properties**, enter parameters and values as needed.

Advanced options

You can provide advanced options when creating a OpenSearch Service node. These options are the same as those available when programming AWS Glue for Spark scripts.

See the section called “OpenSearch Service connections”.

Using connectors and connections with AWS Glue Studio

AWS Glue provides built-in support for the most commonly used data stores (such as Amazon Redshift, Amazon Aurora, Microsoft SQL Server, MySQL, MongoDB, and PostgreSQL) using JDBC connections. AWS Glue also allows you to use custom JDBC drivers in your extract, transform, and load (ETL) jobs. For data stores that are not natively supported, such as SaaS applications, you can use connectors.

A **connector** is an optional code package that assists with accessing data stores in AWS Glue Studio. You can subscribe to several connectors offered in AWS Marketplace.

When creating ETL jobs, you can use a natively supported data store, a connector from AWS Marketplace, or your own custom connectors. If you use a connector, you must first create a connection for the connector. A **connection** contains the properties that are required to connect to a particular data store. You use the connection with your data sources and data targets in the ETL job. Connectors and connections work together to facilitate access to the data stores.

Topics
Overview of using connectors and connections

A connection contains the properties that are required to connect to a particular data store. When you create a connection, it is stored in the AWS Glue Data Catalog. You choose a connector, and then create a connection based on that connector.

You can subscribe to connectors for non-natively supported data stores in AWS Marketplace, and then use those connectors when you're creating connections. Developers can also create their own connectors, and you can use them when creating connections.

The following steps describe the overall process of using connectors in AWS Glue Studio:

1. Subscribe to a connector in AWS Marketplace, or develop your own connector and upload it to AWS Glue Studio. For more information, see Adding connectors to AWS Glue Studio.

2. Review the connector usage information. You can find this information on the Usage tab on the connector product page. For example, if you click the Usage tab on this product page, AWS Glue Connector for Google BigQuery, you can see in the Additional Resources section a link to a blog about using this connector. Other connectors might contain links to the instructions in the Overview section, as shown on the connector product page for Cloudwatch Logs connector for AWS Glue.
3. Create a connection. You choose which connector to use and provide additional information for the connection, such as login credentials, URI strings, and virtual private cloud (VPC) information. For more information, see Creating connections for connectors.

4. Create an IAM role for your job. The job assumes the permissions of the IAM role that you specify when you create it. This IAM role must have the necessary permissions to authenticate with, extract data from, and write data to your data stores.

5. Create an ETL job and configure the data source properties for your ETL job. Provide the connection options and authentication information as instructed by the custom connector provider. For more information, see Authoring jobs with custom connectors.

6. Customize your ETL job by adding transforms or additional data stores, as described in Visual ETL with AWS Glue Studio.

7. If using a connector for the data target, configure the data target properties for your ETL job. Provide the connection options and authentication information as instructed by the custom connector provider. For more information, see the section called “Authoring jobs with custom connectors”.

8. Customize the job run environment by configuring job properties, as described in Modify the job properties.

9. Run the job.

**Adding connectors to AWS Glue Studio**

A connector is a piece of code that facilitates communication between your data store and AWS Glue. You can either subscribe to a connector offered in AWS Marketplace, or you can create your own custom connector.

**Topics**

- Subscribing to AWS Marketplace connectors
- Creating custom connectors

**Subscribing to AWS Marketplace connectors**

AWS Glue Studio makes it easy to add connectors from AWS Marketplace.

**To add a connector from AWS Marketplace to AWS Glue Studio**

1. In the AWS Glue Studio console, choose Connectors in the console navigation pane.
2. On the **Connectors** page, choose **Go to AWS Marketplace**.

3. In AWS Marketplace, in **Featured products**, choose the connector you want to use. You can choose one of the featured connectors, or use search. You can search on the name or type of connector, and you can use options to refine the search results.

   If you want to use one of the featured connectors, choose **View product**. If you used search to locate a connector, then choose the name of the connector.

4. On the product page for the connector, use the tabs to view information about the connector. If you decide to purchase this connector, choose **Continue to Subscribe**.

5. Provide the payment information, and then choose **Continue to Configure**.

6. On the **Configure this software** page, choose the method of deployment and the version of the connector to use. Then choose **Continue to Launch**.

7. On the **Launch this software** page, you can review the **Usage Instructions** provided by the connector provider. When you're ready to continue, choose **Activate connection in AWS Glue Studio**.

   After a small amount of time, the console displays the **Create marketplace connection** page in AWS Glue Studio.

8. Create a connection that uses this connector, as described in **Creating connections for connectors**.

   Alternatively, you can choose **Activate connector only** to skip creating a connection at this time. You must create a connection at a later date before you can use the connector.

### Creating custom connectors

You can also build your own connector and then upload the connector code to AWS Glue Studio.

Custom connectors are integrated into AWS Glue Studio through the AWS Glue Spark runtime API. The AWS Glue Spark runtime allows you to plug in any connector that is compliant with the Spark, Athena, or JDBC interface. It allows you to pass in any connection option that is available with the custom connector.

You can encapsulate all your connection properties with **AWS Glue Connections** and supply the connection name to your ETL job. Integration with Data Catalog connections allows you to use the same connection properties across multiple calls in a single Spark application or across different applications.
You can specify additional options for the connection. The job script that AWS Glue Studio generates contains a Datasource entry that uses the connection to plug in your connector with the specified connection options. For example:

```
Datasource = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {
    "dbTable":"Account","connectionName":"my-custom-jdbc-connection"}, transformation_ctx = "DataSource0")
```

To add a custom connector to AWS Glue Studio

1. Create the code for your custom connector. For more information, see Developing custom connectors.
2. Add support for AWS Glue features to your connector. Here are some examples of these features and how they are used within the job script generated by AWS Glue Studio:

   - **Data type mapping** – Your connector can typecast the columns while reading them from the underlying data store. For example, a `dataTypeMapping` of `{"INTEGER":"STRING"}` converts all columns of type `Integer` to columns of type `String` when parsing the records and constructing the `DynamicFrame`. This helps users to cast columns to types of their choice.

```
DataSource0 = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {
    "dataTypeMapping":{"INTEGER":"STRING"},
    "connectionName":"test-connection-jdbc"}, transformation_ctx = "DataSource0")
```

   - **Partitioning for parallel reads** – AWS Glue allows parallel data reads from the data store by partitioning the data on a column. You must specify the partition column, the lower partition bound, the upper partition bound, and the number of partitions. This feature enables you to make use of data parallelism and multiple Spark executors allocated for the Spark application.

```
DataSource0 = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {
    "upperBound":"200","numPartitions":"4",
    "partitionColumn":"id","lowerBound":"0","connectionName":"test-connection-jdbc"}, transformation_ctx = "DataSource0")
```

   - **Use AWS Secrets Manager for storing credentials** – The Data Catalog connection can also contain a `secretId` for a secret stored in AWS Secrets Manager. The AWS secret can
securely store authentication and credentials information and provide it to AWS Glue at runtime. Alternatively, you can specify the secretId from the Spark script as follows:

```
DataSource = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {"connectionName":"test-connection-jdbc", "secretId"-> "my-secret-id"}, transformation_ctx = "DataSource0")
```

- **Filtering the source data with row predicates and column projections** – The AWS Glue Spark runtime also allows users to push down SQL queries to filter data at the source with row predicates and column projections. This allows your ETL job to load filtered data faster from data stores that support push-downs. An example SQL query pushed down to a JDBC data source is:

```
SELECT id, name, department FROM department WHERE id < 200.
```

```
DataSource = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {
"query":"SELECT id, name, department FROM department WHERE id < 200","connectionName":"test-connection-jdbc"}, transformation_ctx = "DataSource0")
```

- **Job bookmarks** – AWS Glue supports incremental loading of data from JDBC sources. AWS Glue keeps track of the last processed record from the data store, and processes new data records in the subsequent ETL job runs. Job bookmarks use the primary key as the default column for the bookmark key, provided that this column increases or decreases sequentially. For more information about job bookmarks, see [Job Bookmarks](#) in the [AWS Glue Developer Guide](#).

```
DataSource0 = glueContext.create_dynamic_frame.from_options(connection_type = "custom.jdbc", connection_options = {
"jobBookmarkKeys": ["empno"],
"jobBookmarkKeysSortOrder": "asc", "connectionName":"test-connection-jdbc"}, transformation_ctx = "DataSource0")
```

3. Package the custom connector as a JAR file and upload the file to Amazon S3.
4. Test your custom connector. For more information, see the instructions on GitHub at [Glue Custom Connectors: Local Validation Tests Guide](#).
5. In the AWS Glue Studio console, choose Connectors in the console navigation pane.
6. On the Connectors page, choose Create custom connector.
7. On the Create custom connector page, enter the following information:
• The path to the location of the custom code JAR file in Amazon S3.

• A name for the connector that will be used by AWS Glue Studio.

• Your connector type, which can be one of **JDBC, Spark, or Athena**.

• The name of the entry point within your custom code that AWS Glue Studio calls to use the connector.
  • For JDBC connectors, this field should be the class name of your JDBC driver.
  • For Spark connectors, this field should be the fully qualified data source class name, or its alias, that you use when loading the Spark data source with the `format` operator.

• (JDBC only) The base URL used by the JDBC connection for the data store.

• (Optional) A description of the custom connector.

8. Choose **Create connector**.

9. From the **Connectors** page, create a connection that uses this connector, as described in Creating connections for connectors.

**Available connections**

The following connections are available when creating connections for connectors:

• **Amazon Aurora** – a scalable, high-performance relational database engine with built-in security, backup and restore, and in-memory acceleration.

• **Amazon DocumentDB** – a scalable, highly available, and fully managed document database service that supports MongoDB and SQL APIs.

• **Amazon Redshift** – a scalable, highly available, and fully managed document database service that supports MongoDB and SQL APIs.

• **Google BigQuery** – a serverless cloud data warehouse for running fast SQL queries on large datasets.

• **JDBC** – a relational database management system (RDBMS) that uses a Java API for connecting and interacting with data connections.

• **Kafka** – an open-source stream processing platform used for real-time data streaming and messaging.

• **MariaDB** – a community-developed fork of MySQL that offers enhanced performance, scalability, and features.
• **MongoDB** – a cross-platform document-oriented database that provides high scalability, flexibility, and performance.

• **MongoDB Atlas** – a cloud-based database as a service (DBaaS) offering from MongoDB that simplifies the management and scaling of MongoDB deployments.

• **Microsoft SQL Server** – a relational database management system (RDBMS) from Microsoft that provides robust data storage, analysis, and reporting capabilities.

• **MySQL** – an open-source relational database management system (RDBMS) that is widely used in web applications and is known for its reliability and scalability.

• **Network** – a network data source represents a network-accessible resource or service that can be accessed by a data integration platform.

• **OpenSearch** – an OpenSearch data source is an application that OpenSearch can connect to and ingest data from.

• **Oracle** – a relational database management system (RDBMS) from Oracle Corporation that provides robust data storage, analysis, and reporting capabilities.

• **PostgreSQL** – an open-source relational database management system (RDBMS) that provides robust data storage, analysis, and reporting capabilities.

• **Snowflake** – a cloud-based data warehouse that provides scalable, high-performance data storage and analytics services.

• **Teradata** – a relational database management system (RDBMS) that provides high-performance data storage, analysis, and reporting capabilities.

• **Vertica** – a columnar-oriented analytical data warehouse designed for big data analytics that offers fast query performance, advanced analytics, and scalability.

• **SAP HANA** – an in-memory database and analytics platform that provides fast data processing, advanced analytics, and real-time data integration.

• **Azure SQL** – a cloud-based relational database service from Microsoft Azure that provides scalable, reliable, and secure data storage and management capabilities.

• **Cosmos DB** – a globally distributed cloud database service from Microsoft Azure that provides scalable, high-performance data storage and querying capabilities.

**Creating connections for connectors**

An AWS Glue connection is a Data Catalog object that stores connection information for a particular data store. Connections store login credentials, URI strings, virtual private cloud (VPC)
information, and more. Creating connections in the Data Catalog saves the effort of having to specify all connection details every time you create a job.

**To create a connection for a connector**

1. In the AWS Glue Studio console, choose **Connectors** in the console navigation pane. In the **Connections** section, choose **Create connection**.

2. Choose the data source you want to create a connection for in step 1 of the **Create data connection** wizard. There are several ways to view the available data sources, including:
   - Filter the available data sources by choosing a tab. By default, **All connectors** is selected.
   - Toggle **List** to view the data sources as a list or toggle back to **Grid** to view the available connectors in the grid layout.
   - Use the search bar to narrow the list of data sources. As you type, search matches are displayed and non-matching sources are removed from view.

   Once you've chosen the data source, choose **Next**.

3. Configure the connection in Step 2 in the wizard.

   Enter the connection details. Depending on the type of connector you selected, you're prompted to enter additional information:
4. Choose the data source you want to create a connection for in step 1 of the **Create data connection** wizard. There are several ways to view the available data sources. By default, you will see all available data sources in a grid layout. You can also:

- **Toggle List** to view the data sources as a list or toggle back to **Grid** to view the available connectors in the grid layout.

- Use the search bar to narrow the list of data sources. As you type, search matches are displayed and non-matching sources are removed from view.

Once you’ve chosen the data source, choose **Next**.

5. Configure the connection in Step 2 in the wizard.

Enter the connection details. Depending on the type of connector you selected, you may be required to enter additional connection information. This can include:
• **Connection details** – these fields will change depending on the data source you are connecting to. For example, if you are connecting to Amazon DocumentDB databases, you will enter the Amazon DocumentDB URL. If you are connecting to Amazon Aurora, you will choose the database instance and enter the database name. The following is the Connection details required for Amazon Aurora:

![Configure connection](image)

- **Credential type** – choose between **Username and password** or **AWS Secrets Manager**. Enter the requested authentication information.

- For connectors that use JDBC, enter the information required to create the JDBC URL for the data store.

- If you use a virtual private cloud (VPC), then enter the network information for your VPC.

6. Set the connection properties in step 3 of the wizard. You can add a description and tags as an optional part of this step. Name is required and is prepopulated with a default value. Choose Next.

7. Review the connection source, details, and properties. If you need to make any changes, choose **Edit** for the step in the wizard. When ready, choose, **Create connection**.

Choose **Create connection**.

You are returned to the **Connectors** page, and the informational banner indicates the connection that was created. You can now use the connection in your AWS Glue Studio jobs.
Creating a Kafka connection

When creating a Kafka connection, selecting Kafka from the drop-down menu will display additional settings to configure:

- Kafka cluster details
- Authentication
- Encryption
- Network options

Configure Kafka cluster details

1. Choose the cluster location. You can choose from an Amazon managed streaming for Apache Kafka (MSK) cluster or a Customer managed Apache Kafka cluster. For more information on Amazon Managed streaming for Apache Kafka, see Amazon managed streaming for Apache Kafka (MSK).

Note

Amazon Managed Streaming for Apache Kafka only supports TLS and SASL/SCRAM-SHA-512 authentication methods.

**Kafka cluster details**

- Cluster location
  - Amazon managed streaming for Apache Kafka (MSK)
  - Customer managed Apache Kafka

- Kafka bootstrap server URLs
  - A comma-separated list of bootstrap server URLs. Include the port number.

  Enter list of URLs, separated by commas

Example: b-1.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094, b-2.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094, b-3.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094
2. Enter the URLs for your Kafka bootstrap servers. You may enter more than one by separating each server by a comma. Include the port number at the end of the URL by appending :<port number>.

For example: b-1.vpc-test-2.034a88o.kafka-us-east-1.amazonaws.com:9094

Select authentication method

AWS Glue supports the Simple Authentication and Security Layer (SASL) framework for authentication. The SASL framework supports various mechanisms of authentication, and AWS Glue offers both the SCRAM protocol (username and password) and GSSAPI (Kerberos protocol).

When choosing an authentication method from the drop-down menu, the following client authentication methods can be selected:

- None - No authentication. This is useful if you create a connection for testing purposes.
- SASL/SCRAM-SHA-512 - Choose this authentication method to specify authentication credentials. There are two options available:
  - Use AWS Secrets Manager (recommended) - if you select this option, you can store your credentials in AWS Secrets Manager and let AWS Glue access the information when needed. Specify the secret that stores the SSL or SASL authentication credentials.
• Provider username and password directly.

• SASL/GSSAPI (Kerberos) - if you select this option, you can select the location of the keytab file, krb5.conf file and enter the Kerberos principal name and Kerberos service name. The locations for the keytab file and krb5.conf file must be in an Amazon S3 location. Since MSK does not yet support SASL/GSSAPI, this option is only available for customer managed Apache Kafka clusters. For more information, see MIT Kerberos Documentation: Keytab.

• SSL Client Authentication - if you select this option, you can select the location of the Kafka client keystore by browsing Amazon S3. Optionally, you can enter the Kafka client keystore password and Kafka client key password.
Configure encryption settings

1. If the Kafka connection requires SSL connection, select the checkbox for **Require SSL connection**. Note that the connection will fail if it's unable to connect over SSL. SSL for encryption can be used with any of the authentication methods (SASL/SCRAM-SHA-512, SASL/GSSAPI, SSL Client Authentication) and is optional.

   If the authentication method is set to **SSL client authentication**, this option will be selected automatically and will be disabled to prevent any changes.

2. (Optional). Choose the location of private certificate from certificate authority (CA). Note that the location of the certification must be in an S3 location. Choose **Browse** to choose the file from a connected S3 bucket. The path must be in the form `s3://bucket/prefix/path`. It must end with the file name and .pem extension.

3. You can choose to skip validation of certificate from a certificate authority (CA). Choose the checkbox **Skip validation of certificate from certificate authority (CA)**. If this box is not checked, AWS Glue validates certificates for three algorithms:
   - SHA256withRSA
   - SHA384withRSA
   - SHA512withRSA
The following are optional steps to configure VPC, Subnet and Security groups. If your AWS Glue job needs to run on Amazon EC2 instances in a virtual private cloud (VPC) subnet, you must provide additional VPC-specific configuration information.

1. Choose the VPC (virtual private cloud) that contains your data source.
2. Choose the subnet with your VPC.
3. Choose one or more security groups to allow access to the data store in your VPC subnet. Security groups are associated to the ENI attached to your subnet. You must choose at least one security group with a self-referencing inbound rule for all TCP ports.
You can use connectors and connections for both data source nodes and data target nodes in AWS Glue Studio.

Topics

- Create jobs that use a connector for the data source
- Configure source properties for nodes that use connectors
- Configure target properties for nodes that use connectors

Create jobs that use a connector for the data source

When you create a new job, you can choose a connector for the data source and data targets.

To create a job that uses connectors for the data source or data target

1. Sign in to the AWS Management Console and open the AWS Glue Studio console at https://console.aws.amazon.com/gluestudio/.
2. On the Connectors page, in the Your connections resource list, choose the connection you want to use in your job, and then choose Create job.
Alternatively, on the AWS Glue Studio Jobs page, under Create job, choose Source and target added to the graph. In the Source drop-down list, choose the custom connector that you want to use in your job. You can also choose a connector for Target.

3. Choose Create to open the visual job editor.

4. Configure the data source node, as described in Configure source properties for nodes that use connectors.

5. Continue creating your ETL job by adding transforms, additional data stores, and data targets, as described in Visual ETL with AWS Glue Studio.

6. Customize the job run environment by configuring job properties as described in Modify the job properties.

7. Save and run the job.
Configure source properties for nodes that use connectors

After you create a job that uses a connector for the data source, the visual job editor displays a job graph with a data source node configured for the connector. You must configure the data source properties for that node.

To configure the properties for a data source node that uses a connector

1. Choose the connector data source node in the job graph or add a new node and choose the connector for the **Node type**. Then, on the right-side, in the node details panel, choose the **Data source properties** tab, if it's not already selected.

2. In the **Data source properties** tab, choose the connection that you want to use for this job. Enter the additional information required for each connection type:

   **JDBC**

   - **Data source input type**: Choose to provide either a table name or a SQL query as the data source. Depending on your choice, you then need to provide the following additional information:
- **Table name**: The name of the table in the data source. If the data source does not use the term *table*, then supply the name of an appropriate data structure, as indicated by the custom connector usage information (which is available in AWS Marketplace).

- **Filter predicate**: A condition clause to use when reading the data source, similar to a *WHERE* clause, which is used to retrieve a subset of the data.

- **Query code**: Enter a SQL query to use to retrieve a specific dataset from the data source. An example of a basic SQL query is:

  ```sql
  SELECT column_list FROM table_name WHERE where_clause
  ```

- **Schema**: Because AWS Glue Studio is using information stored in the connection to access the data source instead of retrieving metadata information from a Data Catalog table, you must provide the schema metadata for the data source. Choose *Add schema* to open the schema editor.

  For instructions on how to use the schema editor, see [Editing the schema in a custom transform node](#).

- **Partition column**: (Optional) You can choose to partition the data reads by providing values for *Partition column, Lower bound, Upper bound, and Number of partitions*.

  The `lowerBound` and `upperBound` values are used to decide the partition stride, not for filtering the rows in table. All rows in the table are partitioned and returned.

  **Note**
  
  Column partitioning adds an extra partitioning condition to the query used to read the data. When using a query instead of a table name, you should validate that the query works with the specified partitioning condition. For example:

  - If your query format is "SELECT col1 FROM table1", then test the query by appending a *WHERE* clause at the end of the query that uses the partition column.

  - If your query format is "SELECT col1 FROM table1 WHERE col2=val", then test the query by extending the *WHERE* clause with AND and an expression that uses the partition column.
• **Data type casting:** If the data source uses data types that are not available in JDBC, use this section to specify how a data type from the data source should be converted into JDBC data types. You can specify up to 50 different data type conversions. All columns in the data source that use the same data type are converted in the same way.

For example, if you have three columns in the data source that use the `Float` data type, and you indicate that the `Float` data type should be converted to the JDBC `String` data type, then all three columns that use the `Float` data type are converted to `String` data types.

• **Job bookmark keys:** Job bookmarks help AWS Glue maintain state information and prevent the reprocessing of old data. Specify one more one or more columns as bookmark keys. AWS Glue Studio uses bookmark keys to track data that has already been processed during a previous run of the ETL job. Any columns you use for custom bookmark keys must be strictly monotonically increasing or decreasing, but gaps are permitted.

If you enter multiple bookmark keys, they’re combined to form a single compound key. A compound job bookmark key should not contain duplicate columns. If you don’t specify bookmark keys, AWS Glue Studio by default uses the primary key as the bookmark key, provided that the primary key is sequentially increasing or decreasing (with no gaps). If the table doesn’t have a primary key, but the job bookmark property is enabled, you must provide custom job bookmark keys. Otherwise, the search for primary keys to use as the default will fail and the job run will fail.

• **Job bookmark keys sorting order:** Choose whether the key values are sequentially increasing or decreasing.

**Spark**

• **Schema:** Because AWS Glue Studio is using information stored in the connection to access the data source instead of retrieving metadata information from a Data Catalog table, you must provide the schema metadata for the data source. Choose **Add schema** to open the schema editor.

For instructions on how to use the schema editor, see [Editing the schema in a custom transform node](#).
• **Connection options**: Enter additional key-value pairs as needed to provide additional connection information or options. For example, you might enter a database name, table name, a user name, and password.

For example, for OpenSearch, you enter the following key-value pairs, as described in the section called “Tutorial: Using the AWS Glue Connector for Elasticsearch”:

- `es.net.http.auth.user`: `username`
- `es.net.http.auth.pass`: `password`
- `es.nodes`: `https://<Elasticsearch endpoint>`
- `es.port`: 443
- `path`: `<Elasticsearch resource>`
- `es.nodes.wan.only`: `true`

For an example of the minimum connection options to use, see the sample test script `MinimalSparkConnectorTest.scala` on GitHub, which shows the connection options you would normally provide in a connection.

**Athena**

- **Table name**: The name of the table in the data source. If you're using a connector for reading from Athena-CloudWatch logs, you would enter the table name `all_log_streams`.

- **Athena schema name**: Choose the schema in your Athena data source that corresponds to the database that contains the table. If you're using a connector for reading from Athena-CloudWatch logs, you would enter a schema name similar to `/aws/glue/name`.

- **Schema**: Because AWS Glue Studio is using information stored in the connection to access the data source instead of retrieving metadata information from a Data Catalog table, you must provide the schema metadata for the data source. Choose **Add schema** to open the schema editor.

  For instructions on how to use the schema editor, see **Editing the schema in a custom transform node**.

- **Additional connection options**: Enter additional key-value pairs as needed to provide additional connection information or options.
For an example, see the README.md file at https://github.com/aws-samples/aws-glue-samples/tree/master/GlueCustomConnectors/development/Athena. In the steps in this document, the sample code shows the minimal required connection options, which are `tableName`, `schemaName`, and `className`. The code example specifies these options as part of the `optionsMap` variable, but you can specify them for your connection and then use the connection.

3. (Optional) After providing the required information, you can view the resulting data schema for your data source by choosing the **Output schema** tab in the node details panel. The schema displayed on this tab is used by any child nodes that you add to the job graph.

4. (Optional) After configuring the node properties and data source properties, you can preview the dataset from your data source by choosing the Data preview tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

### Configure target properties for nodes that use connectors

If you use a connector for the data target type, you must configure the properties of the data target node.

**To configure the properties for a data target node that uses a connector**

1. Choose the connector data target node in the job graph. Then, on the right-side, in the node details panel, choose the **Data target properties** tab, if it's not already selected.

2. In the **Data target properties** tab, choose the connection to use for writing to the target.

   Enter the additional information required for each connection type:

   **JDBC**

   - **Connection**: Choose the connection to use with your connector. For information about how to create a connection, see [Creating connections for connectors](#).

   - **Table name**: The name of the table in the data target. If the data target does not use the term `table`, then supply the name of an appropriate data structure, as indicated by the custom connector usage information (which is available in AWS Marketplace).
• **Batch size** (Optional): Enter the number of rows or records to insert in the target table in a single operation. The default value is 1000 rows.

**Spark**

• **Connection**: Choose the connection to use with your connector. If you did not create a connection previously, choose **Create connection** to create one. For information about how to create a connection, see [Creating connections for connectors](#).

• **Connection options**: Enter additional key-value pairs as needed to provide additional connection information or options. You might enter a database name, table name, a user name, and password.

For example, for OpenSearch, you enter the following key-value pairs, as described in the section called “Tutorial: Using the AWS Glue Connector for Elasticsearch”:

- `es.net.http.auth.user`: `username`
- `es.net.http.auth.pass`: `password`
- `es.nodes`: `https://<Elasticsearch endpoint>`
- `es.port`: `443`
- `path`: `<Elasticsearch resource>`
- `es.nodes.wan.only`: `true`

For an example of the minimum connection options to use, see the sample test script `MinimalSparkConnectorTest.scala` on GitHub, which shows the connection options you would normally provide in a connection.

3. After providing the required information, you can view the resulting data schema for your data source by choosing the **Output schema** tab in the node details panel.

**Managing connectors and connections**

You use the **Connections** page in AWS Glue to manage your connectors and connections.

**Topics**

• [Viewing connector and connection details](#)
• [Editing connectors and connections](#)
• Deleting connectors and connections
• Cancel a subscription for a connector

Viewing connector and connection details

You can view summary information about your connectors and connections in the Your connectors and Your connections resource tables on the Connectors page. To view detailed information, perform the following steps.

To view connector or connection details

1. In the AWS Glue Studio console, choose Connectors in the console navigation pane.
2. Choose the connector or connection that you want to view detailed information for.
3. Choose Actions, and then choose View details to open the detail page for that connector or connection.
4. On the detail page, you can choose to Edit or Delete the connector or connection.
   • For connectors, you can choose Create connection to create a new connection that uses the connector.
   • For connections, you can choose Create job to create a job that uses the connection.

Editing connectors and connections

You use the Connectors page to change the information stored in your connectors and connections.

To modify a connector or connection

1. In the AWS Glue Studio console, choose Connectors in the console navigation pane.
2. Choose the connector or connection that you want to change.
3. Choose Actions, and then choose Edit.

   You can also choose View details and on the connector or connection detail page, you can choose Edit.

4. On the Edit connector or Edit connection page, update the information, and then choose Save.
Deleting connectors and connections

You use the Connectors page to delete connectors and connections. If you delete a connector, then any connections that were created for that connector should also be deleted.

To remove connectors from AWS Glue Studio

1. In the AWS Glue Studio console, choose Connectors in the console navigation pane.
2. Choose the connector or connection you want to delete.
3. Choose Actions, and then choose Delete.

   You can also choose View details, and on the connector or connection detail page, you can choose Delete.
4. Verify that you want to remove the connector or connection by entering Delete, and then choose Delete.

   When deleting a connector, any connections that were created for that connector are also deleted.

Any jobs that use a deleted connection will no longer work. You can either edit the jobs to use a different data store, or remove the jobs. For information about how to delete a job, see Delete jobs.

If you delete a connector, this doesn't cancel the subscription for the connector in AWS Marketplace. To remove a subscription for a deleted connector, follow the instructions in Cancel a subscription for a connector.

Cancel a subscription for a connector

After you delete the connections and connector from AWS Glue Studio, you can cancel your subscription in AWS Marketplace if you no longer need the connector.

Note

If you cancel your subscription to a connector, this does not remove the connector or connection from your account. Any jobs that use the connector and related connections will no longer be able to use the connector and will fail.

Before you unsubscribe or re-subscribe to a connector from AWS Marketplace, you should delete existing connections and connectors associated with that AWS Marketplace product.
To unsubscribe from a connector in AWS Marketplace

2. Choose Manage subscriptions.
3. On the Manage subscriptions page, choose Manage next to the connector subscription that you want to cancel.
4. Choose Actions and then choose Cancel subscription.
5. Select the check box to acknowledge that running instances are charged to your account, and then choose Yes, cancel subscription.

Developing custom connectors

You can write the code that reads data from or writes data to your data store and formats the data for use with AWS Glue Studio jobs. You can create connectors for Spark, Athena, and JDBC data stores. Sample code posted on GitHub provides an overview of the basic interfaces you need to implement.

You will need a local development environment for creating your connector code. You can use any IDE or even just a command line editor to write your connector. Examples of development environments include:

- A local Scala environment with a local AWS Glue ETL Maven library, as described in Developing Locally with Scala in the AWS Glue Developer Guide.
- IntelliJ IDE, by downloading the IDE from https://www.jetbrains.com/idea/.

Topics

- Developing Spark connectors
- Developing Athena connectors
- Developing JDBC connectors
- Examples of using custom connectors with AWS Glue Studio
- Developing AWS Glue connectors for AWS Marketplace

Developing Spark connectors

You can create a Spark connector with Spark DataSource API V2 (Spark 2.4) to read data.
To create a custom Spark connector

Follow the steps in the AWS Glue GitHub sample library for developing Spark connectors, which is located at https://github.com/aws-samples/aws-glue-samples/tree/master/GlueCustomConnectors/development/Spark/README.md.

Developing Athena connectors

You can create an Athena connector to be used by AWS Glue and AWS Glue Studio to query a custom data source.

To create a custom Athena connector

Follow the steps in the AWS Glue GitHub sample library for developing Athena connectors, which is located at https://github.com/aws-samples/aws-glue-samples/tree/master/GlueCustomConnectors/development/Athena.

Developing JDBC connectors

You can create a connector that uses JDBC to access your data stores.

To create a custom JDBC connector

1. Install the AWS Glue Spark runtime libraries in your local development environment. Refer to the instructions in the AWS Glue GitHub sample library at https://github.com/aws-samples/aws-glue-samples/tree/master/GlueCustomConnectors/development/GlueSparkRuntime/README.md.

2. Implement the JDBC driver that is responsible for retrieving the data from the data source. Refer to the Java Documentation for Java SE 8.

   Create an entry point within your code that AWS Glue Studio uses to locate your connector. The **Class name** field should be the full path of your JDBC driver.

3. Use the GlueContext API to read data with the connector. Users can add more input options in the AWS Glue Studio console to configure the connection to the data source, if necessary. For a code example that shows how to read from and write to a JDBC database with a custom JDBC connector, see Custom and AWS Marketplace connectionType values.

Examples of using custom connectors with AWS Glue Studio

You can refer to the following blogs for examples of using custom connectors:
• **Developing, testing, and deploying custom connectors for your data stores with AWS Glue**

• **Apache Hudi:** [Writing to Apache Hudi tables using AWS Glue Custom Connector](#)

• **Google BigQuery:** [Migrating data from Google BigQuery to Amazon S3 using AWS Glue custom connectors](#)

• **Snowflake (JDBC):** [Performing data transformations using Snowflake and AWS Glue](#)

• **SingleStore:** [Building fast ETL using SingleStore and AWS Glue](#)

• **Salesforce:** [Ingest Salesforce data into Amazon S3 using the CData JDBC custom connector with AWS Glue](#)

• **MongoDB:** [Building AWS Glue Spark ETL jobs using Amazon DocumentDB (with MongoDB compatibility) and MongoDB](#)

• **Amazon Relational Database Service (Amazon RDS):** [Building AWS Glue Spark ETL jobs by bringing your own JDBC drivers for Amazon RDS](#)

• **MySQL (JDBC):** [https://github.com/aws-samples/aws-glue-samples/blob/master/GlueCustomConnectors/development/Spark/SparkConnectorMySQL.scala](#)

### Developing AWS Glue connectors for AWS Marketplace

As an AWS partner, you can create custom connectors and upload them to AWS Marketplace to sell to AWS Glue customers.

The process for developing the connector code is the same as for custom connectors, but the process of uploading and verifying the connector code is more detailed. Refer to the instructions in [Creating Connectors for AWS Marketplace](#) on the GitHub website.

### Restrictions for using connectors and connections in AWS Glue Studio

When you're using custom connectors or connectors from AWS Marketplace, take note of the following restrictions:

- The testConnection API isn't supported with connections created for custom connectors.
- Data Catalog connection password encryption isn't supported with custom connectors.
- You can't use job bookmarks if you specify a filter predicate for a data source node that uses a JDBC connector.
- Creating a Marketplace connection is not supported outside of the AWS Glue Studio user interface.
Connecting to data sources using Visual ETL jobs

While creating a new job, you can use connections to connect to data when editing visual ETL jobs in AWS Glue. You can do this by adding source nodes that use connectors to read in data, and target nodes to specify the location for writing out data.

Topics

• Modifying properties of a data source node
• Using Data Catalog tables for the data source
• Using a connector for the data source
• Using files in Amazon S3 for the data source
• Using a streaming data source
• References

Modifying properties of a data source node

To specify the data source properties, you first choose a data source node in the job diagram. Then, on the right side in the node details panel, you configure the node properties.

To modify the properties of a data source node

1. Go to the visual editor for a new or saved job.
2. Choose a data source node in the job diagram.
3. Choose the Node properties tab in the node details panel, and then enter the following information:
   • Name: (Optional) Enter a name to associate with the node in the job diagram. This name should be unique among all the nodes for this job.
   • Node type: The node type determines the action that is performed by the node. In the list of options for Node type, choose one of the values listed under the heading Data source.
4. Configure the Data source properties information. For more information, see the following sections:
   • Using Data Catalog tables for the data source
   • Using a connector for the data source
   • Using files in Amazon S3 for the data source
Using a streaming data source

5. (Optional) After configuring the node properties and data source properties, you can view the schema for your data source by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and data source properties, you can preview the dataset from your data source by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

Using Data Catalog tables for the data source

For all data sources except Amazon S3 and connectors, a table must exist in the AWS Glue Data Catalog for the source type that you choose. AWS Glue does not create the Data Catalog table.

To configure a data source node based on a Data Catalog table

1. Go to the visual editor for a new or saved job.
2. Choose a data source node in the job diagram.
3. Choose the **Data source properties** tab, and then enter the following information:
   - **S3 source type**: (For Amazon S3 data sources only) Choose the option **Select a Catalog table** to use an existing AWS Glue Data Catalog table.
   - **Database**: Choose the database in the Data Catalog that contains the source table you want to use for this job. You can use the search field to search for a database by its name.
   - **Table**: Choose the table associated with the source data from the list. This table must already exist in the AWS Glue Data Catalog. You can use the search field to search for a table by its name.
   - **Partition predicate**: (For Amazon S3 data sources only) Enter a Boolean expression based on Spark SQL that includes only the partitioning columns. For example: "(year='2020' and month='04')"
   - **Temporary directory**: (For Amazon Redshift data sources only) Enter a path for the location of a working directory in Amazon S3 where your ETL job can write temporary intermediate results.
• **Role associated with the cluster**: (For Amazon Redshift data sources only) Enter a role for your ETL job to use that contains permissions for Amazon Redshift clusters. For more information, see the section called “Data source and data target permissions”.

**Using a connector for the data source**

If you select a connector for the **Node type**, follow the instructions at Authoring jobs with custom connectors to finish configuring the data source properties.

**Using files in Amazon S3 for the data source**

If you choose Amazon S3 as your data source, then you can choose either:

- A Data Catalog database and table.
- A bucket, folder, or file in Amazon S3.

If you use an Amazon S3 bucket as your data source, AWS Glue detects the schema of the data at the specified location from one of the files, or by using the file you specify as a sample file. Schema detection occurs when you use the **Infer schema** button. If you change the Amazon S3 location or the sample file, then you must choose **Infer schema** again to perform the schema detection using the new information.

**To configure a data source node that reads directly from files in Amazon S3**

1. Go to the visual editor for a new or saved job.
2. Choose a data source node in the job diagram for an Amazon S3 source.
3. Choose the **Data source properties** tab, and then enter the following information:

   - **S3 source type**: (For Amazon S3 data sources only) Choose the option **S3 location**.
   - **S3 URL**: Enter the path to the Amazon S3 bucket, folder, or file that contains the data for your job. You can choose **Browse S3** to select the path from the locations available to your account.
   - **Recursive**: Choose this option if you want AWS Glue to read data from files in child folders at the S3 location.
If the child folders contain partitioned data, AWS Glue doesn't add any partition information that's specified in the folder names to the Data Catalog. For example, consider the following folders in Amazon S3:

```
S3://sales/year=2019/month=Jan/day=1  
S3://sales/year=2019/month=Jan/day=2  
```

If you choose **Recursive** and select the `sales` folder as your S3 location, then AWS Glue reads the data in all the child folders, but doesn't create partitions for year, month or day.

- **Data format**: Choose the format that the data is stored in. You can choose JSON, CSV, or Parquet. The value you select tells the AWS Glue job how to read the data from the source file.

  - **JSON (JavaScript Object Notation)**
    - **JsonPath**: Enter a JSON path that points to an object that is used to define a table schema. JSON path expressions always refer to a JSON structure in the same way as XPath expression are used in combination with an XML document. The "root member object" in the JSON path is always referred to as $, even if it's an object or array. The JSON path can be written in dot notation or bracket notation.

      For more information about the JSON path, see [JsonPath](https://github.com/json-path/jsonpath) on the GitHub website.

  - **Records in source files can span multiple lines**: Choose this option if a single record can span multiple lines in the CSV file.

  - **CSV (comma-separated values)**
    - **Delimiter**: Enter a character to denote what separates each column entry in the row, for example, ; or ,.

---

**Note**

If you don't select the correct format for your data, AWS Glue might infer the schema correctly, but the job won't be able to correctly parse the data from the source file.
- **Escape character**: Enter a character that is used as an escape character. This character indicates that the character that immediately follows the escape character should be taken literally, and should not be interpreted as a delimiter.

- **Quote character**: Enter the character that is used to group separate strings into a single value. For example, you would choose **Double quote (")** if you have values such as "This is a single value" in your CSV file.

- **Records in source files can span multiple lines**: Choose this option if a single record can span multiple lines in the CSV file.

- **First line of source file contains column headers**: Choose this option if the first row in the CSV file contains column headers instead of data.

- **Parquet** (Apache Parquet columnar storage)

  There are no additional settings to configure for data stored in Parquet format.

- **Partition predicate**: To partition the data that is read from the data source, enter a Boolean expression based on Spark SQL that includes only the partitioning columns. For example: 
  
  "(year='2020' and month='04')"

- **Advanced options**: Expand this section if you want AWS Glue to detect the schema of your data based on a specific file.

  - **Schema inference**: Choose the option **Choose a sample file from S3** if you want to use a specific file instead of letting AWS Glue choose a file.

  - **Auto-sampled file**: Enter the path to the file in Amazon S3 to use for inferring the schema.

    If you're editing a data source node and change the selected sample file, choose **Reload schema** to detect the schema by using the new sample file.

4. Choose the **Infer schema** button to detect the schema from the sources files in Amazon S3. If you change the Amazon S3 location or the sample file, you must choose **Infer schema** again to infer the schema using the new information.

### Using a streaming data source

You can create streaming extract, transform, and load (ETL) jobs that run continuously and consume data from streaming sources in Amazon Kinesis Data Streams, Apache Kafka, and Amazon Managed Streaming for Apache Kafka (Amazon MSK).
To configure properties for a streaming data source

1. Go to the visual graph editor for a new or saved job.
2. Choose a data source node in the graph for Kafka or Kinesis Data Streams.
3. Choose the **Data source properties** tab, and then enter the following information:

   **Kinesis**
   
   - **Kinesis source type**: Choose the option **Stream details** to use direct access to the streaming source or choose **Data Catalog table** to use the information stored there instead.

   If you choose **Stream details**, specify the following additional information.
   
   - **Location of data stream**: Choose whether the stream is associated with the current user, or if it is associated with a different user.
   
   - **Region**: Choose the AWS Region where the stream exists. This information is used to construct the ARN for accessing the data stream.
   
   - **Stream ARN**: Enter the Amazon Resource Name (ARN) for the Kinesis data stream. If the stream is located within the current account, you can choose the stream name from the drop-down list. You can use the search field to search for a data stream by its name or ARN.
   
   - **Data format**: Choose the format used by the data stream from the list.

   AWS Glue automatically detects the schema from the streaming data.

   If you choose **Data Catalog table**, specify the following additional information.
   
   - **Database**: (Optional) Choose the database in the AWS Glue Data Catalog that contains the table associated with your streaming data source. You can use the search field to search for a database by its name.
   
   - **Table**: (Optional) Choose the table associated with the source data from the list. This table must already exist in the AWS Glue Data Catalog. You can use the search field to search for a table by its name.
   
   - **Detect schema**: Choose this option to have AWS Glue detect the schema from the streaming data, rather than using the schema information in a Data Catalog table. This option is enabled automatically if you choose the **Stream details** option.
• **Starting position**: By default, the ETL job uses the *Earliest* option, which means it reads data starting with the oldest available record in the stream. You can instead choose *Latest*, which indicates the ETL job should start reading from just after the most recent record in the stream.

• **Window size**: By default, your ETL job processes and writes out data in 100-second windows. This allows data to be processed efficiently and permits aggregations to be performed on data that arrives later than expected. You can modify this window size to increase timeliness or aggregation accuracy.

AWS Glue streaming jobs use checkpoints rather than job bookmarks to track the data that has been read.

• **Connection options**: Expand this section to add key-value pairs to specify additional connection options. For information about what options you can specify here, see "connectionType": "kinesis" in the *AWS Glue Developer Guide*.

Kafka

• **Apache Kafka source**: Choose the option *Stream details* to use direct access to the streaming source or choose *Data Catalog table* to use the information stored there instead.

If you choose *Data Catalog table*, specify the following additional information.

• **Database**: (Optional) Choose the database in the AWS Glue Data Catalog that contains the table associated with your streaming data source. You can use the search field to search for a database by its name.

• **Table**: (Optional) Choose the table associated with the source data from the list. This table must already exist in the AWS Glue Data Catalog. You can use the search field to search for a table by its name.

• **Detect schema**: Choose this option to have AWS Glue detect the schema from the streaming data, rather than storing the schema information in a Data Catalog table. This option is enabled automatically if you choose the *Stream details* option.

If you choose *Stream details*, specify the following additional information.

• **Connection name**: Choose the AWS Glue connection that contains the access and authentication information for the Kafka data stream. You must use a connection with
Kafka streaming data sources. If a connection doesn't exist, you can use the AWS Glue console to create a connection for your Kafka data stream.

- **Topic name**: Enter the name of the topic to read from.
- **Data format**: Choose the format to use when reading data from the Kafka event stream.
- **Starting position**: By default, the ETL job uses the **Earliest** option, which means it reads data starting with the oldest available record in the stream. You can instead choose **Latest**, which indicates the ETL job should start reading from just after the most recent record in the stream.
- **Window size**: By default, your ETL job processes and writes out data in 100-second windows. This allows data to be processed efficiently and permits aggregations to be performed on data that arrives later than expected. You can modify this window size to increase timeliness or aggregation accuracy.

AWS Glue streaming jobs use checkpoints rather than job bookmarks to track the data that has been read.

- **Connection options**: Expand this section to add key-value pairs to specify additional connection options. For information about what options you can specify here, see "connectionType": "kafka" in the **AWS Glue Developer Guide**.

### Note
Data previews are not currently supported for streaming data sources.

### References

**Best Practices**

- [Build an ETL service pipeline to load data incrementally from Amazon S3 to Amazon Redshift using AWS Glue](#)

**ETL programming**

- [Connection types and options for ETL in AWS Glue](#)
- [JDBC connectionType values](#)
Adding a JDBC connection using your own JDBC drivers

You can use your own JDBC driver when using a JDBC connection. When the default driver utilized by the AWS Glue crawler is unable to connect to a database, you can use your own JDBC Driver. For example, if you want to use SHA-256 with your Postgres database, and older postgres drivers do not support this, you can use your own JDBC driver.

Supported datasources

<table>
<thead>
<tr>
<th>Supported datasources</th>
<th>Unsupported datasources</th>
</tr>
</thead>
<tbody>
<tr>
<td>MySQL</td>
<td>Snowflake</td>
</tr>
<tr>
<td>Postgres</td>
<td></td>
</tr>
<tr>
<td>Oracle</td>
<td></td>
</tr>
<tr>
<td>Redshift</td>
<td></td>
</tr>
<tr>
<td>SQL Server</td>
<td></td>
</tr>
<tr>
<td>Aurora*</td>
<td></td>
</tr>
</tbody>
</table>

*Supported if the native JDBC driver is being used. Not all driver features can be leveraged.

Adding a JDBC driver to a JDBC connection

Note

If you choose to bring in your own JDBC driver versions, AWS Glue crawlers will consume resources in AWS Glue jobs and Amazon S3 buckets to ensure your provided driver are run in your environment. The additional usage of resources will be reflected in your account. The cost for AWS Glue crawlers and jobs is under the AWS Glue category in billing. Additionally, providing your own JDBC driver does not mean that the crawler is able to leverage all of the driver’s features.
To add your own JDBC driver to a JDBC connection:

1. Add the JDBC driver file to an Amazon S3 location. You can create a bucket and/or folder or use an existing bucket and/or folder.

2. In the AWS Glue console, choose Connections in the left-hand menu under Data Catalog, then create a new connection.

3. Complete the fields for Connection properties and choose JDBC for Connection type.

4. In Connection access, enter the JDBC URL and JDBC Driver Class name – optional. The driver class name must be for a datasource supported by AWS Glue crawlers.

5. Choose the Amazon S3 path where the JDBC driver is located in the JDBC Driver Amazon S3 Path – optional field.
6. Complete the fields for Credential type if entering a username and password or secret. When complete, choose Create connection.

Note

Testing connection is not supported currently. When crawling the data source with a JDBC driver you provided, the crawler skips this step.

7. Add the newly created connection to a crawler. In the AWS Glue console, choose Crawlers in the left-hand menu under Data Catalog, then create a new crawler.

8. In the Add crawler wizard, in Step 2 choose Add a data source.
9. Choose **JDBC** as the data source and choose the connection that was created in the previous steps. Complete

10. In order to use your own JDBC driver with an AWS Glue crawler, add the following permissions to the role used by the crawler:

    • Grant permissions for the following job actions: CreateJob, DeleteJob, GetJob, GetJobRun, StartJobRun.
    • Grant permissions for IAM actions: iam:PassRole
Grant permissions for Amazon S3 actions: s3:DeleteObjects, s3:GetObject, s3:ListBucket, s3:PutObject.

Grant service principal access to bucket/folder in the IAM policy.

Example IAM policy:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "VisualEditor0",
         "Effect": "Allow",
         "Action": [
            "s3:PutObject",
            "s3:GetObject",
            "s3:ListBucket",
            "s3:DeleteObject"
         ],
         "Resource": [
            "arn:aws:s3:::bucket-name/driver-parent-folder/driver.jar",
            "arn:aws:s3:::bucket-name"
         ]
      }
   ]
}
```

11. If you are using a VPC, you must allow access to the AWS Glue endpoint by creating the interface endpoint and add it to your route table. For more information, see Creating an interface VPC endpoint for AWS Glue.

12. If you are using encryption in your Data Catalog, create the AWS KMS interface endpoint and add it to your route table. For more information, see Creating a VPC endpoint for AWS KMS.
Testing an AWS Glue connection

To test a connection, you use the **Connections** page in the AWS Glue console. Testing custom connections is not supported.

As a best practice, before you use an AWS Glue connection in an ETL job, use the AWS Glue console to test the connection. AWS Glue uses the parameters in your connection to confirm that it can access your data store and reports any errors. For information about AWS Glue connections, see [Connecting to data](#).

**To test an AWS Glue connection**

2. In the navigation pane, under **Data Catalog**, choose **Connections**. You can also choose **Data connections** above **Data Catalog** in the navigation pane.
3. In **Connections**, select the check box next to the desired connection, and then choose **Actions**. In the drop-down menu, choose **Test connection**.
4. In the **Test connection** dialog box, select a role or choose **Create IAM role** to go to the AWS Identity and Access Management (IAM) console to create a new role. The role must have permissions on the data store.
5. Choose **Confirm**.

   The test begins and can take several minutes to complete. If the test fails, choose **Troubleshoot** to view the steps to resolve the issue.
6. Choose **Logs** to view the logs in CloudWatch. You must have the required IAM permissions to view the logs. For more information, see [AWS Managed (Predefined) Policies for CloudWatch Logs](#) in the *Amazon CloudWatch Logs User Guide*.

### Configuring AWS calls to go through your VPC

The special job parameter `disable-proxy-v2` allows you to route your calls to services such as Amazon S3, CloudWatch, and AWS Glue through your VPC. By default, AWS Glue uses a local
proxy to send traffic through the AWS Glue VPC to download scripts and libraries from Amazon S3, to send requests to CloudWatch for publishing logs and metrics, and to send requests to AWS Glue for accessing data catalogs. This proxy allows the job to function normally even if your VPC doesn't configure a proper route to other AWS services, such as Amazon S3, CloudWatch, and AWS Glue. AWS Glue now offers a parameter for you to turn off this behavior. For more information, see [Job parameters used by AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/job-parameters.html). AWS Glue will continue to use local proxy for publishing CloudWatch logs of your AWS Glue jobs.

### Note

- This feature is supported for AWS Glue jobs with AWS Glue version 2.0 and above. When using this feature, you need to ensure that your VPC has configured a route to Amazon S3 through a NAT or service VPC endpoint.
- The deprecated job parameter `disable-proxy` only routes your calls to Amazon S3 for downloading scripts and libraries through your VPC. It's recommended to use the new parameter `disable-proxy-v2` instead.

### Example usage

Create an AWS Glue job with `disable-proxy-v2`:

```bash
aws glue create-job
  --name no-proxy-job
  --role GlueDefaultRole
  --command "Name=glueetl,ScriptLocation=s3://my-bucket/glue-script.py"
  --connections Connections="traffic-monitored-connection"
  --default-arguments '{"--disable-proxy-v2" : "true"}''
```

### Connecting to a JDBC data store in a VPC

Typically, you create resources inside Amazon Virtual Private Cloud (Amazon VPC) so that they cannot be accessed over the public internet. By default, AWS Glue can't access resources inside a VPC. To enable AWS Glue to access resources inside your VPC, you must provide additional VPC-specific configuration information that includes VPC subnet IDs and security group IDs. AWS Glue uses this information to set up [elastic network interfaces](https://aws.amazon.com/ec2/elastic-network-interfaces/) that enable your function to connect securely to other resources in your private VPC.
When using a VPC endpoint, add it to your route table. For more information, see Creating an interface VPC endpoint for AWS Glue and Prerequisites.

When using encryption in Data Catalog, create the KMS interface endpoint and add it to your route table. For more information, see Creating a VPC endpoint for AWS KMS.

**Accessing VPC Data Using elastic network interfaces**

When AWS Glue connects to a JDBC data store in a VPC, AWS Glue creates an elastic network interface (with the prefix Glue_) in your account to access your VPC data. You can't delete this network interface as long as it's attached to AWS Glue. As part of creating the elastic network interface, AWS Glue associates one or more security groups to it. To enable AWS Glue to create the network interface, security groups that are associated with the resource must allow inbound access with a source rule. This rule contains a security group that is associated with the resource. This gives the elastic network interface access to your data store with the same security group.

To allow AWS Glue to communicate with its components, specify a security group with a self-referencing inbound rule for all TCP ports. By creating a self-referencing rule, you can restrict the source to the same security group in the VPC and not open it to all networks. The default security group for your VPC might already have a self-referencing inbound rule for ALL Traffic.

You can create rules in the Amazon VPC console. To update rule settings via the AWS Management Console, navigate to the VPC console (https://console.aws.amazon.com/vpc/), and select the appropriate security group. Specify the inbound rule for ALL TCP to have as its source the same security group name. For more information about security group rules, see Security Groups for Your VPC.

Each elastic network interface is assigned a private IP address from the IP address range in the subnets that you specify. The network interface is not assigned any public IP addresses. AWS Glue requires internet access (for example, to access AWS services that don't have VPC endpoints). You can configure a network address translation (NAT) instance inside your VPC, or you can use the Amazon VPC NAT gateway. For more information, see NAT Gateways in the Amazon VPC User Guide. You can't directly use an internet gateway attached to your VPC as a route in your subnet route table because that requires the network interface to have public IP addresses.

The VPC network attributes enableDnsHostnames and enableDnsSupport must be set to true. For more information, see Using DNS with your VPC.
Important

Don't put your data store in a public subnet or in a private subnet that doesn't have internet access. Instead, attach it only to private subnets that have internet access through a NAT instance or an Amazon VPC NAT gateway.

Elastic network interface properties

To create the elastic network interface, you must supply the following properties:

VPC

The name of the VPC that contains your data store.

Subnet

The subnet in the VPC that contains your data store.

Security groups

The security groups that are associated with your data store. AWS Glue associates these security groups with the elastic network interface that is attached to your VPC subnet. To allow AWS Glue components to communicate and also prevent access from other networks, at least one chosen security group must specify a self-referencing inbound rule for all TCP ports.

For information about managing a VPC with Amazon Redshift, see Managing Clusters in an Amazon Virtual Private Cloud (VPC).

For information about managing a VPC with Amazon Relational Database Service (Amazon RDS), see Working with an Amazon RDS DB Instance in a VPC.

Using a MongoDB or MongoDB Atlas connection

After you create a connection for MongoDB or MongoDB Atlas, you can use the connection in your ETL job. You create a table in the AWS Glue Data Catalog and specify the MongoDB or MongoDB Atlas connection for the connection attribute of the table.

AWS Glue stores your connection URL and credentials in the MongoDB connection. The connection URI formats are as follows:
• For MongoDB: mongodb://host:port/database. The host can be a hostname, IP address, or UNIX domain socket. If the connection string doesn't specify a port, it uses the default MongoDB port, 27017.

• For MongoDB Atlas: mongodb+srv://server.example.com/database. The host can be a hostname that follows corresponds to a DNS SRV record. The SRV format does not require a port and will use the default MongoDB port, 27017.

Additionally, you can specify options in your job script. For more information, see the section called “MongoDB connection”.

Crawling an Amazon S3 data store using a VPC endpoint

For security, auditing, or control purposes you may want your Amazon S3 data store or Amazon S3 backed Data Catalog tables to only be accessed through an Amazon Virtual Private Cloud environment (Amazon VPC). This topic describes how to create and test a connection to the Amazon S3 data store or Amazon S3 backed Data Catalog tables in a VPC endpoint using the Network connection type.

Perform the following tasks to run a crawler on the data store:

• the section called “Prerequisites”
• the section called “Creating the connection to Amazon S3”
• the section called “Testing the connection to Amazon S3”
• the section called “Creating a crawler for an Amazon S3 data store”
• the section called “Running a crawler”

Prerequisites

Check that you have met these prerequisites for setting up your Amazon S3 data store or Amazon S3 backed Data Catalog tables to be accessed through an Amazon Virtual Private Cloud environment (Amazon VPC).

• A configured VPC. For example: vpc-01685961063b0d84b. For more information, see Getting started with Amazon VPC in the Amazon VPC User Guide.

• An Amazon S3 endpoint attached to the VPC. For example: vpc-01685961063b0d84b. For more information, see Endpoints for Amazon S3 in the Amazon VPC User Guide.
• A route entry pointing to the VPC endpoint. For example vpce-0ec5da4d265227786 in the route table used by the VPC endpoint(vpce-0ec5da4d265227786).

• A network ACL attached to the VPC allows the traffic.

• A security group attached to the VPC allows the traffic.

Creating the connection to Amazon S3

Typically, you create resources inside Amazon Virtual Private Cloud (Amazon VPC) so that they cannot be accessed over the public internet. By default, AWS Glue can't access resources inside a VPC. To enable AWS Glue to access resources inside your VPC, you must provide additional VPC-
specific configuration information that includes VPC subnet IDs and security group IDs. To create a Network connection you need to specify the following information:

- A VPC ID
- A subnet within the VPC
- A security group

To set up a Network connection:

1. Choose **Add connection** in the navigation pane of the AWS Glue console.
2. Enter the connection name, choose **Network** as the connection type. Choose **Next**.

3. Configure the VPC, Subnet and Security groups information.
   - **VPC**: choose the VPC name that contains your data store.
   - **Subnet**: choose the subnet within your VPC.
   - **Security groups**: choose one or more security groups that allow access to the data store in your VPC.
4. Choose **Next**.

5. Verify the connection information and choose **Finish**.
Testing the connection to Amazon S3

Once you have created your Network connection, you can test the connectivity to your Amazon S3 data store in a VPC endpoint.

The following errors may occur when testing a connection:

- INTERNET CONNECTION ERROR: indicates an Internet connection issue
- INVALID BUCKET ERROR: indicates a problem with the Amazon S3 bucket
- S3 CONNECTION ERROR: indicates a failure to connect to Amazon S3
- INVALID CONNECTION TYPE: indicates the Connection type does not have the expected value, NETWORK
- INVALID CONNECTION TEST TYPE: indicates a problem with the type of network connection test
- INVALID TARGET: indicates that the Amazon S3 bucket has not been specified properly

To test a Network connection:

1. Select the Network connection in the AWS Glue console.
2. Choose Test connection.
3. Choose the IAM role that you created in the previous step and specify an Amazon S3 Bucket.
4. Choose **Test connection** to start the test. It might take few moments to show the result.

If you receive an error, check the following:

- The correct privileges are provided to the role selected.
- The correct Amazon S3 bucket is provided.
- The security groups and Network ACL allow the required incoming and outgoing traffic.
- The VPC you specified is connected to an Amazon S3 VPC endpoint.

Once you have successfully tested the connection, you can create a crawler.

**Creating a crawler for an Amazon S3 data store**

You can now create a crawler that specifies the Network connection you've created. For more details on creating a crawler, see the section called “Working with crawlers on the console”.
1. Start by choosing **Crawlers** in the navigation pane on the AWS Glue console.

2. Choose **Add crawler**.

3. Specify the crawler name and choose **Next**.

4. When asked for the data source, choose **S3**, and specify the Amazon S3 bucket prefix and the connection you created earlier.

5. If you need to, add another data store on the same network connection.

6. Choose IAM role. The IAM role must allow access to the AWS Glue service and the Amazon S3 bucket. For more information, see the section called “Working with crawlers on the console”.
7. Define the schedule for the crawler.

8. Choose an existing database in the Data Catalog, or create a new database entry.

9. Finish the remaining setup.
Creating a crawler for Amazon S3 backed Data Catalog tables

You can now create a crawler that specifies the Network connection you've created and a Catalog source type. For more details on creating a crawler, see the section called “Working with crawlers on the console”.

1. Start by choosing Crawlers in the navigation pane on the AWS Glue console.
2. Choose Add crawler.
3. Specify the crawler name and choose Next.
4. When asked for the crawler source type, choose Existing catalog tables, and specify the existing catalog tables to crawl from the list of available tables.
5. Choose IAM role. The IAM role must allow access to the AWS Glue service and the Amazon S3 bucket. For more information, see the section called “Working with crawlers on the console”.
6. Define the schedule for the crawler.
7. Choose an existing database in the Data Catalog, or create a new database entry.
8. Finish the remaining setup and review your steps.
Running a crawler

Run your crawler.

Troubleshooting

For troubleshooting related to Amazon S3 buckets using a VPC gateway, see Why can’t I connect to an S3 bucket using a gateway VPC endpoint?

Troubleshooting connection issues in AWS Glue

When an AWS Glue crawler or a job uses connection properties to access a data store, you might encounter errors when you try to connect. AWS Glue uses private IP addresses in the subnet when it creates elastic network interfaces in your specified virtual private cloud (VPC) and subnet. Security groups specified in the connection are applied on each of the elastic network interfaces.
Check to see whether security groups allow outbound access and if they allow connectivity to the database cluster.

In addition, Apache Spark requires bidirectional connectivity among driver and executor nodes. One of the security groups needs to allow ingress rules on all TCP ports. You can prevent it from being open to the world by restricting the source of the security group to itself with a self-referencing security group.

Here are some typical actions you can take to troubleshoot connection problems:

- Check the port address of your connection.
- Check the user name and password string in your connection or secret.
- For a JDBC data store, verify that it allows incoming connections.
- Verify that your data store can be accessed within your VPC.
- If you store your connection credentials using AWS Secrets Manager, make sure that your IAM role for AWS Glue has permission to access your secret. For more information, see Example: Permission to retrieve secret values in the AWS Secrets Manager User Guide. Depending on your network setup, you might also need to create a VPC endpoint to establish a private connection between your VPC and Secrets Manager. For more information, see Using an AWS Secrets Manager VPC endpoint.

## Tutorial: Using the AWS Glue Connector for Elasticsearch

Elasticsearch is a popular open-source search and analytics engine for use cases such as log analytics, real-time application monitoring, and clickstream analysis. You can use OpenSearch as a data store for your extract, transform, and load (ETL) jobs by configuring the AWS Glue Connector for Elasticsearch in AWS Glue Studio. This connector is available for free from AWS Marketplace.

### Note

The AWS Marketplace Elasticsearch Spark Connector has been deprecated. Please use the AWS Glue Connector for Elasticsearch instead.

In this tutorial, we will show how to connect to your Amazon OpenSearch Service nodes with a minimal number of steps.

## Topics
Prerequisites

To use this tutorial, you must have the following:

- Access to AWS Glue Studio
- Access to an OpenSearch cluster in the AWS Cloud
- (Optional) Access to AWS Secrets Manager.

Step 1: (Optional) Create an AWS secret for your OpenSearch cluster information

To safely store and use your connection credential, save your credential in AWS Secrets Manager. The secret you create will be used later in the tutorial by the connection. The credential key-value pairs will be fed into the AWS Glue Connector for Elasticsearch as normal connection options.

For more information about creating secrets, see Creating and Managing Secrets with AWS Secrets Manager in the AWS Secrets Manager User Guide.

To create an AWS secret

1. Sign in to the AWS Secrets Manager console.
2. On either the service introduction page or the Secrets list page, choose Store a new secret.
3. On the Store a new secret page, choose Other type of secret. This option means that you must supply the structure and details of your secret.
4. Add a Key and Value pair for the OpenSearch cluster user name. For example:

   es.net.http.auth.user: username
5. Choose + Add row, and enter another key-value pair for the password. For example:

   es.net.http.auth.pass: password

6. Choose Next.

7. Enter a secret name. For example: my-es-secret. You can optionally include a description.

   Record the secret name, which is used later in this tutorial, and then choose Next.

8. Choose Next again, and then choose Store to create the secret.

Next step

Step 2: Subscribe to the connector

Step 2: Subscribe to the connector

The AWS Glue Connector for Elasticsearch is available for free from AWS Marketplace.

To subscribe to the AWS Glue Connector for Elasticsearch on AWS Marketplace

1. If you have not already configured your AWS account to use License Manager, do the following:

   b. Choose Create customer managed license.
   c. In the IAM permissions (one-time setup) window, choose I grant AWS License Manager the required permissions, and then choose Grant permissions.

      If you do not see this window, then you have already configured the necessary permissions.

2. Open the AWS Glue Studio console at https://console.aws.amazon.com/gluestudio/.

3. In the AWS Glue Studio console, expand the menu icon (☰), and then choose Connectors in the navigation pane.

4. On the Connectors page, choose Go to AWS Marketplace.

5. In AWS Marketplace, in the Search AWS Glue Studio products section, enter AWS Glue Connector for Elasticsearch in the search field, and then press Enter.

6. Choose the name of the connector, AWS Glue Connector for Elasticsearch.
7. On the product page for the connector, use the tabs to view information about the connector. When you're ready to continue, choose Continue to Subscribe.

8. Review the terms of use for the software. Click Accept Terms.

9. When the subscription process completes, you will see a notification: "Thank you for subscribing to this product! You can now configure your software." Above the banner will be the button Continue to Configuration. Choose Continue to Configuration.

10. Choose the Fulfillment option on the Configure this software page. You can either choose between AWS Glue 1.0/2.0 or AWS Glue 3.0. Then, choose Continue to Launch.

Next step

Step 3: Activate the connector in AWS Glue Studio and create a connection

Step 3: Activate the connector in AWS Glue Studio and create a connection

After you choose Continue to Launch, you see the Launch this software page in AWS Marketplace. After you use the link to activate the connector in AWS Glue Studio, you create a connection.

To deploy the connector and create a connection in AWS Glue Studio

1. On the Launch this software page in the AWS Marketplace console, choose Usage Instructions, and then choose the link in the window that appears. Your browser is redirected to the AWS Glue Studio console Create marketplace connection page.

2. Enter a name for the connection. For example: my-es-connection.

3. In the Connection access section, for Connection credential type, choose User name and password.

4. For the AWS secret, enter the name of your secret. For example: my-es-secret.

5. In the Network options section, enter the VPC information to connect to OpenSearch cluster.

6. Choose Create connection and activate connector.

Next step

Step 4: Configure an IAM role for your ETL job
Step 4: Configure an IAM role for your ETL job

When you create the AWS Glue ETL job, you specify an AWS Identity and Access Management (IAM) role for the job to use. The role must grant access to all resources used by the job, including Amazon S3 (for any sources, targets, scripts, driver files, and temporary directories), and also AWS Glue Data Catalog objects.

The assumed IAM role for the AWS Glue ETL job must also have access to the secret that was created in the previous section. By default, the AWS managed role AWSGlueServiceRole does not have access to the secret. To set up access control for your secrets, see [Authentication and Access Control for AWS Secrets Manager](#) and [Limiting Access to Specific Secrets](#).

To configure an IAM role for your ETL job

1. Configure the permissions described in the section called “Review IAM permissions needed for ETL jobs”.
2. Configure the additional permissions needed when using connectors with AWS Glue Studio, as described in the section called “Permissions required for using connectors”.

Next step

Step 5: Create a job that uses the OpenSearch connection

Step 5: Create a job that uses the OpenSearch connection

After creating a role for your ETL job, you can create a job in AWS Glue Studio that uses the connection and connector for Open Spark ElasticSearch.

If your job runs within a Amazon Virtual Private Cloud (Amazon VPC), make sure the VPC is configured correctly. For more information, see the section called “Configure a VPC for your ETL job”.

To create a job that uses the Elasticsearch Spark Connector

1. In AWS Glue Studio, choose Connectors.
2. In the Your connections list, select the connection you just created and choose Create job.
3. In the visual job editor, choose the Data source node. On the right, on the Data source properties - Connector tab, configure additional information for the connector.
a. Choose **Add schema** and enter the schema of the data set in the data source. Connections do not use tables stored in the Data Catalog, which means that AWS Glue Studio doesn’t know the schema of the data. You must manually provide this schema information. For instructions on how to use the schema editor, see the section called “Editing the schema in a custom transform node”.

b. Expand **Connection options**.

c. Choose **Add new option** and enter the information needed for the connector that was not entered in the AWS secret:

   - **es.nodes**: https://<OpenSearch domain endpoint>
   - **es.port**: 443
   - **path**: test
   - **es.nodes.wan.only**: true

   For an explanation of these connection options, refer to: https://www.elastic.co/guide/en/elasticsearch/hadoop/current/configuration.html.

4. Add a target node to the graph.

Your data target can be Amazon S3, or it can use information from an AWS Glue Data Catalog or a connector to write data in a different location. For example, you can use a Data Catalog table to write to a database in Amazon RDS, or you can use a connector as your data target to write to data stores that are not natively supported in AWS Glue.

If you choose a connector for your data target, you must choose a connection created for that connector. Also, if required by the connector provider, you must add options to provide additional information to the connector. If you use a connection that contains information for an AWS secret, then you don’t need to provide the user name and password authentication in the connection options.

5. Optionally, add additional data sources and one or more transform nodes as described in the section called “Editing AWS Glue managed data transform nodes”.

6. Configure the job properties as described in the section called “Modify the job properties”, starting with step 3, and save the job.
Next step

Step 6: Run the job

Step 6: Run the job

After you save your job, you can run the job to perform the ETL operations.

To run the job you created for the AWS Glue Connector for Elasticsearch

1. Using the AWS Glue Studio console, on the visual editor page, choose Run.
2. In the success banner, choose Run Details, or you can choose the Runs tab of the visual editor to view information about the job run.
Building AWS Glue jobs with interactive sessions

Data engineers can author AWS Glue jobs faster and more easily than before using interactive sessions in AWS Glue.

Topics

• Overview of AWS Glue interactive sessions
• Getting started with AWS Glue interactive sessions
• Configuring AWS Glue interactive sessions for Jupyter and AWS Glue Studio notebooks
• Getting started with AWS Glue for Ray interactive sessions (preview)
• Interactive sessions with IAM
• Converting a script or notebook into an AWS Glue job
• AWS Glue interactive sessions for streaming
• Developing and testing AWS Glue job scripts locally
• Development endpoints

Overview of AWS Glue interactive sessions

With AWS Glue interactive sessions, you can rapidly build, test, and run data preparation and analytics applications. Interactive sessions provides a programmatic and visual interface for building and testing extract, transform, and load (ETL) scripts for data preparation. Interactive sessions run Apache Spark analytics applications and provide on-demand access to a remote Spark runtime environment. AWS Glue transparently manages serverless Spark for these interactive sessions.

Interactive sessions are flexible, so you build and test your applications from the environment of your choice. You can create and work with interactive sessions through the AWS Command Line Interface and the API. You can use Jupyter-compatible notebooks to visually author and test your notebook scripts. Interactive sessions provide an open-source Jupyter kernel that integrates almost anywhere that Jupyter does, including integrating with IDEs such as PyCharm, IntelliJ, and VS Code. This enables you to author code in your local environment and run it seamlessly on the interactive sessions backend.
Using the interactive sessions API, customers can programmatically run applications that use Apache Spark analytics without having to manage Spark infrastructure. You can run one or more Spark statements within a single interactive session.

Interactive sessions therefore provide a faster, cheaper, more-flexible way to build and run data preparation and analytics applications. To learn how to use interactive sessions, see the documentation in this section.  

**Limitations**

Interactive sessions and notebooks are not currently available in the Middle East (UAE) (me-central-1), Europe (Spain) (eu-south-2), or Europe (Zurich) (eu-central-2) regions, but may be made available later.

Job bookmarks are not supported in interactive sessions.

**Getting started with AWS Glue interactive sessions**

These sections describe how to run AWS Glue interactive sessions locally.

**Prerequisites for setting up interactive sessions locally**

The following are prerequisites for installing interactive sessions:

- Supported Python versions are 3.6 - 3.10+.
- See sections below for MacOS/Linux and Windows instructions.

**Installing Jupyter and AWS Glue interactive sessions Jupyter kernels**

Use the following to install the kernel locally.

The command, `install-glue-kernels`, installs the jupyter kernalspec for both pyspark and spark kernels and also installs logos in the right directory.

```
pip3 install --upgrade jupyter boto3 aws-glue-sessions
```

```
install-glue-kernels
```
Running Jupyter

To run Jupyter Notebook, complete the following steps.

1. Run the following command to launch Jupyter Notebook.
   
   ```
   jupyter notebook
   ```

2. Choose New, and then choose one of the AWS Glue kernels to begin coding against AWS Glue.

Configuring session credentials and region

MacOS/Linux instructions

AWS Glue interactive sessions requires the same IAM permissions as AWS Glue Jobs and Dev Endpoints. Specify the role used with interactive sessions in one of two ways:

1. With the `%iam_role` and `%region` magics
2. With an additional line in `~/.aws/config`

Configuring a session role with magic

In the first cell, type `%iam_role <YourGlueServiceRole>` in the first cell executed.

Configuring a session role with `~/.aws/config`

AWS Glue Service Role for interactive sessions can either be specified in the notebook itself or stored alongside the AWS CLI config. If you have a role you typically use with AWS Glue Jobs this will be that role. If you do not have a role you use for AWS Glue jobs, please follow this guide, Configuring IAM permissions for AWS Glue, to set one up.

To set this role as the default role for interactive sessions:

1. With a text editor, open `~/.aws/config`.
2. Look for the profile you use for AWS Glue. If you don't use a profile, use the [Default] profile.
3. Add a line in the profile for the role you intend to use like
   `glue_role_arn=<AWSGlueServiceRole>`.
4. [Optional]: If your profile does not have a default region set, I recommend adding one with
   `region=us-east-1`, replacing `us-east-1` with your desired region.
5. Save the config.

For more information, see [Interactive sessions with IAM](#).

## Windows instructions

AWS Glue interactive sessions requires the same IAM permissions as AWS Glue Jobs and Dev
Endpoints. Specify the role used with interactive sessions in one of two ways:

1. With the `%iam_role` and `%region` magics
2. With an additional line in `~/.aws/config`

### Configuring a session role with magic

In the first cell, type `%iam_role <YourGlueServiceRole>` in the first cell executed.

### Configuring a session role with `~/.aws/config`

AWS Glue Service Role for interactive sessions can either be specified in the notebook itself or
stored alongside the AWS CLI config. If you have a role you typically use with AWS Glue Jobs this
will be that role. If you do not have a role you use for AWS Glue jobs, please follow this guide,
[Setting up IAM permissions for AWS Glue](#), to set one up.

To set this role as the default role for interactive sessions:

1. With a text editor, open `~/.aws/config`.
2. Look for the profile you use for AWS Glue. If you don't use a profile, use the `[Default]`
   profile.
3. Add a line in the profile for the role you intend to use like
   `glue_role_arn=<AWSGlueServiceRole>`.
4. [Optional]: If your profile does not have a default region set, I recommend adding one with
   `region=us-east-1`, replacing `us-east-1` with your desired region.
5. Save the config.
For more information, see Interactive sessions with IAM.

**Upgrading from the interactive sessions preview**

The kernel was upgraded with new names when it was released with version 0.27. To clean up preview versions of the kernels run the following from a terminal or PowerShell.

```
# Remove Old Glue Kernels
jupyter kernelspec remove glue_python_kernel
jupyter kernelspec remove glue_scala_kernel

# Remove Custom Model
cd ~/.aws/models
rm -rf glue/
```

**Using interactive sessions with SageMaker Studio**

See Prepare Data using AWS Glue interactive sessions.

**Using interactive sessions with Microsoft Visual Studio Code**

**Prerequisites**

- Install AWS Glue interactive sessions and verify it works with Jupyter Notebook.

**To get started with interactive sessions with VSCode**


   In Visual Studio Code, Jupyter kernels will auto-start which will prevent your magics from taking effect as the session will already be started. To disable Auto Start on Windows, go to
File > Preferences > Extensions > Jupyter > right-click on Jupyter then choose Extension Settings.

On MacOS, go to Code > Settings > Extensions > Jupyter > right-click on Jupyter then choose Extension Settings.

Scroll down until you see Jupyter: Disable Jupyter Auto Start. Check the box "When true, disables Jupyter from being automatically started for you. You must instead run a cell to start Jupyter."

2. Go to File > New File > Save to save this file with name of your choice as an .ipynb extension or select jupyter under select a language and save the file.

3. Double-click on the file. The Jupyter shell will display and a notebook will be opened.
4. On Windows, when you first create a file, by default no kernel is selected. Click on Select Kernel and a list of available kernels is displayed. Choose Glue PySpark.

On MacOS, If you do not see the Glue PySpark kernel, try the following steps:

1. Run a local Jupyter session to obtain the URL.

   For example, run the following command to launch Jupyter Notebook.

   ```bash
   jupyter notebook
   ```

   When the notebook first runs, you will see a URL that looks like `http://localhost:8888/?token=3398XXXXXXXXXXXXXXXX`.

   Copy the URL.

2. In VS Code, click the current kernel, then Select Another Kernel..., then select Existing Jupyter Server.... Paste the URL you copied from the step above.

   If you receive an error message, see the VS Code Jupyter wiki.

3. If successful, this will set the kernel to Glue PySpark.
Choose the **Glue PySpark** or **Glue Spark** kernel (for Python and Scala respectively).

If you don't see **AWS Glue PySpark** and **AWS Glue Spark** kernels in the drop-down list, please ensure you have installed the AWS Glue kernel in the step above, or that your `python.pythonPath` in setting Visual Studio Code is correct. To validate the `python.pythonPath` see the steps below.

a. In MS VS Code, navigate to Manage > Settings. Click on the open settings icon.
b. **python.pythonPath** should be pointing to your Python environment `python >location path<`. If you opened Visual Studio Code from a virtual environment with code `.`, it will point to the pythonPath of that virtual environment.

c. If you don’t see **python.pythonPath** please add it and restart Visual Studio Code. See examples below.

```json
{
    "python.pythonPath":"Python path of Python Virtual environment"
}
```

```json
{
    "python.pythonPath": "/Users/username/Documents/interactive_sessions_demo/lib/python3.8"
}
```
5. Create an AWS Glue Interactive Session. Proceed to create a session in the same manner as you did in Jupyter Notebook. Specify any magics at the top of your first cell and run a statement of code.

Configuring AWS Glue interactive sessions for Jupyter and AWS Glue Studio notebooks

Introduction to Jupyter Magics

Jupyter Magics are commands that can be run at the beginning of a cell or as a whole cell body. Magics start with % for line-magics and %% for cell-magics. Line-magics such as %region and %connections can be run with multiple magics in a cell, or with code included in the cell body like the following example.

```
%region us-east-2
%connections my_rds_connection
dy_f = glue_context.create_dynamic_frame.from_catalog(database='rds_tables',
                                          table_name='sales_table')
```

Cell magics must use the entire cell and can have the command span multiple lines. An example of %%sql is below.

```
%%sql
select * from rds_tables.sales_table
```

Magics supported by AWS Glue interactive sessions for Jupyter

The following are magics that you can use with AWS Glue interactive sessions for Jupyter notebooks.
## Sessions magics

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%help</td>
<td>n/a</td>
<td>Return a list of descriptions and input types for all magic commands.</td>
</tr>
<tr>
<td>%profile</td>
<td>String</td>
<td>Specify a profile in your AWS configuration to use as the credentials provider.</td>
</tr>
<tr>
<td>%region</td>
<td>String</td>
<td>Specify the AWS Region; in which to initialize a session. Default from ~/.aws/configure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %region us-west-1</td>
</tr>
<tr>
<td>%idle_timeout</td>
<td>Int</td>
<td>The number of minutes of inactivity after which a session will timeout after a cell has been executed. The default idle timeout value for Spark ETL sessions is the default timeout, 2880 minutes (48 hours). For other session types, consult documentation for that session type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %idle_timeout 3000</td>
</tr>
<tr>
<td>%session_id</td>
<td>String</td>
<td>Return the session ID for the running session. If a String is provided, this will be set as the session ID for the next running session. When you run a Jupyter Notebook in AWS Glue Studio, this magic returns a read-only value that you can't change.</td>
</tr>
<tr>
<td>%session_id_prefix</td>
<td>String</td>
<td>Define a string that will precede all session IDs in the format [session_id_prefix]-[session_id]. If a session ID is not provided, a random UUID will be generated. This magic is not supported</td>
</tr>
</tbody>
</table>
### Magics for running Jupyter Notebooks in AWS Glue Studio

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%session_id_prefix</td>
<td></td>
<td>when you run a Jupyter Notebook in AWS Glue Studio.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: <code>%session_id_prefix 001</code></td>
</tr>
<tr>
<td>%status</td>
<td></td>
<td>Return the status of the current AWS Glue session including its duration, configuration and executing user / role.</td>
</tr>
<tr>
<td>%stop_session</td>
<td></td>
<td>Stop the current session.</td>
</tr>
<tr>
<td>%list_sessions</td>
<td></td>
<td>Lists all currently running sessions by name and ID.</td>
</tr>
<tr>
<td>%session_type</td>
<td>String</td>
<td>Sets the session type to one of Streaming, ETL, or Ray.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: <code>%session_type Streaming</code></td>
</tr>
<tr>
<td>%glue_version</td>
<td>String</td>
<td>The version of AWS Glue to be used by this session.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: <code>%glue_version 3.0</code></td>
</tr>
</tbody>
</table>

### Magics for selecting job types

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%streaming</td>
<td>String</td>
<td>Changes the session type to AWS Glue Streaming.</td>
</tr>
<tr>
<td>%etl</td>
<td>String</td>
<td>Changes the session type to AWS Glue ETL.</td>
</tr>
</tbody>
</table>
AWS Glue

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%glue_ray</td>
<td>String</td>
<td>Changes the session type to AWS Glue for Ray. See <a href="#">Magics supported by AWS Glue Ray interactive sessions</a>.</td>
</tr>
</tbody>
</table>

**AWS Glue for Spark config magics**

The `%configure` magic is a json-formatted dictionary consisting of all configuration parameters for a session. Each parameter can be specified here or through individual magics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>%configure</code></td>
<td>Dictionary</td>
<td>Specify a JSON-formatted dictionary consisting of all configuration parameters for a session. Each parameter can be specified here or through individual magics.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For a list of parameters and examples on how to use <code>%configure</code>, see the table below: <a href="#">Using <code>%configure</code></a>.</td>
</tr>
<tr>
<td>%iam_role</td>
<td>String</td>
<td>Specify an IAM role ARN to execute your session with. Default from ~/.aws/config.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: <code>%iam_role AWSGlueServiceRole</code></td>
</tr>
<tr>
<td>%number_of_workers</td>
<td>Int</td>
<td>The number of workers of a defined worker_type that are allocated when a job runs. worker_type must be set too. The default number_of_workers is 5.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: <code>%number_of_workers 2</code></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>%security_config</td>
<td>String</td>
<td>Define a Security Configuration to be used with this session.</td>
</tr>
<tr>
<td>%additional_python_modules</td>
<td>List</td>
<td>Comma separated list of additional Python modules to include in your cluster (can be from PyPI or S3).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %additional_python_modules pandas, numpy</td>
</tr>
</tbody>
</table>

Magics supported by AWS Glue interactive sessions for Jupyter
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>{%tags%}</td>
<td>String</td>
<td>Adds tags to a session. Specify the tags within curly brackets { }. Each tag name pair is enclosed in parentheses (&quot; &quot;) and separated by a comma (,).</td>
</tr>
</tbody>
</table>

```
{%tags%}
{"billing":"Data-Platform",
 "team":"analytics"}
```

Use the `{status}` magic to view tags associated with the session.

```
{status}
```

Session ID: <sessionId>
Status: READY
Role: <example-role>
CreatedOn: 2023-05-26 11:12:17.056000-07:00
GlueVersion: 3.0
Job Type: glueetl
Tags: {'owner': 'example-owner', 'team': 'analytics', 'billing': 'Data-Platform'}
Worker Type: G.4X
Number of Workers: 5
Region: us-west-2
Applying the following default arguments:
--glue_kernel_version 0.38.0
--enable-glue-datacatalog true
Arguments Passed: ['--glue_kernel_version: 0.38.0', '--enable-glue-datacatalog: true']
## **%%assume_role**

**Type**: Dictionary

Specify a json-formatted dictionary or an IAM role ARN string to create a session for cross-account access.

**Example with ARN:**

```python
%%assume_role
{
   'arn:aws:iam::XXXXXXXXXXXX:role/AWSGlueServiceRole'
}
```

**Example with credentials:**

```python
%%assume_role
{{
   "aws_access_key_id" = "XXXXXXXXXXXX",
   "aws_secret_access_key" = "XXXXXXXXXXXX",
   "aws_session_token" = "XXXXXXXXXXXX"
}}
```

### **%%configure cell magic arguments**

The %%configure magic is a json-formatted dictionary consisting of all configuration parameters for a session. Each parameter can be specified here or through individual magics. See below for examples for arguments supported by the %%configure cell magic.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>max_retries</td>
<td>Int</td>
<td>The maximum number of times to retry this job if it fails.</td>
</tr>
</tbody>
</table>

**%%configure**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;max_retries&quot;: &quot;0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>max_concurrent_runs</td>
<td>Int</td>
<td>The maximum number of concurrent runs allowed for a job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%%configure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;max_concurrent_runs&quot;: &quot;3&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>enable_spark_ui</td>
<td>Boolean</td>
<td>Enable Spark UI to monitor and debug AWS Glue ETL jobs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%%configure</td>
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<tr>
<td></td>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;enable_spark_ui&quot;: &quot;true&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>spark_event_logs_path</td>
<td>String</td>
<td>Specifies an Amazon S3 path. When using the Spark UI monitoring feature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%%configure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;spark_event_logs_path&quot;: &quot;s3://path/to/event/logs/&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>script_location</td>
<td>String</td>
<td>Specifies the S3 path to a script that executes a job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%%configure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;script_location&quot;: &quot;s3://new-folder-here&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>python_version</td>
<td>Number</td>
<td>The Python version being used to execute a Python shell job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
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<td></td>
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<td>```</td>
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<td>%%configure</td>
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<td></td>
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<td>{</td>
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<tr>
<td></td>
<td></td>
<td>&quot;python_version&quot;: &quot;3.16&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>notify_delay_after</td>
<td>Number</td>
<td>After a job run starts, the number of minutes to wait before sending a job run delay notification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
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<tr>
<td></td>
<td></td>
<td>```</td>
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<td>%%configure</td>
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<td></td>
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<td>{</td>
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<tr>
<td></td>
<td></td>
<td>&quot;notify_delay_after&quot;: &quot;10&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>create_security_configuration</td>
<td>Boolean</td>
<td>Create AWS Glue Security Configuration associated with the job. Default is 'false'.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
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<tr>
<td></td>
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<td>```</td>
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<td>%configure</td>
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<tr>
<td></td>
<td></td>
<td>&quot;create_security_configuration&quot;: &quot;true&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>security_configuration_cloudwatch_encryption</td>
<td>Object({</td>
<td>A job_bookmarks_encryption block which contains encryption configuration for job bookmarks. Default is:</td>
</tr>
<tr>
<td></td>
<td>cloudwatch_encryption_mode = string</td>
<td></td>
</tr>
<tr>
<td></td>
<td>kms_key_arn = string</td>
<td></td>
</tr>
<tr>
<td></td>
<td>})</td>
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<td>Example:</td>
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<td>%configure</td>
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<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;security_configuration_cloudwatch_encryption&quot;: &quot;{'cloudwatch_encryption_mode&quot;: 'ENABLED', 'kms_key_arn': 'arn:aws:kms:xxxxxxxxxxxxxxxx'}&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
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<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>security_configuration_job_bookmarks_encryption</td>
<td>Object({</td>
<td>A job_bookmarks_encryption block which contains encryption configuration for job bookmarks. Default is:</td>
</tr>
<tr>
<td></td>
<td>job_bookmarks_encryption_mode = string</td>
<td></td>
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<td></td>
<td>kms_key_arn = string</td>
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<tr>
<td></td>
<td>})</td>
<td>Example:</td>
</tr>
</tbody>
</table>
|                                                                            |                                | %%configure
<p>|                                                                             | {                               |                                                                                                                                              |
|                                                                             | &quot;security_configuration_job    |                                                                                                                                              |
|                                                                             | _bookmarks_encryption&quot;:        |                                                                                                                                              |
|                                                                             | &quot;{'job_bookmarks_encryption    |                                                                                                                                              |
|                                                                             | _mode' = 'ENABLED', 'kms_key_arn |                                                                                                                                              |
|                                                                             | = arn:aws:kms:xxxxxxxxxxxxxxx'  |                                                                                                                                              |
|                                                                             | }&quot;                            |                                                                                                                                              |
|                                                                             | }                              |                                                                                                                                              |</p>
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>security_configuration_s3_encryption</td>
<td>Object({</td>
<td>An s3_encryption block which contains encryption configuration for Amazon S3 data. Default is:</td>
</tr>
<tr>
<td></td>
<td>s3_encryption_mode = string</td>
<td></td>
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<td>kms_key_arn = string</td>
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<td>})</td>
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<tr>
<td>log_group_retention_in_days</td>
<td>Number</td>
<td>The default number of days log events retained in the glue job log group. Default is '7'.</td>
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<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>job_language</td>
<td>String</td>
<td>The script programming language. Accepts a value of 'scala' or 'python'. Default is 'python'. Example:</td>
</tr>
</tbody>
</table>
|                    |         | `%configure
|                    |         |  {
|                    |         |    "job_language": "scala"
|                    |         |  }
| class              | String  | The Scala class that serves as the entry point for your Scala script. Default is null. Example: |
|                    |         | `%configure
|                    |         |  {
|                    |         |    "class": "className"
|                    |         |  }
| user_jars_first    | Boolean | Prioritizes the customer's extra JAR files in the classpath. Default is null. Example: |
|                    |         | `%configure
|                    |         |  {
|                    |         |    "user_jars_first": "true"
|                    |         |  }
<table>
<thead>
<tr>
<th><strong>Parameter</strong></th>
<th><strong>Type</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>use_postgres_driver</td>
<td>Boolean</td>
<td>Prioritizes the Postgres JDBC driver in the class path to avoid a conflict with the Amazon Redshift JDBC driver. Default is null.</td>
</tr>
<tr>
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<td>Example:</td>
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<td>```configure</td>
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<td>{</td>
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<td></td>
<td></td>
<td>&quot;use_postgres_driver&quot;: &quot;true&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>extra_files</td>
<td>List(string)</td>
<td>The Amazon S3 paths to additional files, such as configuration files that AWS Glue copies to the working directory of your script before executing it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
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<td></td>
<td>```</td>
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<td>```configure</td>
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<td>{</td>
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<tr>
<td></td>
<td></td>
<td>&quot;extra_files&quot;: &quot;s3://path/to/additional/files/&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
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<tr>
<td>------------------------</td>
<td>---------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>job_bookmark_option</td>
<td>String</td>
<td>Controls the behavior of a job bookmark. Accepts a value of 'job-bookmark-enable', 'job-bookmark-disable' or 'job-bookmark-pause'. Default is 'job-bookmark-disable'.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
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<td></td>
<td>```</td>
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<td>%%configure</td>
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<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;job_bookmark_option&quot;: &quot;job-bookmark-enable&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>temp_dir</td>
<td>String</td>
<td>Specifies an Amazon S3 path to a bucket that can be used as a temporary directory for the job. Default is null.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example:</td>
</tr>
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<td>```</td>
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<td>%%configure</td>
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<td>{</td>
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<tr>
<td></td>
<td></td>
<td>&quot;temp_dir&quot;: &quot;s3://path/to/temp/dir&quot;</td>
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<td></td>
<td>}</td>
</tr>
<tr>
<td>Parameter</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| enable_s3_parquet_optimized_committer                      | Boolean| Enables the EMRFS Amazon S3-optimized committer for writing Parquet data into Amazon S3. Default is 'true'. | ```
    %%configure
    {
        "enable_s3_parquet_optimized_committer": "false"
    }
``` |
| enable_rename_algorithm_v2                                 | Boolean| Sets the EMRFS rename algorithm version to version 2. Default is 'true'.     | ```
    %%configure
    {
        "enable_rename_algorithm_v2": "false"
    }
``` |
| enable_glue_datacatalog                                    | Boolean| Enables you to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. | ```
    %%configure
    {
        "enable_glue_datacatalog": "false"
    }
``` |
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>enable_metrics</td>
<td>Boolean</td>
<td>Enables the collection of metrics for job profiling for job run. Default is 'false'. Example:</td>
</tr>
</tbody>
</table>
|                                   |           | ```
|                                   |           | %%configure
|                                   |           | {
|                                   |           |   "enable_metrics": "true"
|                                   |           | } |
| enable_continuous_cloudwatch_log | Boolean   | Enables real-time continuous logging for AWS Glue jobs. Default is 'false'. Example: |
|                                   |           | ```
|                                   |           | %%configure
|                                   |           | {
|                                   |           |   "enable_continuous_cloudwatch_log": "true"
|                                   |           | } |
| enable_continuous_log_filter      | Boolean   | Specifies a standard filter or no filter when you create or edit a job enabled for continuous logging. Default is 'true'. Example: |
|                                   |           | ```
|                                   |           | %%configure
|                                   |           | {
|                                   |           |   "enable_continuous_log_filter": "false"
<p>|                                   |           | } |</p>
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>continuous_log_stream_prefix</td>
<td>String</td>
<td>Specifies a custom Amazon CloudWatch log stream prefix for a job enabled for continuous logging. Default is null.</td>
</tr>
<tr>
<td>example</td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td></td>
<td>```configure</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>continuous_log_conversion_pattern</td>
<td>String</td>
<td>Specifies a custom conversion log pattern for a job enabled for continuous logging. Default is null.</td>
</tr>
</tbody>
</table>

**Spark jobs (ETL & streaming) magics**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%worker_type</td>
<td>String</td>
<td>Standard, G.1X, or G.2X. number_of_workers must be set too. The default worker_type is G.1X.</td>
</tr>
<tr>
<td>%connections</td>
<td>List</td>
<td>Specify a comma-separated list of connections to use in the session.</td>
</tr>
<tr>
<td>example</td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>```</td>
</tr>
<tr>
<td></td>
<td></td>
<td>```connections my_rds_connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dy_f = glue_context.create_dynamic_frame.from_catalog(database='rds_tables', table_name='sales_table')</td>
</tr>
</tbody>
</table>

Magics supported by AWS Glue interactive sessions for Jupyter
### Name

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%extra_py_files</td>
<td>List</td>
<td>Comma separated list of additional Python files from Amazon S3.</td>
</tr>
<tr>
<td>%extra_jars</td>
<td>List</td>
<td>Comma-separated list of additional jars to include in the cluster.</td>
</tr>
<tr>
<td>%spark_conf</td>
<td>String</td>
<td>Specify custom spark configurations for your session. For example, %spark_conf=spark.serializer=org.apache.spark.serializer.KryoSerializer</td>
</tr>
</tbody>
</table>

### Magics for Ray jobs

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%min_workers</td>
<td>Int</td>
<td>The minimum number of workers that are allocated to a Ray job. Default: 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %min_workers 2</td>
</tr>
<tr>
<td>%object_memory_head</td>
<td>Int</td>
<td>The percentage of free memory on the instance head node after a warm start. Minimum: 0. Maximum: 100.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %object_memory_head 100</td>
</tr>
<tr>
<td>%object_memory_worker</td>
<td>Int</td>
<td>The percentage of free memory on the instance worker nodes after a warm start. Minimum: 0. Maximum: 100.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: %object_memory_worker 100</td>
</tr>
</tbody>
</table>
## Action magics

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%%sql</td>
<td>String</td>
<td>Run SQL code. All lines after the initial % %%sql magic will be passed as part of the SQL code. Example: %%sql select * from rds_tables.sales_table</td>
</tr>
<tr>
<td>%matplotlib</td>
<td>Matplotlib figure</td>
<td>Visualize your data using the matplotlib library. Example: import matplotlib.pyplot as plt # Set X-axis and Y-axis values x = [5, 2, 8, 4, 9] y = [10, 4, 8, 5, 2] # Create a bar chart plt.bar(x, y) # Show the plot %matplotlib plt</td>
</tr>
<tr>
<td>%plotly</td>
<td>Plotly figure</td>
<td>Visualize your data using the plotly library. Example: import plotly.express as px #Create a graphical figure fig = px.line(x=[&quot;a&quot;,&quot;b&quot;,&quot;c&quot;], y=[1,3,2], title=&quot;sample figure&quot;)</td>
</tr>
</tbody>
</table>
Naming sessions

AWS Glue interactive sessions are AWS resources and require a name. Names should be unique for each session and may be restricted by your IAM administrators. For more information, see Interactive sessions with IAM. The Jupyter kernel automatically generates unique session names for you. However sessions can be named manually in two ways:

2. Using the %session_id_prefix magics. See Magics supported by AWS Glue interactive sessions for Jupyter.

A session name is generated as follows:

- When the prefix and session_id are provided: the session name will be {prefix}-{UUID}.
- When nothing is provided: the session name will be {UUID}.

Prefixing session names allows you to recognize your session when listing it in the AWS CLI or console.

Specifying an IAM role for interactive sessions

You must specify an AWS Identity and Access Management (IAM) role to use with AWS Glue ETL code that you run with interactive sessions.

The role requires the same IAM permissions as those required to run AWS Glue jobs. See Create an IAM role for AWS Glue for more information on creating a role for AWS Glue jobs and interactive sessions.

IAM roles can be specified in two ways:

- Using the AWS Command Line Interface config file located at ~/.aws/config (Recommended). For more information, see Configuring sessions with ~/.aws/config.
• Using the `%iam_role` magic. For more information, see [Magics supported by AWS Glue interactive sessions for Jupyter](#).

**Configuring sessions with named profiles**

AWS Glue interactive sessions uses the same credentials as the AWS Command Line Interface or boto3, and interactive sessions honors and works with named profiles like the AWS CLI found in `~/.aws/config` (Linux and MacOS) or `%USERPROFILE%\.aws\config` (Windows). For more information, see [Using named profiles](#).

Interactive sessions takes advantage of named profiles by allowing the AWS Glue Service Role and Session ID Prefix to be specified in a profile. To configure a profile role, add a line for the `iam_role` key and/or `session_id_prefix` to your named profile as shown below. The `session_id_prefix` does not require quotes. For example, if you want to add a `session_id_prefix`, enter the value of the `session_id_prefix=my_prefix`.

```python
[default]
region=us-east-1
aws_access_key_id=AKIAIOSFODNN7EXAMPLE
aws_secret_access_key=wJalrXUtENFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY
glue_iam_role=arn:aws:iam::<AccountID>:role/<GlueServiceRole>
session_id_prefix=<prefix_for_session_names>

[user1]
region=eu-west-1
aws_access_key_id=AKIAI44QHBEXAMPLE
aws_secret_access_key=je7MtGbC1wBF/2Zp9Utk/h3yCo8nvbEXAMPLEKEY
glue_iam_role=arn:aws:iam::<AccountID>:role/<GlueServiceRoleUser1>
session_id_prefix=<prefix_for_session_names_for_user1>
```

If you have a custom method of generating credentials, you can also configure your profile to use the `credential_process` parameter in your `~/.aws/config` file. For example:
You can find more details about sourcing credentials through the `credential_process` parameter here: [Sourcing credentials with an external process](#).

If a region or `iam_role` are not set in the profile that you are using, you must specify them using the `%region` and `%iam_role` magics in the first cell that you run.

---

**Getting started with AWS Glue for Ray interactive sessions (preview)**

---

**Warning**

Ray interactive sessions are in preview for AWS Glue and are subject to change.

---

**Note**

AWS Glue for Ray is available in US East (N. Virginia), US East (Ohio), US West (Oregon), Asia Pacific (Tokyo), and Europe (Ireland).

---

**Ray interactive sessions in the AWS Glue Studio Console**

In the **Jobs** page in the AWS Glue Studio Console, select the existing **Jupyter Notebook** option. This will open a **Notebook setup** page where you can select your **Kernel**. Select the **Ray** kernel to begin a Ray interactive session. For more information about interactive sessions and how they are used, see the section called “Getting started with AWS Glue interactive sessions”. 

---
Ray interactive sessions using the Jupyter Kernel

To use the Ray Kernel outside of the AWS Glue Studio Console, you will need to install the aws-glue-sessions package, which we publish on PyPI. For more information about using the kernel package, see the section called “Getting started with AWS Glue interactive sessions” documentation.

To update or install the kernel, run `pip install --upgrade aws-glue-sessions`. You will need version .37+ to use the Ray kernel.

Ray interactive sessions have access to the same libraries and versions of Ray as Ray jobs. In preview, all Ray interactive sessions will use Ray 2.4.0.

Ray interactive session timeout defaults

- **Timeout** (for session) default: 8 hours.
- **Idle Timeout** default: 1 hour.
Magics supported by AWS Glue Ray interactive sessions

Magics for the AWS Glue Jupyter kernel when it powers Ray interactive sessions are similar to those for the Spark sessions. For reference, see the section called “Configuring AWS Glue interactive sessions for Jupyter and AWS Glue Studio notebooks.”

Sessions magics

Sessions magics are mostly the same as prior to the AWS Glue for Ray preview. For more information about session magics outside of this preview, see the section called “Magics supported by AWS Glue interactive sessions for Jupyter”. We introduce a new magic to set the session type to AWS Glue for Ray.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%glue_ray</td>
<td>String</td>
<td>Changes the session type to AWS Glue for Ray.</td>
</tr>
</tbody>
</table>

AWS Glue config magics

Magics to configure AWS Glue in an interactive session may be different between session types. Currently, we only support this subset of existing magics when using AWS Glue for Ray.

⚠️ Warning

**Known Issue: additional_python_modules**

In the Ray interactive sessions preview, use of the additional_python_modules magic will cause problems when saving your notebook. To configure python modules for Ray sessions, use the %%configure magic to set the pip-install parameter defined in the section called “Ray job parameters”.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%%configure</td>
<td>Dictionary</td>
<td>Specify a JSON-formatted dictionary consisting of all configuration parameters for a session. Each parameter can be</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>%iam_role</td>
<td>String</td>
<td>Specify an IAM role ARN to execute your session with. Default from ~/.aws/configure</td>
</tr>
<tr>
<td>%number_of_workers</td>
<td>int</td>
<td>The number of workers of a defined worker_type that are allocated when a job runs. worker_type must be set too.</td>
</tr>
<tr>
<td>%worker_type</td>
<td>String</td>
<td>In the AWS Glue for Ray preview, the only supported worker type is Z.2X.</td>
</tr>
<tr>
<td>%additional_python_modules</td>
<td>List</td>
<td>Comma separated list of additional Python modules to include in your cluster (can be from Pypi or S3).</td>
</tr>
</tbody>
</table>

**Action magics**

AWS Glue Ray sessions do not support any action magics.

**Interactive sessions with IAM**

These sections describe security considerations for AWS Glue interactive sessions.

**Topics**

- [IAM principals used with interactive sessions](#)
- [Setting up a client principal](#)
- [Setting up a runtime role](#)
- [Make your session private with TagOnCreate](#)
- [IAM policy considerations](#)
IAM principals used with interactive sessions

You use two IAM principals used with AWS Glue interactive sessions.

- **Client principal**: The client principal (either a user or a role) authorizes API operations for interactive sessions from an AWS Glue client that's configured with the principal's identity-based credentials. For example, this could be an IAM role that you typically use to access the AWS Glue console. This could also be a role given to a user in IAM whose credentials are used for the AWS Command Line Interface, or an AWS Glue client used by the interactive sessions Jupyter kernel.

- **Runtime role**: The runtime role is an IAM role that the client principal passes to interactive sessions API operations. AWS Glue uses this role to run statements in your session. For example, this role could be the one used for running AWS Glue ETL jobs.

For more information, see [Setting up a runtime role](#).

Setting up a client principal

You must attach an identity policy to the client principal to allow it to call the interactive sessions API. This role must have `iam:PassRole` access to the execution role that you would pass to the interactive sessions API, such as `CreateSession`. For example, you can attach the `AWSGlueConsoleFullAccess` managed policy to an IAM role which allows users in your account with the policy attached to access all the sessions created in your account (such as runtime statement or cancel statement).

If you would like to protect your session and make it private only to certain IAM roles, such as ones associated with the user who created the session then you can use AWS Glue Interactive Session's Tag Based Authorization Control called TagOnCreate. For more information, see [Make your session private with TagOnCreate](#) on how an owner tag-based scoped down managed policy can make your session private with TagOnCreate. For more information on identity-based policies, see [Using identity-based policies](#).

Setting up a runtime role

You must pass an IAM role to the `CreateSession` API operation in order to allow AWS Glue to assume and run statements in interactive sessions. The role should have the same IAM permissions as those required to run a typical AWS Glue job. For example, you can create a service role using the `AWSGlueServiceRole` policy that allows AWS Glue to call AWS services on your behalf. If
you use the AWS Glue console, it will automatically create a service role on your behalf or use an existing one. You can also create your own IAM role and attach your own IAM policy to allow similar permissions.

If you would like to protect your session and make it private only to the user who created the session then you can use AWS Glue Interactive Session's Tag Based Authorization Control called TagOnCreate. For more information, see Make your session private with TagOnCreate on how an owner tag-based scoped down managed policy can make your session private with TagOnCreate. For more information on identity-based policies, see Identity-based policies for AWS Glue. If you are creating the execution role by yourself from the IAM console and you want to make your service private with TagOnCreate feature then follow the steps below.

1. Create an IAM role with role type set to Glue.
2. Attach this AWS Glue managed policy: `AwsGlueSessionUserRestrictedServiceRole`
3. Prefix the role name with the policy name `AwsGlueSessionUserRestrictedServiceRole`. For example, you can create a role with name `AwsGlueSessionUserRestrictedServiceRole-myrole` and attach AWS Glue managed policy `AwsGlueSessionUserRestrictedServiceRole`.
4. Attach a trust policy like following to allow AWS Glue to assume the role:

   ```json
   {
   "Version": "2012-10-17",
   "Statement": [
   {
   "Effect": "Allow",
   "Principal": {
   "Service": ["glue.amazonaws.com"]
   },
   "Action": ["sts:AssumeRole"]
   }]
   }
   ```

For an interactive sessions Jupyter kernel, you can specify the `iam_role` key in your AWS Command Line Interface profile. For more information, see Configuring sessions with ~/.aws/
If you're interacting with interactive sessions using an AWS Glue notebook, then you can pass the execution role in the `%%iam_role` magic in the first cell that you run.

**Make your session private with TagOnCreate**

AWS Glue interactive sessions supports tagging and Tag Based Authorization (TBAC) for interactive sessions as a named resource. In addition to TBAC using TagResource and UntagResource APIs, AWS Glue interactive sessions supports the TagOnCreate feature to 'tag' a session with a given tag only during session creation with CreateSession operation. This also means those tags will be removed on DeleteSession, aka UntagOnDelete.

TagOnCreate offers a powerful security mechanism to make your session private to the creator of the session. For example, you can attach an IAM policy with "owner" RequestTag and value of `${aws:userId}` to a client principal (such as an user) in order to allow creating a session only if an "owner" tag with matching value of the callers userId is provided as userId tag in CreateSession request. This policy allows AWS Glue interactive sessions to create a session resource and tag the session with the userId tag only during session creation time. In addition to it you can scope down the access (like running statements) to your session only to the creator (aka owner tag with value `${aws:userId}`) of the session by attaching an IAM policy with "owner" ResourceTag to the execution role you passed in during CreateSession.

In order to make it easier for you to use TagOnCreate feature to make a session private to the session creator, AWS Glue provides specialized managed policies and service roles.

If you want to create a AWS Glue Interactive Session using an IAM AssumeRole principal (that is, using credential vended by assuming an IAM role) and you want to make the session private to the creator, then use policies similar to the `AWSGlueSessionUserRestrictedNotebookPolicy` and `AWSGlueSessionUserRestrictedNotebookServiceRole` respectively. These policies allow AWS Glue to use `${aws:PrincipalTag}` to extract the owner tag value. This requires you to pass a userId tag with value `${aws:userId}` as SessionTag in the assume role credential. See [ID session tags](#). If you are using an Amazon EC2 instance with an instance profile vending the credential and you want to create a session or interact with the session from within the Amazon EC2 instance, then you would require to pass a userId tag with value `${aws:userId}` as SessionTag in the assume role credential.

For example, If you are creating a session using an IAM AssumeRole principal credential and you want to make your service private with TagOnCreate feature then follow the steps below.

1. Create a runtime role yourself from the IAM console. Please attach this AWS Glue managed policy `AwsGlueSessionUserRestrictedNotebookServiceRole` and prefix the role name with the
policy name `AwsGlueSessionUserRestrictedNotebookServiceRole`. For example, you can create a role with name `AwsGlueSessionUserRestrictedNotebookServiceRole-myrole` and attach AWS Glue managed policy `AwsGlueSessionUserRestrictedNotebookServiceRole`.

2. Attach a trust policy like below to allow AWS Glue to assume the above role.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": [
                    "glue.amazonaws.com"
                ],
            },
            "Action": [
                "sts:AssumeRole"
            ]
        }
    ]
}
```

3. Create another role named with a prefix `AwsGlueSessionUserRestrictedNotebookPolicy` and attach the AWS Glue managed policy `AwsGlueSessionUserRestrictedNotebookPolicy` to make the session private. In addition to the managed policy please attach the following inline policy to allow `iam:PassRole` to the role you created in step 1.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iam:PassRole"
            ],
            "Resource": [
                "arn:aws:iam::*:role/AwsGlueSessionUserRestrictedNotebookServiceRole"
            ],
            "Condition": {
                "StringLike": {
```
4. Attach a trust policy like following to the above IAM AWS Glue to assume the role.

```json
{
   "Version": "2012-10-17",
   "Statement": [{
      "Effect": "Allow",
      "Principal": {
         "Service": [
            "glue.amazonaws.com"
         ]
      },
      "Action": [
         "sts:AssumeRole",
         "sts:TagSession"
      ]
   }]
}
```

**Note**

Optionally, you can use a single role (for example, notebook role) and attach both of the above managed policies `AwsGlueSessionUserRestrictedNotebookServiceRole` and `AwsGlueSessionUserRestrictedNotebookPolicy`. Also attach the additional inline policy to allow `iam:passrole` of your role to AWS Glue. And finally attach the above trust policy to allow `sts:AssumeRole` and `sts:TagSession`. 
AWSGlueSessionUserRestrictedNotebookPolicy

The AWSGlueSessionUserRestrictedNotebookPolicy provides access to create a AWS Glue Interactive Session from a notebook only if a tag key "owner" and value matching the AWS user id of the principal (user or Role). For more information, see Where you can use policy variables. This policy is attached to the principal (User or role) that creates AWS Glue Interactive Session notebooks from AWS Glue Studio. This policy also permits sufficient access to the AWS Glue Studio notebook to interact with the AWS Glue Studio Interactive Session resources that are created with the "owner" tag value matching the AWS user ID of the principal. This policy denies permission to change or remove "owner" tag from a AWS Glue session resource after the session is created.

AWSGlueSessionUserRestrictedNotebookServiceRole

The AWSGlueSessionUserRestrictedNotebookServiceRole provides sufficient access to the AWS Glue Studio notebook to interact with the AWS Glue Interactive Session resources that are created with the "owner" tag value matching the AWS user ID of the principal (user or role) of the notebook creator. For more information, see Where you can use policy variables. This service-role policy is attached to the role that is passed as magic to a notebook or passed as execution role to the CreateSession API. This policy also permits to create a AWS Glue Interactive Session from a notebook only if a tag key "owner" and value matching the AWS user ID of the principal. This policy denies permission to change or remove "owner" tag from an AWS Glue session resource after the session is created. This policy also includes permissions for writing and reading from Amazon S3 buckets, writing CloudWatch logs, creating and deleting tags for Amazon EC2 resources used by AWS Glue.

Make your session private with user policies

You can attach the AWSGlueSessionUserRestrictedPolicy to IAM roles attached to each of the users in your account to restrict them from creating a session only with an owner tag with a value matching their own ${aws:userId}. Instead of using the AWSGlueSessionUserRestrictedNotebookPolicy and AWSGlueSessionUserRestrictedNotebookServiceRole you need to use policies similar to the AWSGlueSessionUserRestrictedPolicy and AWSGlueSessionUserRestrictedServiceRole respectively. For more information, see Using-identity based policies. This policy scopes down the access to a session only to the creator, the ${aws:userId} of the user who created the session with an owner tag bearing their own ${aws:userId}. If you have created the execution role yourself using the IAM console by following the steps in Setting up a runtime role, then in addition to attaching the AWSGlueSessionUserRestrictedPolicy managed policy, also attach the following inline policy
to each of the users in your account to allow iam:PassRole for the execution role you created earlier.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iam:PassRole"
      ],
      "Resource": [
        "arn:aws:iam::*:role/AwsGlueSessionUserRestrictedServiceRole*"
      ],
      "Condition": {
        "StringLike": {
          "iam:PassedToService": [
            "glue.amazonaws.com"
          ]
        }
      }
    }
  ]
}
```

**AWSGlueSessionUserRestrictedPolicy**

The **AWSGlueSessionUserRestrictedPolicy** provides access to create an AWS Glue Interactive Session using the CreateSession API only if a tag key "owner" and value matching their AWS user ID is provided. This identity policy is attached to the user that invokes the CreateSession API. This policy also permits to interact with the AWS Glue Interactive Session resources that were created with a "owner" tag and value matching their AWS user id. This policy denies permission to change or remove "owner" tag from an AWS Glue session resource after the session is created.

**AWSGlueSessionUserRestrictedServiceRole**

The **AWSGlueSessionUserRestrictedServiceRole** provides full access to all AWS Glue resources except for sessions and allows users to create and use only the interactive sessions that are associated with the user. This policy also includes other permissions needed by AWS Glue to manage Glue resources in other AWS services. The policy also allows adding tags to AWS Glue resources in other AWS services.
IAM policy considerations

Interactive sessions are IAM resources in AWS Glue. Because they are IAM resources, access and interaction to a session is governed by IAM policies. Based on the IAM policies attached to a client principal or execution role configured by an admin, a client principal (user or role) will be able to create new sessions and interact with its own sessions and other sessions.

If an admin has attached an IAM policy such as AWSGlueConsoleFullAccess or AWSGlueServiceRole that allows access to all AWS Glue resources in that account, a client principal will be able to collaborate with each other. For example, one user will be able to interact with sessions that are created by other users if policies allow this.

If you'd like to configure a policy tailored to your specific needs, see IAM documentation about configuring resources for a policy. For example, in order to isolate sessions that belong to an user, you can use the TagOnCreate feature supported by AWS Glue Interactive sessions. See Make your session private with TagOnCreate.

Interactive sessions supports limiting session creation based on certain VPC conditions. See Control policies that control settings using condition keys.

Converting a script or notebook into an AWS Glue job

There are two ways you can convert a script or notebook into an AWS Glue job:

- Use nbconvert to convert your Jupyter .ipynb notebook document file into a .py file. For more information, see nbconvert: Convert Notebooks to other formats.
- Upload the file to AWS Glue Studio Notebooks.
  - In the AWS Glue Studio console, choose Jobs from the navigation menu.
  - In the Create job section, choose Jupyter Notebook.
  - In the Options section, choose Upload and edit an existing notebook.
  - Select Choose file to upload an .ipynb file.
AWS Glue interactive sessions for streaming

Switching streaming session type

Use the AWS Glue interactive sessions configuration magic, `%streaming`, to define the job you are running and initialize a streaming interactive session.

Sampling input stream for interactive development

One tool we have derived to help enhance the interactive experience in AWS Glue interactive sessions is the addition of a new method under GlueContext to obtain a snapshot of a stream in a static DynamicFrame. GlueContext allows you to inspect, interact and implement your workflow.

With the GlueContext class instance, you will be able to locate the method `getSampleStreamingDynamicFrame`. Required arguments for this method are:

- `dataFrame`: The Spark Streaming DataFrame
- `options`: See available options below

Available options include:

- `windowSize`: This is also called Microbatch Duration. This parameter will determine how long a streaming query will wait after previous batch was triggered. This parameter value must be smaller than `pollingTimeInMs`.
- `pollingTimeInMs`: The total length of time the method will run. It will fire off at least one micro batch to obtain sample records from the input stream.
- `recordPollingLimit`: This parameter helps you limit the total number of records you will poll from the stream.
- (Optional) You can also use `writeStreamFunction` to apply this custom function to every record sampling function. See below for examples in Scala and Python.

Scala

```scala
val sampleBatchFunction = (batchDF: DataFrame, batchId: Long) => {//Optional but you can replace your own forEachBatch function here}
```
val jsonString: String = s"""{"pollingTimeInMs": "10000", "windowSize": "5 seconds"}""
val dynFrame = glueContext.getSampleStreamingDynamicFrame(YOUR_STREAMING_DF, JsonOptions(jsonString), sampleBatchFunction)
dynFrame.show()

Python

def sample_batch_function(batch_df, batch_id):
    //Optional but you can replace your own forEachBatch function here
    options = {
        "pollingTimeInMs": "10000",
        "windowSize": "5 seconds",
    }
    glue_context.getSampleStreamingDynamicFrame(YOUR_STREAMING_DF, options, sample_batch_function)

Note

When the sampled DynFrame is empty, it could be caused by a few reasons:

- The Streaming source is set to "Latest" and no new data has been ingested during the sampling period.
- The polling time is not enough to process the records it ingested. Data won't show up unless the whole batch has been processed.

Running streaming applications in interactive sessions

In AWS Glue interactive sessions, you can run a the AWS Glue streaming application like how you would create a streaming application in the AWS Glue Console. Since interactive sessions is session-based, encountering exceptions in the runtime does not cause the session to stop. We now have the added benefit of developing your batch function iteratively. For example:

def batch_function(data_frame, batch_id):
    log.info(data_frame.count())
    invalid_method_call()
In the example above, we included an invalid usage of a method and unlike regular AWS Glue jobs which will exit the entire application, the user’s coding context and definitions are fully preserved and the session is still operational. There is no need to bootstrap a new cluster and rerun all the preceding transformation. This allows you to focus on quickly iterating your batch function implementations to obtain desirable outcomes.

It is important to note that Interactive Session evaluates each statement in a blocking manner so that the session will only execute one statement at a time. Since streaming queries are continuous and never ending, sessions with active streaming queries won’t be able to handle any follow up statements unless they are interrupted. You can issue the interruption command directly from Jupyter Notebook and our kernel will handle the cancellation for you.

Take the following sequence of statements which are waiting for execution as an example:

```scala
Statement 1:
val number = df.count()
#Spark Action with deterministic result
Result: 5

Statement 2:
streningQuery.start().awaitTermination()
#Spark Streaming Query that will be executing continously
Result: Constantly updated with each microbatch

Statement 3:
val number2 = df.count()
#This will not be executed as previous statement will be running indefinitely
```

**Developing and testing AWS Glue job scripts locally**

When you develop and test your AWS Glue for Spark job scripts, there are multiple available options:

- AWS Glue Studio console
You can choose any of the above options based on your requirements.

If you prefer no code or less code experience, the AWS Glue Studio visual editor is a good choice.

If you prefer an interactive notebook experience, AWS Glue Studio notebook is a good choice. For more information, see Using Notebooks with AWS Glue Studio and AWS Glue. If you want to use your own local environment, interactive sessions is a good choice. For more information, see Using interactive sessions with AWS Glue.

If you prefer local/remote development experience, the Docker image is a good choice. This helps you to develop and test AWS Glue for Spark job scripts anywhere you prefer without incurring AWS Glue cost.

If you prefer local development without Docker, installing the AWS Glue ETL library directory locally is a good choice.

**Developing using AWS Glue Studio**

The AWS Glue Studio visual editor is a graphical interface that makes it easy to create, run, and monitor extract, transform, and load (ETL) jobs in AWS Glue. You can visually compose data transformation workflows and seamlessly run them on AWS Glue's Apache Spark-based serverless ETL engine. You can inspect the schema and data results in each step of the job. For more information, see the AWS Glue Studio User Guide.
Developing using interactive sessions

Interactive sessions allow you to build and test applications from the environment of your choice. For more information, see Using interactive sessions with AWS Glue.

Developing using a Docker image

⚠️ Note

The instructions in this section have not been tested on Microsoft Windows operating systems.
For local development and testing on Windows platforms, see the blog Building an AWS Glue ETL pipeline locally without an AWS account.

For a production-ready data platform, the development process and CI/CD pipeline for AWS Glue jobs is a key topic. You can flexibly develop and test AWS Glue jobs in a Docker container. AWS Glue hosts Docker images on Docker Hub to set up your development environment with additional utilities. You can use your preferred IDE, notebook, or REPL using AWS Glue ETL library. This topic describes how to develop and test AWS Glue version 4.0 jobs in a Docker container using a Docker image.

The following Docker images are available for AWS Glue on Docker Hub.

- For AWS Glue version 4.0: amazon/aws-glue-libs:glue_libs_4.0.0_image_01
- For AWS Glue version 3.0: amazon/aws-glue-libs:glue_libs_3.0.0_image_01
- For AWS Glue version 2.0: amazon/aws-glue-libs:glue_libs_2.0.0_image_01

These images are for x86_64. It is recommended that you test on this architecture. However, it may be possible to rework a local development solution on unsupported base images.

This example describes using amazon/aws-glue-libs:glue_libs_4.0.0_image_01 and running the container on a local machine. This container image has been tested for an AWS Glue version 3.3 Spark jobs. This image contains the following:

- Amazon Linux
- AWS Glue ETL library (aws-glue-libs)
- Apache Spark 3.3.0
• Spark history server
• Jupyter Lab
• Livy
• Other library dependencies (the same set as the ones of AWS Glue job system)

Complete one of the following sections according to your requirements:

• Set up the container to use spark-submit
• Set up the container to use REPL shell (PySpark)
• Set up the container to use Pytest
• Set up the container to use Jupyter Lab
• Set up the container to use Visual Studio Code

Prerequisites

Before you start, make sure that Docker is installed and the Docker daemon is running. For installation instructions, see the Docker documentation for Mac or Linux. The machine running the Docker hosts the AWS Glue container. Also make sure that you have at least 7 GB of disk space for the image on the host running the Docker.

For more information about restrictions when developing AWS Glue code locally, see Local development restrictions.

Configuring AWS

To enable AWS API calls from the container, set up AWS credentials by following steps. In the following sections, we will use this AWS named profile.

1. Set up the AWS CLI, configuring a named profile. For more information about AWS CLI configuration, see Configuration and credential file settings in the AWS CLI documentation.

2. Run the following command in a terminal:

   PROFILE_NAME="<your_profile_name>"

You may also need to set the AWS_REGION environment variable to specify the AWS Region to send requests to.
Setting up and running the container

Setting up the container to run PySpark code through the spark-submit command includes the following high-level steps:

1. Pull the image from Docker Hub.
2. Run the container.

Pulling the image from Docker Hub

Run the following command to pull the image from Docker Hub:

```bash
docker pull amazon/aws-glue-libs:glue_libs_4.0.0_image_01
```

Running the container

You can now run a container using this image. You can choose any of following based on your requirements.

spark-submit

You can run an AWS Glue job script by running the `spark-submit` command on the container.

1. Write the script and save it as `sample1.py` under the `/local_path_to_workspace` directory. Sample code is included as the appendix in this topic.

```bash
$ WORKSPACE_LOCATION=/local_path_to_workspace
$ SCRIPT_FILE_NAME=sample.py
$ mkdir -p ${WORKSPACE_LOCATION}/src
$ vim ${WORKSPACE_LOCATION}/src/${SCRIPT_FILE_NAME}
```

2. Run the following command to execute the `spark-submit` command on the container to submit a new Spark application:

```bash
$ docker run -it -v ~/.aws:/home/glue_user/.aws -v $WORKSPACE_LOCATION:/home/glue_user/workspace -e AWS_PROFILE=$PROFILE_NAME -e DISABLE_SSL=true --rm -p 4040:4040 -p 18080:18080 --name glue_spark_submit amazon/aws-glue-libs:glue_libs_4.0.0_image_01 spark-submit /home/glue_user/workspace/src/$SCRIPT_FILE_NAME
```

22/01/26 09:08:55 INFO D AGScheduler: Job 0 finished: fromRDD at DynamicFrame.scala:305, took 3.639886 s
3. (Optionally) Configure `spark-submit` to match your environment. For example, you can pass your dependencies with the `--jars` configuration. For more information, consult [Launching Applications with `spark-submit`](https://spark.apache.org/docs/latest/running-spark-on-app.html) in the Spark documentation.

**REPL shell (Pyspark)**

You can run REPL (read-eval-print loops) shell for interactive development.

Run the following command to execute the PySpark command on the container to start the REPL shell:

```
```
$ docker run -it -v ~/.aws:/home/glue_user/.aws -e AWS_PROFILE=$PROFILE_NAME -e DISABLE_SSL=true --rm -p 4040:4040 -p 18080:18080 --name glue_pyspark amazon/aws-glue-libs:glue_libs_4.0.0_image_01 pyspark
...

Using Python version 3.7.10 (default, Jun 3 2021 00:02:01)
Spark context Web UI available at http://56e99d000c99:4040
Spark context available as 'sc' (master = local[*], app id = local-1643011860812).
SparkSession available as 'spark'.
>>>

Pytest

For unit testing, you can use pytest for AWS Glue Spark job scripts.

Run the following commands for preparation.

$ WORKSPACE_LOCATION=/local_path_to_workspace
$ SCRIPT_FILE_NAME=sample.py
$ UNIT_TEST_FILE_NAME=test_sample.py
$ mkdir -p ${WORKSPACE_LOCATION}/tests
$ vim ${WORKSPACE_LOCATION}/tests/${UNIT_TEST_FILE_NAME}

Run the following command to execute pytest on the test suite:

$ docker run -it -v ~/.aws:/home/glue_user/.aws -v $WORKSPACE_LOCATION:/home/glue_user/workspace/ -e AWS_PROFILE=$PROFILE_NAME -e DISABLE_SSL=true --rm -p 4040:4040 -p 18080:18080 --name glue_pytest amazon/aws-glue-libs:glue_libs_4.0.0_image_01 -c "python3 -m pytest"

starting org.apache.spark.deploy.history.HistoryServer,
logging to /home/glue_user/spark/logs/spark-glue_user-org.apache.spark.deploy.history.HistoryServer-1-5168f209bd78.out
*================================================================= test session starts
=================================================================
*platform linux -- Python 3.7.10, pytest-6.2.3, py-1.11.0, pluggy-0.13.1
rootdir: /home/glue_user/workspace
plugins: anyio-3.4.0
*collected 1 item *

tests/test_sample.py . [100%]

=================================================================== warnings summary
=====================================================================
tests/test_sample.py::test_counts
/home/glue_user/spark/python/pyspark/sql/context.py:79: DeprecationWarning: Deprecated
in 3.0.0. Use SparkSession.builder.getOrCreate() instead.
DeprecationWarning)

=====================================================================
1 passed, *1 warning* in
21.07s=====================================================================

Jupyter Lab

You can start Jupyter for interactive development and ad-hoc queries on notebooks.

1. Run the following command to start Jupyter Lab:

```
$ JUPYTER_WORKSPACE_LOCATION=/local_path_to_workspace/jupyter_workspace/
$ docker run -it -v ~/.aws:/home/glue_user/.aws -v $JUPYTER_WORKSPACE_LOCATION:/
/home/glue_user/workspace/jupyter_workspace/ -e AWS_PROFILE=$PROFILE_NAME -e
DISABLE_SSL=true --rm -p 4040:4040 -p 18080:18080 -p 8998:8998 -p 8888:8888 --name
  glue_jupyter_lab amazon/aws-glue-libs:glue_libs_4.0.0_image_01 /home/glue_user/
  jupyter/jupyter_start.sh
...
  glue_user/workspace/jupyter_workspace
[I 2022-01-24 08:19:21.368 ServerApp] Use Control-C to stop this server and shut down
  all kernels (twice to skip confirmation).
```

2. Open http://127.0.0.1:8888/lab in your web browser in your local machine, to see the Jupyter
   lab UI.
3. Choose Glue Spark Local (PySpark) under Notebook. You can start developing code in the interactive Jupyter notebook UI.
Setting up the container to use Visual Studio Code

Prerequisites:

1. Install Visual Studio Code.
2. Install Python.
3. Install Visual Studio Code Remote - Containers
5. Choose Settings.
7. Choose Open Settings (JSON).
8. Paste the following JSON and save it.

```json
{
   "python.defaultInterpreterPath": "/usr/bin/python3",
   "python.analysis.extraPaths": [
      "/home/glue_user/aws-glue-libs/PyGlue.zip:/home/glue_user/spark/python/lib/py4j-0.10.9-src.zip:/home/glue_user/spark/python/"
   ]
}
```
Steps:

1. Run the Docker container.

   ```
   $ docker run -it -v ~/.aws:/home/glue_user/.aws -v $WORKSPACE_LOCATION:/home/glue_user/workspace/ -e AWS_PROFILE=$PROFILE_NAME -e DISABLE_SSL=true --rm -p 4040:4040 -p 18080:18080 --name glue_pyspark amazon/aws-glue-libs:glue_libs_4.0.0_image_01 pyspark
   ```


3. Choose **Remote Explorer** on the left menu, and choose `amazon/aws-glue-libs:glue_libs_4.0.0_image_01`.

4. Right click and choose **Attach to Container**. If a dialog is shown, choose **Got it**.

5. Open `/home/glue_user/workspace/`.

6. Create a Glue PySpark script and choose **Run**.

   You will see the successful run of the script.
Appendix: AWS Glue job sample code for testing

This appendix provides scripts as AWS Glue job sample code for testing purposes.

code.py: Sample code to utilize the AWS Glue ETL library with an Amazon S3 API call

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

class GluePythonSampleTest:
    def __init__(self):
        params = []
        if '--JOB_NAME' in sys.argv:
            params.append('JOB_NAME')
            args = getResolvedOptions(sys.argv, params)
            self.context = GlueContext(SparkContext().getOrCreate())
            self.job = Job(self.context)
            if 'JOB_NAME' in args:
                self.job_name = args['JOB_NAME']
            else:
                self.job_name = 'test'
                self.job.init(self.job_name, args)
    
    def run(self):
        dyf = read_json(self.context, 's3://awsglue-datasets/examples/us-legislators/all/persons.json')
        dyf.printSchema()
```
The above code requires Amazon S3 permissions in AWS IAM. You need to grant the IAM managed policy `arn:aws:iam::aws:policy/AmazonS3ReadOnlyAccess` or an IAM custom policy which allows you to call ListBucket and GetObject for the Amazon S3 path.

test_sample.py: Sample code for unit test of sample.py.

```python
import pytest
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions
```
import sys
from src import sample

@pytest.fixture(scope="module", autouse=True)
def glue_context():
    sys.argv.append('--JOB_NAME')
    sys.argv.append('test_count')

    args = getResolvedOptions(sys.argv, ['JOB_NAME'])
    context = GlueContext(SparkContext.getOrCreate())
    job = Job(context)
    job.init(args['JOB_NAME'], args)

    yield(context)

    job.commit()

def test_counts(glue_context):
    dyf = sample.read_json(glue_context, "s3://awsglue-datasets/examples/us-legislators/all/persons.json")
    assert dyf.toDF().count() == 1961

Developing using the AWS Glue ETL library

The AWS Glue ETL library is available in a public Amazon S3 bucket, and can be consumed by the Apache Maven build system. This enables you to develop and test your Python and Scala extract, transform, and load (ETL) scripts locally, without the need for a network connection. Local development with the Docker image is recommended, as it provides an environment properly configured for the use of this library.

Local development is available for all AWS Glue versions, including AWS Glue version 0.9, 1.0, 2.0, and later. For information about the versions of Python and Apache Spark that are available with AWS Glue, see the Glue version job property.

The library is released with the Amazon Software license (https://aws.amazon.com/asl).

Local development restrictions

Keep the following restrictions in mind when using the AWS Glue Scala library to develop locally.
Avoid creating an assembly jar ("fat jar" or "uber jar") with the AWS Glue library because it causes the following features to be disabled:

- **Job bookmarks**
- AWS Glue Parquet writer ([Using the Parquet format in AWS Glue](#))
- FillMissingValues transform ([Scala](#) or [Python](#))

These feature are available only within the AWS Glue job system.

- The **FindMatches transform** is not supported with local development.
- The **vectorized SIMD CSV reader** is not supported with local development.
- The property **customJdbcDriverS3Path** for loading JDBC driver from S3 path is not supported with local development. Alternatively you can download the JDBC driver in your local and load from there.
- The **Glue Data Quality** is not supported with local development.

### Developing locally with Python

Complete some prerequisite steps and then use AWS Glue utilities to test and submit your Python ETL script.

#### Prerequisites for local Python development

Complete these steps to prepare for local Python development:

1. Clone the AWS Glue Python repository from GitHub ([https://github.com/awslabs/aws-glue-libs](https://github.com/awslabs/aws-glue-libs)).
2. Do one of the following:
   - For AWS Glue version 0.9, check out branch `g1ue-0.9`.
   - For AWS Glue versions 1.0, check out branch `g1ue-1.0`. All versions above AWS Glue 0.9 support Python 3.
   - For AWS Glue versions 2.0, check out branch `g1ue-2.0`.
   - For AWS Glue versions 3.0, check out branch `g1ue-3.0`.
   - For AWS Glue version 4.0, check out the `master` branch.
4. Install the Apache Spark distribution from one of the following locations:
5. Export the SPARK_HOME environment variable, setting it to the root location extracted from the Spark archive. For example:

- For AWS Glue version 0.9: `export SPARK_HOME=/home/$USER/spark-2.2.1-bin-hadoop2.7`
- For AWS Glue version 1.0 and 2.0: `export SPARK_HOME=/home/$USER/spark-2.4.3-bin-spark-2.4.3-bin-hadoop2.8`
- For AWS Glue version 3.0: `export SPARK_HOME=/home/$USER/spark-3.1.1-amzn-0-bin-3.2.1-amzn-3`
- For AWS Glue version 4.0: `export SPARK_HOME=/home/$USER/spark-3.3.0-amzn-1-bin-3.3.3-amzn-0`

**Running your Python ETL script**

With the AWS Glue jar files available for local development, you can run the AWS Glue Python package locally.

Use the following utilities and frameworks to test and run your Python script. The commands listed in the following table are run from the root directory of the AWS Glue Python package.

<table>
<thead>
<tr>
<th>Utility</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Glue Shell</td>
<td>./bin/gluepyspark</td>
<td>Enter and run Python scripts in a shell that integrates with AWS Glue ETL libraries.</td>
</tr>
<tr>
<td>Utility</td>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>AWS Glue Submit</td>
<td>./bin/gluesparksubmit</td>
<td>Submit a complete Python script for execution.</td>
</tr>
<tr>
<td>Pytest</td>
<td>./bin/gluepytest</td>
<td>Write and run unit tests of your Python code. The pytest module must be installed and available in the PATH. For more information, see the pytest documentation.</td>
</tr>
</tbody>
</table>

**Developing locally with Scala**

Complete some prerequisite steps and then issue a Maven command to run your Scala ETL script locally.

**Prerequisites for local Scala development**

Complete these steps to prepare for local Scala development.

**Step 1: Install software**

In this step, you install software and set the required environment variable.

2. Install the Apache Spark distribution from one of the following locations:
   - For AWS Glue version 0.9: [https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-0.9/spark-2.2.1-bin-hadoop2.7.tgz](https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-0.9/spark-2.2.1-bin-hadoop2.7.tgz)
   - For AWS Glue version 1.0: [https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-1.0/spark-2.4.3-bin-hadoop2.8.tgz](https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-1.0/spark-2.4.3-bin-hadoop2.8.tgz)
   - For AWS Glue version 2.0: [https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-2.0/spark-2.4.3-bin-hadoop2.8.tgz](https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-2.0/spark-2.4.3-bin-hadoop2.8.tgz)
   - For AWS Glue version 4.0: [https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-4.0/spark-3.3.0-amzn-1-bin-3.3.3-amzn-0.tgz](https://aws-glue-etl-artifacts.s3.amazonaws.com/glue-4.0/spark-3.3.0-amzn-1-bin-3.3.3-amzn-0.tgz)

Developing using the AWS Glue ETL library
3. Export the SPARK_HOME environment variable, setting it to the root location extracted from the Spark archive. For example:

- For AWS Glue version 0.9: `export SPARK_HOME=/home/$USER/spark-2.2.1-bin-hadoop2.7`
- For AWS Glue version 1.0 and 2.0: `export SPARK_HOME=/home/$USER/spark-2.4.3-bin-spark-2.4.3-bin-hadoop2.8`
- For AWS Glue version 3.0: `export SPARK_HOME=/home/$USER/spark-3.1.1-amzn-0-bin-3.2.1-amzn-3`
- For AWS Glue version 4.0: `export SPARK_HOME=/home/$USER/spark-3.3.0-amzn-1-bin-3.3.3-amzn-0`

**Step 2: Configure your Maven project**

Use the following pom.xml file as a template for your AWS Glue Scala applications. It contains the required dependencies, repositories, and plugins elements. Replace the Glue version string with one of the following:

- `4.0.0` for AWS Glue version 4.0
- `3.0.0` for AWS Glue version 3.0
- `1.0.0` for AWS Glue version 1.0 or 2.0
- `0.9.0` for AWS Glue version 0.9

```xml
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.amazonaws</groupId>
  <artifactId>AWSGlueApp</artifactId>
  <version>1.0-SNAPSHOT</version>
  <name>${project.artifactId}</name>
  <description>AWS ETL application</description>

  <properties>
    <scala.version>2.11.1 for AWS Glue 2.0 or below, 2.12.7 for AWS Glue 3.0 and 4.0</scala.version>
    <glue.version>Glue version with three numbers (as mentioned earlier)</glue.version>
  </properties>
</project>
```
<groupId>org.codehaus.mojo</groupId>
<artifactId>exec-maven-plugin</artifactId>
<version>1.6.0</version>
<executions>
   <execution>
      <goals>
         <goal>java</goal>
      </goals>
   </execution>
</executions>
<configuration>
   <systemProperties>
      <systemProperty>
         <key>spark.master</key>
         <value>local[*]</value>
      </systemProperty>
      <systemProperty>
         <key>spark.app.name</key>
         <value>localrun</value>
      </systemProperty>
      <systemProperty>
         <key>org.xerial.snappy.lib.name</key>
         <value>libsnappyjava.jnilib</value>
      </systemProperty>
   </systemProperties>
</configuration>
</plugin>

<plugin>
   <groupId>org.apache.maven.plugins</groupId>
   <artifactId>maven-enforcer-plugin</artifactId>
   <version>3.0.0-M2</version>
   <executions>
      <execution>
         <id>enforce-maven</id>
         <goals>
            <goal>enforce</goal>
         </goals>
         <configuration>
            <rules>
               <requireMavenVersion>
                  <version>3.5.3</version>
               </requireMavenVersion>
            </rules>
         </configuration>
      </execution>
   </executions>
</plugin>
Running your Scala ETL script

Run the following command from the Maven project root directory to run your Scala ETL script.

```bash
mvn exec:java -Dexec.mainClass="mainClass" -Dexec.args="--JOB-NAME jobName"
```

Replace `mainClass` with the fully qualified class name of the script's main class. Replace `jobName` with the desired job name.

Configuring a test environment

For examples of configuring a local test environment, see the following blog articles:

- [Building an AWS Glue ETL pipeline locally without an AWS account](#)
- [Developing AWS Glue ETL jobs locally using a container](#)
If you want to use development endpoints or notebooks for testing your ETL scripts, see [Developing scripts using development endpoints](#).

**Note**

Development endpoints are not supported for use with AWS Glue version 2.0 jobs. For more information, see [Running Spark ETL Jobs with Reduced Startup Times](#).

### Development endpoints

**Note**

The console experience for dev endpoints has been removed as of March 31, 2023. Creating, updating, and monitoring dev endpoints is still available via the [Development endpoints API](#) and [AWS Glue CLI](#).

We strongly recommend migrating from dev endpoints to interactive sessions for the reasons listed below. For required actions on how to migrate from dev endpoints to interactive sessions, see [Migrating from dev endpoints to interactive sessions](#).

<table>
<thead>
<tr>
<th>Description</th>
<th>Dev endpoints</th>
<th>Interactive sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue version support</td>
<td>Supports AWS Glue version 0.9 and 1.0</td>
<td>Supports AWS Glue version 2.0 and later</td>
</tr>
<tr>
<td>Dev endpoints are not available in the Asia Pacific (Jakarta) (ap-southeast-3), Middle East (UAE) (me-central-1), Europe (Spain) (eu-south-2), Europe (Zurich) (eu-central-1), or other new regions going forward</td>
<td>Interactive sessions are not currently available in the Middle East (UAE) (me-central-1) region, but may be made available later</td>
<td></td>
</tr>
</tbody>
</table>
### Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Dev endpoints</th>
<th>Interactive sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access method to the Spark cluster</td>
<td>Supports SSH, REPL shell, Jupyter notebook, IDE (e.g. PyCharm)</td>
<td>supports AWS Glue Studio notebook, Jupyter notebook, various IDEs (for example, Visual Studio Code, PyCharm), and SageMaker notebook</td>
</tr>
<tr>
<td>Time to first query</td>
<td>Requires 10-15 minutes to setup a Spark cluster</td>
<td>Can take up to 1 minute to set up an ephemeral Spark cluster</td>
</tr>
<tr>
<td>Price model</td>
<td>AWS charges for development endpoints based on the time that the endpoint is provisioned and the number of DPUs. Development endpoints do not time out. There is a 10-minute minimum billing duration for each provisioned development endpoint. Additionally, AWS charges for Jupyter notebook on Amazon EC2 instances, and SageMaker notebooks when you configure them with dev endpoints.</td>
<td>AWS charges for interactive sessions based on the time that the session is active and the number of DPUs. Interactive sessions have configurable idle timeouts. AWS Glue Studio notebooks provide a built-in interface for interactive sessions and are offered at no additional cost. There is a 1-minute minimum billing duration for each interactive session. AWS Glue Studio notebooks provide a built-in interface for interactive sessions and are offered at no additional cost</td>
</tr>
<tr>
<td>Console experience</td>
<td>Only available via the CLI and API</td>
<td>Available through the AWS Glue console, CLI, and APIs</td>
</tr>
</tbody>
</table>

### Migrating from dev endpoints to interactive sessions

Use the following checklist to determine the appropriate method to migrate from dev endpoints to interactive sessions.
Does your script depend on AWS Glue 0.9 or 1.0 specific features (for example, HDFS, YARN, etc.)?

If the answer is yes, see [Migrating AWS Glue jobs to AWS Glue version 3.0](#) to learn how to migrate from Glue 0.9 or 1.0 to Glue 3.0 and later.

**Which method do you use to access your dev endpoint?**

<table>
<thead>
<tr>
<th>If you use this method</th>
<th>Then do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>SageMaker notebook, Jupyter notebook, or JupyterLab</td>
<td>Migrate to <a href="#">AWS Glue Studio notebook</a> by downloading <code>.ipynb</code> files on Jupyter and create a new AWS Glue Studio notebook job by uploading the <code>.ipynb</code> file. Alternatively, you can also use <a href="#">SageMaker Studio</a> and select the AWS Glue kernel.</td>
</tr>
<tr>
<td>Zeppelin notebook</td>
<td>Convert the notebook to a Jupyter notebook manually by copying and pasting code or automatically using a third-party converter such as ze2nb. Then, use the notebook in AWS Glue Studio notebook or SageMaker Studio.</td>
</tr>
<tr>
<td>IDE</td>
<td>See <a href="#">Author AWS Glue jobs with PyCharm using AWS Glue interactive sessions</a>, or <a href="#">Using interactive sessions with Microsoft Visual Studio Code</a>.</td>
</tr>
<tr>
<td>REPL</td>
<td>Install the <code>aws-glue-session</code> package locally, then run the following command:</td>
</tr>
<tr>
<td></td>
<td>• For Python: <code>jupyter console --kernal glue_pyspark</code></td>
</tr>
<tr>
<td></td>
<td>• For Scala: <code>jupyter console --kernal glue_spark</code></td>
</tr>
<tr>
<td>SSH</td>
<td>No corresponding option on interactive sessions. Alternatively, you can use a Docker</td>
</tr>
</tbody>
</table>
The following sections provide information on using dev endpoints to develop jobs in AWS Glue version 1.0.

Topics

- Developing scripts using development endpoints
- Managing notebooks

Developing scripts using development endpoints

Note

Development Endpoints are only supported for versions of AWS Glue prior to 2.0. For an interactive environment where you can author and test ETL scripts, use Notebooks on AWS Glue Studio.

AWS Glue can create an environment—known as a development endpoint—that you can use to iteratively develop and test your extract, transform, and load (ETL) scripts. You can create, edit, and delete development endpoints using the AWS Glue console or API.

Managing your development environment

When you create a development endpoint, you provide configuration values to provision the development environment. These values tell AWS Glue how to set up the network so that you can access the endpoint securely and the endpoint can access your data stores.

You can then create a notebook that connects to the endpoint, and use your notebook to author and test your ETL script. When you're satisfied with the results of your development process, you can create an ETL job that runs your script. With this process, you can add functions and debug your scripts in an interactive manner.

Follow the tutorials in this section to learn how to use your development endpoint with notebooks.
Topics

- Development endpoint workflow
- How AWS Glue development endpoints work with SageMaker notebooks
- Adding a development endpoint
- Accessing your development endpoint
- Tutorial: Set up a Jupyter notebook in JupyterLab to test and debug ETL scripts
- Tutorial: Use a SageMaker notebook with your development endpoint
- Tutorial: Use a REPL shell with your development endpoint
- Tutorial: Set up PyCharm professional with a development endpoint
- Advanced configuration: sharing development endpoints among multiple users

Development endpoint workflow

To use an AWS Glue development endpoint, you can follow this workflow:

1. Create a development endpoint using the API. The endpoint is launched in a virtual private cloud (VPC) with your defined security groups.
2. The API polls the development endpoint until it is provisioned and ready for work. When it's ready, connect to the development endpoint using one of the following methods to create and test AWS Glue scripts.
   - Create an SageMaker notebook in your account. For more information about how to create a notebook, see Using Notebooks with AWS Glue.
   - Open a terminal window to connect directly to a development endpoint.
   - If you have the professional edition of the JetBrains PyCharm Python IDE, connect it to a development endpoint and use it to develop interactively. If you insert pydevd statements in your script, PyCharm can support remote breakpoints.
3. When you finish debugging and testing on your development endpoint, you can delete it.

How AWS Glue development endpoints work with SageMaker notebooks

One of the common ways to access your development endpoints is to use Jupyter on SageMaker notebooks. The Jupyter notebook is an open-source web application which is widely used in
visualization, analytics, machine learning, etc. An AWS Glue SageMaker notebook provides you a Jupyter notebook experience with AWS Glue development endpoints. In the AWS Glue SageMaker notebook, the Jupyter notebook environment is pre-configured with SparkMagic, an open source Jupyter plugin to submit Spark jobs to a remote Spark cluster. Apache Livy is a service that allows interaction with a remote Spark cluster over a REST API. In the AWS Glue SageMaker notebook, SparkMagic is configured to call the REST API against a Livy server running on an AWS Glue development endpoint.

The following text flow explains how each component works:

AWS Glue SageMaker notebook: (Jupyter # SparkMagic) # (network) # AWS Glue development endpoint: (Apache Livy # Apache Spark)

Once you run your Spark script written in each paragraph on a Jupyter notebook, the Spark code is submitted to the Livy server via SparkMagic, then a Spark job named "livy-session-N" runs on the Spark cluster. This job is called a Livy session. The Spark job will run while the notebook session is alive. The Spark job will be terminated when you shutdown the Jupyter kernel from the notebook, or when the session is timed out. One Spark job is launched per notebook (.ipynb) file.

You can use a single AWS Glue development endpoint with multiple SageMaker notebook instances. You can create multiple notebook files in each SageMaker notebook instance. When you open an each notebook file and run the paragraphs, then a Livy session is launched per notebook file on the Spark cluster via SparkMagic. Each Livy session corresponds to single Spark job.

Default behavior for AWS Glue development endpoints and SageMaker notebooks

The Spark jobs run based on the Spark configuration. There are multiple ways to set the Spark configuration (for example, Spark cluster configuration, SparkMagic's configuration, etc.).

By default, Spark allocates cluster resources to a Livy session based on the Spark cluster configuration. In the AWS Glue development endpoints, the cluster configuration depends on the worker type. Here's a table which explains the common configurations per worker type.

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>G.1X</th>
<th>G.2X</th>
</tr>
</thead>
<tbody>
<tr>
<td>spark.driver.memory</td>
<td>5G</td>
<td>10G</td>
<td>20G</td>
</tr>
</tbody>
</table>

Developing scripts using development endpoints
<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>G.1X</th>
<th>G.2X</th>
</tr>
</thead>
<tbody>
<tr>
<td>spark.executor.memory</td>
<td>5G</td>
<td>10G</td>
<td>20G</td>
</tr>
<tr>
<td>spark.executor.cores</td>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>spark.dynamicAllocation.enabled</td>
<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

The maximum number of Spark executors is automatically calculated by combination of DPU (or `NumberOfWorkers`) and worker type.

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>G.1X</th>
<th>G.2X</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of max Spark executors</td>
<td>((DPU - 1) \times 2) - 1</td>
<td>((NumberOfWorkers - 1))</td>
<td>((NumberOfWorkers - 1))</td>
</tr>
</tbody>
</table>

For example, if your development endpoint has 10 workers and the worker type is `G.1X`, then you will have 9 Spark executors and the entire cluster will have 90G of executor memory since each executor will have 10G of memory.

Regardless of the specified worker type, Spark dynamic resource allocation will be turned on. If a dataset is large enough, Spark may allocate all the executors to a single Livy session since `spark.dynamicAllocation.maxExecutors` is not set by default. This means that other Livy sessions on the same dev endpoint will wait to launch new executors. If the dataset is small, Spark will be able to allocate executors to multiple Livy sessions at the same time.
### Adding a development endpoint

Use development endpoints to iteratively develop and test your extract, transform, and load (ETL) scripts in AWS Glue. Working with development endpoints is only available through the AWS Command Line Interface.

1. In a command line window, enter a command similar to the following.

```bash
aws glue create-dev-endpoint --endpoint-name "endpoint1" --role-arn "arn:aws:iam::account-id:role/role-name" --number-of-nodes "3" --glue-version "1.0" --arguments '{"GLUE_PYTHON_VERSION": "3"}' --region "region-name"
```

This command specifies AWS Glue version 1.0. Because this version supports both Python 2 and Python 3, you can use the `arguments` parameter to indicate the desired Python version. If the `glue-version` parameter is omitted, AWS Glue version 0.9 is assumed. For more information about AWS Glue versions, see the [Glue version job property](#).

For information about additional command line parameters, see `create-dev-endpoint` in the [AWS CLI Command Reference](#).

2. (Optional) Enter the following command to check the development endpoint status. When the status changes to READY, the development endpoint is ready to use.

```bash
aws glue get-dev-endpoint --endpoint-name "endpoint1"
```

### Accessing your development endpoint

When you create a development endpoint in a virtual private cloud (VPC), AWS Glue returns only a private IP address. The public IP address field is not populated. When you create a non-VPC development endpoint, AWS Glue returns only a public IP address.
If your development endpoint has a **Public address**, confirm that it is reachable with the SSH private key for the development endpoint, as in the following example.

```
ssh -i dev-endpoint-private-key.pem glue@public-address
```

Suppose that your development endpoint has a **Private address**, your VPC subnet is routable from the public internet, and its security groups allow inbound access from your client. In this case, follow these steps to attach an *Elastic IP address* to a development endpoint to allow access from the internet.

**Note**

If you want to use Elastic IP addresses, the subnet that is being used requires an internet gateway associated through the route table.

**To access a development endpoint by attaching an Elastic IP address**

2. In the navigation pane, choose **Dev endpoints**, and navigate to the development endpoint details page. Record the **Private address** for use in the next step.
3. Open the Amazon EC2 console at [https://console.aws.amazon.com/ec2/](https://console.aws.amazon.com/ec2/).
4. In the navigation pane, under **Network & Security**, choose **Network Interfaces**.
5. Search for the **Private DNS (IPv4)** that corresponds to the **Private address** on the AWS Glue console development endpoint details page.
   
   You might need to modify which columns are displayed on your Amazon EC2 console. Note the **Network interface ID** (ENI) for this address (for example, eni-12345678).
6. On the Amazon EC2 console, under **Network & Security**, choose **Elastic IPs**.
7. Choose **Allocate new address**, and then choose **Allocate** to allocate a new Elastic IP address.
8. On the **Elastic IPs** page, choose the newly allocated **Elastic IP**. Then choose **Actions, Associate address**.
9. On the **Associate address** page, do the following:
   
   - For **Resource type**, choose **Network interface**.
   - In the **Network interface** box, enter the **Network interface ID** (ENI) for the private address.
• Choose Associate.

10. Confirm that the newly associated Elastic IP address is reachable with the SSH private key that is associated with the development endpoint, as in the following example.

```
ssh -i dev-endpoint-private-key.pem glue@elastic-ip
```

For information about using a bastion host to get SSH access to the development endpoint’s private address, see the AWS Security Blog post Securely Connect to Linux Instances Running in a Private Amazon VPC.

**Tutorial: Set up a Jupyter notebook in JupyterLab to test and debug ETL scripts**

In this tutorial, you connect a Jupyter notebook in JupyterLab running on your local machine to a development endpoint. You do this so that you can interactively run, debug, and test AWS Glue extract, transform, and load (ETL) scripts before deploying them. This tutorial uses Secure Shell (SSH) port forwarding to connect your local machine to an AWS Glue development endpoint. For more information, see Port forwarding on Wikipedia.

**Step 1: Install JupyterLab and Sparkmagic**

You can install JupyterLab by using conda or pip. conda is an open-source package management system and environment management system that runs on Windows, macOS, and Linux. pip is the package installer for Python.

If you're installing on macOS, you must have Xcode installed before you can install Sparkmagic.

1. Install JupyterLab, Sparkmagic, and the related extensions.

```
$ conda install -c conda-forge jupyterlab
$ pip install sparkmagic
$ jupyter nbextension enable --py --sys-prefix widgetsnbextextension
$ jupyter labextension install @jupyter-widgets/jupyterlab-manager
```

2. Check the sparkmagic directory from Location.

```
$ pip show sparkmagic | grep Location
Location: /Users/username/.pyenv/versions/anaconda3-5.3.1/lib/python3.7/site-packages
```
3. Change your directory to the one returned for Location, and install the kernels for Scala and PySpark.

```bash
$ cd /Users/username/.pyenv/versions/anaconda3-5.3.1/lib/python3.7/site-packages
$ jupyter-kernelspec install sparkmagic/kernels/sparkkernel
$ jupyter-kernelspec install sparkmagic/kernels/pysparkkernel
```

4. Download a sample config file.

```bash
$ curl -o ~/.sparkmagic/config.json https://raw.githubusercontent.com/jupyter-incubator/sparkmagic/master/sparkmagic/example_config.json
```

In this configuration file, you can configure Spark-related parameters like driverMemory and executorCores.

**Step 2: Start JupyterLab**

When you start JupyterLab, your default web browser is automatically opened, and the URL http://localhost:8888/lab/workspaces/{workspace_name} is shown.

```
$ jupyter lab
```

**Step 3: Initiate SSH port forwarding to connect to your development endpoint**

Next, use SSH local port forwarding to forward a local port (here, 8998) to the remote destination that is defined by AWS Glue (169.254.76.1:8998).

1. Open a separate terminal window that gives you access to SSH. In Microsoft Windows, you can use the BASH shell provided by Git for Windows, or you can install Cygwin.

2. Run the following SSH command, modified as follows:

   - Replace `private-key-file-path` with a path to the .pem file that contains the private key corresponding to the public key that you used to create your development endpoint.
   - If you're forwarding a different port than 8998, replace 8998 with the port number that you're actually using locally. The address 169.254.76.1:8998 is the remote port and isn't changed by you.
   - Replace `dev-endpoint-public-dns` with the public DNS address of your development endpoint. To find this address, navigate to your development endpoint in the AWS Glue.
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console, choose the name, and copy the Public address that's listed on the Endpoint details
page.

ssh -i private-key-file-path -NTL 8998:169.254.76.1:8998 glue@dev-endpoint-publicdns

You will likely see a warning message like the following:
The authenticity of host 'ec2-xx-xxx-xxx-xx.us-west-2.compute.amazonaws.com
(xx.xxx.xxx.xx)'
can't be established. ECDSA key fingerprint is SHA256:4e97875Brt+1wKzRko
+JflSnp21X7aTP3BcFnHYLEts.
Are you sure you want to continue connecting (yes/no)?

Enter yes and leave the terminal window open while you use JupyterLab.
3.

Check that SSH port forwarding is working with the development endpoint correctly.
$ curl localhost:8998/sessions
{"from":0,"total":0,"sessions":[]}

Step 4: Run a simple script fragment in a notebook paragraph
Now your notebook in JupyterLab should work with your development endpoint. Enter the
following script fragment into your notebook and run it.
1.

Check that Spark is running successfully. The following command instructs Spark to calculate 1
and then print the value.
spark.sql("select 1").show()

2.

Check if AWS Glue Data Catalog integration is working. The following command lists the tables
in the Data Catalog.
spark.sql("show tables").show()

3.

Check that a simple script fragment that uses AWS Glue libraries works.

Developing scripts using development endpoints

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The following script uses the persons_json table metadata in the AWS Glue Data Catalog to create a DynamicFrame from your sample data. It then prints out the item count and the schema of this data.

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create a Glue context
glueContext = GlueContext(SparkContext.getOrCreate())

# Create a DynamicFrame using the 'persons_json' table
persons_DyF = glueContext.create_dynamic_frame.from_catalog(database="legislators", table_name="persons_json")

# Print out information about *this* data
print("Count:  ", persons_DyF.count())
persons_DyF.printSchema()
```

The output of the script is as follows.

```
Count:  1961
root
  |-- family_name: string
  |-- name: string
  |-- links: array
    |   |-- element: struct
    |     |-- note: string
    |     |-- url: string
  |-- gender: string
  |-- image: string
  |-- identifiers: array
    |     |-- element: struct
    |       |-- scheme: string
    |       |-- identifier: string
  |-- other_names: array
    |     |-- element: struct
    |       |-- note: string
    |       |-- name: string
    |       |-- lang: string
```
Troubleshooting

- During the installation of JupyterLab, if your computer is behind a corporate proxy or firewall, you might encounter HTTP and SSL errors due to custom security profiles managed by corporate IT departments.

The following is an example of a typical error that occurs when conda can't connect to its own repositories:

```
CondaHTTPError: HTTP 000 CONNECTION FAILED for url <https://repo.anaconda.com/pkgs/main/win-64/current_repodata.json>
```

This might happen because your company can block connections to widely used repositories in Python and JavaScript communities. For more information, see Installation Problems on the JupyterLab website.

- If you encounter a connection refused error when trying to connect to your development endpoint, you might be using a development endpoint that is out of date. Try creating a new development endpoint and reconnecting.

Tutorial: Use a SageMaker notebook with your development endpoint

In AWS Glue, you can create a development endpoint and then create a SageMaker notebook to help develop your ETL and machine learning scripts. A SageMaker notebook is a fully managed machine learning compute instance running the Jupyter Notebook application.
1. In the AWS Glue console, choose **Dev endpoints** to navigate to the development endpoints list.

2. Select the check box next to the name of a development endpoint that you want to use, and on the **Action** menu, choose **Create SageMaker notebook**.

3. Fill out the **Create and configure a notebook** page as follows:
   a. Enter a notebook name.
   b. Under **Attach to development endpoint**, verify the development endpoint.
   c. Create or choose an AWS Identity and Access Management (IAM) role.

      Creating a role is recommended. If you use an existing role, ensure that it has the required permissions. For more information, see [the section called “Step 6: Create an IAM policy for SageMaker notebooks”](#).

   d. (Optional) Choose a VPC, a subnet, and one or more security groups.
   e. (Optional) Choose an AWS Key Management Service encryption key.
   f. (Optional) Add tags for the notebook instance.

4. Choose **Create notebook**. On the **Notebooks** page, choose the refresh icon at the upper right, and continue until the **Status** shows **Ready**.

5. Select the check box next to the new notebook name, and then choose **Open notebook**.

6. Create a new notebook: On the **jupyter** page, choose **New**, and then choose **Sparkmagic (PySpark)**.

   Your screen should now look like the following:
7. (Optional) At the top of the page, choose **Untitled**, and give the notebook a name.

8. To start a Spark application, enter the following command into the notebook, and then in the toolbar, choose **Run**.

   ```python
   spark
   ```

   After a short delay, you should see the following response:

9. Create a dynamic frame and run a query against it: Copy, paste, and run the following code, which outputs the count and schema of the `persons_json` table.

   ```python
   import sys
   from pyspark.context import SparkContext
   from awsglue.context import GlueContext
   from awsglue.transforms import *
   glueContext = GlueContext(SparkContext.getOrCreate())
   persons_DyF = glueContext.create_dynamic_frame.from_catalog(database="legislators", table_name="persons_json")
   print ("Count: ", persons_DyF.count())
   persons_DyF.printSchema()
   ```

**Tutorial: Use a REPL shell with your development endpoint**

In AWS Glue, you can create a development endpoint and then invoke a REPL (Read–Evaluate–Print Loop) shell to run PySpark code incrementally so that you can interactively debug your ETL scripts before deploying them.

In order to use a REPL on a development endpoint, you need to have authorization to SSH to the endpoint.

1. On your local computer, open a terminal window that can run SSH commands, and paste in the edited SSH command. Run the command.
Assuming that you accepted AWS Glue version 1.0 with Python 3 for the development endpoint, the output will look like this:

```
Welcome to

   __              __
  / __/__  ___ _____/ /__
 / __/  _ \/ _ `/ __/  '_/
/_/ /_/\_\_,_/_/ /_/

Using Python version 3.6.8 (default, Aug 2 2019 17:42:44)
SparkSession available as 'spark'.
>>> 
```
2. Test that the REPL shell is working correctly by typing the statement, 
   `print(spark.version)`. As long as that displays the Spark version, your REPL is now ready 
   to use.

3. Now you can try executing the following simple script, line by line, in the shell:

   ```python
   import sys
   from pyspark.context import SparkContext
   from awsglue.context import GlueContext
   from awsglue.transforms import *
   glueContext = GlueContext(SparkContext.getOrCreate())
   persons_DyF = glueContext.create_dynamic_frame.from_catalog(database="legislators",
   table_name="persons_json")
   print ("Count: ", persons_DyF.count())
   persons_DyF.printSchema()
   ```

Tutorial: Set up PyCharm professional with a development endpoint

This tutorial shows you how to connect the PyCharm Professional Python IDE running on your 
local machine to a development endpoint so that you can interactively run, debug, and test AWS 
Glue ETL (extract, transfer, and load) scripts before deploying them. The instructions and screen 
captures in the tutorial are based on PyCharm Professional version 2019.3.

To connect to a development endpoint interactively, you must have PyCharm Professional 
installed. You can't do this using the free edition.

**Note**

The tutorial uses Amazon S3 as a data source. If you want to use a JDBC data source 
instead, you must run your development endpoint in a virtual private cloud (VPC). To 
connect with SSH to a development endpoint in a VPC, you must create an SSH tunnel. 
This tutorial does not include instructions for creating an SSH tunnel. For information on 
using SSH to connect to a development endpoint in a VPC, see Securely Connect to Linux 
Instances Running in a Private Amazon VPC in the AWS security blog.

Topics

- Connecting PyCharm professional to a development endpoint
- Deploying the script to your development endpoint
Configuring a remote interpreter
Running your script on the development endpoint

Connecting PyCharm professional to a development endpoint

1. Create a new pure-Python project in PyCharm named legislators.
2. Create a file named get_person_schema.py in the project with the following content:

   ```python
   from pyspark.context import SparkContext
   from awsglue.context import GlueContext

   def main():
       # Create a Glue context
       glueContext = GlueContext(SparkContext.getOrCreate())

       # Create a DynamicFrame using the 'persons_json' table
       persons_DyF =
       glueContext.create_dynamic_frame.from_catalog(database="legislators",
           table_name="persons_json")

       # Print out information about this data
       print("Count: ", persons_DyF.count())
       persons_DyF.printSchema()

   if __name__ == "__main__":
       main()
   ```

3. Do one of the following:

   - For AWS Glue version 0.9, download the AWS Glue Python library file, PyGlue.zip, from https://s3.amazonaws.com/aws-glue-jes-prod-us-east-1-assets/etl/python/PyGlue.zip to a convenient location on your local machine.
   - For AWS Glue version 1.0 and later, download the AWS Glue Python library file, PyGlue.zip, from https://s3.amazonaws.com/aws-glue-jes-prod-us-east-1-assets/etl-1.0/python/PyGlue.zip to a convenient location on your local machine.

4. Add PyGlue.zip as a content root for your project in PyCharm:
• In PyCharm, choose **File, Settings** to open the **Settings** dialog box. (You can also press Ctrl +Alt+S.)

• Expand the legislators project and choose **Project Structure**. Then in the right pane, choose **+ Add Content Root**.

• Navigate to the location where you saved PyGlue.zip, select it, then choose **Apply**.

The **Settings** screen should look something like the following:

![Settings dialog box]

Leave the **Settings** dialog box open after you choose **Apply**.

5. Configure deployment options to upload the local script to your development endpoint using SFTP (this capability is available only in PyCharm Professional):

• In the **Settings** dialog box, expand the **Build, Execution, Deployment** section. Choose the **Deployment** subsection.

• Choose the **+** icon at the top of the middle pane to add a new server. Set its **Type** to SFTP and give it a name.

• Set the **SFTP host** to the **Public address** of your development endpoint, as listed on its details page. (Choose the name of your development endpoint in the AWS Glue console to display the details page). For a development endpoint running in a VPC, set **SFTP host** to the host address and local port of your SSH tunnel to the development endpoint.
• Set the **User name** to glue.

• Set the **Auth type** to **Key pair (OpenSSH or Putty)**. Set the **Private key file** by browsing to the location where your development endpoint's private key file is located. Note that PyCharm only supports DSA, RSA and ECDSA OpenSSH key types, and does not accept keys in Putty's private format. You can use an up-to-date version of `ssh-keygen` to generate a key-pair type that PyCharm accepts, using syntax like the following:

```
ssh-keygen -t rsa -f <key_file_name> -C "<your_email_address>"
```

• Choose **Test connection**, and allow the connection to be tested. If the connection succeeds, choose **Apply**.

The **Settings** screen should now look something like the following:

![Settings Screen](image)

Again, leave the **Settings** dialog box open after you choose **Apply**.

6. Map the local directory to a remote directory for deployment:

   • In the right pane of the **Deployment** page, choose the middle tab at the top, labeled **Mappings**.

   • In the **Deployment Path** column, enter a path under `/home/glue/scripts/` for deployment of your project path. For example: `/home/glue/scripts/legislators`. 
- Choose **Apply**.

The **Settings** screen should now look something like the following:

![Settings screen](image)

Choose **OK** to close the **Settings** dialog box.

### Deploying the script to your development endpoint

1. Choose **Tools**, **Deployment**, and then choose the name under which you set up your development endpoint, as shown in the following image:

![Deployment screen](image)
After your script has been deployed, the bottom of the screen should look something like the following:

2. On the menu bar, choose **Tools, Deployment, Automatic Upload (always)**. Ensure that a check mark appears next to **Automatic Upload (always)**.

   When this option is enabled, PyCharm automatically uploads changed files to the development endpoint.

**Configuring a remote interpreter**

Configure PyCharm to use the Python interpreter on the development endpoint.

1. From the **File** menu, choose **Settings**.
2. Expand the project **legislators** and choose **Project Interpreter**.
3. Choose the gear icon next to the **Project Interpreter** list, and then choose **Add**.
4. In the **Add Python Interpreter** dialog box, in the left pane, choose **SSH Interpreter**.
5. Choose **Existing server configuration**, and in the **Deployment configuration** list, choose your configuration.

   Your screen should look something like the following image.
6. Choose **Move this server to IDE settings**, and then choose **Next**.

7. In the **Interpreter** field, change the path to `/usr/bin/gluepython` if you are using Python 2, or to `/usr/bin/gluepython3` if you are using Python 3. Then choose **Finish**.

**Running your script on the development endpoint**

To run the script:

- In the left pane, right-click the file name and choose **Run `<filename>`**.

After a series of messages, the final output should show the count and the schema.

```
Count: 1961
root
  |-- family_name: string
  |-- name: string
  |-- links: array
    |   |-- element: struct
    |     |-- note: string
    |     |-- url: string
  |-- gender: string
  |-- image: string
  |-- identifiers: array
    |   |-- element: struct
    |     |-- scheme: string
    |     |-- identifier: string
  |-- other_names: array
```
You are now set up to debug your script remotely on your development endpoint.

**Advanced configuration: sharing development endpoints among multiple users**

This section explains how you can take advantage of development endpoints with SageMaker notebooks in typical use cases to share development endpoints among multiple users.

**Single-tenancy configuration**

In single tenant use-cases, to simplify the developer experience and to avoid contention for resources it is recommended that you have each developer use their own development endpoint sized for the project they are working on. This also simplifies the decisions related to worker type and DPU count leaving them up to the discretion of the developer and project they are working on.

You won't need to take care of resource allocation unless you runs multiple notebook files concurrently. If you run code in multiple notebook files at the same time, multiple Livy sessions will be launched concurrently. To segregate Spark cluster configurations in order to run multiple Livy sessions at the same time, you can follow the steps which are introduced in multi tenant use-cases.
For example, if your development endpoint has 10 workers and the worker type is G.1X, then you will have 9 Spark executors and the entire cluster will have 90G of executor memory since each executor will have 10G of memory.

Regardless of the specified worker type, Spark dynamic resource allocation will be turned on. If a dataset is large enough, Spark may allocate all the executors to a single Livy session since `spark.dynamicAllocation.maxExecutors` is not set by default. This means that other Livy sessions on the same dev endpoint will wait to launch new executors. If the dataset is small, Spark will be able to allocate executors to multiple Livy sessions at the same time.

**Note**

For more information about how resources are allocated in different use cases and how you set a configuration to modify the behavior, see Advanced configuration: sharing development endpoints among multiple users.

### Multi-tenancy configuration

**Note**

Please note, development endpoints are intended to emulate the AWS Glue ETL environment as a single-tenant environment. While multi-tenant use is possible, it is an advanced use-case and it is recommended most users maintain a pattern of single-tenancy for each development endpoint.

In multi tenant use-cases, you might need to take care of resource allocation. The key factor is the number of concurrent users who use a Jupyter notebook at the same time. If your team works in a "follow-the-sun" workflow and there is only one Jupyter user at each time zone, then the number of concurrent users is only one, so you won’t need to be concerned with resource allocation. However, if your notebook is shared among multiple users and each user submits code in an ad-hoc basis, then you will need to consider the below points.

To partition Spark cluster resources among multiple users, you can use SparkMagic configurations. There are two different ways to configure SparkMagic.
(A) Use the `%%configure -f` directive

If you want to modify the configuration per Livy session from the notebook, you can run the `%%configure -f` directive on the notebook paragraph.

For example, if you want to run Spark application on 5 executors, you can run the following command on the notebook paragraph.

```
%%configure -f
{"numExecutors":5}
```

Then you will see only 5 executors running for the job on the Spark UI.

We recommend limiting the maximum number of executors for dynamic resource allocation.

```
%%configure -f
{"conf":{"spark.dynamicAllocation.maxExecutors":"5"}}
```

(B) Modify the SparkMagic config file

SparkMagic works based on the Livy API. SparkMagic creates Livy sessions with configurations such as `driverMemory`, `driverCores`, `executorMemory`, `executorCores`, `numExecutors`, `conf`, etc. Those are the key factors that determine how much resources are consumed from the entire Spark cluster. SparkMagic allows you to provide a config file to specify those parameters which are sent to Livy. You can see a sample config file in this Github repository.

If you want to modify configuration across all the Livy sessions from a notebook, you can modify `/home/ec2-user/.sparkmagic/config.json` to add `session_config`.

To modify the config file on a SageMaker notebook instance, you can follow these steps.

1. Open a SageMaker notebook.
2. Open the Terminal kernel.
3. Run the following commands:

   ```
   sh-4.2$ cd .sparkmagic
   sh-4.2$ ls
   config.json logs
   sh-4.2$ sudo vim config.json
   ```
For example, you can add these lines to `/home/ec2-user/.sparkmagic/config.json` and restart the Jupyter kernel from the notebook.

```json
"session_configs": {
  "conf": {
    "spark.dynamicAllocation.maxExecutors":"5"
  }
},
```

Guidelines and best practices

To avoid this kind of resource conflict, you can use some basic approaches like:

- Have a larger Spark cluster by increasing the `NumberOfWorkers` (scaling horizontally) and upgrading the `workerType` (scaling vertically)
- Allocate fewer resources per user (fewer resources per Livy session)

Your approach will depend on your use case. If you have a larger development endpoint, and there is not a huge amount of data, the possibility of a resource conflict will decrease significantly because Spark can allocate resources based on a dynamic allocation strategy.

As described above, the number of Spark executors can be automatically calculated based on a combination of DPU (or `NumberOfWorkers`) and worker type. Each Spark application launches one driver and multiple executors. To calculate you will need the `NumberOfWorkers = NumberOfExecutors + 1`. The matrix below explains how much capacity you need in your development endpoint based on the number of concurrent users.

<table>
<thead>
<tr>
<th>Number of concurrent notebook users</th>
<th>Number of Spark executors you want to allocate per user</th>
<th>Total <code>NumberOfWorkers</code> for your dev endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>300</td>
</tr>
</tbody>
</table>
If you want to allocate fewer resources per user, the `spark.dynamicAllocation.maxExecutors` (or `numExecutors`) would be the easiest parameter to configure as a Livy session parameter. If you set the below configuration in `/home/ec2-user/.sparkmagic/config.json`, then SparkMagic will assign a maximum of 5 executors per Livy session. This will help segregating resources per Livy session.

```
"session_configs": {
    "conf": {
        "spark.dynamicAllocation.maxExecutors":"5"
    }
},
```

Suppose there is a dev endpoint with 18 workers (G.1X) and there are 3 concurrent notebook users at the same time. If your session config has `spark.dynamicAllocation.maxExecutors=5` then each user can make use of 1 driver and 5 executors. There won't be any resource conflicts even when you run multiple notebook paragraphs at the same time.

**Trade-offs**

With this session config "`spark.dynamicAllocation.maxExecutors":"5"`, you will be able to avoid resource conflict errors and you do not need to wait for resource allocation when there are concurrent user accesses. However, even when there are many free resources (for example, there are no other concurrent users), Spark cannot assign more than 5 executors for your Livy session.

**Other notes**

It is a good practice to stop the Jupyter kernel when you stop using a notebook. This will free resources and other notebook users can use those resources immediately without waiting for kernel expiration (auto-shutdown).

**Common issues**

Even when following the guidelines, you may experience certain issues.

**Session not found**

When you try to run a notebook paragraph even though your Livy session has been already terminated, you will see the below message. To activate the Livy session, you need to restart the Jupyter kernel by choosing **Kernel > Restart** in the Jupyter menu, then run the notebook paragraph again.
An error was encountered:
Invalid status code '404' from http://localhost:8998/sessions/13 with error payload:
"Session '13' not found."

**Not enough YARN resources**

When you try to run a notebook paragraph even though your Spark cluster does not have enough resources to start a new Livy session, you will see the below message. You can often avoid this issue by following the guidelines, however, there might be a possibility that you face this issue. To workaround the issue, you can check if there are any unneeded, active Livy sessions. If there are unneeded Livy sessions, you will need to terminate them to free the cluster resources. See the next section for details.

Warning: The Spark session does not have enough YARN resources to start. The code failed because of a fatal error:
  Session 16 did not start up in 60 seconds..

Some things to try:
  a) Make sure Spark has enough available resources for Jupyter to create a Spark context.
  b) Contact your Jupyter administrator to make sure the Spark magics library is configured correctly.
  c) Restart the kernel.

**Monitoring and debugging**

This section describes techniques for monitoring resources and sessions.

**Monitoring and debugging cluster resource allocation**

You can watch the Spark UI to monitor how many resources are allocated per Livy session, and what are the effective Spark configurations on the job. To activate the Spark UI, see Enabling the Apache Spark Web UI for Development Endpoints.

(Optional) If you need a real-time view of the Spark UI, you can configure an SSH tunnel against the Spark history server running on the Spark cluster.

```
ssh -i <private-key.pem> -N -L 8157:<development endpoint public address>:18080
     glue@<development endpoint public address>
```
You can then open http://localhost:8157 on your browser to view the Spark UI.

**Free unneeded Livy sessions**

Review these procedures to shut down any unneeded Livy sessions from a notebook or a Spark cluster.

(a). Terminate Livy sessions from a notebook

You can shut down the kernel on a Jupyter notebook to terminate unneeded Livy sessions.

(b). Terminate Livy sessions from a Spark cluster

If there are unneeded Livy sessions which are still running, you can shut down the Livy sessions on the Spark cluster.

As a pre-requisite to perform this procedure, you need to configure your SSH public key for your development endpoint.

To log in to the Spark cluster, you can run the following command:

```
$ ssh -i <private-key.pem> glue@<development endpoint public address>
```

You can run the following command to see the active Livy sessions:

```
$ yarn application -list
```

You can then shut down the Livy session with the following command:

```
$ yarn application -kill application_1601003432160_0005
```

Developing scripts using development endpoints
Managing notebooks

Des Note

Development Endpoints are only supported for versions of AWS Glue prior to 2.0. For an interactive environment where you can author and test ETL scripts, use Notebooks on AWS Glue Studio.

A notebook enables interactive development and testing of your ETL (extract, transform, and load) scripts on a development endpoint. AWS Glue provides an interface to SageMaker Jupyter notebooks. With AWS Glue, you create and manage SageMaker notebooks. You can also open SageMaker notebooks from the AWS Glue console.

In addition, you can use Apache Spark with SageMaker on AWS Glue development endpoints which support SageMaker (but not AWS Glue ETL jobs). SageMaker Spark is an open source Apache Spark library for SageMaker. For more information, see Using Apache Spark with Amazon SageMaker.

Important

Managing SageMaker notebooks with AWS Glue development endpoints is available in the following AWS Regions:

<table>
<thead>
<tr>
<th>Region</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>US East (Ohio)</td>
<td>us-east-2</td>
</tr>
<tr>
<td>US East (N. Virginia)</td>
<td>us-east-1</td>
</tr>
<tr>
<td>US West (N. California)</td>
<td>us-west-1</td>
</tr>
<tr>
<td>US West (Oregon)</td>
<td>us-west-2</td>
</tr>
<tr>
<td>Asia Pacific (Tokyo)</td>
<td>ap-northeast-1</td>
</tr>
<tr>
<td>Region</td>
<td>Code</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Asia Pacific (Seoul)</td>
<td>ap-northeast-2</td>
</tr>
<tr>
<td>Asia Pacific (Mumbai)</td>
<td>ap-south-1</td>
</tr>
<tr>
<td>Asia Pacific (Singapore)</td>
<td>ap-southeast-1</td>
</tr>
<tr>
<td>Asia Pacific (Sydney)</td>
<td>ap-southeast-2</td>
</tr>
<tr>
<td>Canada (Central)</td>
<td>ca-central-1</td>
</tr>
<tr>
<td>Europe (Frankfurt)</td>
<td>eu-central-1</td>
</tr>
<tr>
<td>Europe (Ireland)</td>
<td>eu-west-1</td>
</tr>
<tr>
<td>Europe (London)</td>
<td>eu-west-2</td>
</tr>
</tbody>
</table>
Building visual ETL jobs with AWS Glue Studio

An AWS Glue job encapsulates a script that connects to your source data, processes it, and then writes it out to your data target. Typically, a job runs extract, transform, and load (ETL) scripts. Jobs can run scripts designed for Apache Spark and Ray runtime environments. Jobs can also run general-purpose Python scripts (Python shell jobs.) AWS Glue triggers can start jobs based on a schedule or event, or on demand. You can monitor job runs to understand runtime metrics such as completion status, duration, and start time.

You can use scripts that AWS Glue generates or you can provide your own. With a source schema and target location or schema, the AWS Glue Studio code generator can automatically create an Apache Spark API (PySpark) script. You can use this script as a starting point and edit it to meet your goals.

AWS Glue can write output files in several data formats. Each job type may support different output formats. For some data formats, common compression formats can be written.

Signing in to the AWS Glue console

A job in AWS Glue consists of the business logic that performs extract, transform, and load (ETL) work. You can create jobs in the ETL section of the AWS Glue console.

To view existing jobs, sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/. Then choose the Jobs tab in AWS Glue. The Jobs list displays the location of the script that is associated with each job, when the job was last modified, and the current job bookmark option.

While creating a new job, or after you have saved your job, you can use can AWS Glue Studio to modify your ETL jobs. You can do this by editing the nodes in the visual editor or by editing the job script in developer mode. You can also add and remove nodes in the visual editor to create more complicated ETL jobs.

Next steps for creating a job in AWS Glue Studio

You use the visual job editor to configure nodes for your job. Each node represents an action, such as reading data from the source location or applying a transform to the data. Each node you add to your job has properties that provide information about either the data location or the transform.
The next steps for creating and managing your jobs are:

- Visual ETL with AWS Glue Studio
- View the job script
- Modify the job properties
- Save the job
- Start a job run
- View information for recent job runs
- Accessing the job monitoring dashboard

**Visual ETL with AWS Glue Studio**

You can use the simple visual interface in AWS Glue Studio to create your ETL jobs. You use the Jobs page to create new jobs. You can also use a script editor or notebook to work directly with code in the AWS Glue Studio ETL job script.

On the Jobs page, you can see all the jobs that you have created either with AWS Glue Studio or AWS Glue. You can view, manage, and run your jobs on this page.

Also see the blog tutorial on another example of how to create ETL jobs with AWS Glue Studio.

**Starting jobs in AWS Glue Studio**

AWS Glue allows you to create a job through a visual interface, an interactive code notebook, or with a script editor. You can start a job by clicking on any of the options or create a new job based on a sample job.

Sample jobs create a job with the tool of your choice. For example, sample jobs allow you to create a visual ETL job that joins CSV files into a catalog table, create a job in an interactive code notebook with AWS Glue for Ray or AWS Glue for Spark when working with pandas, or create a job in an interactive code notebook with SparkSQL.

**To create a job in AWS Glue Studio from scratch**

1. Sign in to the AWS Management Console and open the AWS Glue Studio console at https://console.aws.amazon.com/gluestudio/.
2. Choose ETL jobs from the navigation pane.
3. In the **Create job** section, select a configuration option for your job.

![Create job options](image)

Options to create a job from scratch:

- **Visual ETL** – author in a visual interface focused on data flow
- **Author using an Interactive code notebook** – interactively author jobs in a notebook interface based on Jupyter Notebooks

When you select this option, you must provide additional information before creating a notebook authoring session. For more information about how to specify this information, see [Getting started with notebooks in AWS Glue Studio](#).

- **Author code with a script editor** – For those familiar with programming and writing ETL scripts, choose this option to create a new Spark ETL job. Choose the engine (Python shell, Ray, Spark (Python), or Spark (Scala)). Then, choose **Start fresh** or **Upload script**. Uploading an existing script from a local file. If you choose to use the script editor, you can't use the visual job editor to design or edit your job.

A Spark job is run in an Apache Spark environment managed by AWS Glue. By default, new scripts are coded in Python. To write a new Scala script, see [Creating and editing Scala scripts in AWS Glue Studio](#).

**To create a job in AWS Glue Studio from an example job**

You can choose to create a job from an example job. In the **Example jobs** section, choose a sample job, then choose **Create sample job**. Creating a sample job from one of the options provides a quick template you can work from.
1. Sign in to the AWS Management Console and open the AWS Glue Studio console at https://console.aws.amazon.com/gluestudio/.  
2. Choose **ETL jobs** from the navigation pane.  
3. Select an option **create a job from a sample job**:
   
   - **Visual ETL job to join multiple sources** – Read three CSV files, combine the data, change the data types, then write the data to Amazon S3 and catalog it for querying later.  
   - **Ray notebook for parallelizing Python** – Use the Ray framework for parallel processing in Python. Read parquet files from Amazon S3, explore and filter the data, then save it to a CSV file.  
   - **Spark notebook using Pandas** – Explore and visualize data using the popular Pandas framework combined with Spark.  
   - **Spark notebook using SQL** – Use SQL to get started quickly with Apache Spark. Access data through the AWS Glue Data Catalog and transform it using familiar commands.  
4. Choose **Create sample job**.  

**Job editor features**

The job editor provides the following features for creating and editing jobs.

- A visual diagram of your job, with a node for each job task: Data source nodes for reading the data; transform nodes for modifying the data; data target nodes for writing the data.

    You can view and configure the properties of each node in the job diagram. You can also view the schema and sample data for each node in the job diagram. These features help you to verify that your job is modifying and transforming the data in the right way, without having to run the job.  
- A Script viewing and editing tab, where you can modify the code generated for your job.  
- A Job details tab, where you can configure a variety of settings to customize the environment in which your AWS Glue ETL job runs.  
- A Runs tab, where you can view the current and previous runs of the job, view the status of the job run, and access the logs for the job run.  
- A Data quality tab, where you can apply data quality rules to your job.  
- A Schedules tab, where you can configure the start time for your job, or set up a recurring job runs.  
- A Version Control tab, where you can configure a Git service to use with your job.
Using schema previews in the visual job editor

While creating or editing your job, you can use the Output schema tab to view the schema for your data.

Before you can see the schema, the job editor needs permissions to access the data source. You can specify an IAM role on the Job details tab of the editor or on the Output schema tab for a node. If the IAM role has all the necessary permissions to access the data source, you can then view the schema on the Output schema tab for a node.

Using data previews in the visual job editor

Data previews help you create and test your job using a sample of your data without having to repeatedly run the job. By using data preview, you can:

- Test an IAM role to make sure you have access to your data sources or data targets.
- Check that the transform is modifying the data in the intended way. For example, if you use a Filter transform, you can make sure that the filter is selecting the right subset of data.
- Check your data. If your dataset contains columns with values of multiple types, the data preview shows a list of tuples for these columns. Each tuple contains the data type and its value.

While creating or editing your job, you can use the Data preview tab beneath the job canvas to view a sample of your data. A new data preview session will start automatically when the role is already configured on the job or a default IAM role has been set up in the account. If a role has not been previously configured, you can start a session by selecting the role.
Note

The role you choose for the data preview session will also be used for the job.

You can see the status and the progress of your session as well as the session details by clicking the info icon.

When the session is ready, AWS Glue Studio will load the data for the node you selected. You can view the % complete as it progresses.

As you author your visual job, AWS Glue Studio will automatically update the schema for the selected node when you toggle Infer schema from session in the Output schema tab.
To configure your data preview preferences:

Choose the settings icon (a gear symbol) to configure your preferences for data previews. These settings apply to all nodes in the job diagram. You can:

- Choose to wrap the text from one line to the next. This option is enabled by default
- Change the number of rows (default to 200)
- Choose an IAM role or create an IAM role if needed
- Choose to automatically start a new session when you author a job. This provisions a new interactive session when authoring jobs. **This setting applies at the account level.** Once set, it will apply to all users in your account when editing any job.
- Choose to automatically infer schema. Output schemas will be automatically inferred for the selected node
- Choose to automatically import AWS Glue libraries. This is useful as it will prevent data preview from restarting new sessions when adding new transforms that require a session restart
Additional features include the ability to:

- Choose the **Previewing x of y fields** button to select which columns (fields) to preview. When you preview your data using the default settings, the job editor shows the first 5 columns of your dataset. You can change this to show all or none (not recommended).
• Scroll through the data preview window both horizontally and vertically.

• Use the maximize button to expand the Data preview tab to over-lay the job graph to better view the data and data structures. Similarly, use the minimize button to minimize the Data preview tab. You can also grab the handle pane and drag up to expand the **Data preview** tab.

• Use **End session** to stop the data preview. When you stop the session, you can choose a new IAM role, and set additional settings (such as turn on or off settings to automatically start a new session, infer schema, or import AWS Glue libraries, and start the session again.

### Restrictions when using data previews

When using data previews, you might encounter the following restrictions or limitations.

• The first time you choose the Data preview tab you must choose IAM role. This role must have the necessary permissions to access the data and other resources needed to create the data previews.
• After you provide an IAM role, it takes a while before the data is available for viewing. For datasets with less than 1 GB of data, it can take up to one minute. If you have a large dataset, you should use partitions to improve the loading time. Loading data directly from Amazon S3 has the best performance.

• If you have a very large dataset, and it takes more than 15 minutes to query the data for the data preview, the request will time out. Data previews have a 30 minute IDLE timeout. To alleviate this, reduce the dataset size to use data previews.

• By default, you see the first 50 columns in the Data preview tab. If the columns have no data values, you will get a message that there is no data to display. You can increase the number of rows sampled, or selected different columns to see data values.

• Data previews are currently not supported for streaming data sources, or for data sources that use custom connectors.

• Errors on one node effect the entire job. If any one node has an error with data previews, the error will show up on all nodes until you correct it.

• If you change a data source for the job, then the child nodes of that data source might need to be updated to match the new schema. For example, if you have an ApplyMapping node that modifies a column, and the column does not exist in the replacement data source, you will need to update the ApplyMapping transform node.

• If you view the Data preview tab for a SQL query transform node, and the SQL query uses an incorrect field name, the Data preview tab shows an error.

### Script code generation

When you use the visual editor to create a job, the ETL code is automatically generated for you. AWS Glue Studio creates a functional and complete job script, and saves it in an Amazon S3 location.

There are two forms of code generated by AWS Glue Studio: the original, or Classic version, and a newer, streamlined version. By default, the new code generator is used to create the job script. You can generate a job script using classic code generator on the Script tab by choosing the **Generate classic script** toggle button.

Some of the differences in the new version of the generated code include:

• Large comment blocks are no longer added to the script
• Output structures in the code use the node name that you specify in the visual editor. In the class script, the output structures are simply named DataSource0, DataSource1, Transform0, Transform1, DataSink0, DataSink1, and so on.

• Long commands are split across multiple lines to remove the need to scroll across the page to see the entire command.

New features in AWS Glue Studio require the new version of code generation, and will not work with the classic code script. You are prompted to update these jobs when you attempt to run them.

**Editing AWS Glue managed data transform nodes**

AWS Glue Studio provides two types of transforms:

- **AWS Glue-native transforms** - available to all users and are managed by AWS Glue.
- **Custom visual transforms** - allows you to upload your own transforms to use in AWS Glue Studio

**AWS Glue managed data transform nodes**

AWS Glue Studio provides a set of built-in transforms that you can use to process your data. Your data passes from one node in the job diagram to another in a data structure called a DynamicFrame, which is an extension to an Apache Spark SQL DataFrame.

In the pre-populated diagram for a job, between the data source and data target nodes is the **Change Schema** transform node. You can configure this transform node to modify your data, or you can use additional transforms.

The following built-in transforms are available with AWS Glue Studio:

- **ChangeSchema**: Map data property keys in the data source to data property keys in the data target. You can rename keys, modify the data types for keys, and choose which keys to drop from the dataset.
- **SelectFields**: Choose the data property keys that you want to keep.
- **DropFields**: Choose the data property keys that you want to drop.
- **RenameField**: Rename a single data property key.
- **Spigot**: Write samples of the data to an Amazon S3 bucket.
• **Join**: Join two datasets into one dataset using a comparison phrase on the specified data property keys. You can use inner, outer, left, right, left semi, and left anti joins.

• **Union**: Combine rows from more than one data source that have the same schema.

• **SplitFields**: Split data property keys into two DynamicFrames. Output is a collection of DynamicFrames: one with selected data property keys, and one with the remaining data property keys.

• **SelectFromCollection**: Choose one DynamicFrame from a collection of DynamicFrames. The output is the selected DynamicFrame.

• **FillMissingValues**: Locate records in the dataset that have missing values and add a new field with a suggested value that is determined by imputation.

• **Filter**: Split a dataset into two, based on a filter condition.

• **Drop Null Fields**: Removes columns from the dataset if all values in the column are ‘null’.

• **Drop Duplicates**: Removes rows from your data source by choosing to match entire rows or specify keys.

• **SQL**: Enter SparkSQL code into a text entry field to use a SQL query to transform the data. The output is a single DynamicFrame.

• **Aggregate**: Performs a calculation (such as average, sum, min, max) on selected fields and rows, and creates a new field with the newly calculated value(s).

• **Flatten**: Extract fields inside structs into top level fields.

• **UUID**: Add a column with a Universally Unique Identifier for each row.

• **Identifier**: Add a column with a numeric identifier for each row.

• **To timestamp**: Convert a column to timestamp type.

• **Format timestamp**: Convert a timestamp column to a formatted string.

• **Conditional Router transform**: Apply multiple conditions to incoming data. Each row of the incoming data is evaluated by a group filter condition and processed into its corresponding group.

• **Concatenate Columns transform**: Build a new string column using the values of other columns with an optional spacer.

• **Split String transform**: Break up a string into an array of tokens using a regular expression to define how the split is done.

• **Array To Columns transform**: Extract some or all the elements of a column of type array into new columns.
• **Add Current Timestamp transform**: Mark the rows with the time on which the data was processed. This is useful for auditing purposes or to track latency in the data pipeline.

• **Pivot Rows to Columns transform**: Aggregate a numeric column by rotating unique values on selected columns which become new columns. If multiple columns are selected, the values are concatenated to name the new columns.

• **Unpivot Columns To Rows transform**: Convert columns into values of new columns generating a row for each unique value.

• **Autobalance Processing transform**: Redistribute the data better among the workers. This is useful where the data is unbalanced or as it comes from the source doesn’t allow enough parallel processing on it.

• **Derived Column transform**: Define a new column based on a math formula or SQL expression in which you can use other columns in the data, as well as constants and literals.

• **Lookup transform**: Add columns from a defined catalog table when the keys match the defined lookup columns in the data.

• **Explode Array or Map Into Rows transform**: Extract values from a nested structure into individual rows that are easier to manipulate.

• **Record matching transform**: Invoke an existing Record Matching machine learning data classification transform.

• **Remove null rows transform**: Remove from the dataset rows that have all columns as null, or empty.

• **Parse JSON column transform**: Parse a string column containing JSON data and convert it to a struct or an array column, depending if the JSON is an object or an array, respectively.

• **Extract JSON path transform**: Extract new columns from a JSON string column.

• **Extract string fragments from a regular expression**: Extract string fragments using a regular expression and create new column out of it, or multiple columns if using regex groups.

• **Custom transform**: Enter code into a text entry field to use custom transforms. The output is a collection of DynamicFrames.

**Using a data preparation recipe in AWS Glue Studio**

AWS Glue Studio allows you to use a AWS Glue DataBrew recipe in a visual workflow. This allows a customer's AWS Glue DataBrew recipes to be run in a AWS Glue job along with other AWS Glue Studio nodes.
In DataBrew, a recipe is a set of data transformation steps. DataBrew recipes prescribes how to transform data that have already been read and doesn't describe where and how to read data, as well as how and where to write data. This is configured in Source and Target nodes in AWS Glue Studio. For more information on recipes, see [Creating and using AWS Glue DataBrew recipes](#).

The **Data Preparation Recipe** node is available from the Resource panel. You can connect the **Data Preparation Recipe** node to another node in the visual workflow, whether it is a Data source node or another transformation node. After choosing a AWS Glue DataBrew recipe and version, the applied steps in the recipe are visible in the node properties tab.

### Prerequisites

- You have a AWS Glue DataBrew recipe created in AWS Glue DataBrew.
- You have the required IAM permissions as described in the section below.

### IAM permissions for AWS Glue DataBrew

This topic provides information to help you understand the actions and resources that you an IAM administrator can use in an AWS Identity and Access Management (IAM) policy for the Data Preparation Recipe transform.

For additional information about security in AWS Glue, see [Access Management](#).

The following table lists the permissions that a user needs in order to perform specific operations to use the Data Preparation Recipe transform.

#### Data Preparation Recipe transform actions

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>databrew:ListRecipes</td>
<td>Grants permission to retrieve AWS Glue DataBrew recipes.</td>
</tr>
<tr>
<td>databrew:ListRecipeVersions</td>
<td>Grants permission to retrieve AWS Glue DataBrew recipe versions.</td>
</tr>
<tr>
<td>databrew:DescribeRecipe</td>
<td>Grants permission to retrieve AWS Glue DataBrew recipe description.</td>
</tr>
</tbody>
</table>
The role you're using for accessing this functionality should have a policy that allows several AWS Glue DataBrew. You can achieve this by either using AWSGlueConsoleFullAccess policy that includes necessary actions or add the following inline policy to your role:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "databrew:ListRecipes",
            "databrew:ListRecipeVersions",
            "databrew:DescribeRecipe"
         ],
         "Resource": [
            "*"
         ]
      }
   ]
}
```

To use the Data Preparation Recipe transform, you must add the IAM:PassRole action to the permissions policy.

### Additional required permissions

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>iam:PassRole</td>
<td>Grants permission for IAM to allow the user to pass the approved roles.</td>
</tr>
</tbody>
</table>

Without these permissions the following error occurs:

```json
"errorCode": "AccessDenied"
"errorMessage": "User: arn:aws:sts::account_id:assumed-role/AWSGlueServiceRole is not authorized to perform: iam:PassRole on resource: arn:aws:iam::account_id:role/service-role/AWSGlueServiceRole because no identity-based policy allows the iam:PassRole action"
```
Limitations

- Not all AWS Glue DataBrew recipes are supported by AWS Glue. Some recipes will not be able to be run in AWS Glue Studio.
  - Recipes with UNION and JOIN transforms are not supported, however, AWS Glue Studio already has "Join" and "Union" transform nodes which can be used before or after a Data Preparation Recipe node instead.
- **Data Preparation Recipe** nodes are supported for jobs starting with AWS Glue version 4.0. This version will be auto-selected after a **Data Preparation Recipe** node is added to the job.
- **Data Preparation Recipe** nodes require Python. This is automatically set when the **Data Preparation Recipe** node is added to the job.
- When using **Data Preview**, you will need to restart your data preview session after adding a **Data Preparation Recipe** node to your job.

How to use AWS Glue DataBrew recipes in AWS Glue Studio

To use AWS Glue DataBrew recipes in AWS Glue Studio, begin with creating recipes in AWS Glue DataBrew. If you have recipes you want to use, you can skip this step.

To create a **AWS Glue DataBrew recipe** in **AWS Glue DataBrew**:

1. Author a recipe in AWS Glue DataBrew. For more information, see [Getting started with AWS Glue DataBrew](#).
2. Save your recipe.
3. Publish your recipe. This will publish your recipe as version 1.0.

To use a **Data Preparation Recipe node** in **AWS Glue Studio**:

You can use more than one **Data Preparation Recipe** node in a visual ETL job. To do this, add a **Data Preparation Recipe** node by following the steps below and add another Data Preparation Recipe node to the job. For example, a workflow might follow this pattern:

- Data source 1 > recipe 1 > output 1
- Data source 2 > recipe 2 > output 2
- output 1, output 2 > JOIN
1. Start a AWS Glue job in AWS Glue Studio with a datasource.

2. Add the Data Preparation Recipe node to your datasource.

3. Filter for recipe by name by typing in the recipe name in the search field.

4. Choose the published version. Only published versions are available.

5. Finish authoring the job by adding other transformations nodes as needed and add Data target node(s) to save the job output.

6. Make necessary configuration changes in the Job details tab, like naming your job and adjusting allocated capacity as needed, and save the job.

7. Run the job by choosing Run from the Actions drop-down menu.

**To change schema if the data source is Amazon S3 and the data format is CSV:**

If all the columns in a CSV file are initially loaded as string data type in AWS Glue Studio, you need to ensure that the column data type is compatible with the rest of the steps in the AWS Glue DataBrew recipe.

AWS Glue DataBrew recipes only prescribes how to transform data that have already been read. It doesn't describe where and how to read data.

1. Add a Change Schema node before the Multi-step recipe node.

2. Click the Change Schema node and change the schema to be the same as the column data types in AWS Glue DataBrew by selecting the new data type in the Transform for columns as needed.
To change schema if the data source is headerless:

AWS Glue DataBrew recipes only prescribes how to transform data that have already been read. It doesn't describe where and how to read data.

When loading header-less datasets in AWS Glue Studio, the default header names are different than what are loaded in AWS Glue DataBrew.
1. In the ETL job, add a **Change Schema** node before the **Data Preparation Recipe** node.

2. Choose the **Change Schema** node and change the column names to the same names used in the AWS Glue DataBrew recipe.

### Using Change Schema to remap data property keys

A *Change Schema* transform remaps the source data property keys into the desired configured for the target data. In a Change Schema transform node, you can:

- Change the name of multiple data property keys.
- Change the data type of the data property keys, if the new data type is supported and there is a transformation path between the two data types.
- Choose a subset of data property keys by indicating which data property keys you want to drop.

You can add additional *Change Schema* nodes to the job diagram as needed – for example, to modify additional data sources or following a *Join* transform.

**Note**

The *Change Schema* transform is not case-sensitive.

### To add a Change Schema transform node to your job diagram

1. (Optional) Open the Resource panel and then choose **Change Schema** to add a new transform to your job diagram, if needed.

2. In the node properties panel, enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.

3. Choose the **Transform** tab in the node properties panel.

4. Modify the input schema:

   - To rename a data property key, enter the new name of the key in the **Target key** field.
   - To change the data type for a data property key, choose the new data type for the key from the **Data type** list.
To remove a data property key from the target schema, choose the **Drop** check box for that key.

5. *(Optional)* After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

6. *(Optional)* After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

**Using Drop Duplicates**

The Drop Duplicates transform removes rows from your data source by giving you two options. You can choose to remove the duplicate row that are completely the same, or you can choose to choose the fields to match and remove only those rows based on your chosen fields.

For example, in this data set, you have duplicate rows where all the values in some of the rows are exactly the same as another row, and some of the values in rows are the same or different.

<table>
<thead>
<tr>
<th>Row</th>
<th>Name</th>
<th>Email</th>
<th>Age</th>
<th>State</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Joy</td>
<td>joy@gmail</td>
<td>33</td>
<td>NY</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>45</td>
<td>OH</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>42</td>
<td>OH</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>42</td>
<td>OH</td>
<td>this is a duplicate row and matches completely</td>
</tr>
<tr>
<td>Row</td>
<td>Name</td>
<td>Email</td>
<td>Age</td>
<td>State</td>
<td>Note</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>--------</td>
<td>-----</td>
<td>-------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
<td>This is a duplicate row and matches completely on all values as row #5</td>
</tr>
</tbody>
</table>

If you choose to match entire rows, rows 6 and 7 will be removed from the data set. The data set is now:

<table>
<thead>
<tr>
<th>Row</th>
<th>Name</th>
<th>Email</th>
<th>Age</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Joy</td>
<td>joy@gmail</td>
<td>33</td>
<td>NY</td>
</tr>
<tr>
<td>2</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>45</td>
<td>OH</td>
</tr>
<tr>
<td>3</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
</tr>
<tr>
<td>4</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>42</td>
<td>OH</td>
</tr>
<tr>
<td>5</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
</tr>
</tbody>
</table>

If you chose to specify keys, you can choose to remove rows that match on ‘name’ and ‘email’. This gives you finer control of what is a ‘duplicate row’ for your data set. By specifying ‘name’ and ‘email’, the data set is now:

<table>
<thead>
<tr>
<th>Row</th>
<th>Name</th>
<th>Email</th>
<th>Age</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Joy</td>
<td>joy@gmail</td>
<td>33</td>
<td>NY</td>
</tr>
<tr>
<td>2</td>
<td>Tim</td>
<td>tim@gmail</td>
<td>45</td>
<td>OH</td>
</tr>
<tr>
<td>3</td>
<td>Rose</td>
<td>rose@gmail</td>
<td>23</td>
<td>NJ</td>
</tr>
</tbody>
</table>
Some things to keep in mind:

- In order for rows to be recognized as a duplicate, values are case sensitive. All values in rows need to have the same casing - this applies to either option you choose (Match entire rows or Specify keys).
- All values are read in as strings.
- The **Drop Duplicates** transform utilizes the Spark dropDuplicates command.
- When using the **Drop Duplicates** transform, the first row is kept and other rows are dropped.
- The **Drop Duplicates** transform does not change the schema of the dataframe. If you choose to specify keys, all fields are kept in the resulting dataframe.

### Using SelectFields to remove most data property keys

You can create a subset of data property keys from the dataset using the **SelectFields** transform. You indicate which data property keys you want to keep and the rest are removed from the dataset.

⚠️ **Note**

The **SelectFields** transform is case sensitive. Use **ApplyMapping** if you need a case-insensitive way to select fields.

### To add a SelectFields transform node to your job diagram

1. (Optional) Open the Resource panel, and then choose **SelectFields** to add a new transform to your job diagram, if needed.
2. On the **Node properties** tab, enter a name for the node in the job diagram. If a node parent is not already selected, choose a node from the **Node parents** list to use as the input source for the transform.
3. Choose the **Transform** tab in the node details panel.
4. Under the heading **SelectFields**, choose the data property keys in the dataset that you want to keep. Any data property keys not selected are dropped from the dataset.
You can also choose the check box next to the column heading **Field** to automatically choose all the data property keys in the dataset. Then you can deselect individual data property keys to remove them from the dataset.

5. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

### Using DropFields to keep most data property keys

You can create a subset of data property keys from the dataset using the **DropFields** transform. You indicate which data property keys you want to remove from the dataset and the rest of the keys are retained.

#### Note

The **DropFields** transform is case sensitive. Use **Change Schema** if you need a case-insensitive way to select fields.

#### To add a DropFields transform node to your job diagram

1. (Optional) Open the Resource panel and then choose **DropFields** to add a new transform to your job diagram, if needed.

2. On the **Node properties** tab, enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. Choose the **Transform** tab in the node details panel.

4. Under the heading **DropFields**, choose the data property keys to drop from the data source.
You can also choose the check box next to the column heading Field to automatically choose all the data property keys in the dataset. Then you can deselect individual data property keys so they are retained in the dataset.

5. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the Output schema tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the Job details tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the Data preview tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

### Renaming a field in the dataset

You can use the RenameField transform to change the name for an individual property key in the dataset.

**Note**

The RenameField transform is case sensitive. Use ApplyMapping if you need a case-insensitive transform.

**Tip**

If you use the Change Schema transform, you can rename multiple data property keys in the dataset with a single transform.

### To add a RenameField transform node to your job diagram

1. (Optional) Open the Resource panel and then choose RenameField to add a new transform to your job diagram, if needed.
2. On the **Node properties** tab, enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. Choose the **Transform** tab.

4. Under the heading **Data field**, choose a property key from the source data and then enter a new name in the **New field name** field.

5. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

**Using Spigot to sample your dataset**

To test the transformations performed by your job, you might want to get a sample of the data to check that the transformation works as intended. The Spigot transform writes a subset of records from the dataset to a JSON file in an Amazon S3 bucket. The data sampling method can be either a specific number of records from the beginning of the file or a probability factor used to pick records.

**To add a Spigot transform node to your job diagram**

1. (Optional) Open the Resource panel and then choose **Spigot** to add a new transform to your job diagram, if needed.

2. On the **Node properties** tab, enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. Choose the **Transform** tab in the node details panel.

4. Enter an Amazon S3 path or choose **Browse S3** to choose a location in Amazon S3. This is the location where the job writes the JSON file that contains the data sample.
5. Enter information for the sampling method. You can specify a value for **Number of records** to write starting from the beginning of the dataset and a **Probability threshold** (entered as a decimal value with a maximum value of 1) of picking any given record.

For example, to write the first 50 records from the dataset, you would set **Number of records** to 50 and **Probability threshold** to 1 (100%).

### Joining datasets

The *Join* transform allows you to combine two datasets into one. You specify the key names in the schema of each dataset to compare. The output DynamicFrame contains rows where keys meet the join condition. The rows in each dataset that meet the join condition are combined into a single row in the output DynamicFrame that contains all the columns found in either dataset.

**To add a Join transform node to your job diagram**

1. If there is only one data source available, you must add a new data source node to the job diagram.
2. Choose one of the source nodes for the join. Open the Resource panel and then choose *Join* to add a new transform to your job diagram.
3. On the **Node properties** tab, enter a name for the node in the job diagram.
4. In the **Node properties** tab, under the heading **Node parents**, add a parent node so that there are two datasets providing inputs for the join. The parent can be a data source node or a transform node.

**Note**

A join can have only two parent nodes.

5. Choose the **Transform** tab.

If you see a message indicating that there are conflicting key names, you can either:

- Choose **Resolve it** to automatically add an *ApplyMapping* transform node to your job diagram. The ApplyMapping node adds a prefix to any keys in the dataset that have the same name as a key in the other dataset. For example, if you use the default value of **right**, then any keys in the right dataset that have the same name as a key in the left dataset will be renamed to *(right)key name*. 

- Manually add a transform node earlier in the job diagram to remove or rename the conflicting keys.

6. Choose the type of join in the **Join type** list.

- **Inner join**: Returns a row with columns from both datasets for every match based on the join condition. Rows that don't satisfy the join condition aren't returned.

- **Left join**: All rows from the left dataset and only the rows from the right dataset that satisfy the join condition.

- **Right join**: All rows from the right dataset and only the rows from the left dataset that satisfy the join condition.

- **Outer join**: All rows from both datasets.

- **Left semi join**: All rows from the left dataset that have a match in the right dataset based on the join condition.

- **Left anti join**: All rows in the left dataset that don't have a match in the right dataset based on join condition.

7. On the **Transform** tab, under the heading **Join conditions**, choose **Add condition**. Choose a property key from each dataset to compare. Property keys on the left side of the comparison operator are referred to as the left dataset and property keys on the right are referred to as the right dataset.

   For more complex join conditions, you can add additional matching keys by choosing **Add condition** more than once. If you accidentally add a condition, you can choose the delete icon to remove it.

8. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

9. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.
For an example of the join output schema, consider a join between two datasets with the following property keys:

| Left: {id, dept, hire_date, salary, employment_status} |
| Right: {id, first_name, last_name, hire_date, title} |

The join is configured to match on the id and hire_date keys using the = comparison operator.

Because both datasets contain id and hire_date keys, you chose Resolve it to automatically add the prefix right to the keys in the right dataset.

The keys in the output schema would be:

{id, dept, hire_date, salary, employment_status, (right)id, first_name, last_name, (right)hire_date, title}

**Using Union to combine rows**

You use the Union transform node when you want to combine rows from more than one data source that have the same schema.

There are two types of Union transformations:

1. ALL – when applying ALL, the resulting union does not remove duplicate rows.
2. DISTINCT – when applying DISTINCT, the resulting union removes duplicate rows.

**Unions vs. Joins**

You use Union to combine rows. You use Join to combine columns.

**Using the Union transform in the Visual ETL canvas**

1. Add more than one data source to perform a union transform. To add a data source, open the Resource Panel, then choose the data source from the Sources tab. Before using the Union transformation, you must ensure that all data sources involved in the union have the same schema and structure.
2. When you have at least two data sources that you want to combine using the Union transform, create the Union transform by adding it to the canvas. Open the Resource Panel on the canvas and search for 'Union'. You can also choose the Transforms tab in the Resource Panel and scroll down until you find the Union transform, then choose **Union**.
3. Select the Union node on the job canvas. In the Node properties window, choose the parent nodes to connect to the Union transform.

4. AWS Glue checks for compatibility to make sure that the Union transform can be applied to all data sources. If the schema for the data sources are the same, the operation will be allowed. If the data sources do not have the same schema, an invalid error message is displayed: “The input schemas of this union are not the same. Consider using ApplyMapping to match the schemas.” To fix this, choose Use **ApplyMapping**.

5. Choose the Union type.
   1. All – By default, the All Union type is selected; this will result in duplicate rows if there are any in the data combination.
   2. Distinct – Choose Distinct if you want duplicate rows to be removed from the resulting data combination.

Using SplitFields to split a dataset into two

The *SplitFields* transform allows you to choose some of the data property keys in the input dataset and put them into one dataset and the unselected keys into a separate dataset. The output from this transform is a collection of DynamicFrames.

> **Note**
> You must use a *SelectFromCollection* transform to convert the collection of DynamicFrames into a single DynamicFrame before you can send the output to a target location.

The *SplitFields* transform is case sensitive. Add an *ApplyMapping* transform as a parent node if you need case-insensitive property key names.

**To add a SplitFields transform node to your job diagram**

1. (Optional) Open the Resource panel and then choose *SplitFields* to add a new transform to your job diagram, if needed.
2. On the *Node properties* tab, enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the *Node parents* list to use as the input source for the transform.
3. Choose the **Transform** tab.

4. Choose which property keys you want to put into the first dataset. The keys that you do not choose are placed in the second dataset.

5. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

7. Configure a **SelectFromCollection** transform node to process the resulting datasets.

**Overview of SelectFromCollection transform**

Certain transforms have multiple datasets as their output instead of a single dataset, for example, **SplitFields**. The **SelectFromCollection** transform selects one dataset (DynamicFrame) from a collection of datasets (an array of DynamicFrames). The output for the transform is the selected DynamicFrame.

You must use this transform after you use a transform that creates a collection of DynamicFrames, such as:

- Custom code transforms
- **SplitFields**

If you don't add a **SelectFromCollection** transform node to your job diagram after any of these transforms, you will get an error for your job.

The parent node for this transform must be a node that returns a collection of DynamicFrames. If you choose a parent for this transform node that returns a single DynamicFrame, such as a **Join** transform, your job returns an error.

Similarly, if you use a **SelectFromCollection** node in your job diagram as the parent for a transform that expects a single DynamicFrame as input, your job returns an error.
Using SelectFromCollection to choose which dataset to keep

Use the `SelectFromCollection` transform to convert a collection of `DynamicFrames` into a single `DynamicFrame`.

To add a SelectFromCollection transform node to your job diagram

1. (Optional) Open the Resource panel and then choose `SelectFromCollection` to add a new transform to your job diagram, if needed.
2. On the Node properties tab, enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.
3. Choose the Transform tab.
4. Under the heading Frame index, choose the array index number that corresponds to the DynamicFrame you want to select from the collection of DynamicFrames.

   For example, if the parent node for this transform is a `SplitFields` transform, on the Output schema tab of that node you can see the schema for each DynamicFrame. If you want to keep the DynamicFrame associated with the schema for Output 2, you would select 1 for the value of Frame index, which is the second value in the list.

   Only the DynamicFrame that you choose is included in the output.

5. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the Output schema tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the Job details tab, you are prompted to enter an IAM role here.

6. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the Data preview tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to
access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

**Find and fill missing values in a dataset**

You can use the `FillMissingValues` transform to locate records in the dataset that have missing values and add a new field with a value determined by imputation. The input data set is used to train the machine learning (ML) model that determines what the missing value should be. If you use incremental data sets, then each incremental set is used as the training data for the ML model, so the results might not be as accurate.

**To use a FillMissingValues transform node in your job diagram**

1. (Optional) Open the Resource panel and then choose `FillMissingValues` to add a new transform to your job diagram, if needed.
2. On the **Node properties** tab, enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.
3. Choose the **Transform** tab.
4. For **Data field**, choose the column or field name from the source data that you want to analyze for missing values.
5. (Optional) In the **New field name** field, enter a name for the field added to each record that will hold the estimated replacement value for the analyzed field. If the analyzed field doesn't have a missing value, the value in the analyzed field is copied into the new field.

If you don't specify a name for the new field, the default name is the name of the analyzed column with `_filled` appended. For example, if you enter `Age` for **Data field** and don't specify a value for **New field name**, a new field named `Age_filled` is added to each record.

6. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

7. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to
access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

Filtering keys within a dataset

Use the Filter transform to create a new dataset by filtering records from the input dataset based on a regular expression. Rows that don't satisfy the filter condition are removed from the output.

- For string data types, you can filter rows where the key value matches a specified string.
- For numeric data types, you can filter rows by comparing the key value to a specified value using the comparison operators <, >, =, !=, <=, and >=.

If you specify multiple filter conditions, the results are combined using an AND operator by default, but you can choose OR instead.

The Filter transform is case sensitive. Add an ApplyMapping transform as a parent node if you need case-insensitive property key names.

To add a Filter transform node to your job diagram

1. (Optional) Open the Resource panel and then choose Filter to add a new transform to your job diagram, if needed.
2. On the Node properties tab, enter a name for the node in the job diagram. If a node parent isn't already selected, then choose a node from the Node parents list to use as the input source for the transform.
3. Choose the Transform tab.
4. Choose either Global AND or Global OR. This determines how multiple filter conditions are combined. All conditions are combined using either AND or OR operations. If you have only a single filter conditions, then you can choose either one.
5. Choose the Add condition button in the Filter condition section to add a filter condition.

   In the Key field, choose a property key name from the dataset. In the Operation field, choose the comparison operator. In the Value field, enter the comparison value. Here are some examples of filter conditions:

   - year >= 2018
   - State matches 'CA*'

Editing AWS Glue managed data transform nodes
When you filter on string values, make sure that the comparison value uses a regular expression format that matches the script language selected in the job properties (Python or Scala).

6. Add additional filter conditions, as needed.

7. (Optional) After configuring the transform node properties, you can view the modified schema for your data by choosing the Output schema tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the Job details tab, you are prompted to enter an IAM role here.

8. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the Data preview tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

**Using DropNullFields to remove fields with null values**

Use the DropNullFields transform to remove fields from the dataset if all values in the field are ‘null’. By default, AWS Glue Studio will recognize null objects, but some values such as empty strings, strings that are “null”, -1 integers or other placeholders such as zeros, are not automatically recognized as nulls.

**To use the DropNullFields**

1. Add a DropNullFields node to the job diagram.

2. On the Node properties tab, choose additional values that represent a null value. You can choose to select none or all of the values:
DropNullFields  Info
Remove fields or columns where all the values are the null objects.

Choose additional values that represent a null value below.

- Empty String ("" or ")
- "null" string
- -1 Integer

Add custom null values
Specify custom null values by entering the value and choosing the data type.

- Empty String ("" or ") - fields that contain empty strings will be removed
- "null string" - fields that contain the string with the word 'null' will be removed
- -1 integer - fields that contain a -1 (negative one) integer will be removed

3. If needed, you can also specify custom null values. These are null values that may be unique to your dataset. To add a custom null value, choose Add new value.

4. Enter the custom null value. For example, this can zero, or any value that is being used to represent a null in the dataset.

5. Choose the data type in the drop-down field. Data types can either be String or Integer.

**Note**
Custom null values and their data types must match exactly in order for the fields to be recognized as null values and the fields removed. Partial matches where only the custom null value matches but the data type does not will not result in the fields being removed.
Using a SQL query to transform data

You can use a SQL transform to write your own transform in the form of a SQL query.

A SQL transform node can have multiple datasets as inputs, but produces only a single dataset as output. It contains a text field, where you enter the Apache SparkSQL query. You can assign aliases to each dataset used as input, to help simplify the SQL query. For more information about the SQL syntax, see the Spark SQL documentation.

Note

If you use a Spark SQL transform with a data source located in a VPC, add an AWS Glue VPC endpoint to the VPC that contains the data source. For more information about configuring development endpoints, see Adding a Development Endpoint, Setting Up Your Environment for Development Endpoints, and Accessing Your Development Endpoint in the AWS Glue Developer Guide.

To use a SQL transform node in your job diagram

1. (Optional) Add a transform node to the job diagram, if needed. Choose Spark SQL for the node type.
2. On the Node properties tab, enter a name for the node in the job diagram. If a node parent is not already selected, or if you want multiple inputs for the SQL transform, choose a node from the Node parents list to use as the input source for the transform. Add additional parent nodes as needed.
3. Choose the Transform tab in the node details panel.
4. The source datasets for the SQL query are identified by the names you specified in the Name field for each node. If you do not want to use these names, or if the names are not suitable for a SQL query, you can associate a name to each dataset. The console provides default aliases, such as MyDataSource.
For example, if a parent node for the SQL transform node is named `Rename Org PK field`, you might associate the name `org_table` with this dataset. This alias can then be used in the SQL query in place of the node name.

5. In the text entry field under the heading **Code block**, paste or enter the SQL query. The text field displays SQL syntax highlighting and keyword suggestions.

6. With the SQL transform node selected, choose the **Output schema** tab, and then choose **Edit**. Provide the columns and data types that describe the output fields of the SQL query.

Specify the schema using the following actions in the **Output schema** section of the page:

- To rename a column, place the cursor in the **Key** text box for the column (also referred to as a **field** or **property key**) and enter the new name.
- To change the data type for a column, select the new data type for the column from the drop-down list.
- To add a new top-level column to the schema, choose the **Overflow** button, and then choose **Add root key**. New columns are added at the top of the schema.
- To remove a column from the schema, choose the delete icon to the far right of the Key name.
7. When you finish specifying the output schema, choose **Apply** to save your changes and exit the schema editor. If you do not want to save your changes, choose **Cancel** to edit the schema editor.

8. (Optional) After configuring the node properties and transform properties, you can preview the modified dataset by choosing the **Data preview** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. There is a cost associated with using this feature, and billing starts as soon as you provide an IAM role.

**Using Aggregate to perform summary calculations on selected fields**

**To use the Aggregate transform**

1. Add the Aggregate node to the job diagram.

2. On the **Node properties** tab, choose fields to group together by selecting the drop-down field (optional). You can select more than one field at a time or search for a field name by typing in the search bar.

   When fields are selected, the name and datatype are shown. To remove a field, choose 'X' on the field.
3. Choose **Aggregate another column**. It is required to select at least one field.

4. Choose a field in the **Field to aggregate** drop-down.

5. Choose the aggregation function to apply to the chosen field:
• avg - calculates the average
• countDistinct - calculates the number of unique non-null values
• count - calculates the number of non-null values
• first - returns the first value that satisfies the 'group by' criteria
• last - returns the last value that satisfies the 'group by' criteria
• kurtosis - calculates the the sharpness of the peak of a frequency-distribution curve
• max - returns the highest value that satisfies the 'group by' criteria
• min - returns the lowest value that satisfies the 'group by' criteria
• skewness - measure of the asymmetry of the probability distribution of a normal distribution
• stddev_pop - calculates the population standard deviation and returns the square root of the population variance
• sum - the sum of all values in the group
• sumDistinct - the sum of distinct values in the group
• var_samp - the sample variance of the group (ignores nulls)
• var_pop - the population variance of the group (ignores nulls)

Flatten nested structs

Flatten the fields of nested structs in the data, so they become top level fields. The new fields are named using the field name prefixed with the names of the struct fields to reach it, separated by dots.

For example, if the data has a field of type Struct named “phone_numbers”, which among other fields has one of type “Struct” named “home_phone” with two fields: “country_code” and “number”. Once flattened, these two fields will become top level fields named: “phone_numbers.home_phone.country_code” and “phone_numbers.home_phone.number” respectively.

To add a Flatten transform node in your job diagram

1. Open the Resource panel and then choose the Transforms tab, then Flatten to add a new transform to your job diagram. You can also use the search bar by entering 'Flatten', then clicking the Flatten node. The node selected at the time of adding the node will be its parent.
2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, you can limit the maximum nesting level to flatten. For instance, setting that value to 1 means that only top-level structs will be flattened. Setting the max to 2 will flatten the top level and the structs directly under it.

### Add a UUID column

When you add a *UUID* (Universally Unique Identified) column, each row will be assigned a unique 36-character string.

### To add a UUID transform node in your job diagram

1. Open the Resource panel and then choose **UUID** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.
2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, you can customize the name of the new column. By default it will be named "uuid".

### Add an identifier column

Assign a numeric **Identifier** for each row in the dataset.

**To add an Identifier transform node in your job diagram**

1. Open the Resource panel and then choose **Identifier** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, you can customize the name of the new column. By default, it will be named "id".

4. (Optional) If the job processes and stores data incrementally, you want to avoid the same ids to be reused between job runs.

   On the **Transform** tab, mark the **unique** checkbox option. It will include the job timestamp in the identifier, making it unique between multiple runs. To allow for the larger number, the column instead of type long will be a decimal.

### Convert a column to timestamp type

You can use the transform **To timestamp** to change the data type of a numeric or string column into timestamp, so that it can be stored with that data type or applied to other transforms that require a timestamp.

**To add a To timestamp transform node in your job diagram**

1. Open the Resource panel and then choose **To timestamp** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.
2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. On the **Transform** tab, enter the name of the column to be converted.

4. On the **Transform** tab, define how to parse the column selected by choosing the type.

   If the value is a number, it can be expressed in seconds (Unix/Python timestamp), milliseconds or microseconds, choose the corresponding option.

   If the value is a formatted string, choose the "iso" type, the string needs to conform to one of the variants of the ISO format, for example: “2022-11-02T14:40:59.915Z”.

   If you don’t know the type at this point or different rows use different types, then you can choose “autodetect“ and the system will make its best guess, with a small performance cost.

5. (Optional) On the **Transform** tab, instead of converting the selected column, you can create a new one and keep the original by entering a name for the new column.

### Convert a timestamp column to a formatted string

Format a timestamp column into a string based on a pattern. You can use **Format timestamp** to get date and time as a string with the desired format. You can define the format using **Spark date syntax** as well as most of the **Python date codes**.

For example, if you want your date string to be formatted like “2023-01-01 00:00", you can define such format using the Spark syntax as “yyyy-MM-dd HH:mm” or the equivalent Python date codes as “%Y-%m-%d %H:%M”

**To add a Format timestamp transform node in your job diagram**

1. Open the Resource panel and then choose **Format timestamp** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the **Node parents** list to use as the input source for the transform.

3. On the **Transform** tab, enter the name of the column to be converted.

4. On the **Transform** tab, enter the **Timestamp format** pattern to use, expressed using **Spark date syntax** or **Python date codes**.
5. (Optional) On the Transform tab, instead of converting the selected column, you can create a new one and keep the original by entering a name for the new column.

Creating a Conditional Router transformation

The Conditional Router transform allows you to apply multiple conditions to incoming data. Each row of the incoming data is evaluated by a group filter condition and processed into its corresponding group. If a row meets more than one group filter condition, the transform passes the row to multiple groups. If a row does not meet any condition, it can either be dropped or routed to a default output group.

This transform is similar to the filter transform, but useful for users who want to test the same input data on multiple conditions.

To add a Conditional Router transform:

1. Choose a node where you will perform the conditional router transformation. This can be a source node or another transform.
2. Choose Action, then use the search bar to find and choose 'Conditional Router'. A Conditional Router transform is added along with two output nodes. One output node, 'Default group', contains records which do not meet any of the conditions defined in the other output node(s). The default group cannot be edited.
You can add additional output groups by choosing **Add group**. For each output group, you can name the group and add filter conditions and a logical operator.
3. Rename the output group name by entering a new name for the group. AWS Glue Studio will automatically name your groups for you (for example, 'output_group_1').

4. Choose a logical operator (AND, OR) and add a Filter condition by specifying the Key, Operation, and Value. Logical operators allow you to implement more than one filter condition and perform the logical operator on each filter condition you specify.

When specifying the key, you can choose from available keys in your schema. You can then choose the available operation depending on the type of key you selected. For example, if the key type is 'string', then the available operation to choose from is 'matches'.
5. Enter the value in the **Value** field. To add additional filter conditions, choose **Add condition**. To remove filter conditions, choose the trash can icon.

### Using the Concatenate Columns transform to append columns

The Concatenate transform allows you to build a new string column using the values of other columns with an optional spacer. For example, if we define a concatenated column “date” as the concatenation of “year”, “month” and “day” (in that order) with “-” as the spacer, we would get:

<table>
<thead>
<tr>
<th>day</th>
<th>month</th>
<th>year</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>01</td>
<td>2020</td>
<td>2020-01-01</td>
</tr>
<tr>
<td>02</td>
<td>01</td>
<td>2020</td>
<td>2020-01-02</td>
</tr>
<tr>
<td>03</td>
<td>01</td>
<td>2020</td>
<td>2020-01-03</td>
</tr>
<tr>
<td>04</td>
<td>01</td>
<td>2020</td>
<td>2020-01-04</td>
</tr>
</tbody>
</table>

To add a Concatenate transform:

1. Open the Resource panel. Then choose **Concatenate Columns** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.
3. On the **Transform** tab, enter the name of the column that will hold the concatenated string as well as the columns to concatenate. The order in which you check the columns in the dropdown will be the order used.

![Node properties](image)

- **Name of the concatenated column**
  Name of the string column that will be generated

- **List of column named separated by comma or spaces**
  The fields listed will be concatenated on that order

- **Array new column Name - optional**
  String to place between the concatenated fields, by default there is no spacer.

- **Null value - optional**
  The string to use when a column value is null, for example: 'NULL' or 'NA', by default an empty string will be used

4. **Spacer - optional** – Enter a string to place between the concatenated fields. By default, there is no spacer.

5. **Null value - optional** – Enter a string to use when a column value is null. By default, in the cases where columns have the value 'NULL' or 'NA', an empty string is used.

**Using the Split String transform to break up a string column**

The Split String transform allows you to break up a string into an array of tokens using a regular expression to define how the split is done. You can then keep the column as an array type or apply an Array To Columns transform after this one, to extract the array values onto top level fields, assuming that each token has a meaning we know beforehand. Also, if the order of the tokens is irrelevant (for instance, a set of categories), you can use the **Explode** transform to generate a separate row for each value.
For example, you can split a the column “categories” using a comma as a pattern to add a column “categories_arr”.

<table>
<thead>
<tr>
<th>product_id</th>
<th>categories</th>
<th>categories_arr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>sports,winter</td>
<td>[sports, winter]</td>
</tr>
<tr>
<td>2</td>
<td>garden,tools</td>
<td>[garden, tools]</td>
</tr>
<tr>
<td>3</td>
<td>videogames</td>
<td>[videogames]</td>
</tr>
<tr>
<td>4</td>
<td>game,boardgame,social</td>
<td>[game, boardgame, social]</td>
</tr>
</tbody>
</table>

To add a Split String transform:

1. Open the Resource panel and then choose Split String to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the Node properties tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. On the Transform tab, choose the column to split and enter the pattern to use to split the string. In most cases you can just enter the character(s) unless it has a special meaning as a regular expression and needs to be escaped. The characters that need escaping are: \ [ ] { } ( ) < > + - = ! ^ $ | by adding a backslash in front of the character. For instance if you want to separate by a dot (‘.’) you need to enter \ . However, a comma doesn’t have a special meaning and can just be specified as is: ,.
4. (Optional) If you want to keep the original string column, then you can enter a name for a new array column, this way keeping both the original string column and the new tokenized array column.

Using the Array To Columns transform to extract the elements of an array into top level columns

The Array To Columns transform allows you to extract some or all the elements of a column of type array into new columns. The transform will fill the new columns as much as possible if the array has enough values to extract, optionally taking the elements in the positions specified.

For instance, if you have an array column “subnet”, which was the result of applying the “Split String” transform on an IPv4 subnet, you can extract the first and fourth positions into new columns “first_octect” and “forth_octect”. The output of the transform in this example would be (notice the last two rows have shorter arrays than expected):

<table>
<thead>
<tr>
<th>subnet</th>
<th>first_octect</th>
<th>forth_octect</th>
</tr>
</thead>
<tbody>
<tr>
<td>[54, 240, 197, 238]</td>
<td>54</td>
<td>238</td>
</tr>
<tr>
<td>[192, 168, 0, 1]</td>
<td>192</td>
<td>1</td>
</tr>
</tbody>
</table>
To add a Array To Columns transform:

1. Open the Resource panel and then choose **Array To Columns** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. On the **Transform** tab, choose the array column to extract and enter the list of new columns for the tokens extracted.

4. (Optional) If you don’t want to take the array tokens in order to assign to columns, you can specify the indexes to take which will be assigned to the list of columns in the same order specified. For instance if the output columns are “column1, column2, column3” and the
indexes “4, 1, 3”, the forth element of the array will go to column1, the first to column2 and the third to column3 (if the array is shorter than the index number, a NULL value will be set).

Using the Add Current Timestamp transform

The **Add Current Timestamp** transform allows you to mark the rows with the time on which the data was processed. This is useful for auditing purposes or to track latency in the data pipeline. You can add this new column as a timestamp data type or a formatted string.

To add a Add Current Timestamp transform:

1. Open the Resource panel and then choose **Add Current Timestamp** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, enter a custom name for the new column and a format if you rather the column to be a formatted date string.

Using the Pivot Rows to Columns transform

The **Pivot Rows to Columns** transform allows you to aggregate a numeric column by rotating unique values on selected columns which become new columns (if multiple columns are selected, the values are concatenated to name the new columns). That way rows are consolidated while
having more columns with partial aggregations for each unique value. For example, if you have this dataset of sales by month and country (sorted to be easier to illustrate):

<table>
<thead>
<tr>
<th>year</th>
<th>month</th>
<th>country</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Jan</td>
<td>uk</td>
<td>32</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>de</td>
<td>42</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>us</td>
<td>64</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>uk</td>
<td>67</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>de</td>
<td>4</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>de</td>
<td>7</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>us</td>
<td>6</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>us</td>
<td>12</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>us</td>
<td>90</td>
</tr>
</tbody>
</table>

If you pivot selecting amount as the aggregation column and country and the value, those values rotate to become column with the value as the aggregate of all the matching rows:

<table>
<thead>
<tr>
<th>year</th>
<th>month</th>
<th>de</th>
<th>uk</th>
<th>us</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Jan</td>
<td>42</td>
<td>32</td>
<td>64</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>11</td>
<td>67</td>
<td>18</td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td></td>
<td></td>
<td>90</td>
</tr>
</tbody>
</table>

If instead you want to pivot both the month and county, you get a column for each combination of the values of those columns:
To add a Pivot Rows To Columns transform:

1. Open the Resource panel and then choose Pivot Rows To Columns to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the Node properties tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. On the Transform tab, choose the numeric column which will be aggregated to produce the values for the new columns, the aggregation function to apply and the column(s) to convert its unique values into new columns.
Using the Unpivot Columns To Rows transform

The Unpivot transform allows you convert columns into values of new columns generating a row for each unique value. It's the opposite of pivot but note that it's not equivalent since it cannot separate rows with identical values that were aggregated or split combinations into the original columns (you can do that later using a Split transform). For example, if you have the following table:

<table>
<thead>
<tr>
<th>year</th>
<th>month</th>
<th>de</th>
<th>uk</th>
<th>us</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Jan</td>
<td>42</td>
<td>32</td>
<td>64</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>11</td>
<td>67</td>
<td>18</td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td></td>
<td></td>
<td>90</td>
</tr>
</tbody>
</table>

You can unpivot the columns: “de”, “uk” and “us” into a column “country” with the value “amount”, and get the following (sorted here for illustration purposes):

<table>
<thead>
<tr>
<th>year</th>
<th>month</th>
<th>country</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Jan</td>
<td>uk</td>
<td>32</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>de</td>
<td>42</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>us</td>
<td>64</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>uk</td>
<td>67</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>de</td>
<td>11</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>us</td>
<td>18</td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td>us</td>
<td>90</td>
</tr>
</tbody>
</table>

Notice the columns that have a NULL value (“de” and “uk of Jan 2021) don’t get generated by default. You can enable that option to get:
<table>
<thead>
<tr>
<th>year</th>
<th>month</th>
<th>country</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Jan</td>
<td>uk</td>
<td>32</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>de</td>
<td>42</td>
</tr>
<tr>
<td>2020</td>
<td>Jan</td>
<td>us</td>
<td>64</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>uk</td>
<td>67</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>de</td>
<td>11</td>
</tr>
<tr>
<td>2020</td>
<td>Feb</td>
<td>us</td>
<td>18</td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td>us</td>
<td>90</td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td>de</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>Jan</td>
<td>uk</td>
<td></td>
</tr>
</tbody>
</table>

To add a Unpivot Columns to Rows transform:

1. Open the Resource panel and then choose **Unpivot Columns to Rows** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. On the **Transform** tab, enter the new columns to be created to hold the names and values of the columns chosen to unpivot.
Using the Autobalance Processing transform to optimize your runtime

The **Autobalance Processing** transform redistributes the data among the workers for better performance. This helps in cases where the data is unbalanced or as it comes from the source doesn’t allow enough parallel processing on it. This is common where the source is gzipped or is JDBC. The redistribution of data has a modest performance cost, so the optimization might not always compensate that effort if the data was already well balanced. Underneath, the transform uses Apache Spark repartition to randomly reassign data among a number of partitions optimal for the cluster capacity. For advanced users, it’s possible to enter a number of partitions manually. In addition, it can be used to optimize the writing of partitioned tables by reorganizing the data based on specified columns. This results in output files that are more consolidated.

1. Open the Resource panel and then choose **Autobalance Processing** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, you can enter a number of partitions. In general, it’s recommended that you let the system decide this value, however you can tune the multiplier or enter a specific value if you need to control this. If you are going to save the data
partitioned by columns, you can choose the same columns as repartition columns. This way it will minimize the number of files on each partition and avoid having many files per partitions, which would hinder the performance of the tools querying that data.

Using the Derived Column transform to combine other columns

The Derived Column transform allows you to define a new column based on a math formula or SQL expression in which you can use other columns in the data, as well as constants and literals. For instance, to derive a “percentage” column from the columns "success" and "count", you can enter the SQL expression: "success * 100 / count || '%".

Example result:

<table>
<thead>
<tr>
<th>success</th>
<th>count</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>100</td>
<td>14%</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>3%</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>7.5%</td>
</tr>
</tbody>
</table>

To add a Derived Column transform:

1. Open the Resource panel and then choose Derived Column to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.
2.  (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3.  On the **Transform** tab, enter the name of the column and the expression for its content.

   ![Node properties tab](image)

   ![Transform tab](image)

**Using the Lookup transform to add matching data from a catalog table**

The **Lookup** transform allows you to add columns from a defined catalog table when the keys match the defined lookup columns in the data. This is equivalent to doing a left outer join between the data and the lookup table using as condition matching columns.

**To add a Lookup transform:**

1.  Open the Resource panel and then choose **Lookup** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2.  (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3.  On the **Transform** tab, enter the fully qualified catalog table name to use to perform the lookups. For example, if your database is “mydb” and your table “mytable” then enter “mydb.mytable”. Then enter the criteria to find a match in the lookup table, if the lookup key is composed. Enter the list of key columns separated by commas. If one or more of the key columns don’t have the same name then you need to define the match mapping.
For example, if the data columns are “user_id” and “region” and in the users table the corresponding columns are named “id” and “region”, then in the Columns to match field, enter: “user_id=id, region”. You could do region=region but it’s not needed since they are the same.

4. Finally, enter the columns to bring from the row matched in the lookup table to incorporate them into the data. If no match was found those columns will be set to NULL.

**Note**

Underneath the Lookup transform, it is using a left join in order to be efficient. If the lookup table has a composite key, ensure the columns to match are setup to match all the key columns so that only one match can occur. Otherwise, multiple lookup rows will match and this will result in extra rows added for each of those matches.

---

**Using the Explode Array or Map Into Rows transform**

The Explode transform allows you to extract values from a nested structure into individual rows that are easier to manipulate. In the case of an array, the transform will generate a row for each value of the array, replicating the values for the other columns in the row. In the case of a map,
the transform will generate a row for each entry with the key and value as columns plus any other columns in the row.

For example, if we have this dataset which has a “category” array column with multiple values.

<table>
<thead>
<tr>
<th>product_id</th>
<th>category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[sports, winter]</td>
</tr>
<tr>
<td>2</td>
<td>[garden, tools]</td>
</tr>
<tr>
<td>3</td>
<td>[videogames]</td>
</tr>
<tr>
<td>4</td>
<td>[game, boardgame, social]</td>
</tr>
<tr>
<td>5</td>
<td>[]</td>
</tr>
</tbody>
</table>

If you explode the 'category' column into a column with the same name, you will override the column. You can select that you want NULLs included to get the following (ordered for illustration purposes):

<table>
<thead>
<tr>
<th>product_id</th>
<th>category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>sports</td>
</tr>
<tr>
<td>1</td>
<td>winter</td>
</tr>
<tr>
<td>2</td>
<td>garden</td>
</tr>
<tr>
<td>2</td>
<td>tool</td>
</tr>
<tr>
<td>3</td>
<td>videogames</td>
</tr>
<tr>
<td>4</td>
<td>game</td>
</tr>
<tr>
<td>4</td>
<td>boardgame</td>
</tr>
<tr>
<td>4</td>
<td>social</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
To add an Explode Array Or Map Into Rows transform:

1. Open the Resource panel and then choose **Explode Array Or Map Into Rows** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. (Optional) On the **Node properties** tab, you can enter a name for the node in the job diagram. If a node parent is not already selected, then choose a node from the Node parents list to use as the input source for the transform.

3. On the **Transform** tab, choose the column to explode (it must be an array or map type). Then enter a name for the column for the items of the array or the names of the columns for the keys and values if you are exploding a map.

4. (Optional) On the **Transform** tab, by default if the column to explode is NULL or has an empty structure, it will be omitted on the exploded dataset. If you want to keep the row (with the new columns as NULL) then check “Include NULLs”.

![Node properties tab](image)

- **Column to explode**
  A column of type array or map

- **New column name**
  The name of the column to put the array values or the dictionary keys

- **Values column - optional**
  If exploding a dictionary, you can specify a name for a column to contain the values. Default name: “value”

- **Include NULLs - optional**
  If selected, NULL values will also generate a new rows, otherwise the row with a NULL value is omitted

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Editing AWS Glue managed data transform nodes

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Using the Record Matching transform to invoke an existing data classification transform

This transform invokes an existing Record Matching machine learning data classification transform.

The transform evaluates the current data against the trained model based on labels. A column "match_id" is added to assign each row to a group of items that are considered equivalent based on the algorithm training. For more information, see Record matching with Lake Formation FindMatches.

**Note**

The version of AWS Glue used by the visual job must match the version that AWS Glue used to create the Record Matching transform.

To add a Record Matching transform node to your job diagram

1. Open the Resource panel, and then choose Record Matching to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.
2. In the node properties panel, you can enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.

3. On the **Transform** tab, enter the ID taken from the **Machine learning transforms** page:

   ![Machine learning transforms](image)

   4. (Optional) On the **Transform** tab, you can check the option to add the confidence scores. At the cost of extra computing, the model will estimate a confidence score for each match as an additional column.

**Removing null rows**

This transform removes from the dataset rows that have all columns as null. In addition, you can extend this criteria to include empty fields, so as to keep rows where at least one column is non empty.

**To add a Remove Null Rows transform node to your job diagram**

1. Open the Resource panel, and then choose **Remove Null Rows** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. In the node properties panel, you can enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.

3. (Optional) On the **Transform** tab, check the **Extended** option if you want to require rows not just to not be null but also not empty, this way empty strings, arrays or maps will be considered nulls for the purpose of this transform.
Parsing a string column containing JSON data

This transform parses a string column containing JSON data and convert it to a struct or an array column, depending if the JSON is an object or an array, respectively. Optionally you can keep both the parsed and original column.

The JSON schema can be provided or inferred (in the case of JSON objects), with optional sampling.

To add a Parse JSON Column transform node to your job diagram

1. Open the Resource panel, and then choose *Parse JSON Column* to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. In the node properties panel, you can enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the *Node parents* list to use as the input source for the transform.

3. On the **Transform** tab, select the column containing the JSON string.

4. (Optional) On the **Transform** tab, enter the schema that the JSON data follows using SQL syntax, for instance: "field1 STRING, field2 INT" in the case of an object or "ARRAY<STRING>" in the case of an array.

   If the case of an array the schema is required but in the case of an object, if the schema is not specified it will be inferred using the data. To reduce the impact of inferring the schema (especially on a large dataset), you can avoid reading the whole data twice by entering a *Ratio of samples to use to infer schema*. If the value is lower than 1, the corresponding ratio of random samples is used to infer the schema. If the data is reliable and the object is consistent between rows, you can use a small ratio such as 0.1 to improve performance.

5. (Optional) On the **Transform** tab, you can enter a new column name if you want to keep both the original string column and the parsed column.

Extracting a JSON path

This transform extracts new columns from a JSON string column. This transform is useful when you only need a few data elements and don't want to import the entire JSON content into the table schema.
To add an Extract JSON Path transform node to your job diagram

1. Open the Resource panel, and then choose **Extract JSON Path** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. In the node properties panel, you can enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.

3. On the **Transform** tab, select the column containing the JSON string. Enter one or more JSON path expressions separated by commas, each one referencing how to extract a value out of the JSON array or object. For instance, if the JSON column contained an object with properties "prop_1" and "prop2" you could extract both specifying their names "prop_1, prop_2".

   If the JSON field has special characters, for instance to extract the property from this JSON `"a . a": 1` you could use the path $[ 'a . a ']. The exception is the comma because it is reserved to separate paths. Then enter the corresponding column names for each path, separated by commas.

4. (Optional) On the **Transform** tab, you can check to drop the JSON column once extracted, this makes sense when you don't need the rest of the JSON data once you have extracted the parts you need.

**Extracting string fragments using a regular expression**

This transform extracts string fragments using a regular expression and creates a new column out of it, or multiple columns if using regex groups.

To add a Regex Extractor transform node to your job diagram

1. Open the Resource panel, and then choose **Regex Extractor** to add a new transform to your job diagram. The node selected at the time of adding the node will be its parent.

2. In the node properties panel, you can enter a name for the node in the job diagram. If a node parent isn't already selected, choose a node from the **Node parents** list to use as the input source for the transform.

3. On the **Transform** tab, enter the regular expression and the column on which it needs to be applied. Then enter the name of the new column on which to store the matching string. The new column will be null only if the source column is null, if the regex doesn't match the column will be empty.
If the regex uses groups, there has be a corresponding column name separated by comma but you can skip groups by leaving the column name empty.

For example, if you have a column "purchase_date" with a string using both long and short ISO date formats, then you want to extract the year, month, day and hour, when available. Notice the hour group is optional, otherwise in the rows where not available, all the extracted groups would be empty strings (because the regex didn’t match). In this case, we don't want the group to make the time optional but the inner one, so we leave the name empty and it doesn’t get extracted (that group would include the T character).

Resulting in the data preview:
Creating a custom transformation

If you need to perform more complicated transformations on your data, or want to add data property keys to the dataset, you can add a Custom code transform to your job diagram. The Custom code node allows you to enter a script that performs the transformation.

When using custom code, you must use a schema editor to indicate the changes made to the output through the custom code. When editing the schema, you can perform the following actions:

- Add or remove data property keys
- Change the data type of data property keys
- Change the name of data property keys
- Restructure a nested property key

You must use a SelectFromCollection transform to choose a single DynamicFrame from the result of your Custom transform node before you can send the output to a target location.

Use the following tasks to add a custom transform node to your job diagram.
Adding a custom code transform node to the job diagram

To add a custom transform node to your job diagram

1. (Optional) Open the Resource panel and then choose Custom transform to add a custom transform to your job diagram.

2. On the Node properties tab, enter a name for the node in the job diagram. If a node parent is not already selected, or if you want multiple inputs for the custom transform, then choose a node from the Node parents list to use as the input source for the transform.

Entering code for the custom transform node

You can type or copy code into an input field. The job uses this code to perform the data transformation. You can provide a code snippet in either Python or Scala. The code should take one or more DynamicFrames as input and returns a collection of DynamicFrames.

To enter the script for a custom transform node

1. With the custom transform node selected in the job diagram, choose the Transform tab.

2. In the text entry field under the heading Code block, paste or enter the code for the transformation. The code that you use must match the language specified for the job on the Job details tab.

When referring to the input nodes in your code, AWS Glue Studio names the DynamicFrames returned by the job diagram nodes sequentially based on the order of creation. Use one of the following naming methods in your code:

- Classic code generation – Use functional names to refer to the nodes in your job diagram.
  - Data source nodes: DataSource0, DataSource1, DataSource2, and so on.
  - Transform nodes: Transform0, Transform1, Transform2, and so on.
- New code generation – Use the name specified on the Node properties tab of a node, appended with '_node1', '_node2', and so on. For example, S3bucket_node1, ApplyMapping_node2, S3bucket_node2, MyCustomNodeName_node1.

For more information about the new code generator, see Script code generation.

The following examples show the format of the code to enter in the code box:
Python

The following example takes the first DynamicFrame received, converts it to a DataFrame to apply the native filter method (keeping only records that have over 1000 votes), then converts it back to a DynamicFrame before returning it.

```python
def FilterHighVoteCounts (glueContext, dfc) -> DynamicFrameCollection:
    df = dfc.select(list(dfc.keys())[0]).toDF()
    df_filtered = df.filter(df["vote_count"] > 1000)
    dyf_filtered = DynamicFrame.fromDF(df_filtered, glueContext, "filter_votes")
    return(DynamicFrameCollection({"CustomTransform0": dyf_filtered}, glueContext))
```

Scala

The following example takes the first DynamicFrame received, converts it to a DataFrame to apply the native filter method (keeping only records that have over 1000 votes), then converts it back to a DynamicFrame before returning it.

```scala
object FilterHighVoteCounts {
    def execute(glueContext : GlueContext, input : Seq[DynamicFrame]) :
    Seq[DynamicFrame] = {
        val frame = input(0).toDF()
        val filtered = DynamicFrame(frame.filter(frame("vote_count") > 1000),
        glueContext)
        Seq(filtered)
    }
}
```

**Editing the schema in a custom transform node**

When you use a custom transform node, AWS Glue Studio cannot automatically infer the output schemas created by the transform. You use the schema editor to describe the schema changes implemented by the custom transform code.

A custom code node can have any number of parent nodes, each providing a DynamicFrame as input for your custom code. A custom code node returns a collection of DynamicFrames. Each DynamicFrame that is used as input has an associated schema. You must add a schema that describes each DynamicFrame returned by the custom code node.
When you set your own schema on a custom transform, AWS Glue Studio does not inherit schemas from previous nodes. To update the schema, select the Custom transform node, then choose the Data preview tab. Once the preview is generated, choose 'Use Preview Schema'. The schema will then be replaced by the schema using the preview data.

To edit the output schemas for a custom transform node

1. With the custom transform node selected in the job diagram, in the node details panel, choose the Output schema tab.
2. Choose Edit to make changes to the schema.

   If you have nested data property keys, such as an array or object, you can choose the Expand-Rows icon
   (.expandRowsIcon) on the top right of each schema panel to expand the list of child data property keys. After you choose this icon, it changes to the Collapse-Rows icon
   (.collapseRowsIcon), which you can choose to collapse the list of child property keys.
3. Modify the schema using the following actions in the section on the right side of the page:
   
   • To rename a property key, place the cursor in the Key text box for the property key, then enter the new name.
   • To change the data type for a property key, use the list to choose the new data type for the property key.
   • To add a new top-level property key to the schema, choose the Overflow icon
     (.overflowIcon) to the left of the Cancel button, and then choose Add root key.
   • To add a child property key to the schema, choose the Add-Key icon with the parent key. Enter a name for the child key and choose the data type.
   • To remove a property key from the schema, choose the Remove icon
     (.removeIcon) to the far right of the key name.
4. If your custom transform code uses multiple `DynamicFrames`, you can add additional output schemas.

   - To add a new, empty schema, choose the **Overflow** icon, and then choose **Add output schema**.
   
   - To copy an existing schema to a new output schema, make sure the schema you want to copy is displayed in the schema selector. Choose the **Overflow** icon, and then choose **Duplicate**.

   If you want to remove an output schema, make sure the schema you want to copy is displayed in the schema selector. Choose the **Overflow** icon, and then choose **Delete**.

5. Add new root keys to the new schema or edit the duplicated keys.

6. When you are modifying the output schemas, choose the **Apply** button to save your changes and exit the schema editor.

   If you do not want to save your changes, choose the **Cancel** button.

**Configure the custom transform output**

A custom code transform returns a collection of `DynamicFrames`, even if there is only one `DynamicFrame` in the result set.

**To process the output from a custom transform node**

1. Add a `SelectFromCollection` transform node, which has the custom transform node as its parent node. Update this transform to indicate which dataset you want to use. See Using `SelectFromCollection` to choose which dataset to keep for more information.

2. Add additional `SelectFromCollection` transforms to the job diagram if you want to use additional `DynamicFrames` produced by the custom transform node.

   Consider a scenario in which you add a custom transform node to split a flight dataset into multiple datasets, but duplicate some of the identifying property keys in each output schema,
such as the flight date or flight number. You add a SelectFromCollection transform node for each output schema, with the custom transform node as its parent.

3. (Optional) You can then use each SelectFromCollection transform node as input for other nodes in the job, or as a parent for a data target node.

**AWS Glue custom visual transforms**

Custom visual transforms allow you to create transforms and make them available for use in AWS Glue Studio jobs. Custom visual transforms enable ETL developers, who may not be familiar with coding, to search and use a growing library of transforms using the AWS Glue Studio interface.

You can create a custom visual transform, then upload it to Amazon S3 to make available for use through the visual editor in AWS Glue Studio to work with these jobs.

**Topics**

- [Getting started with custom visual transforms](#)
- [Step 1. Create a JSON config file](#)
- [Step 2. Implement the transform logic](#)
- [Step 3. Validate and troubleshoot custom visual transforms in AWS Glue Studio](#)
- [Step 4. Update custom visual transforms as needed](#)
- [Step 5. Use custom visual transforms in AWS Glue Studio](#)
- [Usage examples](#)
- [Examples of custom visual scripts](#)
- [Video](#)

**Getting started with custom visual transforms**

To create a custom visual transform, you go through the following steps.

- Step 1. Create a JSON config file
- Step 2. Implement the transform logic
- Step 3. Validate the custom visual transform
- Step 4. Update the custom visual transform as needed
- Step 5. Use the custom visual transform in AWS Glue Studio
Get started by setting up the Amazon S3 bucket and continue to **Step 1. Create a JSON config file.**

**Prerequisites**

Customer-supplied transforms reside within a customer AWS account. That account owns the transforms and therefore has all permissions to view (search and use), edit, or delete them.

In order to use a custom transform in AWS Glue Studio, you will need to create and upload two files to the Amazon S3 assets bucket in that AWS account:

- **Python file** – contains the transform function
- **JSON file** – describes the transform. This is also known as the config file that is required to define the transform.

In order to pair the files together, use the same name for both. For example:

- myTransform.json
- myTransform.py

Optionally, you can give your custom visual transform a custom icon by providing a **SVG file** containing the icon. In order to pair the files together, use the same name for the icon:

- myTransform.svg

AWS Glue Studio will automatically match them using their respective file names. File names cannot be the same for any existing module.

**Recommended convention for transform file name**

AWS Glue Studio will import your file as module (for example, `import myTransform`) in your job script. Therefore, your file name must follow the same naming rules set for python variable names (identifiers). Specifically, they must start with either a letter or an underscore and then be composed entirely of letters, digits, and/or underscores.

---

**Note**

Ensure your transform file name is not conflicting with existing loaded python modules (for example, `sys`, `array`, `copy` etc.) to avoid unexpected runtime issues.
Setting up the Amazon S3 bucket

Transforms you create are stored in Amazon S3 and is owned by your AWS account. You create new custom visual transforms by simply uploading files (json and py) to the Amazon S3 assets folder where all job scripts are currently stored (for example, s3://aws-glue-assets-<accountid>-<region>/transforms). If using a custom icon, upload it as well. By default, AWS Glue Studio will read all .json files from the /transforms folder in the same S3 bucket.

Step 1. Create a JSON config file

A JSON config file is required to define and describe your custom visual transform. The schema for the config file is as follows.

JSON file structure

Fields

- **name**: string – (required) the transform system name used to identify transforms. Follow the same naming rules set for python variable names (identifiers). Specifically, they must start with either a letter or an underscore and then be composed entirely of letters, digits, and/or underscores.

- **displayName**: string – (optional) the name of the transform displayed in the AWS Glue Studio visual job editor. If no displayName is specified, the name is used as the name of the transform in AWS Glue Studio.

- **description**: string – (optional) the transform description is displayed in AWS Glue Studio and is searchable.

- **functionName**: string – (required) the Python function name is used to identify the function to call in the Python script.

- **path**: string – (optional) the full Amazon S3 path to the Python source file. If not specified, AWS Glue uses file name matching to pair the .json and .py files together. For example, the name of the JSON file, myTransform.json, will be paired to the Python file, myTransform.py, on the same Amazon S3 location.

- **parameters**: Array of TransformParameter object – (optional) the list of parameters to be displayed when you configure them in the AWS Glue Studio visual editor.

TransformParameter fields
- **name**: `string` – (required) the parameter name that will be passed to the python function as a named argument in the job script. Follow the same naming rules set for python variable names (identifiers). Specifically, they must start with either a letter or an underscore and then be composed entirely of letters, digits, and/or underscores.

- **displayName**: `string` – (optional) the name of the transform displayed in the AWS Glue Studio visual job editor. If no `displayName` is specified, the name is used as the name of the transform in AWS Glue Studio.

- **type**: `string` – (required) the parameter type accepting common Python data types. Valid values: 'str' | 'int' | 'float' | 'list' | 'bool'.

- **isOptional**: `boolean` – (optional) determines whether the parameter is optional. By default all parameters are required.

- **description**: `string` — (optional) description is displayed in AWS Glue Studio to help the user configure the transform parameter.

- **validationType**: `string` – (optional) defines the way this parameter is validated. Currently, it only supports regular expressions. By default, the validation type is set to `RegularExpression`.

- **validationRule**: `string` – (optional) regular expression used to validate form input before submit when `validationType` is set to `RegularExpression`. Regular expression syntax must be compatible with [RegExp EcmaScript specifications](https://www.ecma-international.org/ecma-262/6.0/).

- **validationMessage**: `string` – (optional) the message to display when validation fails.

- **listOptions**: An array of `TransformParameterListOption` object OR a string or the string value ‘column’ – (optional) options to display in Select or Multiselect UI control. Accepting a list of comma separated value or a strongly type JSON object of type `TransformParameterListOption`. It can also dynamically populate the list of columns from the parent node schema by specifying the string value “column”.

- **listType**: `string` – (optional) Define options types for type = 'list'. Valid values: 'str' | 'int' | 'float' | 'list' | 'bool'. Parameter type accepting common python data types.

### `TransformParameterListOption` fields

- **value**: `string | int | float | bool` – (required) option value.

- **label**: `string` – (optional) option label displayed in the select dropdown.
Transform parameters in AWS Glue Studio

By default, parameters are required unless mark as isOptional in the .json file. In AWS Glue Studio, parameters are displayed in the Transform tab. The example shows user-defined parameters such as Email Address, Phone Number, Your age, Your gender and Your origin country.

You can enforce some validations in AWS Glue Studio using regular expressions in the json file by specifying the validationRule parameter and specifying a validation message in validationMessage.

```
"validationRule": "^(?\d{3})\(?[- ]?(\d{3})\)?[- ]?(\d{4})$",
"validationMessage": "Please enter a valid US number"
```

Note
Since validation occurs in the browser, your regular expression syntax must be compatible with RegExp EcmaScript specifications. Python syntax is not supported for these regular expressions.

Adding validation will prevent the user from saving the job with incorrect user input. AWS Glue Studio displays the validation message as displayed in the example:
Parameters are displayed in AWS Glue Studio based on the parameter configuration.

- When type is any of the following: str, int or float, a text input field is displayed. For example, the screenshot shows input fields for 'Email Address' and 'Your age' parameters.

  **Email Address**  
Enter your work email address below

  | wrongEmail.com  

  **⚠️ Please enter a valid email address**

- When type is bool, a checkbox is displayed.
  
  **Do you want to receive promotional newsletter from us?**  

  □

- When type is str and listOptions is provided, a single select list is displayed.

  **Your gender**

  | Male  
  | Male  
  | Female  
  | Other

- When type is list and listOptions and listType are provided, a multi-select list is displayed.
Displaying a column selector as parameter

If the configuration requires the user to choose a column from the schema, you can display a column selector so the user isn't required to type the column name. By setting the `listOptions` field to "column", AWS Glue Studio dynamically displays a column selector based on the parent node output schema. AWS Glue Studio can display either a single or multiple column selector.

The following example uses the schema:
To define your Custom Visual Transform parameter to display a single column:

1. In your JSON file, for the parameters object, set the `listOptions` value to "column". This allows a user to choose a column from a pick list in AWS Glue Studio.

```json
{
    "name": "m_b_to_timestamp",
    "displayName": "MB Convert column to timestamp",
    "description": "Convert a timestamp string or a system epoch column into a new timestamp type column."
    "functionName": "m_b_to_timestamp",
    "parameters": [{
        "name": "oldName",
        "displayName": "Name of the column with the time",
        "type": "list",
        "listOptions": "column",
        "description": "Column with an epoch or string to be converted"
    }]
}
```

2. You can also allow multiple columns selection by defining the parameter as:
   
   - `listOptions: "column"
   - `type: "list"`
Step 2. Implement the transform logic

Note

Custom visual transforms only support Python scripts. Scala is not supported.

To add the code that implements the function defined by the .json config file, it is recommended to place the Python file in the same location as the .json file, with the same name but with the "py" extension. AWS Glue Studio automatically pairs the .json and .py files so that you don't need to specify the path of the Python file in the config file.

In the Python file, add the declared function, with the named parameters configured and register it to be used in DynamicFrame. The following is an example of a Python file:

```python
from awsglue import DynamicFrame

# self refers to the DynamicFrame to transform,
# the parameter names must match the ones defined in the config
# if it's optional, need to provide a default value
def myTransform(self, email, phone, age=None, gender='', country='', promotion=False):
    resulting_dynf = # do some transformation on self
    return resulting_dynf

DynamicFrame.myTransform = myTransform
```
It is recommended to use an AWS Glue notebook for the quickest way to develop and test the python code. See [Getting started with notebooks in AWS Glue Studio](#).

To illustrate how to implement the transform logic, the custom visual transform in the example below is a transform to filter incoming data to keep only the data related to a specific US state. The .json file contains the parameter for `functionName` as `custom_filter_state` and two arguments ("state" and "colName" with type "str").

The example config .json file is:

```json
{
    "name": "custom_filter_state",
    "displayName": "Filter State",
    "description": "A simple example to filter the data to keep only the state indicated.",
    "functionName": "custom_filter_state",
    "parameters": [
        {
            "name": "colName",
            "displayName": "Column name",
            "type": "str",
            "description": "Name of the column in the data that holds the state postal code"
        },
        {
            "name": "state",
            "displayName": "State postal code",
            "type": "str",
            "description": "The postal code of the state whole rows to keep"
        }
    ]
}
```

**To implement the companion script in Python**

1. Start a AWS Glue notebook and run the initial cell provided for the session to be started. Running the initial cell creates the basic components required.

2. Create a function that performs the filtering as describe in the example and register it on `DynamicFrame`. Copy the code below and paste into a cell in the AWS Glue notebook.

```python
from awsglue import DynamicFrame
```

---

Custom visual transforms

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def custom_filter_state(self, colName, state):
    return self.filter(lambda row: row[colName] == state)

DynamicFrame.custom_filter_state = custom_filter_state

3. Create or load sample data to test the code in the same cell or a new cell. If you add the sample data in a new cell, don't forget to run the cell. For example:

# A few of rows of sample data to test
data_sample = [
    {"state": "CA", "count": 4},
    {"state": "NY", "count": 2},
    {"state": "WA", "count": 3}
]
df1 = glueContext.sparkSession.sparkContext.parallelize(data_sample).toDF()
dynf1 = DynamicFrame.fromDF(df1, glueContext, None)

4. Test to validate the “custom_filter_state” with different arguments:

[14]: dynf1.custom_filter_state("state", "NY").show()

{"count": 2, "state": "NY"}

5. After running several tests, save the code with the .py extension and name the .py file with a name that mirrors the .json file name. The .py and .json files should be in the same transform folder.

Copy the following code and paste it to a file and rename it with a .py file extension.

from awsglue import DynamicFrame

def custom_filter_state(self, colName, state):
    return self.filter(lambda row: row[colName] == state)

DynamicFrame.custom_filter_state = custom_filter_state

6. In AWS Glue Studio, open a visual job and add the transform to the job by selecting it from the list of available **Transforms**.
To reuse this transform in a Python script code, add the Amazon S3 path to the .py file in the job under “Referenced files path” and in the script, import the name of the python file (without the extension) by adding it to the top of the file. For example: `import <name of the file (without the extension)>`

Step 3. Validate and troubleshoot custom visual transforms in AWS Glue Studio

AWS Glue Studio validates the JSON config file before custom visual transforms are loaded into AWS Glue Studio. Validation includes:

- Presence of required fields
- JSON format validation
- Incorrect or invalid parameters
- Presence of both the .py and .json files in the same Amazon S3 path
- Matching filenames for the .py and .json

If validation succeeds, the transform is listed in the list of available Actions in the visual editor. If a custom icon has been provided, it should be visible beside the Action.

If validation fails, AWS Glue Studio does not load the custom visual transform.

Step 4. Update custom visual transforms as needed

Once created and used, the transform script can be updated as long as the transform follows the corresponding json definition:

- The name used when assigning to DynamicFrame must match the json functionName.
- The function arguments must be defined in the json file as described in Step 1. Create a JSON config file.
- The Amazon S3 path of the Python file cannot change, since the jobs depend directly on it.

Note

If any updates need to be made, ensure the script and the .json file are consistently updated and any visual jobs are correctly saved again with the new transform. If visual jobs
are not saved after the updates were made, the updates will not be applied and validated. If the Python script file is renamed or not placed next to the .json file, then you need to specify the full path in the .json file.

Custom icon

If you determine the default icon for your Action does not visually distinguish it as part of your workflows, you can provide a custom icon, as described in the section called “Getting started with custom visual transforms”. You can update the icon by updating the corresponding SVG hosted in Amazon S3.

For best results, design your image to be viewed at 32x32px following guidelines from the Cloudscape Design System. For more information about Cloudscape guidelines, see The Cloudscape documentation

Step 5. Use custom visual transforms in AWS Glue Studio

To use a custom visual transform in AWS Glue Studio, you upload the config and source files, then select the transform from the Action menu. Any parameters that need values or input are available to you in the Transform tab.

1. Upload the two files (Python source file and JSON config file) to the Amazon S3 assets folder where the job scripts are stored. By default, AWS Glue pulls all JSON files from the /transforms folder within the same Amazon S3 bucket.
2. From the Action menu, choose the custom visual transform. It is named with the transform displayName or name that you specified in the .json config file.
3. Enter values for any parameters that were configured in the config file.
Usage examples

The following is an example of all possible parameters in a .json config file.

```json
{
    "name": "MyTransform",
    "displayName": "My Transform",
    "description": "This transform description will be displayed in UI",
    "functionName": "myTransform",
    "parameters": [
        {
            "name": "email",
            "displayName": "Email Address",
            "type": "str",
            "description": "Enter your work email address below",
            "validationType": "RegularExpression",
            "validationRule": "^\w+([-\._]?\w+)*@\w+(\[\.-\]?\w+)*(\.\w{2,3})+$",
            "validationMessage": "Please enter a valid email address"
        },
        {
            "name": "phone",
            "displayName": "Phone Number",
            "type": "str",
            "description": "Enter your mobile phone number below",
            "validationRule": "^\(?\(?d{3}\)?\)?-[ -]?\(?d{3}\)[- ]?\(?d{3}\)[- ]?\(?d{4}\)$",
            "validationMessage": "Please enter a valid US number"
        }
    ]
}
```
"name": "age",
"displayName": "Your age",
"type": "int",
"isOptional": true
},
{
  "name": "gender",
  "displayName": "Your gender",
  "type": "str",
  "listOptions": [
    {"label": "Male", "value": "male"},
    {"label": "Female", "value": "female"},
    {"label": "Other", "value": "other"}
  ],
  "isOptional": true
},
{
  "name": "country",
  "displayName": "Your origin country ?",
  "type": "list",
  "listOptions": "Afghanistan,Albania,Algeria,America Samoa,Andorra,Angola,Antigua and Barbuda,Argentina,Armenia,Aruba,Australia,Austria,Azerbaijan,Bahamas,Bahrain,Bangladesh,Belize,Benin,Bermuda,Bhutan,Bolivia,Bosnia and Herzegovina,Botswana,Bouvet Island,Brazil,British Indian Ocean Territory,Brunei Darussalam,Bulgaria,Burkina Faso,Burundi,Cambodia,Cameroon,Cape Verde,Cayman Islands,Central African Republic,Chad,Chile,China,Christmas Island,Cocos (Keeling Islands),Colombia,Comoros,Congo,Cook Islands,Costa Rica,Cote D'Ivoire (Ivory Coast),Croatia (Hrvatska,Cuba,Cyprus,Czech Republic,Denmark,Djibouti,Dominica,Dominican Republic,East Timor,Ecuador,Egypt,El Salvador,Equatorial Guinea,Eritrea,Estonia,Ethiopia,Falkland Islands (Malvinas),Faroe Islands,Fiji,Finland,France,France,metropolitan,French Guiana,French Polynesia,French Southern Territories,Gabon,Gambia,Georgia,Germany,Ghana,Gibraltar,Greece,Greenland,Grenada,Guadeloupe,Guam,Guatemala,Guinea,Guinea-Bissau,Guyana,Haiti,Heard and McDonald Islands,Honduras,Hong Kong,Hungary,Iceland,India,Indonesia,Iran,Iraq,Ireland,Israel,Italy,Jamaica,Japan,Jordan,Kazakhstan,Kenya,Kiribati,Korea (North),Korea (South),Kuwait,Kyrgyzstan,Laos,Latvia,Lebanon,Lesotho,Liberia,Libya,Liechtenstein,Lithuania,Luxemburg,Macao,Macedonia,Madagascar,Malawi,Malaysia,Maldives,Mali,Malta,Marshall Islands,Martinique,Mauritania,Mauritius,Mayotte,Mexico,Micronesia,Moldova,Monaco,Mongolia,Montenegro,Montserrat,Morocco,Mozambique,Myanmar,Namibia,Nauru,Nepal,Netherlands,Netherlands Antilles,New Caledonia,New Zealand,Nicaragua,Niger,Nigeria,Niue,Norfolk Island,Northern Mariana Islands,Norway,Oman,Pakistan,Palau,Panama,Papua New Guinea,Paraguay,Peru,Philippines,Pitcairn,Poland,Portugal,Porto Rico,Qatar,Reunion,Romania,Russian Federation,Rwanda,Saint Kitts and Nevis,Saint
Examples of custom visual scripts

The following examples perform equivalent transformations. However, the second example (SparkSQL) is the cleanest and most efficient, followed by the Pandas UDF and finally the low level mapping in the first example. The following example is a complete example of a simple transformation to add up two columns:

```python
from awsglue import DynamicFrame

# You can have other auxiliary variables, functions or classes on this file, it won't affect the runtime
def record_sum(rec, col1, col2, resultCol):
    rec[resultCol] = rec[col1] + rec[col2]
    return rec

# The number and name of arguments must match the definition on json config file
# (expect self which is the current DynamicFrame to transform
```
def custom_add_columns(self, col1, col2, resultCol="result"):  
    # The mapping will alter the columns order, which could be important  
    fields = [field.name for field in self.schema()]  
    if resultCol not in fields:  
        # If it's a new column put it at the end  
        fields.append(resultCol)  
    return self.map(lambda record: record_sum(record, col1, col2, 
        resultCol)).select_fields(paths=fields)

DynamicFrame.custom_add_columns = custom_add_columns

from awsglue import DynamicFrame

# The number and name of arguments must match the definition on json config file  
# (expect self which is the current DynamicFrame to transform  
# If an argument is optional, you need to define a default value here  
# (resultCol in this example is an optional argument)  
def custom_add_columns(self, col1, col2, resultCol="result"):  
    df = self.toDF()  
    return DynamicFrame.fromDF( 
        df.withColumn(resultCol, df[col1] + df[col2]) # This is the conversion logic  
    , self.glue_ctx, self.name)

DynamicFrame.custom_add_columns = custom_add_columns

from awsglue import DynamicFrame
import pandas as pd
from pyspark.sql.functions import pandas_udf

from awsglue import DynamicFrame
import pandas as pd
from pyspark.sql.functions import pandas_udf

The following example is an equivalent transform leveraging the SparkSQL API.

The following example uses the same transformations but using a pandas UDF, which is more efficient than using a plain UDF. For more information about writing pandas UDFs see: [Apache Spark SQL documentation](https://spark.apache.org/docs/latest/api/python/pyspark.sql.html#pandas-udf).

from awsglue import DynamicFrame
import pandas as pd
from pyspark.sql.functions import pandas_udf
# The number and name of arguments must match the definition on json config file
# (expect self which is the current DynamicFrame to transform
# If an argument is optional, you need to define a default value here
# (resultCol in this example is an optional argument)
def custom_add_columns(self, col1, col2, resultCol="result"):
    @pandas_udf("integer")  # We need to declare the type of the result column
    def add_columns(value1: pd.Series, value2: pd.Series) # pd.Series:
        return value1 + value2

df = self.toDF()
return DynamicFrame.fromDF(
    df.withColumn(resultCol, add_columns(col1, col2))  # This is the conversion logic
    , self.glue_ctx, self.name)

# The name we assign on DynamicFrame must match the configured "functionName"
DynamicFrame.custom_add_columns = custom_add_columns

Video

The following video provides an introduction to visual custom transforms and demonstrates how to use them.

Using Data Lake frameworks with AWS Glue Studio

Overview

Open source data lake frameworks simplify incremental data processing for files stored in data lakes built on Amazon S3. AWS Glue 3.0 and later supports the following open-source data lake storage frameworks:

- Apache Hudi
- Linux Foundation Delta Lake
- Apache Iceberg

As of AWS Glue 4.0, AWS Glue provides native support for these frameworks so that you can read and write data that you store in Amazon S3 in a transactionally consistent manner. There's no need to install a separate connector or complete extra configuration steps in order to use these frameworks in AWS Glue jobs.
Data Lake frameworks can be used as a source or a target within AWS Glue Studio through Spark Script Editor jobs. For more information on using Apache Hudi, Apache Iceberg and Delta Lake see: Using data lake frameworks with AWS Glue ETL jobs.

Creating open table formats from an AWS Glue Streaming source

AWS Glue streaming ETL jobs continuously consume data from streaming sources, clean and transform the data in-flight, and make it available for analysis in seconds.

AWS offers a broad selection of services to support your needs. A database replication service such as AWS Database Migration Service can replicate the data from your source systems to Amazon S3, which commonly hosts the storage layer of the data lake. Although it's straightforward to apply updates on a relational database management system (RDBMS) that backs an online source application, it's difficult to apply this CDC process on your data lakes. The open-source data management frameworks simplify incremental data processing and data pipeline development, and are a good option to solve this problem.

For more information, see:

- Create an Apache Hudi-based near-real-time transactional data lake using AWS Glue Streaming
- Build a real-time GDPR-aligned Apache Iceberg data lake

Using Hudi framework in AWS Glue Studio

When creating or editing a job, AWS Glue Studio automatically adds the corresponding Hudi libraries for you depending on the version of AWS Glue you are using. For more information, see Using the Hudi framework in AWS Glue.

Using Apache Hudi framework in Data Catalog data sources

To add a Hudi data source format to a job:

1. From the Source menu, choose AWS Glue Studio Data Catalog.
2. In the Data source properties tab, choose a database and table.
3. AWS Glue Studio displays the format type as Apache Hudi and the Amazon S3 URL.
Using Hudi framework in Amazon S3 data sources

1. From the Source menu, choose Amazon S3.
2. If you choose Data Catalog table as the Amazon S3 source type, choose a database and table.
3. AWS Glue Studio displays the format as Apache Hudi and the Amazon S3 URL.
4. If you choose Amazon S3 location as the Amazon S3 source type, choose the Amazon S3 URL by clicking Browse Amazon S3.
5. In Data format, select Apache Hudi.

Note
If AWS Glue Studio is unable to infer the schema from the Amazon S3 folder or file you selected, choose Additional options to select a new folder or file.

In Additional options choose from the following options under Schema inference:

- Let AWS Glue Studio automatically choose a sample file — AWS Glue Studio will choose a sample file in the Amazon S3 location so that the schema can be inferred. In the Auto-sampled file field, you can view the file that was automatically selected.
- Choose a sample file from Amazon S3 — choose the Amazon S3 file to use by clicking Browse Amazon S3.
6. Click **Infer schema**. You can then view the output schema by clicking on the **Output schema** tab.

7. Choose **Additional options** to enter a key-value pair.

   Additional options  **Info**  
   Enter additional key-value pairs for your data source connection.

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   [Add new option]

**Using Apache Hudi framework in data targets**

**Using Apache Hudi framework in Data Catalog data targets**

1. From the **Target** menu, choose AWS Glue Studio Data Catalog.
2. In the **Data source properties** tab, choose a database and table.
3. AWS Glue Studio displays the format type as Apache Hudi and the Amazon S3 URL.

**Using Apache Hudi framework in Amazon S3 data targets**

Enter values or select from the available options to configure Apache Hudi format. For more information on Apache Hudi, see [Apache Hudi documentation](#).
### Node properties

#### Data target properties - S3

**Format**
- Apache Hudi

**Hudi Table Name**

**Hudi Storage Type**
- Copy on write
  - Recommended for optimizing read performance
- Merge on read
  - Recommended for minimizing write latency

**Hudi Write Operation**
- Upsert

**Hudi Record Key Fields**
- Set your primary key(s)

  - Select a source location to view schema

**Hudi Deduplicate Records by Field Value**
- Set your field to choose the largest value when inserting records with duplicate key(s)

  - Select a source location to view schema

**Compression Type**
- GZIP

**S3 Target Location**
- Choose an S3 location in the format s3://bucket/prefix/object/ with a trailing slash (/).

  - View
  - Browse S3

### Data Catalog update options

**Info**
- Choose how you want to update the Data Catalog table’s schema and partitions. These options will only apply if the Data Catalog table is an S3 backed source.

- Do not update the Data Catalog
- Create a table in the Data Catalog and on subsequent runs, update the schema and add new partitions
- Create a table in the Data Catalog and on subsequent runs, keep existing schema and add new partitions

**Partition keys - optional**
- Add partition keys.
• **Hudi Table Name** — this is the name of your hudi table.

• **Hudi Storage Type** — choose from two options:
  - **Copy on write** — recommended for optimizing read performance. This is the default Hudi storage type. Each update creates a new version of files during a write.
  - **Merge on read** — recommended for minimizing write latency. Updates are logged to row-based delta files and are compacted as needed to create new versions of the columnar files.

• **Hudi Write Operation** - choose from the following options:
  - **Upsert** — this is the default operation where the input records are first tagged as inserts or updates by looking up the index. Recommended where you are updating existing data.
  - **Insert** — this inserts records but doesn't check for existing records and may result in duplicates.
  - **Bulk Insert** — this inserts records and is recommended for large amounts of data.

• **Hudi Record Key Fields** — use the search bar to search for and choose primary record keys. Records in Hudi are identified by a primary key which is a pair of record key and partition path where the record belongs to.

• **Hudi Precombine Field** — this is the field used in preCombining before actual write. When two records have the same key value, AWS Glue Studio will pick the one with the largest value for the precombine field. Set a field with incremental value (e.g. updated_at) belongs to.

• **Compression Type** — choose from one of the compression type options: Uncompressed, GZIP, LZO, or Snappy.

• **Amazon S3 Target Location** — choose the Amazon S3 target location by clicking *Browse S3*. 

• **Data Catalog update options** — choose from the following options:
  - Do not update the Data Catalog: (Default) Choose this option if you don't want the job to update the Data Catalog, even if the schema changes or new partitions are added.
  - Create a table in the Data Catalog and on subsequent runs, update the schema and add new partitions: If you choose this option, the job creates the table in the Data Catalog on the first run of the job. On subsequent job runs, the job updates the Data Catalog table if the schema changes or new partitions are added.

You must also select a database from the Data Catalog and enter a table name.

• Create a table in the Data Catalog and on subsequent runs, keep existing schema and add new partitions: If you choose this option, the job creates the table in the Data Catalog on the first run of the job. On subsequent job runs, the job updates the Data Catalog table only to add new partitions.
You must also select a database from the Data Catalog and enter a table name.

- **Partition keys**: Choose which columns to use as partitioning keys in the output. To add more partition keys, choose Add a partition key.
- **Additional options** — enter a key-value pair as needed.

**Generating code through AWS Glue Studio**

When the job is saved, the following job parameters are added to the job if a Hudi source or target are detected:

- **--datalake-formats** – a distinct list of data lake formats detected in the visual job (either directly by choosing a “Format” or indirectly by selecting a catalog table that is backed by a data lake).
- **--conf** — generated based on the value of **--datalake-formats**. For example, if the value for **--datalake-formats** is 'hudi', AWS Glue generates a value of `spark.serializer=org.apache.spark.serializer.KryoSerializer` —conf `spark.sql.hive.convertMetastoreParquet=false` for this parameter.

**Overriding AWS Glue-provided libraries**

To use a version of Hudi that AWS Glue doesn't support, you can specify your own Hudi library JAR files. To use your own JAR file:

- use the **--extra-jars** job parameter. For example, `'--extra-jars': 's3path/to/jarfile.jar'`. For more information, see [AWS Glue job parameters](#).
- do not include `hudi` as a value for the **--datalake-formats** job parameter. Entering a blank string as a value ensures that no data lake libraries are provided for you by AWS Glue automatically. For more information, see [Using the Hudi framework in AWS Glue](#).

**Using Delta Lake framework in AWS Glue Studio**

**Using Delta Lake framework in data sources**

**Using Delta Lake framework in Amazon S3 data sources**

1. From the Source menu, choose Amazon S3.
2. If you choose Data Catalog table as the Amazon S3 source type, choose a database and table.

3. AWS Glue Studio displays the format as Delta Lake and the Amazon S3 URL.

4. Choose **Additional options** to enter a key-value pair. For example, a key-value pair could be: **key**: timestampAsOf and **value**: 2023-02-24 14:16:18.

Additional options

Enter additional key-value pairs for your data source connection.

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Add new option]

5. If you choose Amazon S3 location as the **Amazon S3 source type**, choose the Amazon S3 URL by clicking **Browse Amazon S3**.

6. In **Data format**, choose Delta Lake.

**Note**

If AWS Glue Studio is unable to infer the schema from the Amazon S3 folder or file you selected, choose **Additional options** to select a new folder or file. In **Additional options**, choose from the following options under **Schema inference**:

- Let AWS Glue Studio automatically choose a sample file — AWS Glue Studio will choose a sample file in the Amazon S3 location so that the schema can be inferred. In the **Auto-sampled file** field, you can view the file that was automatically selected.
- Choose a sample file from Amazon S3 — choose the Amazon S3 file to use by clicking **Browse Amazon S3**.

7. Click **Infer schema**. You can then view the output schema by clicking on the **Output schema** tab.

**Using Delta Lake framework in Data Catalog data sources**

1. From the **Source** menu, choose AWS Glue Studio Data Catalog.

2. In the **Data source properties** tab, choose a database and table.
3. AWS Glue Studio displays the format type as Delta Lake and the Amazon S3 URL.

**Note**

If your Delta Lake source is not registered as the AWS Glue Data Catalog table yet, you have two options:

1. Create an AWS Glue crawler for the Delta Lake data store. For more information, see [How to specify configuration options for a Delta Lake data store](#).
2. Use an Amazon S3 data source to select your Delta Lake data source. See [Using Delta Lake framework in Amazon S3 data sources](#).

---

**Using Delta Lake formats in data targets**

**Using Delta Lake formats in Data Catalog data targets**

1. From the **Target** menu, choose AWS Glue Studio Data Catalog.
2. In the **Data source properties** tab, choose a database and table.
3. AWS Glue Studio displays the format type as Delta Lake and the Amazon S3 URL.

**Using Delta Lake formats in Amazon S3 data sources**

Enter values or select from the available options to configure Delta Lake format.

- **Compression Type** — choose from one of the compression type options: Uncompressed or Snappy.
- **Amazon S3 Target Location** — choose the Amazon S3 target location by clicking **Browse S3**.
- **Data Catalog update options** — updating the Data Catalog is not supported for this format in the Glue Studio visual editor.
  - Do not update the Data Catalog: (Default) Choose this option if you don't want the job to update the Data Catalog, even if the schema changes or new partitions are added.
  - To update the Data Catalog after the AWS Glue job execution, run or schedule a AWS Glue crawler. For more information, see [How to specify configuration options for a Delta Lake data store](#).
- **Partition keys** — Choose which columns to use as partitioning keys in the output. To add more partition keys, choose **Add a partition key**.
• Optionally, choose **Additional options** to enter a key-value pair. For example, a key-value pair could be: **key**: timestampAsOf and **value**: 2023-02-24 14:16:18.

**Using Apache Iceberg framework in AWS Glue Studio**

**Using Apache Iceberg framework in data targets**

**Using Apache Iceberg framework in Data Catalog data targets**

1. From the **Target** menu, choose AWS Glue Studio Data Catalog.
2. In the **Data source properties** tab, choose a database and table.
3. AWS Glue Studio displays the format type as Apache Iceberg and the Amazon S3 URL.

**Using Apache Iceberg framework in Amazon S3 data targets**

Enter values or select from the available options to configure Apache Iceberg format.

• **Format** – choose **Apache Iceberg** from the drop-down menu.

• **Amazon S3 Target Location** – choose the Amazon S3 target location by clicking **Browse S3**.

• **Data Catalog update options** – Create a table in the Data Catalog and on subsequent runs, keep existing schema and add new partitions must be selected to proceed. Writing a new Iceberg table using AWS Glue requires the Data Catalog to be configured as the catalog for the Iceberg table. To update an existing Iceberg table that has been registered in the Data Catalog, choose Data Catalog as the target.

• **Database** – Choose the database from the Data Catalog.

• **Table Name** – Enter the value for your table name. Apache Iceberg table names must be in all lower case. Use underscores if needed since spaces are not allowed. For example "data_lake_format_tables".
### Using Apache Iceberg framework in Amazon S3 data sources

### Using Apache Iceberg framework in Data Catalog data sources

1. From the **Source** menu, choose AWS Glue Studio Data Catalog.
2. In the **Data source properties** tab, choose a database and table.
3. AWS Glue Studio displays the format type as Apache Iceberg and the Amazon S3 URL.
### Using Apache Iceberg framework in Amazon S3 data sources

Apache Iceberg is not available as a data option for Amazon S3 source nodes in AWS Glue Studio.

#### Configuring data target nodes

The data target is where the job writes the transformed data.

#### Overview of data target options

Your data target (also called a *data sink*) can be:

<table>
<thead>
<tr>
<th>Node properties</th>
<th>Data source properties - S3</th>
<th>Output schema</th>
<th>Data preview</th>
</tr>
</thead>
</table>

**S3 source type**
- **S3 location**
  - Choose a file or folder in an S3 bucket.
- **Data Catalog table**

**Database**
Choose a database.

```plaintext
data_lake_format_tables
```

**Table**

```plaintext
source_iceberg
```

**Format**
Apache Iceberg

**S3 URL**

```plaintext
s3://data-lake-format-data/Iceberg/
```

**Partition predicate - optional**
Enter a boolean expression supported by Spark SQL, using only partition columns.

Partition predicate syntax for Spark SQL is year = year(date_sub(current_date, 7)) AND month = month(date_sub(current_date, 7)) AND day = day(date_sub(current_date, 7)).
• S3 – The job writes the data in a file in the Amazon S3 location you choose and in the format you specify.

If you configure partition columns for the data target, then the job writes the dataset to Amazon S3 into directories based on the partition key.

• AWS Glue Data Catalog – The job uses the information associated with the table in the Data Catalog to write the output data to a target location.

You can create the table manually or with the crawler. You can also use AWS CloudFormation templates to create tables in the Data Catalog.

• A connector – A connector is a piece of code that facilitates communication between your data store and AWS Glue. The job uses the connector and associated connection to write the output data to a target location. You can either subscribe to a connector offered in AWS Marketplace, or you can create your own custom connector. For more information, see Adding connectors to AWS Glue Studio.

You can choose to update the Data Catalog when your job writes to an Amazon S3 data target. Instead of requiring a crawler to update the Data Catalog when the schema or partitions change, this option makes it easy to keep your tables up to date. This option simplifies the process of making your data available for analytics by optionally adding new tables to the Data Catalog, updating table partitions, and updating the schema of your tables directly from the job.

Editing the data target node

The data target is where the job writes the transformed data.

To add or configure a data target node in your job diagram

1. (Optional) If you need to add a target node, choose Target in the toolbar at the top of the visual editor, and then choose either S3 or Glue Data Catalog.

   • If you choose S3 for the target, then the job writes the dataset to one or more files in the Amazon S3 location you specify.
   • If you choose AWS Glue Data Catalog for the target, then the job writes to a location described by the table selected from the Data Catalog.

2. Choose a data target node in the job diagram. When you choose a node, the node details panel appears on the right-side of the page.

3. Choose the Node properties tab, and then enter the following information:
• **Name**: Enter a name to associate with the node in the job diagram.

• **Node type**: A value should already be selected, but you can change it as needed.

• **Node parents**: The parent node is the node in the job diagram that provides the output data you want to write to the target location. For a pre-populated job diagram, the target node should already have the parent node selected. If there is no parent node displayed, then choose a parent node from the list.

A target node has a single parent node.

4. Configure the **Data target properties** information. For more information, see the following sections:

   • [Using Amazon S3 for the data target](#)
   
   • [Using Data Catalog tables for the data target](#)
   
   • [Using a connector for the data target](#)

5. (Optional) After configuring the data target node properties, you can view the output schema for your data by choosing the **Output schema** tab in the node details panel. The first time you choose this tab for any node in your job, you are prompted to provide an IAM role to access the data. If you have not specified an IAM role on the **Job details** tab, you are prompted to enter an IAM role here.

**Using Amazon S3 for the data target**

For all data sources except Amazon S3 and connectors, a table must exist in the AWS Glue Data Catalog for the source type that you choose. AWS Glue Studio does not create the Data Catalog table.

**To configure a data target node that writes to Amazon S3**

1. Go to the visual editor for a new or saved job.
2. Choose a data source node in the job diagram.
3. Choose the **Data source properties** tab, and then enter the following information:

   • **Format**: Choose a format from the list. The available format types for the data results are:
     
     • **JSON**: JavaScript Object Notation.
     
     • **CSV**: Comma-separated values.
- **Avro**: Apache Avro JSON binary.
- **Parquet**: Apache Parquet columnar storage.
- **Glue Parquet**: A custom Parquet writer type that is optimized for DynamicFrames as the data format. Instead of requiring a precomputed schema for the data, it computes and modifies the schema dynamically.
- **ORC**: Apache Optimized Row Columnar (ORC) format.

To learn more about these format options, see [Format Options for ETL Inputs and Outputs in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/) in the *AWS Glue Developer Guide*.

- **Compression Type**: You can choose to optionally compress the data using either the gzip or bzip2 format. The default is no compression, or None.

- **S3 Target Location**: The Amazon S3 bucket and location for the data output. You can choose the [Browse S3](https://aws.amazon.com/) button to see the Amazon S3 buckets that you have access to and choose one as the target destination.

- **Data catalog update options**
  - **Do not update the Data Catalog**: (Default) Choose this option if you don't want the job to update the Data Catalog, even if the schema changes or new partitions are added.
  
  - **Create a table in the Data Catalog and on subsequent runs, update the schema and add new partitions**: If you choose this option, the job creates the table in the Data Catalog on the first run of the job. On subsequent job runs, the job updates the Data Catalog table if the schema changes or new partitions are added.

  You must also select a database from the Data Catalog and enter a table name.

  - **Create a table in the Data Catalog and on subsequent runs, keep existing schema and add new partitions**: If you choose this option, the job creates the table in the Data Catalog on the first run of the job. On subsequent job runs, the job updates the Data Catalog table only to add new partitions.

    You must also select a database from the Data Catalog and enter a table name.

  - **Partition keys**: Choose which columns to use as partitioning keys in the output. To add more partition keys, choose **Add a partition key**.
Using Data Catalog tables for the data target

For all data sources except Amazon S3 and connectors, a table must exist in the AWS Glue Data Catalog for the target type that you choose. AWS Glue Studio does not create the Data Catalog table.

To configure the data properties for a target that uses a Data Catalog table

1. Go to the visual editor for a new or saved job.
2. Choose a data target node in the job diagram.
3. Choose the Data target properties tab, and then enter the following information:

   - **Database**: Choose the database that contains the table you want to use as the target from the list. This database must already exist in the Data Catalog.
   - **Table**: Choose the table that defines the schema of your output data from the list. This table must already exist in the Data Catalog.

A table in the Data Catalog consists of the names of columns, data type definitions, partition information, and other metadata about the target dataset. Your job writes to a location described by this table in the Data Catalog.

For more information about creating tables in the Data Catalog, see Defining Tables in the Data Catalog in the AWS Glue Developer Guide.

- **Data catalog update options**
  - **Do not change table definition**: (Default) Choose this option if you don't want the job to update the Data Catalog, even if the schema changes, or new partitions are added.
  - **Update schema and add new partitions**: If you choose this option, the job updates the Data Catalog table if the schema changes or new partitions are added.
  - **Keep existing schema and add new partitions**: If you choose this option, the job updates the Data Catalog table only to add new partitions.
  - **Partition keys**: Choose which columns to use as partitioning keys in the output. To add more partition keys, choose Add a partition key.

Using a connector for the data target

If you select a connector for the Node type, follow the instructions at Authoring jobs with custom connectors to finish configuring the data target properties.
Editing or uploading a job script

Use the AWS Glue Studio visual editor to edit the job script or upload your own script.

You can use the visual editor to edit job nodes only if the jobs were created with AWS Glue Studio. If the job was created using the AWS Glue console, through API commands, or with the command line interface (CLI), you can use the script editor in AWS Glue Studio to edit the job script, parameters, and schedule. You can also edit the script for a job created in AWS Glue Studio by converting the job to script-only mode.

To edit the job script or upload your own script

1. If creating a new job, on the Jobs page, choose the Spark script editor option to create a Spark job or choose the Python Shell script editor to create a Python shell job. You can either write a new script, or upload an existing script. If you choose Spark script editor, you can write or upload either a Scala or Python script. If you choose Python Shell script editor, you can only write or upload a Python script.

   After choosing the option to create a new job, in the Options section that appears, you can choose to either start with a starter script (Create a new script with boilerplate code), or you can upload a local file to use as the job script.

   If you chose Spark script editor, you can upload either Python or Scala script files. Scala scripts must have the file extension .scala. Python scripts must be recognized as files of type Python. If you chose Python Shell script editor, you can upload only Python script files.

   When you are finished making your choices, choose Create to create the job and open the visual editor.

2. Go to the visual job editor for the new or saved job, and then choose the Script tab.

3. If you didn't create a new job using one of the script editor options, and you have never edited the script for an existing job, the Script tab displays the heading Script (Locked). This means the script editor is in read-only mode. Choose Edit script to unlock the script for editing.

   To make the script editable, AWS Glue Studio converts your job from a visual job to a script-only job. If you unlock the script for editing, you can't use the visual editor anymore for this job after you save it.

   In the confirmation window, choose Confirm to continue or Cancel to keep the job available for visual editing.
If you choose **Confirm**, the **Visual** tab no longer appears in the editor. You can use AWS Glue Studio to modify the script using the script editor, modify the job details or schedule, or view job runs.

**Note**

Until you save the job, the conversion to a script-only job is not permanent. If you refresh the console web page, or close the job before saving it and reopen it in the visual editor, you will still be able to edit the individual nodes in the visual editor.

4. Edit the script as needed.

   When you are done editing the script, choose **Save** to save the job and permanently convert the job from visual to script-only.

5. (Optional) You can download the script from the AWS Glue Studio console by choosing the **Download** button on the **Script** tab. When you choose this button, a new browser window opens, displaying the script from its location in Amazon S3. The **Script filename** and **Script path** parameters in the **Job details** tab of the job determine the name and location of the script file in Amazon S3.
When you save the job, AWS Glue save the job script at the location specified by these fields. If you modify the script file at this location within Amazon S3, AWS Glue Studio will load the modified script the next time you edit the job.

Creating and editing Scala scripts in AWS Glue Studio

When you choose the script editor for creating a job, by default, the job programming language is set to Python 3. If you choose to write a new script instead of uploading a script, AWS Glue Studio starts a new script with boilerplate text written in Python. If you want to write a Scala script instead, you must first configure the script editor to use Scala.

Note

If you choose Scala as the programming language for the job and use the visual editor to design your job, the generated job script is written in Scala, and no further actions are needed.
To write a new Scala script in AWS Glue Studio

1. Create a new job by choosing the **Spark script editor** option.
2. Under **Options**, choose **Create a new script with boilerplate code**.
3. Choose the **Job details** tab and set **Language** to Scala (instead of Python 3).

   **Note**
   The **Type** property for the job is automatically set to Spark when you choose the **Spark script editor** option to create a job.

4. Choose the **Script** tab.
5. Remove the Python boilerplate text. You can replace it with the following Scala boilerplate text.

   ```scala
   import com.amazonaws.services.glue.{DynamicRecord, GlueContext}
   import org.apache.spark.SparkContext
   import com.amazonaws.services.glue.util.JsonOptions
   import com.amazonaws.services.glue.util.GlueArgParser
   import com.amazonaws.services.glue.util.Job

   object MyScript {
     def main(args: Array[String]): Unit = {
       val sc: SparkContext = new SparkContext()
       val glueContext: GlueContext = new GlueContext(sc)
     }
   }
   ```

6. Write your Scala job script in the editor. Add additional `import` statements as needed.

Creating and editing Python shell jobs in AWS Glue Studio

When you choose the Python shell script editor for creating a job, you can upload an existing Python script, or write a new one. If you choose to write a new script, boilerplate code is added to the new Python job script.

**To create a new Python shell job**

Refer to the instructions at [Starting jobs in AWS Glue Studio](#).
The job properties that are supported for Python shell jobs are not the same as those supported for Spark jobs. The following list describes the changes to the available job parameters for Python shell jobs on the Job details tab.

- The Type property for the job is automatically set to Python Shell and can't be changed.
- Instead of Language, there is a Python version property for the job. Currently, Python shell jobs created in AWS Glue Studio use Python 3.6.
- The Glue version property is not available, because it does not apply to Python shell jobs.
- Instead of Worker type and Number of workers, a Data processing units property is shown instead. This job property determines how many data processing units (DPUs) are consumed by the Python shell when running the job.
- The Job bookmark property is not available, because it is not supported for Python shell jobs.
- Under Advanced properties, the following properties are not available for Python shell jobs.
  - Job metrics
  - Continuous logging
  - Spark UI and Spark UI logs path
  - Dependent jars path, under the heading Libraries

### Changing the parent nodes for a node in the job diagram

You can change a node's parents to move nodes within the job diagram or to change a data source for a node.

**To change the parent node**

1. Choose the node in the job diagram that you want to modify.
2. In the node details panel, on the Node properties tab, under the heading Node parents remove the current parent for the node.
3. Choose a new parent node from the list.
4. Modify the other properties of the node as needed to match the newly selected parent node.

If you modified a node by mistake, you can use the Undo button on the toolbar to reverse the action.
Deleting nodes from the job diagram

You can remove nodes from the job diagram.

To remove a node

1. Go to the visual editor for a new or saved job and choose the Visual tab.
2. Choose the node you want to remove.
3. In the toolbar at the top of the visual editing pane, choose the Remove button.
4. If the node you removed had children nodes, modify the parents for those nodes as needed.

If you removed a node by mistake, you can use the Undo button on the toolbar to reverse the action.

Adding source and target parameters to the AWS Glue Data Catalog node

AWS Glue Studio allows you to parameterize visual jobs. Since catalog table names in production and development environment may be different, you can define and select runtime parameters for databases and tables that will run when your job runs.

Job parameterization allows you to parameterize sources and targets, and save those parameters to the job when using the AWS Glue Data Catalog node. When you specify sources and targets as parameters, you are enabling the reusability of jobs, particularly when using the same job in multiple environments. This is useful when promoting code across deployment environments by saving time and effort in managing your sources and targets. In addition, the custom parameters you specify will override any default arguments for specific runs of AWS Glue jobs.

To add source and target parameters

Whether you are using the AWS Glue Data Catalog node as a source or a target, you can define runtime parameters in the Advanced properties section on the Job details tab.

1. Choose the AWS Glue Data Catalog node as either the source node or the target node.
2. Choose the Job details tab.
3. Choose Advanced properties.
4. In the Job parameters section, enter a key value. For example, --db.source would be the parameter for a database source. You can enter any name for the key, as long as the key name is followed by the 'dash dash'.

<table>
<thead>
<tr>
<th>Job parameters</th>
<th>Key</th>
<th>Value - optional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add new parameter</td>
<td></td>
<td>Remove</td>
</tr>
</tbody>
</table>

5. Enter the value. For example, databasename would be the value for database being parameterized.

6. Choose Add new parameter if you want to add more parameters. Max 50 parameters is allowed. Once the key value pair has been defined, you can use the parameter in the AWS Glue Data Catalog node.

To select a runtime parameter

**Note**

The process to select runtime parameters for databases and tables is the same whether the the AWS Glue Data Catalog node is the source or the target.

1. Choose the AWS Glue Data Catalog node as either the source node or the target node.

2. In the Data source properties - Data Catalog tab, under Database, choose Use runtime parameters.
3. Choose a parameter from the drop-down menu. For example, when you select a parameter you defined for a source database, the database will automatically populate in the database drop-down menu when you choose **Apply**.

4. In the Table section, choose a parameter you already defined as a source table. When you choose **Apply**, the table is automatically populated as the table to use.

5. When you save and run the job, AWS Glue Studio will reference the selected parameters during the job run.

**Using Git version control systems in AWS Glue**

![Image](https://example.com)

### Note

Notebooks are not currently supported for version control in AWS Glue Studio. However, version control for AWS Glue job scripts and visual ETL jobs are supported.

If you have remote repositories and want to manage your AWS Glue jobs using your repositories, you can use AWS Glue Studio or the AWS CLI to sync changes to your repositories and your jobs in AWS Glue. When you sync changes this way, you're pushing the job from AWS Glue Studio to your repository, or pulling from the repository to AWS Glue Studio.

With Git integration in AWS Glue Studio, you can:

- Integrate with Git version control systems, such as AWS CodeCommit, GitHub, GitLab, and Bitbucket
- Edit AWS Glue jobs in AWS Glue Studio whether you use visual jobs or script jobs and sync them to a repository
Parameterize sources and targets in jobs

Pull jobs from a repository and edit them in AWS Glue Studio

Test jobs by pulling from branches and/or pushing to branches utilizing multi-branch workflows in AWS Glue Studio

Download files from a repository and upload jobs into AWS Glue Studio for cross-account job creation

Use your automation tool of choice (for example, Jenkins, AWS CodeDeploy, etc.)

This video demonstrates how you can integrate AWS Glue with Git and build a continuous and collaborative code pipeline.

**IAM permissions**

Ensure the job has one of the following IAM permissions. For more information on how to set up IAM permissions, see [Set up IAM permissions for AWS Glue Studio](#).

- AWSGlueServiceRole
- AWSGlueConsoleFullAccess

At minimum, the following actions are needed for Git integration:

- `glue:UpdateJobFromSourceControl` — to be able to update AWS Glue with a job present in a version control system
- `glue:UpdateSourceControlFromJob` — to be able to update the version control system with a job stored in AWS Glue
- `s3:GetObject` — to be able to retrieve the script for the job while pushing to version control system
- `s3:PutObject` — to be able to update the script when pulling a job from a source control system

**Prerequisites**

In order to push jobs to a source control repository, you will need:

- a repository that has already been created by your administrator
- a branch in the repository
• a personal access token (for Bitbucket, this is the Repository Access Token)

• the username of the repository owner

• set permissions in the repository to allow AWS Glue Studio to read and write to the repository
  
  • **GitLab** – set token scopes to api, read_repository, and write_repository
  
  • **Bitbucket** – set permissions to:
    
    • **Workspace membership** – read, write
    
    • **Projects** – write, admin read
    
    • **Repositories** – read, write, admin, delete

**Note**

When using AWS CodeCommit, personal access token and repository owner are not needed. See [Getting started with Git and AWS CodeCommit](#).

**Using jobs from your source control repository in AWS Glue Studio**

In order to pull a job from your source control repository that is not in AWS Glue Studio, and to use that job in AWS Glue Studio, the prerequisites will depend on the type of job.

**For visual jobs:**

• you need a folder and a JSON file of the job definition that matches the job name

For example, see the job definition below. The branch in your repository should contain a path `my-visual-job/my-visual-job.json` where both the folder and the JSON file match the job name

```json
{
   "name" : "my-visual-job",
   "description" : "",
   "role" : "arn:aws:iam::aws_account_id:role/Rolename",
   "command" : {
      "name" : "glueetl",
      "scriptLocation" : "s3://foldername/scripts/my-visual-job.py",
      "pythonVersion" : "3"
   }
}
```
For script jobs:

- you need a folder, a JSON file of the job definition, and the script
- the folder and JSON file should match the job name. The script name needs to match the `scriptLocation` in the job definition along with the file extension

For example, in the job definition below, the branch in your repository should contain a path `my-script-job/my-script-job.json` and `my-script-job/my-script-job.py`. The script name should match the name in the `scriptLocation` including the extension of the script.

```json
{
   "name" : "my-script-job",
   "description" : "",
   "role" : "arn:aws:iam::aws_account_id:role/Rolename",
   "command" : {
      "name" : "glueetl",
      "scriptLocation" : "s3://foldername/scripts/my-script-job.py",
      "pythonVersion" : "3"
   }
}
```
Connecting version control repositories with AWS Glue

You can enter your version control repository details and manage them in the Version Control tab in the AWS Glue Studio job editor. To integrate with your Git repository, you must connect to your repository every time you log in to AWS Glue Studio.

To connect a Git version control system:

1. In AWS Glue Studio, start a new job and choose the Version Control tab.

2. In Version control system, choose the Git Service from the available options by clicking on the drop-down menu.
   - AWS CodeCommit
   - GitHub
   - GitLab
   - Bitbucket

3. Depending on the Git version control system you choose, you will have different fields to complete.

   For AWS CodeCommit:
Complete the repository configuration by selecting the repository and branch for your job:

- **Repository** — if you have set up repositories in AWS CodeCommit, select the repository from the drop-down menu. Your repositories will automatically populate in the list
- **Branch** — select the branch from the drop-down menu
- **Folder** — *optional* - enter the name of the folder in which to save your job. If left empty, a folder is automatically created. The folder name defaults to the job name

**For GitHub:**

Complete the GitHub configuration by completing the fields:

- **Personal access token** — this is the token provided by the GitHub repository. For more information on personal access tokens, see [GitHub Docs](#)
- **Repository owner** — this is the owner of the GitHub repository.

Complete the repository configuration by selecting the repository and branch from GitHub.

- **Repository** — if you have set up repositories in GitHub, select the repository from the drop-down menu. Your repositories will automatically populate in the list
- **Branch** — select the branch from the drop-down menu
- **Folder** — *optional* - enter the name of the folder in which to save your job. If left empty, a folder is automatically created. The folder name defaults to the job name

**For GitLab:**

- **Personal access token** — this is the token provided by the GitLab repository. For more information on personal access tokens, see [GitLab Personal access tokens](#)
- **Repository owner** — this is the owner of the GitLab repository.

Complete the repository configuration by selecting the repository and branch from GitLab.

- **Repository** — if you have set up repositories in GitLab, select the repository from the drop-down menu. Your repositories will automatically populate in the list
• **Branch** — select the branch from the drop-down menu

• **Folder** — *optional* - enter the name of the folder in which to save your job. If left empty, a folder is automatically created. The folder name defaults to the job name

**For Bitbucket:**

• **Personal access token** — this is the Repository Access Token provided by the Bitbucket repository. For more information on Repository Access Tokens, see [Create a Repository Access Token](#).

• **Repository owner** — this is the owner of the Bitbucket repository. In Bitbucket, the owner is the creator of the repository.

Complete the repository configuration by selecting the workspace, repository, branch, and folder from Bitbucket.

• **Workspace** – if you have workspaces set up in Bitbucket, select the workspace from the drop-down menu. Your workspaces are automatically populated

• **Repository** — if you have set up repositories in Bitbucket, select the repository from the drop-down menu. Your repositories are automatically populated

• **Branch** — select the branch from the drop-down menu. Your branches are automatically populated

• **Folder** — *optional* - enter the name of the folder in which to save your job. If left empty, a folder is automatically created with the job name.

4. Choose **Save** at the top of the AWS Glue Studio job

### Pushing AWS Glue jobs to the source repository

Once you've entered the details of your version control system, you can edit jobs in AWS Glue Studio and push the jobs to your source repository. If you're unfamiliar with Git concepts such as pushing and pulling, see this tutorial on [Getting started with Git and AWS CodeCommit](#).

In order to push your job to a repository, you need to enter the details of your version control system and save your job.

1. In the AWS Glue Studio job, choose **Actions**. This will open additional menu options.
2. Choose **Push to repository**.

This action will save the job. When you push to repository, AWS Glue Studio pushes the last saved change. If the job in the repository was modified by you or another user and is out of sync with the job in AWS Glue Studio, the job in the repository is overwritten with the job saved in AWS Glue Studio when you push the job from AWS Glue Studio.

3. Choose **Confirm** to complete the action. This creates a new commit in the repository. If you are using AWS CodeCommit, a confirmation message will display a link to the latest commit on AWS CodeCommit.

**Pulling AWS Glue jobs from the source repository**

Once you've entered details of your Git repository into the **Version control** tab, you can also pull jobs from your repository and edit them in AWS Glue Studio.

1. In the AWS Glue Studio job, choose **Actions**. This will open additional menu options.
2. Choose **Pull from repository**.

3. Choose **Confirm**. This takes the latest commit from the repository and updates your job in AWS Glue Studio.

4. Edit your job in AWS Glue Studio. If you make changes, you can sync your job to your repository by choosing **Push to repository** from the **Actions** drop-down menu.

**Authoring code with AWS Glue Studio notebooks**

Data engineers can author AWS Glue jobs faster and more easily than before using the interactive notebook interface in AWS Glue Studio or interactive sessions in AWS Glue.

**Topics**

- [Overview of using notebooks](#)
- [Creating an ETL job using notebooks in AWS Glue Studio](#)
- [Notebook editor components](#)
- [Saving your notebook and job script](#)
- [Managing notebook sessions](#)
- [Using CodeWhisperer with AWS Glue Studio notebooks](#)
Overview of using notebooks

AWS Glue Studio allows you to interactively author jobs in a notebook interface based on Jupyter Notebooks. Through notebooks in AWS Glue Studio, you can edit job scripts and view the output without having to run a full job, and you can edit data integration code and view the output without having to run a full job, and you can add markdown and save notebooks as .ipynb files and job scripts. You can start a notebook without installing software locally or managing servers. When you are satisfied with your code, AWS Glue Studio can convert your notebook to a Glue job with the click of a button.

Some benefits of using notebooks include:

- No cluster to provision or manage
- No idle clusters to pay for
- No up-front configuration required
- No installation of Jupyter notebooks required
- The same runtime/platform as AWS Glue ETL

When you start a notebook through AWS Glue Studio, all the configuration steps are done for you so that you can explore your data and start developing your job script after only a few seconds. AWS Glue Studio configures a Jupyter notebook with the AWS Glue Jupyter kernel. You don’t have to configure VPCs, network connections, or development endpoints to use this notebook.

To create jobs using the notebook interface:

- configure the necessary IAM permissions.
- start a notebook session to create a job
- write code in the cells in the notebook
- run and test the code to view the output
- save the job

After your notebook is saved, your notebook is a full AWS Glue job. You can manage all aspects of the job, such as scheduling jobs runs, setting job parameters, and viewing the job run history right along side your notebook.
Creating an ETL job using notebooks in AWS Glue Studio

To start using notebooks in the AWS Glue Studio console

1. Attach AWS Identity and Access Management policies to the AWS Glue Studio user and create an IAM role for your ETL job and notebook.
2. Configure additional IAM security for notebooks, as described in Granting permissions for the IAM role.

   Note
   Check that your browser does not block third-party cookies. Any browser that blocks third party cookies either by default or as a user-enabled setting will prevent notebooks from launching. For more information on managing cookies, see:

   - Chrome
   - Firefox
   - Safari

4. Choose the Jobs link in the left-side navigation menu.
5. Choose Jupyter notebook and then choose Create to start a new notebook session.
6. On the Create job in Jupyter notebook page, provide the job name, and choose the IAM role to use. Choose Create job.

   After a short time period, the notebook editor appears.
7. After you add the code you must execute the cell to initiate a session. There are multiple ways to execute the cell:

   - Press the play button.
   - Use a keyboard shortcut:
     - On MacOS, Command + Enter to run the cell.
     - On Windows, Shift + Enter to run the cell.
For information about writing code using a Jupyter notebook interface, see "The Jupyter Notebook User Documentation".

8. To test your script, run the entire script, or individual cells. Any command output will be displayed in the area beneath the cell.

9. After you have finished developing your notebook, you can save the job and then run it. You can find the script in the **Script** tab. Any magics you added to the notebook will be stripped away and won’t be saved as part of the script of the generated AWS Glue job. AWS Glue Studio will auto-add a `job.commit()` to the end of your generated script from the notebook contents.

For more information about running jobs, see **Start a job run**.

**Notebook editor components**

The notebook editor interface has the following main sections.

- **Notebook interface (main panel) and toolbar**
- **Job editing tabs**

**The notebook editor**

The AWS Glue Studio notebook editor is based on the Jupyter Notebook Application. The AWS Glue Studio notebook interface is similar to that provided by Jupyter Notebooks, which is described in the section "Notebook user interface". The notebook used by interactive sessions is a Jupyter Notebook.

Although the AWS Glue Studio notebook is similar to Jupyter Notebooks, it differs in a few key ways:

- currently, the AWS Glue Studio notebook cannot install extensions
- you cannot use multiple tabs; there is a 1:1 relationship between a job and a notebook
- the AWS Glue Studio notebook does not have the same top file menu that exists in Jupyter Notebooks
• currently, the AWS Glue Studio notebook only runs with the AWS Glue kernel. Note that you cannot update the kernel on your own.

AWS Glue Studio job editing tabs

The tabs that you use to interact with the ETL job are at the top of the notebook page. They are similar to tabs that appear in the visual job editor of AWS Glue Studio, and they perform the same actions.

• **Notebook** – Use this tab to view the job script using the notebook interface.
• **Job details** – Configure the environment and properties for the job runs.
• **Runs** – View information about previous runs of this job.
• **Schedules** – Configure a schedule for running your job at specific times.

Saving your notebook and job script

You can save your notebook and the job script you are creating at any time. Simply choose the **Save** button in the upper right corner, the same as if you were using the visual or script editor.

When you choose **Save**, the notebook file is saved in the default locations:

• By default, the job script is saved to the Amazon S3 location indicated in the **Job Details** tab, under **Advanced properties**, in the Job details property **Script path**. Job scripts are saved in a subfolder named Scripts.
• By default, the notebook file (.ipynb) is saved to the Amazon S3 location indicated in the **Job Details** tab, under **Advanced properties**, in the Job details **Script path**. Notebook files are saved in a subfolder named Notebooks.

**Note**

When you save the job, the job script contains only the code cells from the notebook. The Markdown cells and magics aren't included in the job script. However, the .ipynb file will contain any markdown and magics.

After you save the job, you can then run the job using the script that you created in the notebook.
Managing notebook sessions

Notebooks in AWS Glue Studio are based on the interactive sessions feature of AWS Glue. There is a cost for using interactive sessions. To help manage your costs, you can monitor the sessions created for your account, and configure the default settings for all sessions.

Change the default timeout for all notebook sessions

By default, the provisioned AWS Glue Studio notebook times out after 12 hours if the notebook was launched and no cells have been executed. There is no cost associated to it and the timeout is not configurable.

Once you execute a cell this will start an interactive session. This session has a default timeout of 48 hours. This timeout can be configured by passing an \%idle_timeout magic before executing a cell.

To modify the default session timeout for notebooks in AWS Glue Studio

1. In the notebook, enter the \%idle_timeout magic in a cell and specify the timeout value in minutes.
2. For example: \%idle_timeout 15 will change the default timeout to 15 minutes. If the session is not used in 15 minutes, the session is automatically stopped.

Installing additional Python modules

If you would like to install additional modules to your session using pip you can do so by using \%additional_python_modules to add them to your session:

```bash
%additional_python_modules awswrangler, s3://mybucket/mymodule.whl
```

All arguments to additional_python_modules are passed to `pip3 install -m <>`

For a list of available Python modules, see [Using Python libraries with AWS Glue](#).
Changing AWS Glue Configuration

You can use magics to control AWS Glue job configuration values. If you want to change a job configuration value you have to use the proper magic in the notebook. See Magics supported by AWS Glue interactive sessions for Jupyter.

Note

Overriding properties for a running session is no longer available. In order to change the session's configurations, you can stop the session, set the new configurations and then start a new session.

AWS Glue supports various worker types. You can set the worker type with `%%worker_type`. For example: `%%worker_type G.2X`. The default is G.1X.

You can also specify the Number of workers with `%%number_of_workers`. For example, to specify 40 workers: `%%number_of_workers 40`.

For more information see Defining Job Properties

Stop a notebook session

To stop a notebook session, use the magic `%%stop_session`.

If you navigate away from the notebook in the AWS console, you will receive a warning message where you can choose to stop the session.

Using CodeWhisperer with AWS Glue Studio notebooks

AWS Glue Studio allows you to interactively author jobs in a notebook interface based on Jupyter Notebooks. Using CodeWhisperer improves the authoring experience within AWS Glue Studio notebooks.

The Amazon CodeWhisperer extension supports writing code by generating code recommendations and suggesting improvements related to code issues.

What is Amazon CodeWhisperer?

Amazon CodeWhisperer is a service powered by machine learning that helps improve developer productivity. CodeWhisperer achieves this by generating code recommendations based on
developers' comments in natural language and their code in the IDE. During preview, Amazon CodeWhisperer is available for the Java, JavaScript, Python, C# and TypeScript programming languages. The service integrates with JupyterLab, Amazon SageMaker Studio, Amazon SageMaker notebook instances, and other integrated development environments (IDEs).

For more information, see the [Setting up CodeWhisperer with AWS Glue Studio](#).

**AWS Glue job run statuses on the console**

You can view the status of an AWS Glue extract, transform, and load (ETL) job while it is running or after it has stopped. You can view the status using the AWS Glue console. For more information about job run statuses, see the [section called “Job run statuses”](#).

**Accessing the job monitoring dashboard**

You access the job monitoring dashboard by choosing the [Monitoring](#) link in the AWS Glue navigation pane.

**Overview of the job monitoring dashboard**

The job monitoring dashboard provides an overall summary of the job runs, with totals for the jobs with a status of Running, Canceled, Success, or Failed. Additional tiles provide the overall job run success rate, the estimated DPU usage for jobs, a breakdown of the job status counts by job type, worker type, and by day.

The graphs in the tiles are interactive. You can choose any block in a graph to run a filter that displays only those jobs in the [Job runs](#) table at the bottom of the page.

You can change the date range for the information displayed on this page by using the [Date range](#) selector. When you change the date range, the information tiles adjust to show the values for the specified number of days before the current date. You can also use a specific date range if you choose [Custom](#) from the date range selector.

**Job runs view**

The [Job runs](#) resource list shows the jobs for the specified date range and filters.

You can filter the jobs on additional criteria, such as status, worker type, job type, and the job name. In the filter box at the top of the table, you can enter the text to use as a filter. The table results are updated with rows that contain matching text as you enter the text.
You can view a subset of the jobs by choosing elements from the graphs on the job monitoring dashboard. For example, if you choose the number of running jobs in the **Job runs summary** tile, then the **Job runs** list displays only the jobs that currently have a status of Running. If you choose one of the bars in the **Worker type breakdown** bar chart, then only job runs with the matching worker type and status are shown in the **Job runs** list.

The **Job runs** resource list displays the details for the job runs. You can sort the rows in the table by choosing a column heading. The table contains the following information:

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job name</td>
<td>The name of the job.</td>
</tr>
<tr>
<td>Type</td>
<td>The type of job environment:</td>
</tr>
<tr>
<td></td>
<td>• <strong>Glue ETL</strong>: Runs in an Apache Spark environment managed by AWS Glue.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Glue Streaming</strong>: Runs in an Apache Spark environment and performs ETL on data streams.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Python shell</strong>: Runs Python scripts as a shell.</td>
</tr>
<tr>
<td>Start time</td>
<td>The date and time at which this job run was started.</td>
</tr>
<tr>
<td>End time</td>
<td>The date and time that this job run completed.</td>
</tr>
<tr>
<td>Run status</td>
<td>The current state of the job run. Values can be:</td>
</tr>
<tr>
<td></td>
<td>• STARTING</td>
</tr>
<tr>
<td></td>
<td>• RUNNING</td>
</tr>
<tr>
<td></td>
<td>• STOPPING</td>
</tr>
<tr>
<td></td>
<td>• STOPPED</td>
</tr>
<tr>
<td></td>
<td>• SUCCEEDED</td>
</tr>
<tr>
<td></td>
<td>• FAILED</td>
</tr>
<tr>
<td></td>
<td>• TIMEOUT</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Run time</td>
<td>The amount of time that the job run consumed resources.</td>
</tr>
<tr>
<td>Capacity</td>
<td>The number of AWS Glue data processing units (DPUs) that were allocated for this job run. For more information about capacity planning, see <a href="https://docs.aws.amazon.com/glue/latest-devguide/">Monitoring for DPU Capacity Planning</a> in the <em>AWS Glue Developer Guide</em>.</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Worker type</td>
<td>The type of predefined worker that was allocated when the job ran. Values can be G.1X, G.2X, G.4X or G.8X.</td>
</tr>
<tr>
<td></td>
<td>• <strong>G.1X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free). We recommend this worker type for memory-intensive jobs. This is the default <strong>Worker type</strong> for AWS Glue Version 2.0 or later jobs.</td>
</tr>
<tr>
<td></td>
<td>• <strong>G.2X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free). We recommend this worker type for memory-intensive jobs and jobs that run machine learning transforms.</td>
</tr>
<tr>
<td></td>
<td>• <strong>G.4X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free). We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(Frankfurt), Europe (Ireland), and Europe (Stockholm).</td>
<td></td>
</tr>
<tr>
<td><strong>G.8X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free). We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the <strong>G.4X</strong> worker type.</td>
<td></td>
</tr>
<tr>
<td>DPU hours</td>
<td>The estimated number of DPUs used for the job run. A DPU is a relative measure of processing power. DPUs are used to determine the cost of running your job. For more information, see the <a href="https://aws.amazon.com/glue/pricing/">AWS Glue pricing</a> page.</td>
</tr>
</tbody>
</table>

You can choose any job run in the list and view additional information. Choose a job run, and then do one of the following:

- Choose the **Actions** menu and the **View job** option to view the job in the visual editor.
- Choose the **Actions** menu and the **Stop run** option to stop the current run of the job.
- Choose the **View CloudWatch logs** button to view the job run logs for that job.
- Choose **View details** to view the job run details page.

**Viewing the job run logs**

You can view the job logs in a variety of ways:
On the Monitoring page, in the Job runs table, choose a job run, and then choose View CloudWatch logs.

In the visual job editor, on the Runs tab for a job, choose the hyperlinks to view the logs:

- **Logs** – Links to the Apache Spark job logs written when continuous logging is enabled for a job run. When you choose this link, it takes you to the Amazon CloudWatch logs in the /aws-glue/jobs/logs-v2 log group. By default, the logs exclude non-useful Apache Hadoop YARN heartbeat and Apache Spark driver or executor log messages. For more information about continuous logging, see Continuous Logging for AWS Glue Jobs in the AWS Glue Developer Guide.

- **Error logs** – Links to the logs written to stderr for this job run. When you choose this link, it takes you to the Amazon CloudWatch logs in the /aws-glue/jobs/error log group. You can use these logs to view details about any errors that were encountered during the job run.

- **Output logs** – Links to the logs written to stdout for this job run. When you choose this link, it takes you to the Amazon CloudWatch logs in the /aws-glue/jobs/output log group. You can use these logs to see all the details about the tables that were created in the AWS Glue Data Catalog and any errors that were encountered.

### Viewing the details of a job run

You can choose a job in the Job runs list on the Monitoring page, and then choose View run details to see detailed information for that run of the job.

The information displayed on the job run detail page includes:

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job name</td>
<td>The name of the job.</td>
</tr>
<tr>
<td>Run Status</td>
<td>The current state of the job run. Values can be:</td>
</tr>
<tr>
<td></td>
<td>• STARTING</td>
</tr>
<tr>
<td></td>
<td>• RUNNING</td>
</tr>
<tr>
<td></td>
<td>• STOPPING</td>
</tr>
<tr>
<td></td>
<td>• STOPPED</td>
</tr>
<tr>
<td></td>
<td>• SUCCEEDED</td>
</tr>
<tr>
<td></td>
<td>• FAILED</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Glue version</td>
<td>The AWS Glue version used by the job run.</td>
</tr>
<tr>
<td>Recent attempt</td>
<td>The number of automatic retry attempts for this job run.</td>
</tr>
<tr>
<td>Start time</td>
<td>The date and time at which this job run was started.</td>
</tr>
<tr>
<td>End time</td>
<td>The date and time that this job run completed.</td>
</tr>
<tr>
<td>Start-up time</td>
<td>The amount of time spent preparing to run the job.</td>
</tr>
<tr>
<td>Execution time</td>
<td>The amount of time spent running the job script.</td>
</tr>
<tr>
<td>Trigger name</td>
<td>The name of the trigger associated with the job.</td>
</tr>
<tr>
<td>Last modified on</td>
<td>The date when the job was last modified.</td>
</tr>
<tr>
<td>Security configuration</td>
<td>The security configuration for the job, which includes Amazon S3 encryption, CloudWatch encryption, and job bookmarks encryption settings.</td>
</tr>
<tr>
<td>Timeout</td>
<td>The job run timeout threshold value.</td>
</tr>
<tr>
<td>Allocated capacity</td>
<td>The number of AWS Glue data processing units (DPUs) that were allocated for this job run. For more information about capacity planning, see Monitoring for DPU Capacity Planning in the AWS Glue Developer Guide.</td>
</tr>
<tr>
<td>Max capacity</td>
<td>The maximum capacity available to the job run.</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Number of workers</td>
<td>The number of workers used for the job run.</td>
</tr>
<tr>
<td>Worker type</td>
<td>The type of predefined workers allocated for the job run. Values can be G.1X or G.2X.</td>
</tr>
<tr>
<td></td>
<td>• <strong>G.1X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 1 DPU (4 vCPUs, 16 GB of memory, 64 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs. This is the default <strong>Worker type</strong> for AWS Glue Version 2.0 or later jobs.</td>
</tr>
<tr>
<td></td>
<td>• <strong>G.2X</strong> – When you choose this type, you also provide a value for <strong>Number of workers</strong>. Each worker maps to 2 DPUs (8 vCPUs, 32 GB of memory, 128 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs and jobs that run machine learning transforms.</td>
</tr>
<tr>
<td>Logs</td>
<td>A link to the job logs for continuous logging (/aws-glue/jobs/logs-v2 ).</td>
</tr>
<tr>
<td>Output Logs</td>
<td>A link to the job output log files (/aws-glue/jobs/output ).</td>
</tr>
<tr>
<td>Error logs</td>
<td>A link to the job error log files (/aws-glue/jobs/error ).</td>
</tr>
</tbody>
</table>

You can also view the following additional items, which are available when you view information for recent job runs. For more information, see the section called “View information for recent job runs”.

- Input arguments
• **Continuous logs**

• **Metrics** – You can see visualizations of basic metrics. For more information on included metrics, see the section called “Viewing Amazon CloudWatch metrics for a Spark job run”.

• **Spark UI** – You can visualize Spark logs for your job in the Spark UI. For more information about using the Spark Web UI, see the section called “Monitoring with the Spark UI”. Enable this feature by following the procedure in the section called “Enabling the Spark UI for jobs”.

### Viewing Amazon CloudWatch metrics for a Spark job run

On the details page for a job run, below the Run details section, you can view the job metrics. AWS Glue Studio sends job metrics to Amazon CloudWatch for every job run.

AWS Glue reports metrics to Amazon CloudWatch every 30 seconds. The AWS Glue metrics represent delta values from the previously reported values. Where appropriate, metrics dashboards aggregate (sum) the 30-second values to obtain a value for the entire last minute. However, the Apache Spark metrics that AWS Glue passes on to Amazon CloudWatch are generally absolute values that represent the current state at the time they are reported.

**Note**

You must configure your account to access Amazon CloudWatch, .

The metrics provide information about your job run, such as:

• **ETL Data Movement** – The number of bytes read from or written to Amazon S3.

• **Memory Profile: Heap used** – The number of memory bytes used by the Java virtual machine (JVM) heap.

• **Memory Profile: heap usage** – The fraction of memory (scale: 0–1), shown as a percentage, used by the JVM heap.

• **CPU Load** – The fraction of CPU system load used (scale: 0–1), shown as a percentage.

### Viewing Amazon CloudWatch metrics for a Ray job run

On the details page for a job run, below the Run details section, you can view the job metrics. AWS Glue Studio sends job metrics to Amazon CloudWatch for every job run.
AWS Glue reports metrics to Amazon CloudWatch every 30 seconds. The AWS Glue metrics represent delta values from the previously reported values. Where appropriate, metrics dashboards aggregate (sum) the 30-second values to obtain a value for the entire last minute. However, the Apache Spark metrics that AWS Glue passes on to Amazon CloudWatch are generally absolute values that represent the current state at the time they are reported.

**Note**
You must configure your account to access Amazon CloudWatch, as described in .

In Ray jobs, you can view the following aggregated metric graphs. With these, you can build a profile of your cluster and tasks, and can access detailed information about each node. The time-series data that back these graphs is available in CloudWatch for further analysis.

**Task Profile: Task State**
Shows the number of Ray tasks in the system. Each task lifecycle is given its own time series.

**Task Profile: Task Name**
Shows the number of Ray tasks in the system. Only pending and active tasks are shown. Each type of task (by name) is given its own time series.

**Cluster Profile: CPUs in use**
Shows the number of CPU cores that are used. Each node is given its own time series. Nodes are identified by IP addresses, which are ephemeral and only used for identification.

**Cluster Profile: Object store memory use**
Shows memory use by the Ray object cache. Each memory location (physical memory, cached on disk, and spilled in Amazon S3) is given its own time series. The object store manages data storage across all nodes in the cluster. For more information, see **Objects** in the Ray documentation.

**Cluster Profile: Node count**
Shows the number of nodes provisioned for the cluster.

**Node Detail: CPU use**
Shows CPU utilization on each node as a percentage. Each series shows an aggregated percentage of CPU usage across all cores on the node.
Node Detail: Memory use

Shows memory use on each node in GB. Each series shows memory aggregated between all processes on the node, including Ray tasks and the Plasma store process. This will not reflect objects stored to disk or spilled to Amazon S3.

Node Detail: Disk use

Shows disk use on each node in GB.

Node Detail: Disk I/O speed

Shows disk I/O on each node in KB/s.

Node Detail: Network I/O throughput

Shows network I/O on each node in KB/s.

Node Detail: CPU use by Ray component

Shows CPU use in fractional cores. Each ray component on each node is given its own time series.

Node Detail: Memory use by Ray component

Shows memory use in GiB. Each ray component on each node is given its own time series.

Detect and process sensitive data

The Detect PII transform identifies Personal Identifiable Information (PII) in your data source. You choose the PII entity to identify, how you want the data to be scanned, and what to do with the PII entity that have been identified by the Detect PII transform.

The Detect PII transform provides the ability to detect, mask, or remove entities that you define, or are pre-defined by AWS. This enables you to increase compliance and reduce liability. For example, you may want to ensure that no personally identifiable information exists in your data that can be read and want to mask social security numbers with a fixed string (such as xxx-xx-xxxx), phone numbers, or addresses.

To work with sensitive data outside of AWS Glue Studio, see Using Sensitive Data Detection outside AWS Glue Studio

Topics

- Choosing how you want the data to be scanned
Choosing how you want the data to be scanned

When you scan your dataset for sensitive data like personally identifiable information (PII), you can choose to detect PII in each row or detect the columns that contain PII data.

When you choose **Detect PII in each cell**, you're choosing to scan all rows in the data source. This is a comprehensive scan to ensure that PII entities are identified.

When you choose **Detect fields containing PII**, you're choosing to scan a sample of rows for PII entities. This is a way to keep costs and resources low while also identifying the fields where PII entities are found.

When you choose to detect fields that contain PII, you can reduce costs and improve performance by sampling a portion of rows. Choosing this option will allow you to specify additional options:

- **Sample portion**: This allows you to specify the percentage of rows to sample. For example, if you enter ‘50’, you’re specifying that you want 50 percent of scanned rows for the PII entity.
• **Detection threshold:** This allows you to specify the percentage of rows that contain the PII entity in order for the entire column to be identified as having the PII entity. For example, if you enter ‘10’, you’re specifying that the number of the PII entity, US Phone, in the rows that are scanned must be 10 percent or greater in order for the field to be identified as having the PII entity, US Phone. If the percentage of rows that contain the PII entity is less than 10 percent, that field will not be labeled as having the PII entity, US Phone, in it.

## Choosing the PII entities to detect

If you choose **Detect PII in each cell**, you can choose from one of three options:

- **All available PII patterns** - this includes AWS entities.
- **Select categories** - when you select categories, PII patterns will automatically include patterns in the categories that you select.
- **Select specific patterns** - Only the patterns that you select will be detected.

For a full list of managed sensitive data types, see [Managed data types](#).

### Choose from all available PII patterns

If you choose **All available PII patterns**, select entities pre-defined by AWS. You can select one, more than one, or all entities.
### Select entities to detect

#### Available entities (19)

<table>
<thead>
<tr>
<th>Entity name</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person's name</td>
<td>Universal, HIPAA</td>
</tr>
<tr>
<td>Email (General)</td>
<td>Universal</td>
</tr>
<tr>
<td>Credit Card</td>
<td>Universal</td>
</tr>
<tr>
<td>IP Address</td>
<td>Networking</td>
</tr>
<tr>
<td>MAC Address</td>
<td>Networking</td>
</tr>
<tr>
<td>US Phone</td>
<td>United States, HIPAA</td>
</tr>
<tr>
<td>US Passport</td>
<td>United States</td>
</tr>
<tr>
<td>Social Security Number (SSN)</td>
<td>United States, HIPAA</td>
</tr>
<tr>
<td>US Individual Taxpayer Identification Number (ITIN)</td>
<td>United States, HIPAA</td>
</tr>
<tr>
<td>US/Canada bank account</td>
<td>United States, HIPAA</td>
</tr>
<tr>
<td>US driving license</td>
<td>HIPAA</td>
</tr>
<tr>
<td>Healthcare Common Procedure Coding System (HCPCS) code</td>
<td>HIPAA</td>
</tr>
<tr>
<td>National Drug Code (NDC)</td>
<td>HIPAA</td>
</tr>
<tr>
<td>National Provider Identifier (NPI)</td>
<td>HIPAA</td>
</tr>
<tr>
<td>Drug Enforcement Agency (DEA) Registration Number</td>
<td>HIPAA</td>
</tr>
<tr>
<td>Health Insurance Claim Number (HICN)</td>
<td>HIPAA</td>
</tr>
<tr>
<td>Medicare Beneficiary Identifier</td>
<td>HIPAA</td>
</tr>
</tbody>
</table>

Choosing the PII entities to detect

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Select categories

If you chose Select categories as the PII patterns to detect, you can select from the options in the drop-down menu. Note that some entities can belong to more than one category. For example, Person's name is an entity that belongs to the Universal and HIPAA categories.

- Universal (examples: Email, Credit Card)
- HIPAA (examples: US Driving License, Healthcare Common Procedure Coding System (HCPCS) code)
- Networking (examples: IP Address, MAC Address)
- Argentina
- Australia
- Austria
- Belgium
- Bosnia
- Bulgaria
- Canada
- Chile
- Colombia
- Croatia
- Cyprus
- Czechia
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Korea
- Japan
Select specific patterns

If you choose Select specific patterns as the PII patterns to detect, you can search or browse from a list of patterns you've already created, or create a new detection entity pattern.

The steps below describe how to create a new custom pattern for detecting sensitive data. You will create the custom pattern by entering a name for the custom pattern, add a regular expression, and optionally, define context words.

1. To create a new pattern, click the Create new button.
2. In the Create detection entity page, enter the entity name and a regular expression. The regular expression (Regex) is what AWS Glue will use to match entities.

3. Click **Validate**. If the validation is successful, you will see a confirmation message stating that the string is a valid regular expression. If the validation is not successful, you will see a message stating that the string does not conform to proper formatting and accepted character literals, operators or constructs.

4. You can choose to add Context words in addition to the regular expression. Context words may increase the likelihood of a match. These can be useful in cases where field names are not descriptive of the entity. For example, social security numbers may be named 'SSN' or 'SS'. Adding these context words can help match the entity.

5. Click **Create** to create the detection entity. Any created entities are visible in the AWS Glue Studio console. Click on **Detection entities** in the left-hand navigation menu.

   You can edit, delete, or create detection entities from the **Detection entities** page. You can also search for a pattern using the search field.

---

**Specifying the level of detection sensitivity**

You can set the level of sensitivity when using detecting sensitive data.

- **High** – (Default) Detects more entities for use cases that require a higher level of sensitivity. All AWS Glue jobs created after November 2023 are automatically opted-in to this setting.
- **Low** – Detects fewer entities and reduces false positives.

**Select global detection sensitivity**

Choose the level of detection sensitivity to apply to your data set.

- **High (default)**
  - Detects more entities for use cases that require a higher level of sensitivity.
- **Low**
  - Detects fewer entities and reduces false positives.

**Choosing what to do with identified PII data**

If you chose to detect PII in the entire data source, you can select a global action to apply:
- **Enrich data with detection results:** If you chose Detect PII in each cell, you can store the detected entities into a new column.

- **Redact detected text:** You can replace the detected PII value with a string that you specify in the optional Replacing text input field. If no string is specified, the detected PII entity is replaced with '*******'.

- **Partially redact detected text:** You can replace part of the detected PII value with a string you choose. There are two possible options: to either leave the ends unmasked or to mask by providing an explicit regex pattern. This feature is not available in AWS Glue 2.0.

- **Apply cryptographic hash:** You can pass the detected PII value to a SHA-256 cryptographic hash function and replace the value with the function's output.

Select global action (required)

Choose an action to take on detected entities.

- DETECT. Enrich data with detection results.
  - Create a new column that will contain any entity type detected in that row.

- REDACT. Redact detected text.
  - Replace detected entity with a string you choose.

- PARTIAL_REDACT. Partially redact detected text.
  - Replace part of a detected entity with a string you choose.

- SHA256_HASH. Apply cryptographic hash.
  - Apply a SHA-256 cryptographic hash function to the input string.

Differences between AWS Glue versions 2.0 and 3.0+

AWS Glue 2.0 jobs will return a new DataFrame with the detected PII information for each column in a supplementary column. Any redaction or hash work is visible within the AWS Glue script in the visual tab.

AWS Glue 3.0 and 4.0 jobs will return a new DataFrame with this same supplementary column. A new key for “actionUsed” is present and can be one of DETECT, REDACT, PARTIAL_REDACT, or SHA256_HASH. If a masking action is selected, the DataFrame will return data with sensitive data masked.

**Adding fine-grained action overrides**

Additional detection and action settings can be added to the fine-grained actions overrides table. This allows you to:
- **Include or exclude certain columns from detection** – An inferred schema on the data source will populate the table with available columns.

- **Specify specific settings that are more fine-grained than using global actions** – For example, you can specify different redaction text settings for different entity types.

- **Specify a different action than the global action** – If a different action wants to be applied on a different sensitive data type, that can be done here. Note that two different edit-in-place actions (redaction and hashing) cannot be used on the same column, but detect can always be used.

---

**Fine grained actions (overrides) (0)**

<table>
<thead>
<tr>
<th>Edit as JSON</th>
<th>Delete</th>
<th>Edit</th>
<th>Add</th>
</tr>
</thead>
</table>

Select entities to add a fine grained action different from the global action above.

---

**Managing ETL jobs with AWS Glue Studio**

You can use the simple graphical interface in AWS Glue Studio to manage your ETL jobs. Using the navigation menu, choose **Jobs** to view the **Jobs** page. On this page, you can see all the jobs that you have created either with AWS Glue Studio or the AWS Glue console. You can view, manage, and run your jobs on this page.

**You can also perform the following tasks on this page:**

- [Start a job run](#)
- [Schedule job runs](#)
- [Manage job schedules](#)
- [Stop job runs](#)
- [View your jobs](#)
- [View information for recent job runs](#)
• View the job script
• Modify the job properties
• Save the job
• Clone a job
• Delete jobs

Start a job run

In AWS Glue Studio, you can run your jobs on demand. A job can run multiple times, and each time you run the job, AWS Glue collects information about the job activities and performance. This information is referred to as a job run and is identified by a job run ID.

You can initiate a job run in the following ways in AWS Glue Studio:

• On the Jobs page, choose the job you want to start, and then choose the Run job button.
• If you're viewing a job in the visual editor and the job has been saved, you can choose the Run button to start a job run.

For more information about job runs, see Working with Jobs on the AWS Glue Console in the AWS Glue Developer Guide.

Schedule job runs

In AWS Glue Studio, you can create a schedule to have your jobs run at specific times. You can specify constraints, such as the number of times that the jobs run, which days of the week they run, and at what time. These constraints are based on cron and have the same limitations as cron. For example, if you choose to run your job on day 31 of each month, keep in mind that some months don't have 31 days. For more information about cron, see Cron Expressions in the AWS Glue Developer Guide.

To run jobs according to a schedule

1. Create a job schedule using one of the following methods:
   • On the Jobs page, choose the job you want to create a schedule for, choose Actions, and then choose Schedule job.
If you're viewing a job in the visual editor and the job has been saved, choose the Schedules tab. Then choose Create Schedule.

2. On the Schedule job run page, enter the following information:

   - **Name**: Enter a name for your job schedule.
   - **Frequency**: Enter the frequency for the job schedule. You can choose the following:
     - **Hourly**: The job will run every hour, starting at a specific minute. You can specify the Minute of the hour that the job should run. By default, when you choose hourly, the job runs at the beginning of the hour (minute 0).
     - **Daily**: The job will run every day, starting at a time. You can specify the Minute of the hour that the job should run and the Start hour for the job. Hours are specified using a 23-hour clock, where you use the numbers 13 to 23 for the afternoon hours. The default values for minute and hour are 0, which means that if you select Daily, the job by default will run at midnight.
     - **Weekly**: The job will run every week on one or more days. In addition to the same settings described previous for Daily, you can choose the days of the week on which the job will run. You can choose one or more days.
     - **Monthly**: The job will run every month on a specific day. In addition to the same settings described previous for Daily, you can choose the day of the month on which the job will run. Specify the day as a numeric value from 1 to 31. If you select a day that does not exist in a month, for example the 30th day of February, then the job does not run that month.
     - **Custom**: Enter an expression for your job schedule using the cron syntax. Cron expressions allow you to create more complicated schedules, such as the last day of the month (instead of a specific day of the month) or every third month on the 7th and 21st days of the month.

     See [Cron Expressions](https://aws.amazon.com/documentation/glue/developer-guide/cron-expressions) in the AWS Glue Developer Guide

   - **Description**: You can optionally enter a description for your job schedule. If you plan to use the same schedule for multiple jobs, having a description makes it easier to determine what the job schedule does.

3. Choose Create schedule to save the job schedule.

4. After you create the schedule, a success message appears at the top of the console page. You can choose Job details in this banner to view the job details. This opens the visual job editor page, with the Schedules tab selected.
Manage job schedules

After you have created schedules for a job, you can open the job in the visual editor and choose the Schedules tab to manage the schedules.

On the Schedules tab of the visual editor, you can perform the following tasks:

• Create a new schedule.

  Choose Create schedule, then enter the information for your schedule as described in the section called “Schedule job runs”.

• Edit an existing schedule.

  Choose the schedule you want to edit, then choose Action followed by Edit schedule. When you choose to edit an existing schedule, the Frequency shows as Custom, and the schedule is displayed as a cron expression. You can either modify the cron expression, or specify a new schedule using the Frequency button. When you finish with your changes, choose Update schedule.

• Pause an active schedule.

  Choose an active schedule, and then choose Action followed by Pause schedule. The schedule is instantly deactivated. Choose the refresh (reload) button to see the updated job schedule status.

• Resume a paused schedule.

  Choose a deactivated schedule, and then choose Action followed by Resume schedule. The schedule is instantly activated. Choose the refresh (reload) button to see the updated job schedule status.

• Delete a schedule.

  Choose the schedule you want to remove, and then choose Action followed by Delete schedule. The schedule is instantly deleted. Choose the refresh (reload) button to see the updated job schedule list. The schedule will show a status of Deleting until it has been completely removed.

Stop job runs

You can stop a job before it has completed its job run. You might choose this option if you know that the job isn’t configured correctly, or if the job is taking too long to complete.
On the **Monitoring** page, in the **Job runs** list, choose the job that you want to stop, choose **Actions**, and then choose **Stop run**.

**View your jobs**

You can view all your jobs on the **Jobs** page. You can access this page by choosing **Jobs** in the navigation pane.

On the **Jobs** page, you can see all the jobs that were created in your account. The **Your jobs** list shows the job name, its type, the status of the last run of that job, and the dates on which the job was created and last modified. You can choose the name of a job to see detailed information for that job.

You can also use the Monitoring dashboard to view all your jobs. You can access the dashboard by choosing **Monitoring** in the navigation pane.

**Customize the job display**

You can customize how the jobs are displayed in the **Your jobs** section of the **Jobs** page. Also, you can enter text in the search text field to display only jobs with a name that contains that text.

If you choose the settings icon

in the **Your jobs** section, you can customize how AWS Glue Studio displays the information in the table. You can choose to wrap the lines of text in the display, change the number of jobs displayed on the page, and specify which columns to display.

**View information for recent job runs**

A job can run multiple times as new data is added at the source location. Each time a job runs, the job run is assigned a unique ID, and information about that job run is collected. You can view this information by using the following methods:

- Choose the **Runs** tab of the visual editor to view the job run information for the currently displayed job.

  On the **Runs** tab (the **Recent job runs** page), there is a card for each job run. The information displayed on the **Runs** tab includes:

  - Job run ID
- Number of attempts to run this job
- Status of the job run
- Start and end time for the job run
- The runtime for the job run
- A link to the job log files
- A link to the job error log files
- The error returned for failed jobs

You can select a job run to view additional information about the job, including the following:

- **Input arguments**
- **Continuous logs**
- **Metrics** – You can see visualizations of basic metrics. For more information on included metrics, see the section called “Viewing Amazon CloudWatch metrics for a Spark job run”.
- **Spark UI** – You can visualize Spark logs for your job in the Spark UI. For more information about using the Spark Web UI, see the section called “Monitoring with the Spark UI”. Enable this feature by following the procedure in the section called “Enabling the Spark UI for jobs”.

You can select **View details** to view similar information on the job run details page. Alternatively, you can navigate to the job run details page through the Monitoring page. In the navigation pane, choose Monitoring. Scroll down to the **Job runs** list. Choose the job and then choose **View run details**. The contents are described in Viewing the details of a job run.

For more information about the job logs, see Viewing the job run logs.

**View the job script**

After you provide information for all the nodes in the job, AWS Glue Studio generates a script that is used by the job to read the data from the source, transform the data, and write the data in the target location. If you save the job, you can view this script at any time.

**To view the generated script for your job**

1. Choose **Jobs** in the navigation pane.

2. On the **Jobs** page, in the **Your Jobs** list, choose the name of the job you want to review. Alternatively, you can select a job in the list, choose the **Actions** menu, and then choose **Edit job**.
3. On the visual editor page, choose the **Script** tab at the top to view the job script.

   If you want to edit the job script, see [AWS Glue programming guide](#).

**Modify the job properties**

The nodes in the job diagram define the actions performed by the job, but there are several properties that you can configure for the job as well. These properties determine the environment that the job runs in, the resources it uses, the threshold settings, the security settings, and more.

**To customize the job run environment**

1. Choose **Jobs** in the navigation pane.
2. On the **Jobs** page, in the **Your Jobs** list, choose the name of the job you want to review.
3. On the visual editor page, choose the **Job details** tab at the top of the job editing pane.
4. Modify the job properties, as needed.

   For more information about the job properties, see [Defining Job Properties](#) in the [AWS Glue Developer Guide](#).

5. Expand the **Advanced properties** section if you need to specify these additional job properties:

   - **Script filename** – The name of the file that stores the job script in Amazon S3.
   - **Script path** – The Amazon S3 location where the job script is stored.
   - **Job metrics** – (Not available for Python shell jobs) Turns on the creation of Amazon CloudWatch metrics when this job runs.
   - **Continuous logging** – (Not available for Python shell jobs) Turns on continuous logging to CloudWatch, so the logs are available for viewing before the job completes.
   - **Spark UI and Spark UI logs path** – (Not available for Python shell jobs) Turns on the use of Spark UI for monitoring this job and specifies the location for the Spark UI logs.
   - **Maximum concurrency** – Sets the maximum number of concurrent runs that are allowed for this job.
   - **Temporary path** – The location of a working directory in Amazon S3 where temporary intermediate results are written when AWS Glue runs the job script.
   - **Delay notification threshold (minutes)** – Specify a delay threshold for the job. If the job runs for a longer time than that specified by the threshold, then AWS Glue sends a delay notification for the job to CloudWatch.
- **Security configuration** and **Server-side encryption** – Use these fields to choose the encryption options for the job.

- **Use Glue Data Catalog as the Hive metastore** – Choose this option if you want to use the AWS Glue Data Catalog as an alternative to Apache Hive Metastore.

- **Additional network connection** – For a data source in a VPC, you can specify a connection of type Network to ensure your job accesses your data through the VPC.

- **Python library path, Dependent jars path** (Not available for Python shell jobs), or **Referenced files path** – Use these fields to specify the location of additional files used by the job when it runs the script.

- **Job Parameters** – You can add a set of key-value pairs that are passed as named parameters to the job script. In Python calls to AWS Glue APIs, it's best to pass parameters explicitly by name. For more information about using parameters in a job script, see [Passing and Accessing Python Parameters in AWS Glue](#) in the *AWS Glue Developer Guide*.

- **Tags** – You can add tags to the job to help you organize and identify them.

6. After you have modified the job properties, save the job.

**Store Spark shuffle files on Amazon S3**

Some ETL jobs require reading and combining information from multiple partitions, for example, when using a join transform. This operation is referred to as *shuffling*. During a shuffle, data is written to disk and transferred across the network. With AWS Glue version 3.0, you can configure Amazon S3 as a storage location for these files. AWS Glue provides a shuffle manager which writes and reads shuffle files to and from Amazon S3. Writing and reading shuffle files from Amazon S3 is slower (by 5%-20%) compared to local disk (or Amazon EBS which is heavily optimized for Amazon EC2). However, Amazon S3 provides unlimited storage capacity, so you don't have to worry about "No space left on device" errors when running your job.

**To configure your job to use Amazon S3 for shuffle files**

1. On the **Jobs** page, in the **Your Jobs** list, choose the name of the job you want to modify.

2. On the visual editor page, choose the **Job details** tab at the top of the job editing pane.

   Scroll down to the **Job parameters** section.

3. Specify the following key-value pairs.

   • `--write-shuffle-files-to-s3 — true`
This is the main parameter that configures the shuffle manager in AWS Glue to use Amazon S3 buckets for writing and reading shuffle data. By default, this parameter has a value of false.

- (Optional) `--write-shuffle-spills-to-s3` — true

This parameter allows you to offload spill files to Amazon S3 buckets, which provides additional resiliency to your Spark job in AWS Glue. This is only required for large workloads that spill a lot of data to disk. By default, this parameter has a value of false.

- (Optional) `--conf spark.shuffle.glue.s3ShuffleBucket` — S3://<shuffle-bucket>

This parameter specifies the Amazon S3 bucket to use when writing the shuffle files. If you do not set this parameter, the location is the `shuffle-data` folder in the location specified for Temporary path (`--TempDir`).

**Note**

Make sure the location of the shuffle bucket is in the same AWS Region in which the job runs. Also, the shuffle service does not clean the files after the job finishes running, so you should configure the Amazon S3 storage life cycle policies on the shuffle bucket location. For more information, see [Managing your storage lifecycle](https://docs.aws.amazon.com/AmazonS3/latest/userguide/managing-storage-lifecycle.html) in the *Amazon S3 User Guide*.

**Save the job**

A red Job has not been saved callout is displayed to the left of the Save button until you save the job.

![Job has not been saved](red) ![Save](icon)

**To save your job**

1. Provide all the required information in the Visual and Job details tabs.
2. Choose the Save button.
After you save the job, the 'not saved' callout changes to display the time and date that the job was last saved.

If you exit AWS Glue Studio before saving your job, the next time you sign in to AWS Glue Studio, a notification appears. The notification indicates that there is an unsaved job, and asks if you want to restore it. If you choose to restore the job, you can continue to edit it.

**Troubleshooting errors when saving a job**

If you choose the **Save** button, but your job is missing some required information, then a red callout appears on the tab where the information is missing. The number in the callout indicates how many missing fields were detected.

- If a node in the visual editor isn't configured correctly, the **Visual tab** shows a red callout, and the node with the error displays a warning symbol.

1. Choose the node. In the node details panel, a red callout appears on the tab where the missing or incorrect information is located.

2. Choose the tab in the node details panel that shows a red callout, and then locate the problem fields, which are highlighted. An error message below the fields provides additional information about the problem.
If there is a problem with the job properties, the **Job details** tab shows a red callout. Choose that tab and locate the problem fields, which are highlighted. The error messages below the fields provide additional information about the problem.
Clone a job

You can use the **Clone job** action to copy an existing job into a new job.

**To create a new job by copying an existing job**

1. On the **Jobs** page, in the **Your jobs** list, choose the job that you want to duplicate.
2. From the **Actions** menu, choose **Clone job**.
3. Enter a name for the new job. You can then save or edit the job.

Delete jobs

You can remove jobs that are no longer needed. You can delete one or more jobs in a single operation.
To remove jobs from AWS Glue Studio

1. On the Jobs page, in the Your jobs list, choose the jobs that you want to delete.
2. From the Actions menu, choose Delete job.
3. Verify that you want to delete the job by entering delete.

You can also delete a saved job when you're viewing the Job details tab for that job in the visual editor.
Working with jobs in AWS Glue

The following sections provide information on ETL and Ray jobs in AWS Glue.

Topics

- AWS Glue versions
- Working with Spark jobs in AWS Glue
- Working with Ray jobs in AWS Glue
- Python shell jobs in AWS Glue
- Monitoring AWS Glue
- AWS Glue job run statuses

AWS Glue versions

You can configure the AWS Glue version parameter when you add or update a job. The AWS Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The Python version indicates the version that's supported for jobs of type Spark. The following table lists the available AWS Glue versions, the corresponding Spark and Python versions, and other changes in functionality.

### AWS Glue versions

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported runtime environment versions</th>
<th>Changes in functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Glue 4.0</td>
<td><strong>Spark environment versions</strong></td>
<td>AWS Glue 4.0 is the latest version of AWS Glue. There are several optimizations and upgrades built into this AWS Glue release, such as:</td>
</tr>
<tr>
<td></td>
<td>• Spark 3.3.0</td>
<td>• Many Spark functionality upgrades from Spark 3.1 to Spark 3.3:</td>
</tr>
<tr>
<td></td>
<td>• Python 3.10</td>
<td></td>
</tr>
</tbody>
</table>

AWS Glue versions
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<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported runtime environment versions</th>
<th>Changes in functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Several functionality improvements when paired with Pandas. For more information, see <a href="#">What's New in Spark 3.3</a>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Additional optimizations developed on Amazon EMR.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Upgrade to EMR File System (EMRFS) 2.53.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Log4j 2 migration from Log4j 1.x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Several Python module updates from AWS Glue 3.0, such as an upgraded version of Boto.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Upgrade of several connectors, including the default Amazon Redshift connector. See <a href="#">Appendix C: Connector upgrades</a>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Upgrade of several JDBC drivers. See <a href="#">Appendix B: JDBC driver upgrades</a>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Updated with a new Amazon Redshift connector and JDBC driver.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Native support for open-data lake frameworks with Apache Hudi, Delta Lake, and Apache Iceberg.</td>
</tr>
<tr>
<td>AWS Glue version</td>
<td>Supported runtime environment versions</td>
<td>Changes in functionality</td>
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<tr>
<td></td>
<td></td>
<td>• Native support for the Amazon S3-based Cloud Shuffle Storage Plugin (an Apache Spark plugin) to use Amazon S3 for shuffling and elastic storage capacity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Limitations</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following are limitations with AWS Glue 4.0:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• AWS Glue machine learning and personally identifiable information (PII) transforms are not yet available in AWS Glue 4.0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For more information about migrating to AWS Glue version 4.0, see <a href="#">Migrating AWS Glue for Spark jobs to AWS Glue version 4.0</a>.</td>
</tr>
<tr>
<td>AWS Glue version</td>
<td>Supported runtime environment versions</td>
<td>Changes in functionality</td>
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<tr>
<td>------------------</td>
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</tr>
<tr>
<td></td>
<td>Ray environment versions</td>
<td>Build and run distributed Python applications with AWS Glue for Ray.</td>
</tr>
<tr>
<td></td>
<td>• Ray 2.4.0</td>
<td>• Supports Ray-2.4.0 data distribution ([ray[data]] ) with Python 3.9. For more information on this Ray release, see <a href="https://ray.io">Ray-2.4.0</a> in the Ray GitHub repository.</td>
</tr>
<tr>
<td></td>
<td>• Python 3.9</td>
<td>• Supports installing additional Python libraries into the Ray2.4 runtime environment. For more information, see the section called “Additional Python modules for Ray jobs”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Integrates logs and metrics from Ray jobs with Amazon CloudWatch. For more information, see the section called “Troubleshooting Ray errors” and the section called “Ray job metrics”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Aggregates and visualizes metrics for Ray jobs in AWS Glue Studio, on each job run page.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Supports distributing files to each working directory across your cluster, spilling objects from the Ray object store to Amazon S3, and</td>
</tr>
<tr>
<td>AWS Glue version</td>
<td>Supported runtime environment versions</td>
<td>Changes in functionality</td>
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</tr>
</tbody>
</table>

controlling the minimum number of worker nodes allocated to your Ray job. For more information, see the section called “Ray job parameters”.

**Limitations on Ray jobs in AWS Glue 4.0**

- AWS Glue interactive sessions for Ray remain in preview for this release.
- AWS Glue for Ray integration with Amazon VPC is not currently available. Resources in a VPC in AWS will not be accessible without a public route. For more information about using AWS Glue with Amazon VPC, see the section called “VPC endpoints (AWS PrivateLink)”.
- AWS Glue for Ray is available in US East (N. Virginia), US East (Ohio), US West (Oregon), Asia Pacific (Tokyo), and Europe (Ireland).
<table>
<thead>
<tr>
<th>AWS Glue version</th>
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</thead>
</table>
| AWS Glue 3.0     | • Spark 3.1.1<br>• Python 3.7         | In addition to the Spark engine upgrade to 3.0, there are optimizations and upgrades built into this AWS Glue release, such as:  
• Builds the AWS Glue ETL Library against Spark 3.0, which is a major release for Spark.  
• Streaming jobs are supported on AWS Glue 3.0.  
• Includes new AWS Glue Spark runtime optimizations for performance and reliability:  
  • Faster in-memory columnar processing based on Apache Arrow for reading CSV data.  
  • SIMD-based execution for vectorized reads with CSV data.  
  • Spark upgrade also includes additional optimizations developed on Amazon EMR.  
  • Upgraded EMRFS from 2.38 to 2.46 enabling new features and bug fixes for Amazon S3 access. |
<table>
<thead>
<tr>
<th>AWS Glue version</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Upgraded several dependencies that were required for the new Spark version. See <a href="#">Appendix A: notable dependency upgrades</a>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Upgraded JDBC drivers for our natively supported data sources. See <a href="#">Appendix B: JDBC driver upgrades</a>.</td>
</tr>
</tbody>
</table>

**Limitations**

The following are limitations with AWS Glue 3.0:

- AWS Glue machine learning transforms are not yet available in AWS Glue 3.0.
- Some custom Spark connectors do not work with AWS Glue 3.0 if they depend on Spark 2.4 and do not have compatibility with Spark 3.1.

For more information about migrating to AWS Glue version 3.0, see [Migrating AWS Glue for Spark jobs to AWS Glue version 3.0](#).
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<tr>
<th>AWS Glue version</th>
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<tbody>
<tr>
<td>AWS Glue 2.0</td>
<td>• Spark 2.4.3</td>
<td>In addition to the features provided in AWS Glue version 1.0, AWS Glue version 2.0 also provides:</td>
</tr>
<tr>
<td></td>
<td>• Python 3.7</td>
<td>• An upgraded infrastructure for running Apache Spark ETL jobs in AWS Glue with reduced startup times.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Default logging is now real time, with separate streams for drivers and executors, and outputs and errors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support for specifying additional Python modules or different versions at the job level.</td>
</tr>
</tbody>
</table>

**Note**

AWS Glue version 2.0 differs from AWS Glue version 1.0 for some dependencies and versions due to underlying architectural changes. Validate your AWS Glue jobs before migrating across major AWS Glue version releases.
<table>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For more information about AWS Glue version 2.0 features and limitations, see <a href="#">Running Spark ETL jobs with reduced startup times.</a></td>
</tr>
<tr>
<td>AWS Glue version</td>
<td>Supported runtime environment versions</td>
<td>Changes in functionality</td>
</tr>
<tr>
<td>------------------</td>
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<td>--------------------------</td>
</tr>
</tbody>
</table>
| AWS Glue 1.0 (deprecated, end of support) | • Spark 2.4.3  
• Python 2.7  
• Python 3.6 | You can maintain job bookmarks for Parquet and ORC formats in AWS Glue ETL jobs (using AWS Glue version 1.0). Previously, you were only able to bookmark common Amazon S3 source formats such as JSON, CSV, Apache Avro, and XML in AWS Glue ETL jobs.  
When setting format options for ETL inputs and outputs, you can specify to use Apache Avro reader/writer format 1.8 to support Avro logical type reading and writing (using AWS Glue version 1.0). Previously, only the version 1.7 Avro reader/writer format was supported.  
The DynamoDB connection type supports a writer option (using AWS Glue version 1.0). |

**Limitations**

The following are limitations with AWS Glue 1.0:

- AWS Glue versions 0.9 and 1.0 are not available in the Asia Pacific (Jakarta) (ap-southeast-3),
Running Spark ETL jobs with reduced startup times

AWS Glue versions 2.0 and later provide an upgraded infrastructure for running Apache Spark ETL (extract, transform, and load) jobs in AWS Glue with reduced startup times. With the reduced wait times, data engineers can be more productive and increase their interactivity with AWS Glue. The reduced variance in job start times can help you meet or exceed your SLAs of making data available for analytics.

To use this feature with your AWS Glue ETL jobs, choose 2.0 or a later version for the Glue version when creating your jobs.

Topics

- New features supported
New features supported

This section describes new features supported with AWS Glue versions 2.0 and later.

Support for specifying additional Python modules at the job level

AWS Glue versions 2.0 and later also let you provide additional Python modules or different versions at the job level. You can use the `--additional-python-modules` option with a list of comma-separated Python modules to add a new module or change the version of an existing module.

For example to update or to add a new `scikit-learn` module use the following key/value: "--additional-python-modules", "scikit-learn==0.21.3".

Also, within the `--additional-python-modules` option you can specify an Amazon S3 path to a Python wheel module. For example:

```
--additional-python-modules s3://aws-glue-native-spark/tests/j4.2/ephem-3.7.7.1-cp37-cp37m-linux_x86_64.whl,s3://aws-glue-native-spark/tests/j4.2/fbprophet-0.6-py3-none-any.whl,scikit-learn==0.21.3
```

AWS Glue uses the Python Package Installer (pip3) to install the additional modules. You can pass additional options specified by the `python-modules-installer-option` to pip3 for installing the modules. Any incompatibility or limitations from pip3 will apply.

Python modules already provided in AWS Glue version 2.0

AWS Glue version 2.0 supports the following python modules out of the box:

- `setuptools`—45.2.0
- `subprocess32`—3.5.4
- `ptvsd`—4.3.2
- `pydevd`—1.9.0
- `PyMySQL`—0.9.3

Running Spark ETL jobs with reduced startup times
• docutils—0.15.2
• jmespath—0.9.4
• six—1.14.0
• python_dateutil—2.8.1
• urllib3—1.25.8
• botocore—1.15.4
• s3transfer—0.3.3
• boto3—1.12.4
• certifi—2019.11.28
• chardet—3.0.4
• idna—2.9
• requests—2.23.0
• pyparsing—2.4.6
• enum34—1.1.9
• pytz—2019.3
• numpy—1.18.1
• cycler—0.10.0
• kiwisolver—1.1.0
• scipy—1.4.1
• pandas—1.0.1
• pyarrow—0.16.0
• matplotlib—3.1.3
• pyhocon—0.3.54
• mpmath—1.1.0
• sympy—1.5.1
• patsy—0.5.1
• statsmodels—0.11.1
• fsspec—0.6.2
• s3fs—0.4.0
• Cython—0.29.15
• joblib—0.14.1
• pmdarima—1.5.3
• scikit-learn—0.22.1
• tbats—1.0.9

Logging behavior

AWS Glue versions 2.0 and later support different default logging behavior. The differences include:

• Logging occurs in realtime.
• There are separate streams for drivers and executors.
• For each driver and executor there are two streams, the output stream and the error stream.

Driver and executor streams

Driver streams are identified by the job run ID. Executor streams are identified by the job <run id>_<executor task id>. For example:

• "logStreamName":
  "jr_8255308b426fff1b4e09e00e0bd5612b1b4ec848d7884cebe61ed33a31789..._g-f65f617bd31d54bd94482af755b6cdf464542..."

Output and errors streams

The output stream has the standard output (stdout) from your code. The error stream has logging messages from the your code/library.

• Log streams:
  • Driver log streams have <jr>, where <jr> is the job run ID.
  • Executor log streams have <jr>_<g>, where <g> is the task ID for the executor. You can look up the executor task ID in the driver error log.

The default log groups for AWS Glue version 2.0 are as follows:
- /aws-glue/jobs/logs/output for output
- /aws-glue/jobs/logs/error for errors

When a security configuration is provided, the log group names change to:

- /aws-glue/jobs/\(<\text{security configuration}>\)-role/\(<\text{Role Name}>\)/output
- /aws-glue/jobs/\(<\text{security configuration}>\)-role/\(<\text{Role Name}>\)/error

On the console the **Logs** link points to the output log group and the **Error** link points to the error log group. When continuous logging is enabled, the **Logs** links points to the continuous log group, and the **Output** link points to the output log group.

**Logging rules**

⚠️ **Note**

The default log groupname for continuous logging is `/aws-glue/jobs/logs-v2`.

In AWS Glue versions 2.0 and later, continuous logging has the same behavior as in AWS Glue version 1.0:

- Default log group: `/aws-glue/jobs/logs-v2`
- Driver log stream: `<jr>`-driver
- Executor log stream: `<jr>`-`<executor ID>`

The log group name can be changed by setting `--continuous-log-logGroupName`

The log streams name can be prefixed by setting `--continous-log-logStreamPrefix`

**Features not supported**

The following AWS Glue features are not supported:

- Development endpoints
- AWS Glue versions 2.0 and later do not run on Apache YARN, so YARN settings do not apply
- AWS Glue versions 2.0 and later do not have a Hadoop Distributed File System (HDFS)
• AWS Glue versions 2.0 and later do not use dynamic allocation, hence the ExecutorAllocationManager metrics are not available

• For AWS Glue version 2.0 or later jobs, you specify the number of workers and worker type, but do not specify a maxCapacity.

• AWS Glue versions 2.0 and later do not support s3n out of the box. We recommend using s3 or s3a. If jobs need to use s3n for any reason, you can pass the following additional argument:

  --conf spark.hadoop.fs.s3n.impl=com.amazon.ws.emr.hadoop.fs.EmrFileSystem

Migrating AWS Glue for Spark jobs to AWS Glue version 3.0

This topic describes the changes between AWS Glue versions 0.9, 1.0, 2.0 and 3.0 to allow you to migrate your Spark applications and ETL jobs to AWS Glue 3.0.

To use this feature with your AWS Glue ETL jobs, choose 3.0 for the Glue version when creating your jobs.

Topics

• New features supported
• Actions to migrate to AWS Glue 3.0
• Migration check list
• Migrating from AWS Glue 0.9 to AWS Glue 3.0
• Migrating from AWS Glue 1.0 to AWS Glue 3.0
• Migrating from AWS Glue 2.0 to AWS Glue 3.0
• Appendix A: notable dependency upgrades
• Appendix B: JDBC driver upgrades

New features supported

This section describes new features and advantages of AWS Glue version 3.0.

• It is based on Apache Spark 3.1.1, which has optimizations from open-source Spark and developed by the AWS Glue and EMR services such as adaptive query execution, vectorized readers, and optimized shuffles and partition coalescing.
• Upgraded JDBC drivers for all Glue native sources including MySQL, Microsoft SQL Server, Oracle, PostgreSQL, MongoDB, and upgraded Spark libraries and dependencies brought in by Spark 3.1.1.

• Optimized Amazon S3 access with upgraded EMRFS and enabled Amazon S3 optimized output committers by default.

• Optimized Data Catalog access with partition indexes, push down predicates, partition listing, and upgraded Hive metastore client.

• Integration with Lake Formation for governed catalog tables with cell-level filtering and data lake transactions.

• Improved Spark UI experience with Spark 3.1.1 with new Spark executor memory metrics and Spark structured streaming metrics.

• Reduced startup latency improving overall job completion times and interactivity, similar to AWS Glue 2.0.

• Spark jobs are billed in 1-second increments with a 10x lower minimum billing duration—from a 10-minute minimum to a 1-minute minimum, similar to AWS Glue 2.0.

**Actions to migrate to AWS Glue 3.0**

For existing jobs, change the Glue version from the previous version to Glue 3.0 in the job configuration.

• In the console, choose Spark 3.1, Python 3 (Glue Version 3.0) or Spark 3.1, Scala 2 (Glue Version 3.0) in Glue version.

• In AWS Glue Studio, choose Glue 3.0 - Supports spark 3.1, Scala 2, Python 3 in Glue version.

• In the API, choose 3.0 in the GlueVersion parameter in the UpdateJob API.

For new jobs, choose Glue 3.0 when you create a job.

• In the console, choose Spark 3.1, Python 3 (Glue Version 3.0) or Spark 3.1, Scala 2 (Glue Version 3.0) in Glue version.

• In AWS Glue Studio, choose Glue 3.0 - Supports spark 3.1, Scala 2, Python 3 in Glue version.

• In the API, choose 3.0 in the GlueVersion parameter in the CreateJob API.
To view Spark event logs of AWS Glue 3.0, launch an upgraded Spark history server for Glue 3.0 using CloudFormation or Docker.

Migration check list

Review this checklist for migration.

- Does your job depend on HDFS? If yes, try replacing HDFS with S3.
  - Search the file system path starting with hdfs:// or / as DFS path in the job script code.
  - Check if your default file system is not configured with HDFS. If it is configured explicitly, you need to remove the fs.defaultFS configuration.
  - Check if your job contains any dfs.* parameters. If it contains any, you need to verify it is okay to disable the parameters.
- Does your job depend on YARN? If yes, verify the impacts by checking if your job contains the following parameters. If it contains any, you need to verify it is okay to disable the parameters.
  - spark.yarn.*
    
    For example:
    
    ```
    spark.yarn.executor.memoryOverhead
    spark.yarn.driver.memoryOverhead
    spark.yarn.scheduler.reporterThread.maxFailures
    ```
  
  - yarn.*
    
    For example:
    
    ```
    yarn.scheduлер.maximum-allocation-mb
    yarn.nodemanager.resource.memory-mb
    ```
- Does your job depend on Spark 2.2.1 or Spark 2.4.3? If yes, verify the impacts by checking if your job uses features changed in Spark 3.1.1.
    
    For example the percentile_approx function, or the SparkSession with SparkSession.builder.getOrCreate() when there is an existing SparkContext.
For example the arrayContains function, or the CURRENT_DATE, CURRENT_TIMESTAMP function with spark.sql.caseSensitive=true.

• Do your job's extra jars conflict in Glue 3.0?
  • From AWS Glue 0.9/1.0: Extra jars supplied in existing AWS Glue 0.9/1.0 jobs may bring in classpath conflicts due to upgraded or new dependencies available in Glue 3.0. You can avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter or by shading your dependencies.
  • From AWS Glue 2.0: You can still avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter or by shading your dependencies.

• Do your jobs depend on Scala 2.11?
  • AWS Glue 3.0 uses Scala 2.12 so you need to rebuild your libraries with Scala 2.12 if your libraries depend on Scala 2.11.

• Do your job's external Python libraries depend on Python 2.7/3.6?
  • Use the --additional-python-modules parameters instead of setting the egg/wheel/zip file in the Python library path.
  • Update the dependent libraries from Python 2.7/3.6 to Python 3.7 as Spark 3.1.1 removed Python 2.7 support.

**Migrating from AWS Glue 0.9 to AWS Glue 3.0**

Note the following changes when migrating:

• AWS Glue 0.9 uses open-source Spark 2.2.1 and AWS Glue 3.0 uses EMR-optimized Spark 3.1.1.
  • Several Spark changes alone may require revision of your scripts to ensure removed features are not being referenced.
  • For example, Spark 3.1.1 does not enable Scala-untyped UDFs but Spark 2.2 does allow them.
• All jobs in AWS Glue 3.0 will be executed with significantly improved startup times. Spark jobs will be billed in 1-second increments with a 10x lower minimum billing duration since startup latency will go from 10 minutes maximum to 1 minute maximum.
• Logging behavior has changed since AWS Glue 2.0.
• Several dependency updates, highlighted in Appendix A: notable dependency upgrades.
• Scala is also updated to 2.12 from 2.11, and Scala 2.12 is not backwards compatible with Scala 2.11.
• Python 3.7 is also the default version used for Python scripts, as AWS Glue 0.9 was only utilizing Python 2.
  • Python 2.7 is not supported with Spark 3.1.1.
  • A new mechanism of installing additional Python modules is available.
• AWS Glue 3.0 does not run on Apache YARN, so YARN settings do not apply.
• AWS Glue 3.0 does not have a Hadoop Distributed File System (HDFS).
• Any extra jars supplied in existing AWS Glue 0.9 jobs may bring in conflicting dependencies since there were upgrades in several dependencies in 3.0 from 0.9. You can avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter.
• AWS Glue 3.0 does not yet support dynamic allocation, hence the ExecutorAllocationManager metrics are not available.
• In AWS Glue version 3.0 jobs, you specify the number of workers and worker type, but do not specify a maxCapacity.
• AWS Glue 3.0 does not yet support machine learning transforms.
• AWS Glue 3.0 does not yet support development endpoints.

Refer to the Spark migration documentation:
• see Upgrading from Spark SQL 2.2 to 2.3
• see Upgrading from Spark SQL 2.3 to 2.4
• see Upgrading from Spark SQL 2.4 to 3.0
• see Upgrading from Spark SQL 3.0 to 3.1
• see Changes in Datetime behavior to be expected since Spark 3.0.

Migrating from AWS Glue 1.0 to AWS Glue 3.0

Note the following changes when migrating:
• AWS Glue 1.0 uses open-source Spark 2.4 and AWS Glue 3.0 uses EMR-optimized Spark 3.1.1.
  • Several Spark changes alone may require revision of your scripts to ensure removed features are not being referenced.
  • For example, Spark 3.1.1 does not enable Scala-untyped UDFs but Spark 2.4 does allow them.
All jobs in AWS Glue 3.0 will be executed with significantly improved startup times. Spark jobs will be billed in 1-second increments with a 10x lower minimum billing duration since startup latency will go from 10 minutes maximum to 1 minute maximum.

Logging behavior has changed since AWS Glue 2.0.

Several dependency updates, highlighted in

Scala is also updated to 2.12 from 2.11, and Scala 2.12 is not backwards compatible with Scala 2.11.

Python 3.7 is also the default version used for Python scripts, as AWS Glue 0.9 was only utilizing Python 2.

Python 2.7 is not supported with Spark 3.1.1.

A new mechanism of installing additional Python modules is available.

AWS Glue 3.0 does not run on Apache YARN, so YARN settings do not apply.

AWS Glue 3.0 does not have a Hadoop Distributed File System (HDFS).

Any extra jars supplied in existing AWS Glue 1.0 jobs may bring in conflicting dependencies since there were upgrades in several dependencies in 3.0 from 1.0. You can avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter.

AWS Glue 3.0 does not yet support dynamic allocation, hence the ExecutorAllocationManager metrics are not available.

In AWS Glue version 3.0 jobs, you specify the number of workers and worker type, but do not specify a maxCapacity.

AWS Glue 3.0 does not yet support machine learning transforms.

AWS Glue 3.0 does not yet support development endpoints.

Refer to the Spark migration documentation:

- see Upgrading from Spark SQL 2.4 to 3.0
- see Changes in Datetime behavior to be expected since Spark 3.0.

Migrating from AWS Glue 2.0 to AWS Glue 3.0

Note the following changes when migrating:

- All existing job parameters and major features that exist in AWS Glue 2.0 will exist in AWS Glue 3.0.
• The EMRFS S3-optimized committer for writing Parquet data into Amazon S3 is enabled by default in AWS Glue 3.0. However, you can still disable it by setting --enable-s3-parquet-optimized-committer to false.

• AWS Glue 2.0 uses open-source Spark 2.4 and AWS Glue 3.0 uses EMR-optimized Spark 3.1.1.

• Several Spark changes alone may require revision of your scripts to ensure removed features are not being referenced.

• For example, Spark 3.1.1 does not enable Scala-untyped UDFs but Spark 2.4 does allow them.

• AWS Glue 3.0 also features an update to EMRFS, updated JDBC drivers, and inclusions of additional optimizations onto Spark itself provided by AWS Glue.

• All jobs in AWS Glue 3.0 will be executed with significantly improved startup times. Spark jobs will be billed in 1-second increments with a 10x lower minimum billing duration since startup latency will go from 10 minutes maximum to 1 minute maximum.

• Python 2.7 is not supported with Spark 3.1.1.

• Several dependency updates, highlighted in Appendix A: notable dependency upgrades.

• Scala is also updated to 2.12 from 2.11, and Scala 2.12 is not backwards compatible with Scala 2.11.

• Any extra jars supplied in existing AWS Glue 2.0 jobs may bring in conflicting dependencies since there were upgrades in several dependencies in 3.0 from 2.0. You can avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter.

• AWS Glue 3.0 has different Spark task parallelism for driver/executor configuration compared to AWS Glue 2.0 and improves the performance and better utilizes the available resources. Both spark.driver.cores and spark.executor.cores are configured to number of cores on AWS Glue 3.0 (4 on the standard and G.1X worker, and 8 on the G.2X worker). These configurations do not change the worker type or hardware for the AWS Glue job. You can use these configurations to calculate the number of partitions or splits to match the Spark task parallelism in your Spark application.

In general, jobs will see either similar or improved performance compared to AWS Glue 2.0. If jobs run slower, you can increase the task parallelism by passing the following job argument:

• key: --executor-cores value: <desired number of tasks that can run in parallel>

• The value should not exceed 2x the number of vCPUs on the worker type, which is 8 on G.1X, 16 on G.2X, 32 on G.4X and 64 on G.8X. You should exercise caution while updating this
configuration as it could impact job performance because the increased parallelism causes memory and disk pressure, as well as it could throttle the source and target systems.

- AWS Glue 3.0 uses Spark 3.1, which changes the behavior to loading/saving of timestamps from/to parquet files. For more details, see [Upgrading from Spark SQL 3.0 to 3.1](#).

We recommend to set the following parameters when reading/writing parquet data that contains timestamp columns. Setting those parameters can resolve the calendar incompatibility issue that occurs during the Spark 2 to Spark 3 upgrade, for both the AWS Glue Dynamic Frame and Spark Data Frame. Use the CORRECTED option to read the datetime value as it is; and the LEGACY option to rebase the datetime values with regard to the calendar difference during reading.

- **Key:** --conf
- **Value:** spark.sql.legacy.parquet.int96RebaseModeInRead=[CORRECTED|LEGACY] --conf spark.sql.legacy.parquet.int96RebaseModeInWrite=[CORRECTED|LEGACY] --conf spark.sql.legacy.parquet.datetimeRebaseModeInRead=[CORRECTED|LEGACY]

Refer to the Spark migration documentation:

- see [Upgrading from Spark SQL 2.4 to 3.0](#)
- see [Changes in Datetime behavior to be expected since Spark 3.0](#)

### Appendix A: notable dependency upgrades

The following are dependency upgrades:

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Version in AWS Glue 0.9</th>
<th>Version in AWS Glue 1.0</th>
<th>Version in AWS Glue 2.0</th>
<th>Version in AWS Glue 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spark</td>
<td>2.2.1</td>
<td>2.4.3</td>
<td>2.4.3</td>
<td>3.1.1-amzn-0</td>
</tr>
<tr>
<td>Hadoop</td>
<td>2.7.3-amzn-6</td>
<td>2.8.5-amzn-1</td>
<td>2.8.5-amzn-5</td>
<td>3.2.1-amzn-3</td>
</tr>
<tr>
<td>Scala</td>
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<td>2.11</td>
<td>2.11</td>
<td>2.12</td>
</tr>
<tr>
<td>Jackson</td>
<td>2.7.x</td>
<td>2.7.x</td>
<td>2.7.x</td>
<td>2.10.x</td>
</tr>
<tr>
<td>Hive</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>2.3.7-amzn-4</td>
</tr>
</tbody>
</table>
### Appendix B: JDBC driver upgrades

The following are JDBC driver upgrades:

<table>
<thead>
<tr>
<th>Driver</th>
<th>JDBC driver version in past AWS Glue versions</th>
<th>JDBC driver version in AWS Glue 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>MySQL</td>
<td>5.1</td>
<td>8.0.23</td>
</tr>
<tr>
<td>Microsoft SQL Server</td>
<td>6.1.0</td>
<td>7.0.0</td>
</tr>
<tr>
<td>Oracle Databases</td>
<td>11.2</td>
<td>21.1</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>42.1.0</td>
<td>42.2.18</td>
</tr>
<tr>
<td>MongoDB</td>
<td>2.0.0</td>
<td>4.0.0</td>
</tr>
</tbody>
</table>

### Migrating AWS Glue for Spark jobs to AWS Glue version 4.0

This topic describes the changes between AWS Glue versions 0.9, 1.0, 2.0, and 3.0 to allow you to migrate your Spark applications and ETL jobs to AWS Glue 4.0. It also describes the features in AWS Glue 4.0 and the advantages of using it.

To use this feature with your AWS Glue ETL jobs, choose `4.0` for the Glue version when creating your jobs.

**Topics**
New features supported

This section describes new features and advantages of AWS Glue version 4.0.

- It is based on Apache Spark 3.3.0, but includes optimizations in AWS Glue, and Amazon EMR, such as adaptive query runs, vectorized readers, and optimized shuffles and partition coalescing.
- Upgraded JDBC drivers for all AWS Glue native sources including MySQL, Microsoft SQL Server, Oracle, PostgreSQL, MongoDB, and upgraded Spark libraries and dependencies brought in by Spark 3.3.0.
- Updated with a new Amazon Redshift connector and JDBC driver.
- Optimized Amazon S3 access with upgraded EMR File System (EMRFS) and enabled Amazon S3-optimized output committers, by default.
- Optimized Data Catalog access with partition indexes, pushdown predicates, partition listing, and an upgraded Hive metastore client.
- Integration with Lake Formation for governed catalog tables with cell-level filtering and data lake transactions.
- Reduced startup latency to improve overall job completion times and interactivity.
- Spark jobs are billed in 1-second increments with a 10x lower minimum billing duration—from a 10-minute minimum to a 1-minute minimum.
- Native support for open-data lake frameworks with Apache Hudi, Delta Lake, and Apache Iceberg.
Native support for the Amazon S3-based Cloud Shuffle Storage Plugin (an Apache Spark plugin) to use Amazon S3 for shuffling and elastic storage capacity.

**Major enhancements from Spark 3.1.1 to Spark 3.3.0**

Note the following enhancements:

- Row-level runtime filtering ([SPARK-32268](#)).
- ANSI enhancements ([SPARK-38860](#)).
- Error message improvements ([SPARK-38781](#)).
- Support complex types for Parquet vectorized reader ([SPARK-34863](#)).
- Hidden file metadata support for Spark SQL ([SPARK-37273](#)).
- Provide a profiler for Python/Pandas UDFs ([SPARK-37443](#)).
- Introduce Trigger.AvailableNow for running streaming queries like Trigger.Once in multiple batches ([SPARK-36533](#)).
- More comprehensive Datasource V2 pushdown capabilities ([SPARK-38788](#)).
- Migrating from log4j 1 to log4j 2 ([SPARK-37814](#)).

**Other notable changes**

Note the following changes:

- Breaking changes
  - Drop references to Python 3.6 support in docs and Python/docs ([SPARK-36977](#)).
  - Remove named tuple hack by replacing built-in pickle to cloudpickle ([SPARK-32079](#)).
  - Bump minimum pandas version to 1.0.5 ([SPARK-37465](#)).

**Actions to migrate to AWS Glue 4.0**

For existing jobs, change the Glue version from the previous version to Glue 4.0 in the job configuration.

- In AWS Glue Studio, choose Glue 4.0 - Supports Spark 3.3, Scala 2, Python 3 in Glue version.
- In the API, choose 4.0 in the GlueVersion parameter in the UpdateJob API operation.
For new jobs, choose Glue 4.0 when you create a job.

- In the console, choose Spark 3.3, Python 3 (Glue Version 4.0) or Spark 3.3, Scala 2 (Glue Version 3.0) in Glue version.
- In AWS Glue Studio, choose Glue 4.0 - Supports Spark 3.3, Scala 2, Python 3 in Glue version.
- In the API, choose 4.0 in the GlueVersion parameter in the CreateJob API operation.

To view Spark event logs of AWS Glue 4.0 coming from AWS Glue 2.0 or earlier, launch an upgraded Spark history server for AWS Glue 4.0 using AWS CloudFormation or Docker.

Migration checklist

Review this checklist for migration:

โปรดทราบว่าสำหรับรายการที่ให้ความสำคัญกับ AWS Glue 3.0 ให้ดู Migration check list.

- Do your job's external Python libraries depend on Python 2.7/3.6?
  - Update the dependent libraries from Python 2.7/3.6 to Python 3.10 as Spark 3.3.0 completely removed Python 2.7 and 3.6 support.

Migrating from AWS Glue 3.0 to AWS Glue 4.0

Note the following changes when migrating:

- All existing job parameters and major features that exist in AWS Glue 3.0 will exist in AWS Glue 4.0.
- AWS Glue 3.0 uses Amazon EMR-optimized Spark 3.1.1, and AWS Glue 4.0 uses Amazon EMR-optimized Spark 3.3.0.

Several Spark changes alone might require revision of your scripts to ensure that removed features are not being referenced.
- AWS Glue 4.0 also features an update to EMRFS and Hadoop. For the specific version, see Appendix A: Notable dependency upgrades.
• The AWS SDK provided in ETL jobs is now upgraded from 1.11 to 1.12.

• All Python jobs will be using Python version 3.10. Previously, Python 3.7 was used in AWS Glue 3.0.

As a result, some pymodules brought out-of-the-box by AWS Glue are upgraded.

• Log4j has been upgraded to Log4j2.
  - For information on the Log4j2 migration path, see the Log4j documentation.
  - You must rename any custom log4j.properties file as a log4j2.properties file instead, with the appropriate log4j2 properties.

• For migrating certain connectors, see Connector and JDBC driver migration for AWS Glue 4.0.

• The AWS Encryption SDK is upgraded from 1.x to 2.x. AWS Glue jobs using AWS Glue security configurations and jobs dependent on the AWS Encryption SDK dependency provided in runtime are affected. See the instructions for AWS Glue job migration.

  You can safely upgrade an AWS Glue 2.0/3.0 job to an AWS Glue 4.0 job because AWS Glue 2.0/3.0 already contains the AWS Encryption SDK bridge version.

Refer to the Spark migration documentation:

• Upgrading from Spark SQL 3.1 to 3.2
• Upgrading from Spark SQL 3.2 to 3.3

Migrating from AWS Glue 2.0 to AWS Glue 4.0

Note the following changes when migrating:

**Note**

For migration steps related to AWS Glue 3.0, see Migrating from AWS Glue 3.0 to AWS Glue 4.0.

• All existing job parameters and major features that exist in AWS Glue 2.0 will exist in AWS Glue 4.0.
• The EMRFS S3-optimized committer for writing Parquet data into Amazon S3 is enabled by default since AWS Glue 3.0. However, you can still disable it by setting `--enable-s3-parquet-optimized-committer` to `false`.

• AWS Glue 2.0 uses open-source Spark 2.4 and AWS Glue 4.0 uses Amazon EMR-optimized Spark 3.3.0.
  - Several Spark changes alone may require revision of your scripts to ensure that removed features are not being referenced.
  - For example, Spark 3.3.0 does not enable Scala-untyped UDFs, but Spark 2.4 does allow them.

• The AWS SDK provided in ETL jobs is now upgraded from 1.11 to 1.12.

• AWS Glue 4.0 also features an update to EMRFS, updated JDBC drivers, and inclusions of additional optimizations onto Spark itself provided by AWS Glue.

• Scala is updated to 2.12 from 2.11, and Scala 2.12 is not backward compatible with Scala 2.11.

• Python 3.10 is the default version used for Python scripts, as AWS Glue 2.0 was only using Python 3.7 and 2.7.
  - Python 2.7 is not supported with Spark 3.3.0. Any job requesting Python 2 in the job configuration will fail with an `IllegalArgumentException`.
  - A new mechanism of installing additional Python modules is available since AWS Glue 2.0.

• Several dependency updates, highlighted in [Appendix A: Notable dependency upgrades](#).

• Any extra JAR files supplied in existing AWS Glue 2.0 jobs might bring in conflicting dependencies because there were upgrades in several dependencies in 4.0 from 2.0. You can avoid classpath conflicts in AWS Glue 4.0 with the `--user-jars-first` AWS Glue job parameter.

• AWS Glue 4.0 uses Spark 3.3. Starting with Spark 3.1, there was a change in the behavior of loading/saving of timestamps from/to parquet files. For more details, see [Upgrading from Spark SQL 3.0 to 3.1](#).

We recommend to set the following parameters when reading/writing parquet data that contains timestamp columns. Setting those parameters can resolve the calendar incompatibility issue that occurs during the Spark 2 to Spark 3 upgrade, for both the AWS Glue Dynamic Frame and Spark Data Frame. Use the `CORRECTED` option to read the datetime value as it is; and the `LEGACY` option to rebase the datetime values with regard to the calendar difference during reading.

- Key: `--conf`
For migrating certain connectors, see [Connector and JDBC driver migration for AWS Glue 4.0](#). The AWS Encryption SDK is upgraded from 1.x to 2.x. AWS Glue jobs using AWS Glue security configurations and jobs dependent on the AWS Encryption SDK dependency provided in runtime are affected. See these instructions for AWS Glue job migration:

- You can safely upgrade an AWS Glue 2.0 job to an AWS Glue 4.0 job because AWS Glue 2.0 already contains the AWS Encryption SDK bridge version.

Refer to the Spark migration documentation:

- [Upgrading from Spark SQL 2.4 to 3.0](#)
- [Upgrading from Spark SQL 3.1 to 3.2](#)
- [Upgrading from Spark SQL 3.2 to 3.3](#)
- [Changes in Datetime behavior to be expected since Spark 3.0](#)

### Migrating from AWS Glue 1.0 to AWS Glue 4.0

Note the following changes when migrating:

- AWS Glue 1.0 uses open-source Spark 2.4 and AWS Glue 4.0 uses Amazon EMR-optimized Spark 3.3.0.
  - Several Spark changes alone may require revision of your scripts to ensure that removed features are not being referenced.
  - For example, Spark 3.3.0 does not enable Scala-untyped UDFs, but Spark 2.4 does allow them.
- All jobs in AWS Glue 4.0 will be run with significantly improved startup times. Spark jobs will be billed in 1-second increments with a 10x lower minimum billing duration since startup latency will go from 10 minutes maximum to 1 minute maximum.
- Logging behavior has changed significantly in AWS Glue 4.0, Spark 3.3.0 has a minimum requirement of Log4j2.
- Several dependency updates, highlighted in the appendix.
- Scala is also updated to 2.12 from 2.11, and Scala 2.12 is not backward compatible with Scala 2.11.
• Python 3.10 is also the default version used for Python scripts, as AWS Glue 0.9 was only using Python 2.

    Python 2.7 is not supported with Spark 3.3.0. Any job requesting Python 2 in the job configuration will fail with an IllegalArgumentException.

• A new mechanism of installing additional Python modules through pip is available since AWS Glue 2.0. For more information, see Installing additional Python modules with pip in AWS Glue 2.0+.

• AWS Glue 4.0 does not run on Apache YARN, so YARN settings do not apply.

• AWS Glue 4.0 does not have a Hadoop Distributed File System (HDFS).

• Any extra JAR files supplied in existing AWS Glue 1.0 jobs might bring in conflicting dependencies because there were upgrades in several dependencies in 4.0 from 1.0. We enable AWS Glue 4.0 with the --user-jars-first AWS Glue job parameter by default, to avoid this problem.

• AWS Glue 4.0 supports auto scaling. Therefore, the ExecutorAllocationManager metric will be available when auto scaling is enabled.

• In AWS Glue version 4.0 jobs, you specify the number of workers and worker type, but do not specify a maxCapacity.

• AWS Glue 4.0 does not yet support machine learning transforms.

• For migrating certain connectors, see Connector and JDBC driver migration for AWS Glue 4.0.

• The AWS Encryption SDK is upgraded from 1.x to 2.x. AWS Glue jobs using AWS Glue security configurations and jobs dependent on the AWS Encryption SDK dependency provided in runtime are affected. See these instructions for AWS Glue job migration.

    • You cannot migrate an AWS Glue 0.9/1.0 job to an AWS Glue 4.0 job directly. This is because when upgrading directly to version 2.x or later and enabling all new features immediately, the AWS Encryption SDK won't be able to decrypt the ciphertext encrypted under earlier versions of the AWS Encryption SDK.

    • To safely upgrade, we first recommend that you migrate to an AWS Glue 2.0/3.0 job that contains the AWS Encryption SDK bridge version. Run the job once to utilize the AWS Encryption SDK bridge version.

    • Upon completion, you can safely migrate the AWS Glue 2.0/3.0 job to AWS Glue 4.0.

Refer to the Spark migration documentation:
Upgrading from Spark SQL 2.4 to 3.0
Upgrading from Spark SQL 3.0 to 3.1
Upgrading from Spark SQL 3.1 to 3.2
Upgrading from Spark SQL 3.2 to 3.3
Changes in Datetime behavior to be expected since Spark 3.0.

Migrating from AWS Glue 0.9 to AWS Glue 4.0

Note the following changes when migrating:

- AWS Glue 0.9 uses open-source Spark 2.2.1 and AWS Glue 4.0 uses Amazon EMR-optimized Spark 3.3.0.
  - Several Spark changes alone might require revision of your scripts to ensure that removed features are not being referenced.
  - For example, Spark 3.3.0 does not enable Scala-untyped UDFs, but Spark 2.2 does allow them.
- All jobs in AWS Glue 4.0 will be run with significantly improved startup times. Spark jobs will be billed in 1-second increments with a 10x lower minimum billing duration because startup latency will go from 10 minutes maximum to 1 minute maximum.
- Logging behavior has changed significantly since AWS Glue 4.0, Spark 3.3.0 has a minimum requirement of Log4j2 as mentioned here (https://spark.apache.org/docs/latest/core-migration-guide.html#upgrading-from-core-32-to-33).
  - Several dependency updates, highlighted in the appendix.
- Scala is also updated to 2.12 from 2.11, and Scala 2.12 is not backward compatible with Scala 2.11.
- Python 3.10 is also the default version used for Python scripts, as AWS Glue 0.9 was only using Python 2.
  - Python 2.7 is not supported with Spark 3.3.0. Any job requesting Python 2 in the job configuration will fail with an IllegalArgumentException.
  - A new mechanism of installing additional Python modules through pip is available.
- AWS Glue 4.0 does not run on Apache YARN, so YARN settings do not apply.
- AWS Glue 4.0 does not have a Hadoop Distributed File System (HDFS).
- Any extra JAR files supplied in existing AWS Glue 0.9 jobs might bring in conflicting dependencies because there were upgrades in several dependencies in 3.0 from 0.9.
can avoid classpath conflicts in AWS Glue 3.0 with the --user-jars-first AWS Glue job parameter.

- AWS Glue 4.0 supports auto scaling. Therefore, the ExecutorAllocationManager metric will be available when auto scaling is enabled.
- In AWS Glue version 4.0 jobs, you specify the number of workers and worker type, but do not specify a maxCapacity.
- AWS Glue 4.0 does not yet support machine learning transforms.
- For migrating certain connectors, see Connector and JDBC driver migration for AWS Glue 4.0.
- The AWS Encryption SDK is upgraded from 1.x to 2.x. AWS Glue jobs using AWS Glue security configurations and jobs dependent on the AWS Encryption SDK dependency provided in runtime are affected. See these instructions for AWS Glue job migration.
- You cannot migrate an AWS Glue 0.9/1.0 job to an AWS Glue 4.0 job directly. This is because when upgrading directly to version 2.x or later and enabling all new features immediately, the AWS Encryption SDK won't be able to decrypt the ciphertext encrypted under earlier versions of the AWS Encryption SDK.
- To safely upgrade, we first recommend that you migrate to an AWS Glue 2.0/3.0 job that contains the AWS Encryption SDK bridge version. Run the job once to utilize the AWS Encryption SDK bridge version.
- Upon completion, you can safely migrate the AWS Glue 2.0/3.0 job to AWS Glue 4.0.

Refer to the Spark migration documentation:

- Upgrading from Spark SQL 2.2 to 2.3
- Upgrading from Spark SQL 2.3 to 2.4
- Upgrading from Spark SQL 2.4 to 3.0
- Upgrading from Spark SQL 3.0 to 3.1
- Upgrading from Spark SQL 3.1 to 3.2
- Upgrading from Spark SQL 3.2 to 3.3
- Changes in Datetime behavior to be expected since Spark 3.0.

**Connector and JDBC driver migration for AWS Glue 4.0**

For the versions of JDBC and data lake connectors that were upgraded, see:
Hudi

Spark SQL support improvements:

- Through the `Call Procedure` command, there is added support for upgrade, downgrade, bootstrap, clean, and repair. `Create/Drop/Show/Refresh Index` syntax is possible in Spark SQL.
- A performance gap has been closed between usage through a Spark DataSource as opposed to Spark SQL. Datasource writes in the past used to be faster than SQL.
- All built-in key generators implement more performant Spark-specific API operations.
- Replaced UDF transformation in the bulk `insert` operation with RDD transformations to cut down on costs of using SerDe.
- Spark SQL with Hudi requires a `primaryKey` to be specified by `tblproperites` or options in the SQL statement. For update and delete operations, the `preCombineField` is required as well.
- Any Hudi table created before version 0.10.0 without a `primaryKey` needs to be recreated with a `primaryKey` field since version 0.10.0.

PostgreSQL

- Several vulnerabilities (CVEs) were addressed.
- Java 8 is natively supported.
- If the job is using Arrays of Arrays, with the exception of byte arrays, this scenario can be treated as multidimensional arrays.

MongoDB

- The current MongoDB connector supports Spark version 3.1 or later and MongoDB version 4.0 or later.
- Due to the connector upgrade, a few property names changed. For example, the URI property name changed to `connection.uri`. For more information on the current options, see the MongoDB Spark Connector blog.
• Using MongoDB 4.0 hosted by Amazon DocumentDB has some functional differences. For more information, see these topics:
  • Functional Differences: Amazon DocumentDB and MongoDB
  • Supported MongoDB APIs, Operations, and Data Types.

• The "partitioner" option is restricted to ShardedPartitioner, PaginateIntoPartitionsPartitioner, and SinglePartitionPartitioner. It cannot use default SamplePartitioner and PaginateBySizePartitioner for Amazon DocumentDB because the stage operator does not support the MongoDB API. For more information, see Supported MongoDB APIs, Operations, and Data Types.

Delta Lake

• Delta Lake now supports time travel in SQL to query older data easily. With this update, time travel is now available both in Spark SQL and through the DataFrame API. Support has been added for the current version of TIMESTAMP in SQL.

• Spark 3.3 introduces Trigger.AvailableNow for running streaming queries as an equivalent to Trigger.Once for batch queries. This support is also available when using Delta tables as a streaming source.

• Support for SHOW COLUMNS to return the list of columns in a table.

• Support for DESCRIBE DETAIL in the Scala and Python DeltaTable API. It retrieves detailed information about a Delta table using either the DeltaTable API or Spark SQL.

• Support for returning operation metrics from SQL Delete, Merge, and Update commands. Previously these SQL commands returned an empty DataFrame, now they return a DataFrame with useful metrics about the operation performed.

• Optimize performance improvements:
  • Set the configuration option
    spark.databricks.delta.optimize.repartition.enabled=true to use repartition(1) instead of coalesce(1) in the Optimize command for better performance when compacting many small files.
  • Improved performance by using a queue-based approach to parallelize compaction jobs.

• Other notable changes:
  • Support for using variables in the VACUUM and OPTIMIZE SQL commands.
  • Improvements for CONVERT TO DELTA with catalog tables including:
    • Autofill the partition schema from the catalog when it's not provided.
• **Use partition information** from the catalog to find the data files to commit instead of doing a full directory scan. Instead of committing all data files in the table directory, only data files under the directories of active partitions will be committed.

• **Support for Change Data Feed (CDF) batch reads** on column mapping enabled tables when DROP COLUMN and RENAME COLUMN have not been used. For more information, see the [Delta Lake documentation](#).

• **Improve Update command performance** by enabling schema pruning in the first pass.

**Apache Iceberg**

• Added several **performance improvements** for scan planning and Spark queries.

• Added a common REST catalog client that uses change-based commits to resolve commit conflicts on the service side.

• AS OF syntax for SQL time travel queries is supported.

• Added merge-on-read support for MERGE and UPDATE queries.

• Added support to rewrite partitions using Z-order.

• Added a spec and implementation for Puffin, a format for large stats and index blobs, like Theta sketches or bloom filters.

• Added new interfaces for consuming data incrementally (both append and changelog scans).

• Added support for bulk operations and ranged reads to FileIO interfaces.

• Added more metadata tables to show delete files in the metadata tree.

• The drop table behavior changed. In Iceberg 0.13.1, running DROP TABLE removes the table from the catalog and deletes the table contents as well. In Iceberg 1.0.0, DROP TABLE only removes the table from the catalog. To delete the table contents use DROP TABLE PURGE.

• Parquet vectorized reads are enabled by default in Iceberg 1.0.0. If you want to disable vectorized reads, set read.parquet.vectorization.enabled to false.

**Oracle**

Changes are minor.

**MySQL**

Changes are minor.
Amazon Redshift

AWS Glue 4.0 features a new Amazon Redshift connector with a new JDBC driver. For information about the enhancements and how to migrate from previous AWS Glue versions, see the section called “Redshift connections”.

Appendix A: Notable dependency upgrades

The following are dependency upgrades:

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Version in AWS Glue 4.0</th>
<th>Version in AWS Glue 3.0</th>
<th>Version in AWS Glue 2.0</th>
<th>Version in AWS Glue 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spark</td>
<td>3.3.0-amzn-1</td>
<td>3.1.1-amzn-0</td>
<td>2.4.3</td>
<td>2.4.3</td>
</tr>
<tr>
<td>Hadoop</td>
<td>3.3.3-amzn-0</td>
<td>3.2.1-amzn-3</td>
<td>2.8.5-amzn-5</td>
<td>2.8.5-amzn-1</td>
</tr>
<tr>
<td>Scala</td>
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<td>2.11</td>
<td>2.11</td>
</tr>
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<td>Jackson</td>
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<td>2.7.x</td>
</tr>
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<td>3.7.0</td>
<td>3.0.0</td>
<td>1.10.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Python</td>
<td>3.10</td>
<td>3.7</td>
<td>2.7 &amp; 3.6</td>
<td>2.7 &amp; 3.6</td>
</tr>
<tr>
<td>Boto</td>
<td>1.26</td>
<td>1.18</td>
<td>1.12</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Appendix B: JDBC driver upgrades

The following are JDBC driver upgrades:
# Appendix C: Connector upgrades

The following are connector upgrades:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Connector version in AWS Glue 3.0</th>
<th>Connector version in AWS Glue 4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>MongoDB</td>
<td>3.0.0</td>
<td>10.0.4</td>
</tr>
<tr>
<td>Hudi</td>
<td>0.10.1</td>
<td>0.12.1</td>
</tr>
<tr>
<td>Delta Lake</td>
<td>1.0.0</td>
<td>2.1.0</td>
</tr>
<tr>
<td>Iceberg</td>
<td>0.13.1</td>
<td>1.0.0</td>
</tr>
<tr>
<td>DynamoDB</td>
<td>1.11</td>
<td>1.12</td>
</tr>
</tbody>
</table>
Migrating AWS Glue for Ray from preview to the Ray2.4 runtime environment

⚠️ Warning
When you save your AWS Glue for Ray (preview) job in AWS Glue Studio, it will be automatically upgraded to the Ray2.4 runtime. If you experience compatibility issues with your script, please contact support.

You should migrate AWS Glue jobs that were created during the AWS Glue for Ray (preview) to AWS Glue for Ray. This will involve a few concurrent changes to your job configuration.

- In the Runtime field, provide the Ray2.4 runtime value. This will upgrade the underlying Ray version from 2.0.0 to 2.4.0.

- Certain Python libraries included by default in the preview are no longer provided. If your job takes advantage of the AWS SDK for pandas (awswrangler), dask, modin, or pymars, you will need to include these as additional libraries. For more information on including additional Python libraries, see [the section called “Additional Python modules for Ray jobs”](#).

- If you're using the --additional-python-modules parameter, the parameters used to support this workflow have been broken out into --pip-install and --s3-py-modules. For more information about these parameters, see [the section called “Additional Python modules for Ray jobs”](#).

- If you're using the --auto-scaling-ray-min-workers parameter, it has been renamed --min-workers.

AWS Glue version support policy

AWS Glue is a serverless data integration service that makes it easy to discover, prepare, and combine data for analytics, machine learning, and application development. An AWS Glue job contains the business logic that performs the data integration work in AWS Glue. There are three types of jobs in AWS Glue: Spark (*batch and streaming*), Ray and Python shell. When you define your job, you specify the AWS Glue version, which configures versions in the underlying Spark, Ray or Python runtime environment. For example: an AWS Glue version 2.0 Spark job supports Spark 2.4.3 and Python 3.7.
Support policy

Occasionally AWS Glue discontinues support for old AWS Glue versions. However, jobs running on deprecated versions are no longer eligible for technical support. AWS Glue will no longer apply security patches or other updates to deprecated versions. AWS Glue will also not honor SLAs when jobs are run on deprecated versions.

When end of support occurs for AWS Glue version 2.0 or later, you will not be able to create jobs, but only edit or run jobs.

The following AWS Glue versions have reached or are scheduled for end of support. End of support starts at midnight (Pacific time zone) on the specified date.

<table>
<thead>
<tr>
<th>Type</th>
<th>Glue version</th>
<th>End of support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spark</td>
<td>Spark 2.2, Scala 2 (Glue version 0.9)</td>
<td>6/1/2022</td>
</tr>
<tr>
<td>Spark</td>
<td>Spark 2.2, Python 2 (Glue version 0.9)</td>
<td>6/1/2022</td>
</tr>
<tr>
<td>Spark</td>
<td>Spark 2.4, Python 2 (Glue version 1.0)</td>
<td>6/1/2022</td>
</tr>
<tr>
<td>Spark</td>
<td>Spark 2.4, Python 3 (Glue version 1.0)</td>
<td>9/30/2022</td>
</tr>
<tr>
<td>Spark</td>
<td>Spark 2.4, Scala 2 (Glue version 1.0)</td>
<td>9/30/2022</td>
</tr>
<tr>
<td>Spark</td>
<td>Glue version 2.0</td>
<td>1/31/2024</td>
</tr>
<tr>
<td>Type</td>
<td>Python version</td>
<td>End of support</td>
</tr>
<tr>
<td>Python shell</td>
<td>Python 2 (Glue Version 1.0)</td>
<td>6/1/2022</td>
</tr>
<tr>
<td>Type</td>
<td>Notebook version</td>
<td>End of support</td>
</tr>
<tr>
<td>Development endpoint</td>
<td>Zeppelin notebook</td>
<td>9/30/2022</td>
</tr>
</tbody>
</table>
AWS strongly recommends that you migrate your jobs to supported versions.

For information on migrating your Spark jobs to the latest AWS Glue version, see [Migrating AWS Glue jobs to AWS Glue version 4.0](#).

For migrating your Python shell jobs to the latest AWS Glue version:

- In the console, choose **Python 3 (Glue Version 4.0)**.
- In the **CreateJob**/**UpdateJob** API, set the GlueVersion parameter to **4.0**, and the PythonVersion to **3** under the Command parameter.
- You need to make your job script compatible with Python 3.

**Note**

All AWS Regions that were launched prior to the launch of the Jakarta, Indonesia (ap-southeast-3) Region in August 2022 have an allow list of customers who are allowed to run AWS Glue version 0.9/1.0 job runs. In these older Regions, you can create a job with a null value and it will default to version 0.9/1.0 depending on Region. For any later launched AWS Regions, you must explicitly set the AWS Glue version in the API. AWS Glue no longer accepts a null parameter. If you pass 0.9 or 1.0 in the parameter you encounter the error "Glue Version 0.9 (or) 1.0 is not supported."

---

**Working with Spark jobs in AWS Glue**

Provides information on AWS Glue for Spark ETL jobs.

**Topics**

- [AWS Glue job parameters](#)
- [AWS Glue Spark and PySpark jobs](#)
- [Streaming ETL jobs in AWS Glue](#)
- [Record matching with AWS Lake Formation FindMatches](#)
- [Migrate Apache Spark programs to AWS Glue](#)
AWS Glue job parameters

When creating an AWS Glue job, you set some standard fields, such as Role and WorkerType. You can provide additional configuration information through the Argument fields (Job Parameters in the console). In these fields, you can provide AWS Glue jobs with the arguments (parameters) listed in this topic. For more information about the AWS Glue Job API, see the section called “Jobs”.

Setting job parameters

You can configure a job through the console on the Job details tab, under the Job Parameters heading. You can also configure a job through the AWS CLI by setting DefaultArguments or NonOverridableArguments on a job, or setting Arguments on a job run. Arguments set on the job will be passed in every time the job is run, while arguments set on the job run will only be passed in for that individual run.

For example, the following is the syntax for running a job using --arguments to set a job parameter.

```
$ aws glue start-job-run --job-name "CSV to CSV" --arguments='--scriptLocation="s3://my_glue/libraries/test_lib.py"'
```

Accessing job parameters

When writing AWS Glue scripts, you may want to access job parameter values to alter the behavior of your own code. We provide helper methods to do so in our libraries. These methods resolve job run parameter values that override job parameter values. When resolving parameters set in multiple places, job NonOverridableArguments will override job run Arguments, which will override job DefaultArguments.

In Python:

In Python jobs, we provide a function named getResolvedParameters. For more information, see the section called “getResolvedOptions”. Job parameters are available in the sys.argv variable.

In Scala:

In Scala jobs, we provide an object named GlueArgParser. For more information, see the section called “GlueArgParser”. Job parameters are available in the sysArgs variable.
Job parameter reference

AWS Glue recognizes the following argument names that you can use to set up the script environment for your jobs and job runs:

--additional-python-modules

A comma delimited list representing a set of Python packages to be installed. You can install packages from PyPI or provide a custom distribution. A PyPI package entry will be in the format `package==version`, with the PyPI name and version of your target package. A custom distribution entry is the S3 path to the distribution.

Entries use Python version matching to match package and version. This means you will need to use two equals signs, such as `==`. There are other version matching operators, for more information see [PEP 440](https://www.python.org/dev/peps/pep-0440/).

To pass module installation options to `pip3`, use the `--python-modules-installer-option` parameter.

--auto-scale-within-microbatch

The default value is false. This parameter can only be used for AWS Glue streaming jobs, which process the streaming data in a series of micro batches, and auto scaling must be enabled. When setting this value to false, it computes the exponential moving average of batch duration for completed micro-batches and compares this value with the window size to determine whether to scale up or scale down the number of executors. Scaling only happens when a micro batch is completed. When setting this value to true, during a micro-batch, it scales up when the number of Spark tasks remains the same for 30 seconds, or the current batch processing is greater than the window size. The number of executors will drop if an executor has been idle for more than 60 seconds, or the exponential moving average of batch duration is low.

--class

The Scala class that serves as the entry point for your Scala script. This applies only if your `--job-language` is set to scala.

--continuous-log-conversionPattern

Specifies a custom conversion log pattern for a job enabled for continuous logging. The conversion pattern applies only to driver logs and executor logs. It does not affect the AWS Glue progress bar.
--continuous-log-logGroup

Specifies a custom Amazon CloudWatch log group name for a job enabled for continuous logging.

--continuous-log-logStreamPrefix

Specifies a custom CloudWatch log stream prefix for a job enabled for continuous logging.

--datalake-formats

Supported in AWS Glue 3.0 and later versions.

Specifies the data lake framework to use. AWS Glue adds the required JAR files for the frameworks that you specify into the classpath. For more information, see Using data lake frameworks with AWS Glue ETL jobs.

You can specify one or more of the following values, separated by a comma:

- hudi
- delta
- iceberg

For example, pass the following argument to specify all three frameworks.

'--datalake-formats': 'hudi,delta,iceberg'

--disable-proxy-v2

Disable the service proxy to allow AWS service calls to Amazon S3, CloudWatch, and AWS Glue originating from your script through your VPC. For more information, see Configuring AWS calls to go through your VPC. To disable the service proxy, set the value of this parameter to true.

--enable-auto-scaling

Turns on auto scaling and per-worker billing when you set the value to true.

--enable-continuous-cloudwatch-log

Enables real-time continuous logging for AWS Glue jobs. You can view real-time Apache Spark job logs in CloudWatch.
--enable-continuous-log-filter

Specifies a standard filter (true) or no filter (false) when you create or edit a job enabled for continuous logging. Choosing the standard filter prunes out non-useful Apache Spark driver/executor and Apache Hadoop YARN heartbeat log messages. Choosing no filter gives you all the log messages.

--enable-glue-datacatalog

Enables you to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To enable this feature, set the value to true.

--enable-job-insights

Enables additional error analysis monitoring with AWS Glue job run insights. For details, see the section called “Monitoring with AWS Glue job run insights”. By default, the value is set to true and job run insights are enabled.

This option is available for AWS Glue version 2.0 and 3.0.

--enable-metrics

Enables the collection of metrics for job profiling for this job run. These metrics are available on the AWS Glue console and the Amazon CloudWatch console. The value of this parameter is not relevant. To enable this feature, you can provide this parameter with any value, but true is recommended for clarity. To disable this feature, remove this parameter from your job configuration.

--enable-observability-metrics

Enables a set of Observability metrics to generate insights into what is happening inside each job run on Job Runs Monitoring page under AWS Glue console and the Amazon CloudWatch console. To enable this feature, set the value of this parameter to true. To disable this feature, set it to false or remove this parameter from your job configuration.

--enable-rename-algorithm-v2

Sets the EMRFS rename algorithm version to version 2. When a Spark job uses dynamic partition overwrite mode, there is a possibility that a duplicate partition is created. For instance, you can end up with a duplicate partition such as s3://bucket/table/location/p1=1/p1=1. Here, P1 is the partition that is being overwritten. Rename algorithm version 2 fixes this issue.

This option is only available on AWS Glue version 1.0.
**--enable-s3-parquet-optimized-committer**

Enables the EMRFS S3-optimized committer for writing Parquet data into Amazon S3. You can supply the parameter/value pair via the AWS Glue console when creating or updating an AWS Glue job. Setting the value to `true` enables the committer. By default, the flag is turned on in AWS Glue 3.0 and off in AWS Glue 2.0.

For more information, see [Using the EMRFS S3-optimized Committer](#).

**--enable-spark-ui**

When set to `true`, turns on the feature to use the Spark UI to monitor and debug AWS Glue ETL jobs.

**--executor-cores**

Number of spark tasks that can run in parallel. This option is supported on AWS Glue 3.0+. The value should not exceed 2x the number of vCPUs on the worker type, which is 8 on G.1X, 16 on G.2X, 32 on G.4X and 64 on G.8X. You should exercise caution while updating this configuration as it could impact job performance because increased task parallelism causes memory, disk pressure as well as it could throttle the source and target systems (for example: it would cause more concurrent connections on Amazon RDS).

**--extra-files**

The Amazon S3 paths to additional files, such as configuration files that AWS Glue copies to the working directory of your script before running it. Multiple values must be complete paths separated by a comma (,). Only individual files are supported, not a directory path. This option is not supported for Python Shell job types.

**--extra-jars**

The Amazon S3 paths to additional Java `.jar` files that AWS Glue adds to the Java classpath before executing your script. Multiple values must be complete paths separated by a comma (,).

**--extra-py-files**

The Amazon S3 paths to additional Python modules that AWS Glue adds to the Python path before running your script. Multiple values must be complete paths separated by a comma (,). Only individual files are supported, not a directory path.

**--job-bookmark-option**

Controls the behavior of a job bookmark. The following option values can be set.
<table>
<thead>
<tr>
<th>--job-bookmark-option value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>job-bookmark-enable</td>
<td>Keep track of previously processed data. When a job runs, process new data since the last checkpoint.</td>
</tr>
<tr>
<td>job-bookmark-disable</td>
<td>Always process the entire dataset. You are responsible for managing the output from previous job runs.</td>
</tr>
<tr>
<td>job-bookmark-pause</td>
<td>Process incremental data since the last successful run or the data in the range identified by the following suboptions, without updating the state of the last bookmark. You are responsible for managing the output from previous job runs. The two suboptions are as follows:</td>
</tr>
<tr>
<td></td>
<td>• <strong>job-bookmark-from</strong> <code>&lt;from-value&gt;</code> is the run ID that represents all the input that was processed until the last successful run before and including the specified run ID. The corresponding input is ignored.</td>
</tr>
<tr>
<td></td>
<td>• <strong>job-bookmark-to</strong> <code>&lt;to-value&gt;</code> is the run ID that represents all the input that was processed until the last successful run before and including the specified run ID. The corresponding input excluding the input identified by the <code>&lt;from-value&gt;</code> is processed by the job. Any input later than this input is also excluded for processing.</td>
</tr>
<tr>
<td></td>
<td>The job bookmark state is not updated when this option set is specified.</td>
</tr>
<tr>
<td></td>
<td>The suboptions are optional. However, when used, both suboptions must be provided.</td>
</tr>
</tbody>
</table>

For example, to enable a job bookmark, pass the following argument.

'--job-bookmark-option': 'job-bookmark-enable'
--job-language

The script programming language. This value must be either scala or python. If this parameter is not present, the default is python.

--python-modules-installer-option

A plaintext string that defines options to be passed to pip3 when installing modules with --additional-python-modules. Provide options as you would in the command line, separated by spaces and prefixed by dashes. For more information about usage, see the section called “Installing additional Python modules with pip in AWS Glue 2.0+”.

ℹ️ Note

This option is not supported for AWS Glue jobs when you use Python 3.9.

--scriptLocation

The Amazon Simple Storage Service (Amazon S3) location where your ETL script is located (in the form s3://path/to/my/script.py). This parameter overrides a script location set in the JobCommand object.

--spark-event-logs-path

Specifies an Amazon S3 path. When using the Spark UI monitoring feature, AWS Glue flushes the Spark event logs to this Amazon S3 path every 30 seconds to a bucket that can be used as a temporary directory for storing Spark UI events.

--TempDir

Specifies an Amazon S3 path to a bucket that can be used as a temporary directory for the job.

For example, to set a temporary directory, pass the following argument.

'--TempDir': 's3-path-to-directory'

ℹ️ Note

AWS Glue creates a temporary bucket for jobs if a bucket doesn't already exist in a Region. This bucket might permit public access. You can either modify the bucket in
Amazon S3 to set the public access block, or delete the bucket later after all jobs in that Region have completed.

--use-postgres-driver

When setting this value to true, it prioritizes the Postgres JDBC driver in the class path to avoid a conflict with the Amazon Redshift JDBC driver. This option is only available in AWS Glue version 2.0.

--user-jars-first

When setting this value to true, it prioritizes the customer’s extra JAR files in the classpath. This option is only available in AWS Glue version 2.0 or later.

--conf

Controls Spark config parameters. It is for advanced use cases.

--encryption-type

Legacy parameter. The corresponding behavior should be configured using security configurations. For more information about security configurations, see the section called “Encrypting data written by AWS Glue”.

AWS Glue uses the following arguments internally and you should never use them:

- --debug — Internal to AWS Glue. Do not set.
- --mode — Internal to AWS Glue. Do not set.
- --JOB_NAME — Internal to AWS Glue. Do not set.
- --endpoint — Internal to AWS Glue. Do not set.

AWS Glue supports bootstrapping an environment with Python’s site module using sitecustomize to perform site-specific customizations. Bootstrapping your own initialization functions is recommended for advanced use cases only and is supported on a best-effort basis on AWS Glue 4.0.

The environment variable prefix, GLUE_CUSTOMER, is reserved for customer use.
AWS Glue Spark and PySpark jobs

The following sections provide information on AWS Glue Spark and PySpark jobs.

Topics

• Adding Spark and PySpark jobs in AWS Glue
• Using auto scaling for AWS Glue
• Tracking processed data using job bookmarks
• Workload partitioning with bounded execution
• AWS Glue Spark shuffle plugin with Amazon S3
• Monitoring AWS Glue Spark jobs

Adding Spark and PySpark jobs in AWS Glue

The following sections provide information on adding Spark and PySpark jobs in AWS Glue.

Topics

• Adding jobs in AWS Glue
• Editing Spark scripts in the AWS Glue console
• Jobs (legacy)

Adding jobs in AWS Glue

An AWS Glue job encapsulates a script that connects to your source data, processes it, and then writes it out to your data target. Typically, a job runs extract, transform, and load (ETL) scripts. Jobs can also run general-purpose Python scripts (Python shell jobs.) AWS Glue triggers can start jobs based on a schedule or event, or on demand. You can monitor job runs to understand runtime metrics such as completion status, duration, and start time.

You can use scripts that AWS Glue generates or you can provide your own. With a source schema and target location or schema, the AWS Glue code generator can automatically create an Apache Spark API (PySpark) script. You can use this script as a starting point and edit it to meet your goals.

AWS Glue can write output files in several data formats, including JSON, CSV, ORC (Optimized Row Columnar), Apache Parquet, and Apache Avro. For some data formats, common compression formats can be written.
There are three types of jobs in AWS Glue: *Spark*, *Streaming ETL*, and *Python shell*.

- A Spark job is run in an Apache Spark environment managed by AWS Glue. It processes data in batches.
- A streaming ETL job is similar to a Spark job, except that it performs ETL on data streams. It uses the Apache Spark Structured Streaming framework. Some Spark job features are not available to streaming ETL jobs.
- A Python shell job runs Python scripts as a shell and supports a Python version that depends on the AWS Glue version you are using. You can use these jobs to schedule and run tasks that don't require an Apache Spark environment.

**Defining job properties for Spark jobs**

When you define your job on the AWS Glue console, you provide values for properties to control the AWS Glue runtime environment.

The following list describes the properties of a Spark job. For the properties of a Python shell job, see [Defining job properties for Python shell jobs](#). For properties of a streaming ETL job, see [the section called “Defining job properties for a streaming ETL job”](#).

The properties are listed in the order in which they appear on the **Add job** wizard on AWS Glue console.

**Name**

Provide a UTF-8 string with a maximum length of 255 characters.

**IAM role**

Specify the IAM role that is used for authorization to resources used to run the job and access data stores. For more information about permissions for running jobs in AWS Glue, see [Identity and access management for AWS Glue](#).

**Type**

Specify the type of job environment to run:

- Choose **Spark** to run an Apache Spark ETL script with the job command `glueetl`.
- Choose **Spark Streaming** to run an Apache Spark streaming ETL script with the job command `gluestreaming`. For more information, see [the section called “Streaming ETL jobs”](#).
• Choose **Python shell** to run a Python script with the job command `pythonshell`. For more information, see [Python shell jobs in AWS Glue](#).

### AWS Glue version

AWS Glue version determines the versions of Apache Spark and Python that are available to the job, as specified in the following table.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported Spark and Python versions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>• Spark 3.3.0&lt;br&gt;• Python 3.10</td>
</tr>
<tr>
<td>3.0</td>
<td>• Spark 3.1.1&lt;br&gt;• Python 3.7</td>
</tr>
<tr>
<td>2.0</td>
<td>• Spark 2.4.3&lt;br&gt;• Python 3.7</td>
</tr>
<tr>
<td>1.0</td>
<td>• Spark 2.4.3&lt;br&gt;• Python 2.7&lt;br&gt;• Python 3.6</td>
</tr>
<tr>
<td>0.9</td>
<td>• Spark 2.2.1&lt;br&gt;• Python 2.7</td>
</tr>
</tbody>
</table>

### This job runs (generated or custom script)

The code in the ETL script defines your job's logic. The script can be coded in Python or Scala. You can choose whether the script that the job runs is generated by AWS Glue or provided by you. You provide the script name and location in Amazon Simple Storage Service (Amazon S3). Confirm that there isn't a file with the same name as the script directory in the path. To learn more about writing scripts, see [AWS Glue programming guide](#).

### Scala class name

If the script is coded in Scala, you must provide a class name. The default class name for AWS Glue generated scripts is **GlueApp**.
Temporary directory

Provide the location of a working directory in Amazon S3 where temporary intermediate results are written when AWS Glue runs the script. Confirm that there isn't a file with the same name as the temporary directory in the path. This directory is used when AWS Glue reads and writes to Amazon Redshift and by certain AWS Glue transforms.

Note

AWS Glue creates a temporary bucket for jobs if a bucket doesn't already exist in a region. This bucket might permit public access. You can either modify the bucket in Amazon S3 to set the public access block, or delete the bucket later after all jobs in that region have completed.

Note

Source and target are not listed under the console Details tab for a job. Review the script to see source and target details.

Advanced Properties

Job bookmark

Specify how AWS Glue processes state information when the job runs. You can have it remember previously processed data, update state information, or ignore state information. For more information, see the section called “Tracking processed data using job bookmarks”.

Monitoring options

Job metrics

Turn on or turn off the creation of Amazon CloudWatch metrics when this job runs. To see profiling data, you must enable this option. For more information about how to turn on and visualize metrics, see Job monitoring and debugging.

Continuous logging

Turn on continuous logging to Amazon CloudWatch. If this option is not enabled, logs are available only after the job completes. For more information, see the section called “Continuous logging for AWS Glue jobs”.

Spark and PySpark jobs
Spark UI

Turn on the use of Spark UI for monitoring this job. For more information, see Enabling the Apache Spark web UI for AWS Glue jobs.

Tags

Tag your job with a **Tag key** and an optional **Tag value**. After tag keys are created, they are read-only. Use tags on some resources to help you organize and identify them. For more information, see AWS tags in AWS Glue.

Security configuration, script libraries, and job parameters

Security configuration

Choose a security configuration from the list. A security configuration specifies how the data at the Amazon S3 target is encrypted: no encryption, server-side encryption with AWS KMS-managed keys (SSE-KMS), or Amazon S3-managed encryption keys (SSE-S3).

Server-side encryption

If you select this option, when the ETL job writes to Amazon S3, the data is encrypted at rest using SSE-S3 encryption. Both your Amazon S3 data target and any data that is written to an Amazon S3 temporary directory is encrypted. This option is passed as a job parameter. For more information, see Protecting Data Using Server-Side Encryption with Amazon S3-Managed Encryption Keys (SSE-S3) in the Amazon Simple Storage Service User Guide.

⚠️ Important

This option is ignored if a security configuration is specified.

Python library path, Dependent jars path, and Referenced files path

Specify these options if your script requires them. You can define the comma-separated Amazon S3 paths for these options when you define the job. You can override these paths when you run the job. For more information, see Providing your own custom scripts.

Worker type

The following worker types are available:
The resources available on AWS Glue workers are measured in DPUs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory.

- **G.1X** – When you choose this type, you also provide a value for **Number of workers**. Each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free). We recommend this worker type for workloads such as data transforms, joins, and queries, to offer a scalable and cost effective way to run most jobs.

- **G.2X** – When you choose this type, you also provide a value for **Number of workers**. Each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free). We recommend this worker type for workloads such as data transforms, joins, and queries, to offer a scalable and cost effective way to run most jobs.

- **G.4X** – When you choose this type, you also provide a value for **Number of workers**. Each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free). We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).

- **G.8X** – When you choose this type, you also provide a value for **Number of workers**. Each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free). We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the G.4X worker type.

- **G.025X** – When you choose this type, you also provide a value for **Number of workers**. Each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free). We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

You are charged an hourly rate based on the number of DPUs used to run your ETL jobs. For more information, see the [AWS Glue pricing page](https://aws.amazon.com/glue/pricing/).

For AWS Glue version 1.0 or earlier jobs, when you configure a job using the console and specify a **Worker type** of **Standard**, the **Maximum capacity** is set and the **Number of workers** becomes the value of **Maximum capacity** - 1. If you use the AWS Command Line
Interface (AWS CLI) or AWS SDK, you can specify the **Max capacity** parameter, or you can specify both **Worker type** and the **Number of workers**.

For AWS Glue version 2.0 or later jobs, you cannot specify a **Maximum capacity**. Instead, you should specify a **Worker type** and the **Number of workers**.

**Number of workers**

For most worker types, you must specify the number of workers that are allocated when the job runs.

**Execution class**

When you configure a job using AWS Studio or the API you may specify a standard or flexible job execution class. Your jobs may have varying degrees of priority and time sensitivity. The standard execution-class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

The flexible execution class is appropriate for non-urgent jobs such as pre-production jobs, testing, and one-time data loads. Flexible job runs are supported for jobs using AWS Glue version 3.0 or later and G.1X or G.2X worker types.

Flex job runs are billed based on the number of workers running at any point in time. Number of workers may be added or removed for a running flexible job run. Instead of billing as a simple calculation of **Max Capacity * Execution Time**, each worker will contribute for the time it ran during the job run. The bill is the sum of (**Number of DPUs per worker** * **time each worker ran**).

For more information, see the help panel in AWS Studio, or [Jobs](https://aws.amazon.com) and [Job runs](https://aws.amazon.com).

**Maximum capacity**

For AWS Glue version 1.0 or earlier jobs, using the standard worker type, you must specify the maximum number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. You are charged an hourly rate based on the number of DPUs used to run your ETL jobs. For more information, see the [AWS Glue pricing page](https://aws.amazon.com).

Choose an integer from 2 to 100. The default is 10. This job type cannot have a fractional DPU allocation.

For AWS Glue version 2.0 or later jobs, you cannot instead specify a **Maximum capacity**. Instead, you should specify a **Worker type** and the **Number of workers**. For more information, see [Jobs](https://aws.amazon.com).
Max concurrency

Sets the maximum number of concurrent runs that are allowed for this job. The default is 1. An error is returned when this threshold is reached. The maximum value you can specify is controlled by a service limit. For example, if a previous run of a job is still running when a new instance is started, you might want to return an error to prevent two instances of the same job from running concurrently.

Job timeout

Sets the maximum execution time in minutes. The default is 2880 minutes (48 hours) for batch jobs. When the job execution time exceeds this limit, the job run state changes to TIMEOUT.

For streaming jobs that run indefinitely, leave the value blank, which is the default value for streaming jobs.

Delay notification threshold

Sets the threshold (in minutes) before a delay notification is sent. You can set this threshold to send notifications when a RUNNING, STARTING, or STOPPING job run takes more than an expected number of minutes.

Number of retries

Specify the number of times, from 0 to 10, that AWS Glue should automatically restart the job if it fails. Jobs that reach the timeout limit are not restarted.

Job parameters

A set of key-value pairs that are passed as named parameters to the script. These are default values that are used when the script is run, but you can override them in triggers or when you run the job. You must prefix the key name with --; for example: --myKey. You pass job parameters as a map when using the AWS Command Line Interface.

For examples, see Python parameters in Passing and accessing Python parameters in AWS Glue.

Non-overrideable Job parameters

A set of special job parameters that cannot be overridden in triggers or when you run the job. These key-value pairs are passed as named parameters to the script. These values are used when the script is run, and you cannot override them in triggers.
or when you run the job. You must prefix the key name with --; for example: --myKey. getResolvedOptions() returns both job parameters and non-overridable job parameters in a single map. For more information, see the section called “getResolvedOptions”.

Catalog options

Use AWS Glue data catalog as the Hive metastore

Select to use the AWS Glue Data Catalog as the Hive metastore. The IAM role used for the job must have the glue:CreateDatabase permission. A database called “default” is created in the Data Catalog if it does not exist.

Data source

Choose a Data Catalog table.

Transform type

Choose one of the following:

Change schema

Adds the ApplyMapping transform to the generated script. Allows you to change the schema of the source data and create a new target dataset.

Find matching records

Allows you to choose a machine learning transform to use to find matching records within your source data.

Target

Do one of the following:

- To specify an Amazon S3 path or JDBC data store, choose Create tables in your data target.
- To specify a catalog table, choose Use tables in the data catalog and update your data target.

For Amazon S3 target locations, provide the location of a directory where your output is written. Confirm that there isn't a file with the same name as the target path directory in the path. For JDBC targets, AWS Glue creates schema objects as needed if the specified objects do not exist.
Restrictions for jobs that access Lake Formation managed tables

Keep in mind the following notes and restrictions when creating jobs that read from or write to tables managed by AWS Lake Formation:

- The following features are not supported in jobs that access tables with cell-level filters:
  - Job bookmarks and bounded execution
  - Push-down predicates
  - Server-side catalog partition predicates
  - enableUpdateCatalog

Editing Spark scripts in the AWS Glue console

A script contains the code that extracts data from sources, transforms it, and loads it into targets. AWS Glue runs a script when it starts a job.

AWS Glue ETL scripts can be coded in Python or Scala. Python scripts use a language that is an extension of the PySpark Python dialect for extract, transform, and load (ETL) jobs. The script contains *extended constructs* to deal with ETL transformations. When you automatically generate the source code logic for your job, a script is created. You can edit this script, or you can provide your own script to process your ETL work.

For information about defining and editing scripts in AWS Glue, see [AWS Glue programming guide](#).

Additional libraries or files

If your script requires additional libraries or files, you can specify them as follows:

Python library path

Comma-separated Amazon Simple Storage Service (Amazon S3) paths to Python libraries that are required by the script.

Note

Only pure Python libraries can be used. Libraries that rely on C extensions, such as the pandas Python Data Analysis Library, are not yet supported.
Dependent jars path

Comma-separated Amazon S3 paths to JAR files that are required by the script.

Note
Currently, only pure Java or Scala (2.11) libraries can be used.

Referenced files path

Comma-separated Amazon S3 paths to additional files (for example, configuration files) that are required by the script.

Jobs (legacy)

A script contains the code that performs extract, transform, and load (ETL) work. You can provide your own script, or AWS Glue can generate a script with guidance from you. For information about creating your own scripts, see Providing your own custom scripts.

You can edit a script in the AWS Glue console. When you edit a script, you can add sources, targets, and transforms.

To edit a script

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/. Then choose the Jobs tab.
2. Choose a job in the list, and then choose Action, Edit script to open the script editor.

You can also access the script editor from the job details page. Choose the Script tab, and then choose Edit script.

Script editor

The AWS Glue script editor lets you insert, modify, and delete sources, targets, and transforms in your script. The script editor displays both the script and a diagram to help you visualize the flow of data.
To create a diagram for the script, choose **Generate diagram**. AWS Glue uses annotation lines in the script beginning with `##` to render the diagram. To correctly represent your script in the diagram, you must keep the parameters in the annotations and the parameters in the Apache Spark code in sync.

The script editor lets you add code templates wherever your cursor is positioned in the script. At the top of the editor, choose from the following options:

- To add a source table to the script, choose **Source**.
- To add a target table to the script, choose **Target**.
- To add a target location to the script, choose **Target location**.
- To add a transform to the script, choose **Transform**. For information about the functions that are called in your script, see Program AWS Glue ETL scripts in PySpark.
- To add a Spigot transform to the script, choose **Spigot**.

In the inserted code, modify the parameters in both the annotations and Apache Spark code. For example, if you add a Spigot transform, verify that the path is replaced in both the @args annotation line and the output code line.

The **Logs** tab shows the logs that are associated with your job as it runs. The most recent 1,000 lines are displayed.

The **Schema** tab shows the schema of the selected sources and targets, when available in the Data Catalog.

**Using auto scaling for AWS Glue**

Auto Scaling is available for your AWS Glue ETL and streaming jobs with AWS Glue version 3.0 or later.

With Auto Scaling enabled, you will get the following benefits:

- AWS Glue automatically adds and removes workers from the cluster depending on the parallelism at each stage or microbatch of the job run.
- It removes the need for you to experiment and decide on the number of workers to assign for your AWS Glue ETL jobs.
- If you choose the maximum number of workers, AWS Glue will choose the right size resources for the workload.
• You can see how the size of the cluster changes during the job run by looking at CloudWatch metrics on the job run details page in AWS Glue Studio.

Auto Scaling for AWS Glue ETL and streaming jobs enables on-demand scaling up and scaling down of the computing resources of your AWS Glue jobs. On-demand scale-up helps you to only allocate the required computing resources initially on job run startup, and also to provision the required resources as per demand during the job.

Auto Scaling also supports dynamic scale-down of the AWS Glue job resources over the course of a job. Over a job run, when more executors are requested by your Spark application, more workers will be added to the cluster. When the executor has been idle without active computation tasks, the executor and the corresponding worker will be removed.

Common scenarios where Auto Scaling helps with cost and utilization for your Spark applications include a Spark driver listing a large number of files in Amazon S3 or performing a load while executors are inactive, Spark stages running with only a few executors due to overprovisioning, and data skews or uneven computation demand across Spark stages.

Requirements

Auto Scaling is only available for AWS Glue version 3.0 or later. To use Auto Scaling, you can follow the migration guide to migrate your existing jobs to AWS Glue version 3.0 or later or create new jobs with AWS Glue version 3.0 or later.

Auto Scaling is available for AWS Glue jobs with the G.1X, G.2X, G.4X, G.8X, or G.025X (only for Streaming jobs) worker types. Standard DPUs are not supported.

Enabling Auto Scaling in AWS Glue Studio

On the Job details tab in AWS Glue Studio, choose the type as Spark or Spark Streaming, and Glue version as Glue 3.0 or Glue 4.0. Then a check box will show up below Worker type.

• Select the Automatically scale the number of workers option.
• Set the Maximum number of workers to define the maximum number of workers that can be vended to the job run.
Enabling Auto Scaling with the AWS CLI or SDK

To enable Auto Scaling From the AWS CLI for your job run, run `start-job-run` with the following configuration:

```json
{
    "JobName": "<your job name>",
    "Arguments": {
        "--enable-auto-scaling": "true"
    },
    "WorkerType": "G.2X", // G.1X and G.2X are allowed for Auto Scaling Jobs
    "NumberOfWorkers": 20, // represents Maximum number of workers
}
```
Once at ETL job run is finished, you can also call `get-job-run` to check the actual resource usage of the job run in DPU-seconds. Note: the new field `DPUSeconds` will only show up for your batch jobs on AWS Glue 3.0 or later enabled with Auto Scaling. This field is not supported for streaming jobs.

```
$ aws glue get-job-run --job-name your-job-name --run-id jr_xx --endpoint https://glue.us-east-1.amazonaws.com --region us-east-1
{
   "JobRun": {
      ...
      "GlueVersion": "3.0",
      "DPUSeconds": 386.0
   }
}
```

You can also configure job runs with Auto Scaling using the AWS Glue SDK with the same configuration.

**Monitoring Auto Scaling with Amazon CloudWatch metrics**

The CloudWatch executor metrics are available for your AWS Glue 3.0 or later jobs if you enable Auto Scaling. The metrics can be used to monitor the demand and optimized usage of executors in their Spark applications enabled with Auto Scaling. For more information, see Monitoring AWS Glue using Amazon CloudWatch metrics.

- `glue.driver.ExecutorAllocationManager.executors.numberAllExecutors`
- `glue.driver.ExecutorAllocationManager.executors.numberMaxNeededExecutors`
For more details on these metrics, see [Monitoring for DPU capacity planning](#).

### Monitoring Auto Scaling with Spark UI

With Auto Scaling enabled, you can also monitor executors being added and removed with dynamic scale-up and scale-down based on the demand in your AWS Glue jobs using the Glue Spark UI. For more information, see [Enabling the Apache Spark web UI for AWS Glue jobs](#).

### Monitoring Auto Scaling job run DPU usage

You may use the [AWS Glue Studio Job run view](#) to check the DPU usage of your Auto Scaling jobs.

1. Choose **Monitoring** from the AWS Glue Studio navigation pane. The Monitoring page appears.
2. Scroll down to the Job runs chart.
3. Navigate to the job run you are interested and scroll to the DPU hours column to check the usage for the specific job run.

Limitations
AWS Glue streaming Auto Scaling currently doesn't support a streaming DataFrame join with a static DataFrame created outside of ForEachBatch. A static DataFrame created inside the ForEachBatch will work as expected.

Tracking processed data using job bookmarks
AWS Glue tracks data that has already been processed during a previous run of an ETL job by persisting state information from the job run. This persisted state information is called a job bookmark. Job bookmarks help AWS Glue maintain state information and prevent the reprocessing of old data. With job bookmarks, you can process new data when rerunning on a scheduled interval. A job bookmark is composed of the states for various elements of jobs, such as sources, transformations, and targets. For example, your ETL job might read new partitions in an Amazon S3 file. AWS Glue tracks which partitions the job has processed successfully to prevent duplicate processing and duplicate data in the job's target data store.

Job bookmarks are implemented for JDBC data sources, the Relationalize transform, and some Amazon Simple Storage Service (Amazon S3) sources. The following table lists the Amazon S3 source formats that AWS Glue supports for job bookmarks.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Amazon S3 source formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 0.9</td>
<td>JSON, CSV, Apache Avro, XML</td>
</tr>
<tr>
<td>Version 1.0 and later</td>
<td>JSON, CSV, Apache Avro, XML, Parquet, ORC</td>
</tr>
</tbody>
</table>

For information about AWS Glue versions, see [Defining job properties for Spark jobs](#).

The job bookmarks feature has additional functionalities when accessed through AWS Glue scripts. When browsing your generated script, you may see transformation contexts, which are related to this feature. For more information, see the section called “Using job bookmarks”.

Topics
- [Using job bookmarks in AWS Glue](#)
• Operational details of the job bookmarks feature

Using job bookmarks in AWS Glue

The job bookmark option is passed as a parameter when the job is started. The following table describes the options for setting job bookmarks on the AWS Glue console.

<table>
<thead>
<tr>
<th>Job bookmark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable</td>
<td>Causes the job to update the state after a run to keep track of previously processed data. If your job has a source with job bookmark support, it will keep track of processed data, and when a job runs, it processes new data since the last checkpoint.</td>
</tr>
<tr>
<td>Disable</td>
<td>Job bookmarks are not used, and the job always processes the entire dataset. You are responsible for managing the output from previous job runs. This is the default.</td>
</tr>
<tr>
<td>Pause</td>
<td>Process incremental data since the last successful run or the data in the range identified by the following sub-options, without updating the state of last bookmark. You are responsible for managing the output from previous job runs. The two sub-options are:</td>
</tr>
</tbody>
</table>

- **job-bookmark-from** <from-value> is the run ID which represents all the input that was processed until the last successful run before and including the specified run ID. The corresponding input is ignored.

- **job-bookmark-to** <to-value> is the run ID which represents all the input that was processed until the last successful run before and including the specified run ID. The corresponding input excluding the input identified by the <from-value> is processed by the job. Any input later than this input is also excluded for processing.

The job bookmark state is not updated when this option set is specified.

The sub-options are optional, however when used both the sub-options needs to be provided.
For details about the parameters passed to a job on the command line, and specifically for job bookmarks, see AWS Glue job parameters.

For Amazon S3 input sources, AWS Glue job bookmarks check the last modified time of the objects to verify which objects need to be reprocessed. If your input source data has been modified since your last job run, the files are reprocessed when you run the job again.

For JDBC sources, the following rules apply:

- For each table, AWS Glue uses one or more columns as bookmark keys to determine new and processed data. The bookmark keys combine to form a single compound key.
- AWS Glue by default uses the primary key as the bookmark key, provided that it is sequentially increasing or decreasing (with no gaps).
- You can specify the columns to use as bookmark keys in your AWS Glue script. For more information about using Job bookmarks in AWS Glue scripts, see the section called “Using job bookmarks”.
- AWS Glue doesn’t support using columns with case-sensitive names as job bookmark keys.

You can rewind your job bookmarks for your AWS Glue Spark ETL jobs to any previous job run. You can support data backfilling scenarios better by rewinding your job bookmarks to any previous job run, resulting in the subsequent job run reprocessing data only from the bookmarked job run.

If you intend to reprocess all the data using the same job, reset the job bookmark. To reset the job bookmark state, use the AWS Glue console, the ResetJobBookmark action (Python: reset_job_bookmark) API operation, or the AWS CLI. For example, enter the following command using the AWS CLI:

```
aws glue reset-job-bookmark --job-name my-job-name
```

When you rewind or reset a bookmark, AWS Glue does not clean the target files because there could be multiple targets and targets are not tracked with job bookmarks. Only source files are tracked with job bookmarks. You can create different output targets when rewinding and reprocessing the source files to avoid duplicate data in your output.

AWS Glue keeps track of job bookmarks by job. If you delete a job, the job bookmark is deleted.
In some cases, you might have enabled AWS Glue job bookmarks but your ETL job is reprocessing data that was already processed in an earlier run. For information about resolving common causes of this error, see Troubleshooting errors in AWS Glue for Spark.

Operational details of the job bookmarks feature

This section describes more of the operational details of using job bookmarks.

Job bookmarks store the states for a job. Each instance of the state is keyed by a job name and a version number. When a script invokes job.init, it retrieves its state and always gets the latest version. Within a state, there are multiple state elements, which are specific to each source, transformation, and sink instance in the script. These state elements are identified by a transformation context that is attached to the corresponding element (source, transformation, or sink) in the script. The state elements are saved atomically when job.commit is invoked from the user script. The script gets the job name and the control option for the job bookmarks from the arguments.

The state elements in the job bookmark are source, transformation, or sink-specific data. For example, suppose that you want to read incremental data from an Amazon S3 location that is being constantly written to by an upstream job or process. In this case, the script must determine what has been processed so far. The job bookmark implementation for the Amazon S3 source saves information so that when the job runs again, it can filter only the new objects using the saved information and recompute the state for the next run of the job. A timestamp is used to filter the new files.

In addition to the state elements, job bookmarks have a run number, an attempt number, and a version number. The run number tracks the run of the job, and the attempt number records the attempts for a job run. The job run number is a monotonically increasing number that is incremented for every successful run. The attempt number tracks the attempts for each run, and is only incremented when there is a run after a failed attempt. The version number increases monotonically and tracks the updates to a job bookmark.

In the AWS Glue service database, the bookmark states for all the transformations are stored together as key-value pairs:

```json
{
    "job_name": ..., 
    "run_id": ..., 
    "run_number": ..., 
    "attempt_number": ...
}
```
Best practices

The following are best practices for using job bookmarks.

- **Do not change the data source property with the bookmark enabled.** For example, there is a datasource0 pointing to an Amazon S3 input path A, and the job has been reading from a source which has been running for several rounds with the bookmark enabled. If you change the input path of datasource0 to Amazon S3 path B without changing the transformation_ctx, the AWS Glue job will use the old bookmark state stored. That will result in missing or skipping files in the input path B as AWS Glue would assume that those files had been processed in previous runs.

- **Use a catalog table with bookmarks for better partition management.** Bookmarks works both for data sources from the Data Catalog or from options. However, it's difficult to remove/add new partitions with the from options approach. Using a catalog table with crawlers can provide better automation to track the newly added partitions and give you the flexibility to select particular partitions with a pushdown predicate.

- **Use the AWS Glue Amazon S3 file lister for large datasets.** A bookmark will list all files under each input partition and do the filtering, so if there are too many files under a single partition the bookmark can run into driver OOM. Use the AWS Glue Amazon S3 file lister to avoid listing all files in memory at once.

**Workload partitioning with bounded execution**

Errors in Spark applications commonly arise from inefficient Spark scripts, distributed in-memory execution of large-scale transformations, and dataset abnormalities. There are many reasons that may cause driver or executor out of memory issues, for example a data skew, listing too many objects, or large data shuffles. These issues often appear when you are processing huge amounts of backlog data with Spark.
AWS Glue allows you to solve OOM issues and make your ETL processing easier with workload partitioning. With workload partitioning enabled, each ETL job run only picks unprocessed data, with an upper bound on the dataset size or the number of files to be processed with this job run. Future job runs will process the remaining data. For example, if there are 1000 files need to be processed, you can set the number of files to be 500 and separate them into two job runs.

Workload partitioning is supported only for Amazon S3 data sources.

**Enabling workload partitioning**

You can enable bounded execution by manually setting the options in your script or by adding catalog table properties.

**To enable workload partitioning with bounded execution in your script:**

1. To avoid reprocessing data, enable job bookmarks in the new job or existing job. For more information, see [Tracking Processed Data Using Job Bookmarks](#).

2. Modify your script and set the bounded limit in the additional options in the AWS Glue `getSource` API. You should also set the transformation context for the job bookmark to store the state element. For example:

    **Python**
    ```python
    glueContext.create_dynamic_frame.from_catalog(
        database = "database",
        table_name = "table_name",
        redshift_tmp_dir = "",
        transformation_ctx = "datasource0",
        additional_options = {
            "boundedFiles" : "500", # need to be string
            # "boundedSize" : "1000000000" unit is byte
        }
    )
    ```

    **Scala**
    ```scala
    val datasource0 = glueContext.getCatalogSource(
        database = "database", tableName = "table_name", redshiftTmpDir = "",
        transformationContext = "datasource0",
        additionalOptions = JsonOptions(
            Map("boundedFiles" -> "500") // need to be string
        )
    ```
To enable workload partitioning with bounded execution in your Data Catalog table:

1. Set the key-value pairs in the parameters field of your table structure in the Data Catalog. For more information, see [Viewing and Editing Table Details](#).

2. Set the upper limit for the dataset size or the number of files processed:
   
   - Set `boundedSize` to the target size of the dataset in bytes. The job run will stop after reaching the target size from the table.
   - Set `boundedFiles` to the target number of files. The job run will stop after processing the target number of files.

   ```scala
   val connectionOptions = JsonOptions的优点(  
     Map("paths" -> List(baseLocation), "boundedFiles" -> "30")  
   )
   val source = glueContext.getSource("s3", connectionOptions, "datasource0", "")
   ```

   **Note**
   
   You should only set one of `boundedSize` or `boundedFiles`, as only a single boundary is supported.

**Setting up an AWS Glue trigger to automatically run the job**

Once you have enabled bounded execution, you can set up an AWS Glue trigger to automatically run the job and incrementally load the data in sequential runs. Go to the AWS Glue Console and create a trigger, setup the schedule time, and attach to your job. Then it will automatically trigger the next job run and process the new batch of data.

You can also use AWS Glue workflows to orchestrate multiple jobs to process data from different partitions in parallel. For more information, see [AWS Glue Triggers](#) and [AWS Glue Workflows](#).

For more information on use cases and options, please refer to the blog [Optimizing Spark applications with workload partitioning in AWS Glue](#).
AWS Glue Spark shuffle plugin with Amazon S3

Shuffling is an important step in a Spark job whenever data is rearranged between partitions. This is required because wide transformations such as `join`, `groupByKey`, `reduceByKey`, and `repartition` require information from other partitions to complete processing. Spark gathers the required data from each partition and combines it into a new partition. During a shuffle, data is written to disk and transferred across the network. As a result, the shuffle operation is bound to local disk capacity. Spark throws a `No space left on device` or `MetadataFetchFailedException` error when there is not enough disk space left on the executor and there is no recovery.

Note

AWS Glue Spark shuffle plugin with Amazon S3 is only supported for AWS Glue ETL jobs.

Solution

With AWS Glue, you can now use Amazon S3 to store Spark shuffle data. Amazon S3 is an object storage service that offers industry-leading scalability, data availability, security, and performance. This solution disaggregates compute and storage for your Spark jobs, and gives complete elasticity and low-cost shuffle storage, allowing you to run your most shuffle-intensive workloads reliably.
We are introducing a new Cloud Shuffle Storage Plugin for Apache Spark to use Amazon S3. You can turn on Amazon S3 shuffling to run your AWS Glue jobs reliably without failures if they are known to be bound by the local disk capacity for large shuffle operations. In some cases, shuffling...
to Amazon S3 is marginally slower than local disk (or EBS) if you have a large number of small partitions or shuffle files written out to Amazon S3.

Prerequisites for using Cloud Shuffle Storage Plugin

In order to use the Cloud Shuffle Storage Plugin with AWS Glue ETL jobs, you need the following:

- An Amazon S3 bucket located in the same region as your job run, for storing the intermediate shuffle and spilled data. The Amazon S3 prefix of shuffle storage can be specified with `--conf spark.shuffle.glue.s3ShuffleBucket=s3://<prefix>/`, as in the following example:

  ```
  --conf spark.shuffle.glue.s3ShuffleBucket=s3://glue-shuffle-123456789-us-east-1/glue-shuffle-data/
  ```

- Set the Amazon S3 storage lifecycle policies on the `prefix` (such as `glue-shuffle-data`) as the shuffle manager does not clean the files after the job is done. The intermediate shuffle and spilled data should be deleted after a job is finished. Users can set a short lifecycle policies on the prefix. Instructions for setting up an Amazon S3 lifecycle policy are available at Setting lifecycle configuration on a bucket in the Amazon Simple Storage Service User Guide.

Using AWS Glue Spark shuffle manager from the AWS console

To set up the AWS Glue Spark shuffle manager using the AWS Glue console or AWS Glue Studio when configuring a job: choose the `--write-shuffle-files-to-s3` job parameter to turn on Amazon S3 shuffling for the job.

Using AWS Glue Spark shuffle plugin

The following job parameters turn on and tune the AWS Glue shuffle manager. These parameters are flags, so any values provided are not considered.
• **--write-shuffle-files-to-s3** — The main flag, which enables the AWS Glue Spark shuffle manager to use Amazon S3 buckets for writing and reading shuffle data. When the flag is not specified, the shuffle manager is not used.

• **--write-shuffle-spills-to-s3** — (Supported only on AWS Glue version 2.0). An optional flag that allows you to offload spill files to Amazon S3 buckets, which provides additional resiliency to your Spark job. This is only required for large workloads that spill a lot of data to disk. When the flag is not specified, no intermediate spill files are written.

• **--conf spark.shuffle.glue.s3ShuffleBucket=s3://<shuffle-bucket>** — Another optional flag that specifies the Amazon S3 bucket where you write the shuffle files. By default, `--TempDir/shuffle-data`. AWS Glue 3.0+ supports writing shuffle files to multiple buckets by specifying buckets with comma delimiter, as in `--conf spark.shuffle.glue.s3ShuffleBucket=s3://shuffle-bucket-1/prefix,s3://shuffle-bucket-2/prefix/`. Using multiple buckets improves performance.

You need to provide security configuration settings to enable encryption at-rest for the shuffle data. For more information about security configurations, see the section called “Setting up encryption”. AWS Glue supports all other shuffle related configurations provided by Spark.

**Software binaries for the Cloud Shuffle Storage plugin**

You can also download the software binaries of the Cloud Shuffle Storage Plugin for Apache Spark under the Apache 2.0 license and run it on any Spark environment. The new plugin comes with out-of-the box support for Amazon S3, and can also be easily configured to use other forms of cloud storage such as Google Cloud Storage and Microsoft Azure Blob Storage. For more information, see Cloud Shuffle Storage Plugin for Apache Spark.

**Notes and limitations**

The following are notes or limitations for the AWS Glue shuffle manager:

• AWS Glue shuffle manager doesn't automatically delete the (temporary) shuffle data files stored in your Amazon S3 bucket after a job is completed. To ensure data protection, follow the instructions in Prerequisites for using Cloud Shuffle Storage Plugin before enabling the Cloud Shuffle Storage Plugin.

• You can use this feature if your data is skewed.
Cloud Shuffle Storage Plugin for Apache Spark

The Cloud Shuffle Storage Plugin is an Apache Spark plugin compatible with the [ShuffleDataIO API](#) which allows storing shuffle data on cloud storage systems (such as Amazon S3). It helps you to supplement or replace local disk storage capacity for large shuffle operations, commonly triggered by transformations such as `join`, `reduceByKey`, `groupByKey` and `repartition` in your Spark applications, thereby reducing common failures or price/performance dislocation of your serverless data analytics jobs and pipelines.

AWS Glue

AWS Glue versions 3.0 and 4.0 comes with the plugin pre-installed and ready to enable shuffling to Amazon S3 without any extra steps. For more information, see [AWS Glue Spark shuffle plugin with Amazon S3](#) to enable the feature for your Spark applications.

Other Spark environments

The plugin requires the following Spark configurations to be set on other Spark environments:

- `--conf spark.shuffle.sort.io.plugin.class=com.amazonaws.spark.shuffle.io.cloud.ChopperPlugin`: This informs Spark to use this plugin for Shuffle IO.
- `--conf spark.shuffle.storage.path=s3://bucket-name/shuffle-file-dir`: The path where your shuffle files will be stored.

Note

The plugin overwrites one Spark core class. As a result, the plugin jar needs to be loaded before Spark jars. You can do this using `userClassPathFirst` in on-prem YARN environments if the plugin is used outside AWS Glue.

Bundling the plugin with your Spark applications

You can bundle the plugin with your Spark applications and Spark distributions (versions 3.1 and above) by adding the plugin dependency in your Maven `pom.xml` while developing your Spark applications locally. For more information on the plugin and Spark versions, see [Plugin versions](#).
You can alternatively download the binaries from AWS Glue Maven artifacts directly and include them in your Spark application as follows.

```bash
#!/bin/bash
```

**Example spark-submit**

```
spark-submit --deploy-mode cluster \
--conf spark.shuffle.storage.s3.path=s3://<ShuffleBucket>/<shuffle-dir> \
--conf spark.driver.extraClassPath=<Path to plugin jar> \
--conf spark.executor.extraClassPath=<Path to plugin jar> \
--class <your test class name> s3://<ShuffleBucket>/<Your application jar>
```

**Optional configurations**

These are optional configuration values that control Amazon S3 shuffle behavior.

- `spark.shuffle.storage.s3.enableServerSideEncryption`: Enable/disable S3 SSE for shuffle and spill files. Default value is `true`.
- `spark.shuffle.storage.s3.serverSideEncryption.algorithm`: The SSE algorithm to be used. Default value is `AES256`.
- `spark.shuffle.storage.s3.serverSideEncryption.kms.key`: The KMS key ARN when SSE aws:kms is enabled.
Along with these configurations, you may need to set configurations such as `spark.hadoop.fs.s3.enableServerSideEncryption` and other environment-specific configurations to ensure appropriate encryption is applied for your use case.

**Plugin versions**

This plugin is supported for the Spark versions associated with each AWS Glue version. The following table shows the AWS Glue version, Spark version and associated plugin version with Amazon S3 location for the plugin's software binary.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Spark version</th>
<th>Plugin version</th>
<th>Amazon S3 location</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>3.3</td>
<td>3.3-amzn-LATEST</td>
<td>s3://aws-glue-etl-artifacts/release/com/amazonaws/chopper-plugin/3.3-amzn-0/chopper-plugin-3.3-amzn-LATEST.jar</td>
</tr>
</tbody>
</table>

**License**

The software binary for this plugin is licensed under the Apache-2.0 License.

**Monitoring AWS Glue Spark jobs**

**Topics**

- [Spark Metrics available in AWS Glue Studio](#)
- [Monitoring jobs using the Apache Spark web UI](#)
Monitoring with AWS Glue job run insights
Monitoring with Amazon CloudWatch
Job monitoring and debugging

Spark Metrics available in AWS Glue Studio

The Metrics tab shows metrics collected when a job runs and profiling is turned on. The following graphs are shown in Spark jobs:

- ETL Data Movement
- Memory Profile: Driver and Executors

Choose View additional metrics to show the following graphs:

- ETL Data Movement
- Memory Profile: Driver and Executors
- Data Shuffle Across Executors
- CPU Load: Driver and Executors
- Job Execution: Active Executors, Completed Stages & Maximum Needed Executors

Data for these graphs is pushed to CloudWatch metrics if the job is configured to collect metrics. For more information about how to turn on metrics and interpret the graphs, see Job monitoring and debugging.

Example ETL data movement graph

The ETL Data Movement graph shows the following metrics:

- The number of bytes read from Amazon S3 by all executors — glue.ALL.s3.filesystem.read_bytes
- The number of bytes written to Amazon S3 by all executors — glue.ALL.s3.filesystem.write_bytes
Example Memory profile graph

The Memory Profile graph shows the following metrics:

- The fraction of memory used by the JVM heap for this driver (scale: 0–1) by the driver, an executor identified by executorId, or all executors—
  - glue.driver.jvm.heap.usage
  - glue.executorId.jvm.heap.usage
  - glue.ALL.jvm.heap.usage

Example Data shuffle across executors graph

The Data Shuffle Across Executors graph shows the following metrics:
• The number of bytes read by all executors to shuffle data between them—`glue.driver.aggregate.shuffleLocalBytesRead`
• The number of bytes written by all executors to shuffle data between them—`glue.driver.aggregate.shuffleBytesWritten`

![Data Shuffle Across Executors](image)

**Example CPU load graph**

The CPU Load graph shows the following metrics:

• The fraction of CPU system load used (scale: 0–1) by the driver, an executor identified by `executorId`, or all executors—
  • `glue.driver.system.cpuSystemLoad`
  • `glue.executorId.system.cpuSystemLoad`
  • `glue.ALL.system.cpuSystemLoad`

![CPU Load: Driver and Executors](image)

**Example Job execution graph**

The Job Execution graph shows the following metrics:

Spark and PySpark jobs
- The number of actively running executors
  — `glue.driver.ExecutorAllocationManager.executors.numberAllExecutors`
- The number of completed stages—`glue.aggregate.numCompletedStages`
- The number of maximum needed executors
  — `glue.driver.ExecutorAllocationManager.executors.numberMaxNeededExecutors`

### Monitoring jobs using the Apache Spark web UI

You can use the Apache Spark web UI to monitor and debug AWS Glue ETL jobs running on the AWS Glue job system, and also Spark applications running on AWS Glue development endpoints. The Spark UI enables you to check the following for each job:

- The event timeline of each Spark stage
- A directed acyclic graph (DAG) of the job
- Physical and logical plans for SparkSQL queries
- The underlying Spark environmental variables for each job

For more information about using the Spark Web UI, see [Web UI](#) in the Spark documentation.

For newer jobs, you can see the Spark UI in the AWS Glue console. This is available when an AWS Glue job runs on AWS Glue 3.0 or later versions with logs generated in the Standard (rather than legacy) format, which is the default for newer jobs. For more information on finding the Spark UI in the console, see the section called “View information for recent job runs”. For other versions of AWS Glue, provision your own history server. For more information, see the section called “Launching the Spark history server”.

You can enable the Spark UI by using the AWS Glue console or the AWS Command Line Interface (AWS CLI). When you enable the Spark UI, AWS Glue ETL jobs and Spark applications on AWS Glue
development endpoints can back up Spark event logs to a location that you specify in Amazon Simple Storage Service (Amazon S3). You can use the backed up event logs in Amazon S3 with the Spark UI, both in real time as the job is operating and after the job is complete. While the logs remain in Amazon S3, the Spark UI in the AWS Glue console can view them.

In order to use the Spark UI in the AWS Glue console, your console role must have the glue:UseGlueStudio permission. For more information about this permission, see the section called “Creating Custom IAM Policies for AWS Glue Studio”.

Limitations:

- Spark UI in the AWS Glue console is not available for job runs that occurred before 20 Nov 2023 because they are in the legacy log format.
- Spark UI in the AWS Glue console does not support rolling logs, such as those generated by default in streaming jobs.

You can turn off rolling logs for a streaming job by passing an additional configuration. Note that very large log files may be costly to maintain.

To turn off rolling logs, provide the following configuration:

```python
'--spark-ui-event-logs-path': 'true',
'--conf': 'spark.eventLog.rolling.enabled=false'
```

Example: Apache Spark web UI

This example shows you how to use the Spark UI to understand your job performance. Screen shots show the Spark web UI as provided by a self-managed Spark history server. Spark UI in the AWS Glue console provides similar views. For more information about using the Spark Web UI, see Web UI in the Spark documentation.

The following is an example of a Spark application that reads from two data sources, performs a join transform, and writes it out to Amazon S3 in Parquet format.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
```

Spark and PySpark jobs
from awsglue.job import Job
from pyspark.sql.functions import count, when, expr, col, sum, isnull
from pyspark.sql.functions import countDistinct
from awsglue.dynamicframe import DynamicFrame

args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

job = Job(glueContext)
job.init(args['JOB_NAME'])

df_persons = spark.read.json("s3://awsglue-datasets/examples/us-legislators/all/persons.json")
df_memberships = spark.read.json("s3://awsglue-datasets/examples/us-legislators/all/memberships.json")

df_joined = df_persons.join(df_memberships, df_persons.id == df_memberships.person_id, 'fullouter')
df_joined.write.parquet("s3://aws-glue-demo-sparkui/output/")

job.commit()

The following DAG visualization shows the different stages in this Spark job.
The following event timeline for a job shows the start, execution, and termination of different Spark executors.
Details for Job 2

Status: SUCCEEDED
Completed Stages: 3

Event Timeline
Enable zooming

DAG Visualization
Completed Stages (3)
The following screen shows the details of the SparkSQL query plans:

- Parsed logical plan
- Analyzed logical plan
- Optimized logical plan
- Physical plan for execution
Details for Query 0

Submitted Time: 2019/09/11 02:30:37
Duration: 34 s
Succeeded Jobs: 2

--- Parsed Logical Plan ---
Join FullOuter, (id#14 = person_id#50)

-- Relation[birth_date#8, contact_details#9, death_date#10, family_name#11, gender#12, given_name#13, id#14, identifiers#15, image#16, images#17, links#18, name#19, other_names#20, sort_name#21] json

-- Relation[area_id#45, end_date#46, legislative_period_id#47, on_behalf_of_id#48, organization_id#49, person_id#50, role#51, start_date#52] json

--- Analyzed Logical Plan ---
birth_date: string, contact_details: array<struct<type:string, value:string>>, death_date: string, family_name: string, gender: string, given_name: string, id: string, identifiers: array<struct<identifier:string, scheme:string>>, image: string, images: array<struct<url:string>>, links:
array<struct<clang:string, name:string, note:string>>, name: string, other_names: array<string>, sort_name: string, area_id: string, end_date: string, legislative_period_id: string, on_behalf_of_id: string, organization_id: string, person_id: string, role: string, start_date: string
Join FullOuter, (id#14 = person_id#50)
Enabling the Apache Spark web UI for AWS Glue jobs

You can use the Apache Spark web UI to monitor and debug AWS Glue ETL jobs running on the AWS Glue job system. You can configure the Spark UI using the AWS Glue console or the AWS Command Line Interface (AWS CLI).

Every 30 seconds, AWS Glue backs up the Spark event logs to the Amazon S3 path that you specify.

Configuring the Spark UI (console)

Follow these steps to configure the Spark UI by using the AWS Management Console. When creating an AWS Glue job, Spark UI is enabled by default.

To turn on the Spark UI when you create or edit a job

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, choose Jobs.
3. Choose Add job, or select an existing one.
4. In Job details, open the Advanced properties.
5. Under the Spark UI tab, choose Write Spark UI logs to Amazon S3.
6. Specify an Amazon S3 path for storing the Spark event logs for the job. Note that if you use a security configuration in the job, the encryption also applies to the Spark UI log file. For more information, see Encrypting data written by AWS Glue.
7. Under Spark UI logging and monitoring configuration:
   - Select Standard if you are generating logs to view in the AWS Glue console.
- Select **Legacy** if you are generating logs to view on a Spark history server.
- You can also choose to generate both.

**Configuring the Spark UI (AWS CLI)**

To generate logs for viewing with Spark UI, in the AWS Glue console, use the AWS CLI to pass the following job parameters to AWS Glue jobs. For more information, see the section called “Job parameters”.

```bash
'--enable-spark-ui': 'true',
'--spark-event-logs-path': 's3://s3-event-log-path'
```

To distribute logs to their legacy locations, set the `--enable-spark-ui-legacy-path` parameter to "true". If you do not want to generate logs in both formats, remove the `--enable-spark-ui` parameter.

**Configuring the Spark UI for sessions using Notebooks**

⚠️ **Warning**

AWS Glue interactive sessions do not currently support Spark UI in the console. Configure a Spark history server.

If you use AWS Glue notebooks, set up SparkUI config before starting the session. To do this, use the `%%configure` cell magic:

```bash
%%configure { "--enable-spark-ui": "true", "--spark-event-logs-path": "s3://path" }
```

**Launching the Spark history server**

You can use a Spark history server to visualize Spark logs on your own infrastructure. You can see the same visualizations in the AWS Glue console for AWS Glue job runs on AWS Glue 4.0 or later versions with logs generated in the Standard (rather than legacy) format. For more information, see the section called “Monitoring with the Spark UI”.

You can launch the Spark history server using a AWS CloudFormation template that hosts the server on an EC2 instance, or launch locally using Docker.
Topics

- Launching the Spark history server and viewing the Spark UI using AWS CloudFormation
- Launching the Spark history server and viewing the Spark UI using Docker

Launching the Spark history server and viewing the Spark UI using AWS CloudFormation

You can use an AWS CloudFormation template to start the Apache Spark history server and view the Spark web UI. These templates are samples that you should modify to meet your requirements.

To start the Spark history server and view the Spark UI using AWS CloudFormation

1. Choose one of the Launch Stack buttons in the following table. This launches the stack on the AWS CloudFormation console.

<table>
<thead>
<tr>
<th>Region</th>
<th>Launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>US East (Ohio)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>US East (N. Virginia)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>US West (N. California)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>US West (Oregon)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Africa (Cape Town)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Hong Kong)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Mumbai)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Osaka)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Seoul)</td>
<td><img src="image" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Region</td>
<td>Launch</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Asia Pacific (Singapore)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Sydney)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Asia Pacific (Tokyo)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Canada (Central)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (Frankfurt)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (Ireland)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (London)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (Milan)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (Paris)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Europe (Stockholm)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>Middle East (Bahrain)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
<tr>
<td>South America (São Paulo)</td>
<td><img src="Launch%20Stack.png" alt="Launch Stack" /></td>
</tr>
</tbody>
</table>

2. On the **Specify template** page, choose **Next**.

3. On the **Specify stack details** page, enter the **Stack name**. Enter additional information under **Parameters**.
   
a. **Spark UI configuration**

   Provide the following information:
• **IP address range** — The IP address range that can be used to view the Spark UI. If you want to restrict access from a specific IP address range, you should use a custom value.

• **History server port** — The port for the Spark UI. You can use the default value.

• **Event log directory** — Choose the location where Spark event logs are stored from the AWS Glue job or development endpoints. You must use `s3a://` for the event logs path scheme.

• **Spark package location** — You can use the default value.

• **Keystore path** — SSL/TLS keystore path for HTTPS. If you want to use a custom keystore file, you can specify the S3 path `s3://path_to_your_keystore_file` here. If you leave this parameter empty, a self-signed certificate based keystore is generated and used.

• **Keystore password** — Enter a SSL/TLS keystore password for HTTPS.

b. **EC2 instance configuration**

Provide the following information:

• **Instance type** — The type of Amazon EC2 instance that hosts the Spark history server. Because this template launches Amazon EC2 instance in your account, Amazon EC2 cost will be charged in your account separately.

• **Latest AMI ID** — The AMI ID of Amazon Linux 2 for the Spark history server instance. You can use the default value.

• **VPC ID** — The virtual private cloud (VPC) ID for the Spark history server instance. You can use any of the VPCs available in your account. Using a default VPC with a [default Network ACL](https://docs.aws.amazon.com/vpc/latest/userguide/default-vpc-default-network-ACL.html) is not recommended. For more information, see [Default VPC and Default Subnets](https://docs.aws.amazon.com/vpc/latest/userguide/default-vpc-default-subnets.html) and [Creating a VPC](https://docs.aws.amazon.com/vpc/latest/userguide/creating-a-vpc.html) in the [Amazon VPC User Guide](https://docs.aws.amazon.com/vpc/latest/userguide/.)

• **Subnet ID** — The ID for the Spark history server instance. You can use any of the subnets in your VPC. You must be able to reach the network from your client to the subnet. If you want to access via the internet, you must use a public subnet that has the internet gateway in the route table.

c. Choose **Next**.

4. On the **Configure stack options** page, to use the current user credentials for determining how CloudFormation can create, modify, or delete resources in the stack, choose **Next**. You can also specify a role in the **Permissions** section to use instead of the current user permissions, and then choose **Next**.
5. On the **Review** page, review the template.

   Select I **acknowledge that AWS CloudFormation might create IAM resources**, and then choose **Create stack**.

6. Wait for the stack to be created.

7. Open the **Outputs** tab.

   a. Copy the URL of **SparkUiPublicUrl** if you are using a public subnet.
   
   b. Copy the URL of **SparkUiPrivateUrl** if you are using a private subnet.

8. Open a web browser, and paste in the URL. This lets you access the server using HTTPS on the specified port. Your browser may not recognize the server's certificate, in which case you have to override its protection and proceed anyway.

### Launching the Spark history server and viewing the Spark UI using Docker

If you prefer local access (not to have an EC2 instance for the Apache Spark history server), you can also use Docker to start the Apache Spark history server and view the Spark UI locally. This Dockerfile is a sample that you should modify to meet your requirements.

### Prerequisites

For information about how to install Docker on your laptop see the [Docker Engine community](https://docs.docker.com).

### To start the Spark history server and view the Spark UI locally using Docker

1. Download files from GitHub.

   Download the Dockerfile and pom.xml from [AWS Glue code samples](https://github.com/aws-glue-code-samples).

2. Determine if you want to use your user credentials or federated user credentials to access AWS.

   - To use the current user credentials for accessing AWS, get the values to use for AWS_ACCESS_KEY_ID and AWS_SECRET_ACCESS_KEY in the docker run command. For more information, see [Managing access keys for IAM users](https://docs.aws.amazon.com/IAM/latest/userguide/iam-users-managing-access-keys.html) in the *IAM User Guide*.

   - To use SAML 2.0 federated users for accessing AWS, get the values for AWS_ACCESS_KEY_ID, AWS_SECRET_ACCESS_KEY, and AWS_SESSION_TOKEN. For more information, see [Requesting temporary security credentials](https://docs.aws.amazon.com/IAM/latest/userguide/saml-service-tokens.html).

3. Determine the location of your event log directory, to use in the docker run command.
4. Build the Docker image using the files in the local directory, using the name `glue/sparkui`, and the tag `latest`.

\[
\text{
$\text{docker build -t glue/sparkui:latest .}$
}\]

5. Create and start the docker container.

In the following commands, use the values obtained previously in steps 2 and 3.

a. To create the docker container using your user credentials, use a command similar to the following:

\[
\text{
docker run -itd -e SPARK\_HISTORY\_OPTS=\"$SPARK\_HISTORY\_OPTS -Dspark.history.fs.logDirectory=s3a://path\_to\_eventlog -Dspark.hadoop.fs.s3a.access.key=AWS\_ACCESS\_KEY\_ID -Dspark.hadoop.fs.s3a.secret.key=AWS\_SECRET\_ACCESS\_KEY\" -p 18080:18080 glue/sparkui:latest "/opt/spark/bin/spark-class org.apache.spark.deploy.history.HistoryServer"
}\]

b. To create the docker container using temporary credentials, use `org.apache.hadoop.fs.s3a.TemporaryAWSCredentialsProvider` as the provider, and provide the credential values obtained in step 2. For more information, see Using Session Credentials with TemporaryAWSCredentialsProvider in the Hadoop: Integration with Amazon Web Services documentation.

\[
\text{
docker run -itd -e SPARK\_HISTORY\_OPTS=\"$SPARK\_HISTORY\_OPTS -Dspark.history.fs.logDirectory=s3a://path\_to\_eventlog -Dspark.hadoop.fs.s3a.access.key=AWS\_ACCESS\_KEY\_ID -Dspark.hadoop.fs.s3a.secret.key=AWS\_SECRET\_ACCESS\_KEY -Dspark.hadoop.fs.s3a.session.token=AWS\_SESSION\_TOKEN -Dspark.hadoop.fs.s3a.aws.credentials.provider=org.apache.hadoop.fs.s3a.TemporaryAWSCredentialsProvider\" -p 18080:18080 glue/sparkui:latest "/opt/spark/bin/spark-class org.apache.spark.deploy.history.HistoryServer"
}\]
Note

These configuration parameters come from the **Hadoop-AWS Module**. You may need to add specific configuration based on your use case. For example: users in isolated regions will need to configure the `spark.hadoop.fs.s3a.endpoint`.


**Monitoring with AWS Glue job run insights**

AWS Glue job run insights is a feature in AWS Glue that simplifies job debugging and optimization for your AWS Glue jobs. AWS Glue provides **Spark UI**, and **CloudWatch logs and metrics** for monitoring your AWS Glue jobs. With this feature, you get this information about your AWS Glue job's execution:

- Line number of your AWS Glue job script that had a failure.
- Spark action that executed last in the Spark query plan just before the failure of your job.
- Spark exception events related to the failure presented in a time-ordered log stream.
- Root cause analysis and recommended action (such as tuning your script) to fix the issue.
- Common Spark events (log messages relating to a Spark action) with a recommended action that addresses the root cause.

All these insights are available to you using two new log streams in the CloudWatch logs for your AWS Glue jobs.

**Requirements**

The AWS Glue job run insights feature is available for AWS Glue version 2.0 and AWS Glue version 3.0. You can follow the **migration guide** for your existing jobs to upgrade them from older AWS Glue versions.

**Enabling job run insights for an AWS Glue ETL job**

You can enable job run insights through AWS Glue Studio or the CLI.
AWS Glue Studio

When creating a job via AWS Glue Studio, you can enable or disable job run insights under the Job Details tab. Check that the Generate job insights box is selected (enabled by default).

<table>
<thead>
<tr>
<th>Requested number of workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of workers you want AWS Glue to allocate to this job.</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

The maximums are 299 for G.1X and 149 for G.2X, and the minimum is 2.

Generate job insights

AWS Glue will analyze your job runs and provide insights on how to optimize your jobs and the reasons for job failures.

Command line

If creating a job via the CLI, you can start a job run with a single new job parameter: `--enable-job-insights = true`.

By default, the job run insights log streams are created under the same default log group used by AWS Glue continuous logging, that is, `/aws-glue/jobs/logs-v2/`. You may set up custom log group name, log filters and log group configurations using the same set of arguments for continuous logging. For more information, see Enabling Continuous Logging for AWS Glue Jobs.

Accessing the job run insights log streams in CloudWatch

With the job run insights feature enabled, there may be two log streams created when a job run fails. When a job finishes successfully, neither of the streams are generated.

1. Exception analysis log stream: `<job-run-id>-job-insights-rca-driver`. This stream provides the following:
   - Line number of your AWS Glue job script that caused the failure.
   - Spark action that executed last in the Spark query plan (DAG).
   - Concise time-ordered events from the Spark driver and executors that are related to the exception. You can find details such as complete error messages, the failed Spark task and its executors ID that help you to focus on the specific executor's log stream for a deeper investigation if needed.

2. Rule-based insights stream:
   - Root cause analysis and recommendations on how to fix the errors (such as using a specific job parameter to optimize the performance).
- Relevant Spark events serving as the basis for root cause analysis and a recommended action.

**Note**

The first stream will exist only if any exception Spark events are available for a failed job run, and the second stream will exist only if any insights are available for the failed job run. For example, if your job finishes successfully, neither of the streams will be generated; if your job fails but there isn't a service-defined rule that can match with your failure scenario, then only the first stream will be generated.

If the job is created from AWS Glue Studio, the links to the above streams are also available under the job run details tab (Job run insights) as "Concise and consolidated error logs" and "Error analysis and guidance".
Example for AWS Glue job run insights

In this section we present an example of how the job run insights feature can help you resolve an issue in your failed job. In this example, a user forgot to import the required module (tensorflow) in an AWS Glue job to analyze and build a machine learning model on their data.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from pyspark.sql.types import *
from pyspark.sql.functions import udf,col

args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

data_set_1 = [1, 2, 3, 4]
data_set_2 = [5, 6, 7, 8]

scoresDf = spark.createDataFrame(data_set_1, IntegerType())

def data_multiplier_func(factor, data_vector):
    import tensorflow as tf
    with tf.compat.v1.Session() as sess:
        x1 = tf.constant(factor)
        x2 = tf.constant(data_vector)
        result = tf.multiply(x1, x2)
        return sess.run(result).tolist()

data_multiplier_udf = udf(lambda x: data_multiplier_func(x, data_set_2), ArrayType(IntegerType(), False))
factoredDf = scoresDf.withColumn("final_value", data_multiplier_udf(col("value")))
print(factoredDf.collect())
```

Without the job run insights feature, as the job fails, you only see this message thrown by Spark:
An error occurred while calling o111.collectToPython. Traceback (most recent call last):

The message is ambiguous and limits your debugging experience. In this case, this feature provides with you additional insights in two CloudWatch log streams:

1. The job-insights-rca-driver log stream:

   - **Exception events**: This log stream provides you the Spark exception events related to the failure collected from the Spark driver and different distributed workers. These events help you understand the time-ordered propagation of the exception as faulty code executes across Spark tasks, executors, and stages distributed across the AWS Glue workers.

   - **Line numbers**: This log stream identifies line 21, which made the call to import the missing Python module that caused the failure; it also identifies line 24, the call to Spark Action `collect()`, as the last executed line in your script.

2. The job-insights-rule-driver log stream:

   - **Root cause and recommendation**: In addition to the line number and last executed line number for the fault in your script, this log stream shows the root cause analysis and recommendation for you to follow the AWS Glue doc and set up the necessary job parameters in order to use an additional Python module in your AWS Glue job.

   - **Basis event**: This log stream also shows the Spark exception event that was evaluated with the service-defined rule to infer the root cause and provide a recommendation.
Monitoring with Amazon CloudWatch

You can monitor AWS Glue using Amazon CloudWatch, which collects and processes raw data from AWS Glue into readable, near-real-time metrics. These statistics are recorded for a period of two weeks so that you can access historical information for a better perspective on how your web application or service is performing. By default, AWS Glue metrics data is sent to CloudWatch automatically. For more information, see What Is Amazon CloudWatch? in the Amazon CloudWatch User Guide, and AWS Glue metrics.

Continuous logging

AWS Glue also supports real-time continuous logging for AWS Glue jobs. When continuous logging is enabled for a job, you can view the real-time logs on the AWS Glue console or the CloudWatch console dashboard. For more information, see Continuous logging for AWS Glue jobs.

Observability metrics

When Job observability metrics is enabled, additional Amazon CloudWatch metrics are generated when the job is run. Use AWS Glue Observability metrics to generate insights into what is happening inside your AWS Glue to improve triaging and analysis of issues.

Topics

- Monitoring AWS Glue using Amazon CloudWatch metrics
- Setting up Amazon CloudWatch alarms on AWS Glue job profiles
- Continuous logging for AWS Glue jobs
Monitoring AWS Glue using Amazon CloudWatch metrics

You can profile and monitor AWS Glue operations using AWS Glue job profiler. It collects and processes raw data from AWS Glue jobs into readable, near real-time metrics stored in Amazon CloudWatch. These statistics are retained and aggregated in CloudWatch so that you can access historical information for a better perspective on how your application is performing.

Note

You may incur additional charges when you enable job metrics and CloudWatch custom metrics are created. For more information, see Amazon CloudWatch pricing.

AWS Glue metrics overview

When you interact with AWS Glue, it sends metrics to CloudWatch. You can view these metrics using the AWS Glue console (the preferred method), the CloudWatch console dashboard, or the AWS Command Line Interface (AWS CLI).

To view metrics using the AWS Glue console dashboard

You can view summary or detailed graphs of metrics for a job, or detailed graphs for a job run.

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.

2. In the navigation pane, choose Job run monitoring.

3. In Job runs choose Actions to stop a job that is currently running, view a job, or rewind job bookmark.

4. Select a job, then choose View run details to view additional information about the job run.

To view metrics using the CloudWatch console dashboard

Metrics are grouped first by the service namespace, and then by the various dimension combinations within each namespace.

2. In the navigation pane, choose **Metrics**.

3. Choose the **Glue** namespace.

**To view metrics using the AWS CLI**

- At a command prompt, use the following command.

  ```bash
  aws cloudwatch list-metrics --namespace Glue
  ```

AWS Glue reports metrics to CloudWatch every 30 seconds, and the CloudWatch metrics dashboards are configured to display them every minute. The AWS Glue metrics represent delta values from the previously reported values. Where appropriate, metrics dashboards aggregate (sum) the 30-second values to obtain a value for the entire last minute.

**AWS Glue metrics behavior for Spark jobs**

AWS Glue metrics are enabled at initialization of a `GlueContext` in a script and are generally updated only at the end of an Apache Spark task. They represent the aggregate values across all completed Spark tasks so far.

However, the Spark metrics that AWS Glue passes on to CloudWatch are generally absolute values representing the current state at the time they are reported. AWS Glue reports them to CloudWatch every 30 seconds, and the metrics dashboards generally show the average across the data points received in the last 1 minute.

AWS Glue metrics names are all preceded by one of the following types of prefix:

- `glue.driver.` – Metrics whose names begin with this prefix either represent AWS Glue metrics that are aggregated from all executors at the Spark driver, or Spark metrics corresponding to the Spark driver.
- `glue.executorId`. – The `executorId` is the number of a specific Spark executor. It corresponds with the executors listed in the logs.
- `glue.ALL`. – Metrics whose names begin with this prefix aggregate values from all Spark executors.
AWS Glue metrics

AWS Glue profiles and sends the following metrics to CloudWatch every 30 seconds, and the AWS Glue Metrics Dashboard report them once a minute:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.aggregate.bytesRead</td>
<td>The number of bytes read from all data sources by all completed Spark tasks running in all executors. Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), and Type (count). Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation. Unit: Bytes Can be used to monitor: • Bytes read. • Job progress. • JDBC data sources. • Job Bookmark Issues. • Variance across Job Runs. This metric can be used the same way as the glue.ALL.s3.filesystem.read_bytes metric, with the difference that this metric is updated at the end of a Spark task and captures non-S3 data sources as well.</td>
</tr>
<tr>
<td>glue.driver.aggregate.elapsedTime</td>
<td>The ETL elapsed time in milliseconds (does not include the job bootstrap times).</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation.</td>
</tr>
<tr>
<td></td>
<td>Unit: Milliseconds</td>
</tr>
<tr>
<td></td>
<td>Can be used to determine how long it takes a job run to run on average.</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Set alarms for stragglers.</td>
</tr>
<tr>
<td></td>
<td>• Measure variance across job runs.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>glue.driver.aggregate.numCompletedStages</td>
<td>The number of completed stages in the job. Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), and Type (count). Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation. Unit: Count Can be used to monitor: • Job progress. • Per-stage timeline of job execution, when correlated with other metrics. Some ways to use the data: • Identify demanding stages in the execution of a job. • Set alarms for correlated spikes (demanding stages) across job runs.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>glue.driver.aggregate.numCompletedTasks</code></td>
<td>The number of completed tasks in the job.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation.</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Job progress.</td>
</tr>
<tr>
<td></td>
<td>• Parallelism within a stage.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>glue.driver.aggregate.numFailedTasks</td>
<td>The number of failed tasks. Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (count). Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation. Unit: Count. Can be used to monitor: Data abnormalities that cause job tasks to fail. Cluster abnormalities that cause job tasks to fail. Script abnormalities that cause job tasks to fail. The data can be used to set alarms for increased failures that might suggest abnormalities in data, cluster or scripts.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| `glue.driver.aggregate.num KilledTasks`     | The number of tasks killed. **Valid dimensions:** JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), and Type (count). **Valid Statistics:** SUM. **Unit:** Count. **Can be used to monitor:**  
  - Abnormalities in Data Skew that result in exceptions (OOMs) that kill tasks.  
  - Script abnormalities that result in exceptions (OOMs) that kill tasks. **Some ways to use the data:**  
  - Set alarms for increased failures indicating data abnormalities.  
  - Set alarms for increased failures indicating cluster abnormalities.  
  - Set alarms for increased failures indicating script abnormalities. |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.aggregate.recordsRead</td>
<td>The number of records read from all data sources by all completed Spark tasks running in all executors.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation.</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Records read.</td>
</tr>
<tr>
<td></td>
<td>• Job progress.</td>
</tr>
<tr>
<td></td>
<td>• JDBC data sources.</td>
</tr>
<tr>
<td></td>
<td>• Job Bookmark Issues.</td>
</tr>
<tr>
<td></td>
<td>• Skew in Job Runs over days.</td>
</tr>
<tr>
<td></td>
<td>This metric can be used in a similar way to the glue.ALL.s3.filesystem.read_bytes metric, with the difference that this metric is updated at the end of a Spark task.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>glue.driver.aggregate.shuffleBytesWritten</td>
<td>The number of bytes written by all executors to shuffle data between them since the previous report (aggregated by the AWS Glue Metrics Dashboard as the number of bytes written for this purpose during the previous minute).</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation.</td>
</tr>
<tr>
<td></td>
<td>Unit: Bytes</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor: Data shuffle in jobs (large joins, groupBy, repartition, coalesce).</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Repartition or decompress large input files before further processing.</td>
</tr>
<tr>
<td></td>
<td>• Repartition data more uniformly to avoid hot keys.</td>
</tr>
<tr>
<td></td>
<td>• Pre-filter data before joins or groupBy operations.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| glue.driver.aggregate.shuffleLocalBytesRead | The number of bytes read by all executors to shuffle data between them since the previous report (aggregated by the AWS Glue Metrics Dashboard as the number of bytes read for this purpose during the previous minute).

Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (count).

Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard, a SUM statistic is used for aggregation.

Unit: Bytes

Can be used to monitor: Data shuffle in jobs (large joins, groupBy, repartition, coalesce).

Some ways to use the data:

- Repartition or decompress large input files before further processing.
- Repartition data more uniformly using hot keys.
- Pre-filter data before joins or groupBy operations. |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
</table>
| glue.driver.BlockManager.disk.diskSpaceUsed_MB | The number of megabytes of disk space used across all executors.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), and Type (gauge).  
Valid Statistics: Average. This is a Spark metric, reported as an absolute value.  
Unit: Megabytes  
Can be used to monitor:  
• Disk space used for blocks that represent cached RDD partitions.  
• Disk space used for blocks that represent intermediate shuffle outputs.  
• Disk space used for blocks that represent broadcasts.  
Some ways to use the data:  
• Identify job failures due to increased disk usage.  
• Identify large partitions resulting in spilling or shuffling.  
• Increase provisioned DPU capacity to correct these issues. |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>glue.driver.ExecutorAllocationManager.executors.number</code></td>
<td>The number of actively running job executors.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: <code>JobName</code> (the name of the AWS Glue Job), <code>JobRunId</code> (the JobRun ID. or ALL), and <code>Type</code> (gauge).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Average. This is a Spark metric, reported as an absolute value.</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Job activity.</td>
</tr>
<tr>
<td></td>
<td>• Straggling executors (with a few executors running only)</td>
</tr>
<tr>
<td></td>
<td>• Current executor-level parallelism.</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Repartition or decompress large input files beforehand if cluster is under-utilized.</td>
</tr>
<tr>
<td></td>
<td>• Identify stage or job execution delays due to straggler scenarios.</td>
</tr>
<tr>
<td></td>
<td>• Compare with <code>numberMaxNeededExecutors</code> to understand backlog for provisioning more DPUs.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>glue.driver.ExecutorAllocationManager.executors.numberMaxNeededExecutors</code></td>
<td>The number of maximum (actively running and pending) job executors needed to satisfy the current load.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: <code>JobName</code> (the name of the AWS Glue Job), <code>JobRunId</code> (the JobRun ID. or ALL), and <code>Type</code> (gauge).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Maximum. This is a Spark metric, reported as an absolute value.</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Job activity.</td>
</tr>
<tr>
<td></td>
<td>• Current executor-level parallelism and backlog of pending tasks not yet scheduled because of unavailable executors due to DPU capacity or killed/failed executors.</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Identify pending/backlog of scheduling queue.</td>
</tr>
<tr>
<td></td>
<td>• Identify stage or job execution delays due to straggler scenarios.</td>
</tr>
<tr>
<td></td>
<td>• Compare with <code>numberAllExecutors</code> to understand backlog for provisioning more DPUs.</td>
</tr>
<tr>
<td></td>
<td>• Increase provisioned DPU capacity to correct the pending executor backlog.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>glue.driver.jvm.heap.usage</td>
<td>The fraction of memory used by the JVM heap for this driver (scale: 0-1) for driver, executor identified by executorId, or ALL executors.</td>
</tr>
<tr>
<td>glue.exeuctorId.jvm.heap.usage</td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), and Type (gauge).</td>
</tr>
<tr>
<td>glue.ALL.jvm.heap.usage</td>
<td>Valid Statistics: Average. This is a Spark metric, reported as an absolute value.</td>
</tr>
<tr>
<td></td>
<td>Unit: Percentage</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Driver out-of-memory conditions (OOM) using glue.driver.jvm.heap.usage.</td>
</tr>
<tr>
<td></td>
<td>• Executor out-of-memory conditions (OOM) using glue.ALL.jvm.heap.usage.</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Identify memory-consuming executor ids and stages.</td>
</tr>
<tr>
<td></td>
<td>• Identify straggling executor ids and stages.</td>
</tr>
<tr>
<td></td>
<td>• Identify a driver out-of-memory condition (OOM).</td>
</tr>
<tr>
<td></td>
<td>• Identify an executor out-of-memory condition (OOM) and obtain the corresponding executor ID so as to be able to get a stack trace from the executor log.</td>
</tr>
<tr>
<td></td>
<td>• Identify files or partitions that may have data skew resulting in stragglers or out-of-memory conditions (OOMs).</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>glue.driver.jvm.heap.used</code></td>
<td>The number of memory bytes used by the JVM heap for the driver, the executor identified by <code>executorId</code>, or ALL executors.</td>
</tr>
<tr>
<td><code>glue.executorId.jvm.heap.used</code></td>
<td>Valid dimensions: <code>JobName</code> (the name of the AWS Glue Job), <code>JobRunId</code> (the JobRun ID or ALL), and <code>Type</code> (gauge).</td>
</tr>
<tr>
<td><code>glue.ALL.jvm.heap.used</code></td>
<td>Valid Statistics: Average. This is a Spark metric, reported as an absolute value.</td>
</tr>
<tr>
<td></td>
<td>Unit: Bytes</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Driver out-of-memory conditions (OOM).</td>
</tr>
<tr>
<td></td>
<td>• Executor out-of-memory conditions (OOM).</td>
</tr>
<tr>
<td></td>
<td>Some ways to use the data:</td>
</tr>
<tr>
<td></td>
<td>• Identify memory-consuming executor ids and stages.</td>
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<td>• Identify straggling executor ids and stages.</td>
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<td></td>
<td>• Identify a driver out-of-memory condition (OOM).</td>
</tr>
<tr>
<td></td>
<td>• Identify an executor out-of-memory condition (OOM) and obtain the corresponding executor ID so as to be able to get a stack trace from the executor log.</td>
</tr>
<tr>
<td></td>
<td>• Identify files or partitions that may have data skew resulting in stragglers or out-of-memory conditions (OOMs).</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>glue.driver.s3.filesystem.readFile_bytes</td>
<td>The number of bytes read from Amazon S3 by the driver, an executor identified by <code>executorId</code>, or ALL executors since the previous report (aggregated by the AWS Glue Metrics Dashboard as the number of bytes read during the previous minute).</td>
</tr>
<tr>
<td>glue.executorId.s3.filesystem.readFile_bytes</td>
<td>Valid dimensions: JobName, JobRunId, and Type (gauge).</td>
</tr>
<tr>
<td>glue.ALL.s3.filesystem.readFile_bytes</td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard a SUM statistic is used for aggregation. The area under the curve on the AWS Glue Metrics Dashboard can be used to visually compare bytes read by two different job runs.</td>
</tr>
</tbody>
</table>

Unit: Bytes.

Can be used to monitor:

- ETL data movement.
- Job progress.
- Job bookmark issues (data processed, reprocessed, and skipped).
- Comparison of reads to ingestion rate from external data sources.
- Variance across job runs.

Resulting data can be used for:

- DPU capacity planning.
- Setting alarms for large spikes or dips in data read for job runs and job stages.
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.s3.filesystem.write_bytes</td>
<td>The number of bytes written to Amazon S3 by the driver, an executor identified by <code>executorId</code>, or ALL executors since the previous report (aggregated by the AWS Glue Metrics Dashboard as the number of bytes written during the previous minute).</td>
</tr>
<tr>
<td>glue.executorId.s3.filesystem.write_bytes</td>
<td>Valid dimensions: JobName, JobRunId, and Type (gauge).</td>
</tr>
<tr>
<td>glue.ALL.s3.filesystem.write_bytes</td>
<td>Valid Statistics: SUM. This metric is a delta value from the last reported value, so on the AWS Glue Metrics Dashboard a SUM statistic is used for aggregation. The area under the curve on the AWS Glue Metrics Dashboard can be used to visually compare bytes written by two different job runs. Unit: Bytes</td>
</tr>
</tbody>
</table>

Can be used to monitor:

- ETL data movement.
- Job progress.
- Job bookmark issues (data processed, reprocessed, and skipped).
- Comparison of reads to ingestion rate from external data sources.
- Variance across job runs.

Some ways to use the data:

- DPU capacity planning.
- Setting alarms for large spikes or dips in data read for job runs and job stages.
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.streaming.numRecords</td>
<td>The number of records that are received in a micro-batch. This metric is only available for AWS Glue streaming jobs with AWS Glue version 2.0 and above.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue job), JobRunId (the JobRun ID. or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Sum, Maximum, Minimum, Average, Percentile</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Records read.</td>
</tr>
<tr>
<td></td>
<td>• Job progress.</td>
</tr>
<tr>
<td>glue.driver.streaming.batchProcessingTimeInMs</td>
<td>The time it takes to process the batches in milliseconds. This metric is only available for AWS Glue streaming jobs with AWS Glue version 2.0 and above.</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue job), JobRunId (the JobRun ID. or ALL), and Type (count).</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Sum, Maximum, Minimum, Average, Percentile</td>
</tr>
<tr>
<td></td>
<td>Unit: Count</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor:</td>
</tr>
<tr>
<td></td>
<td>• Job progress.</td>
</tr>
<tr>
<td></td>
<td>• Script performance.</td>
</tr>
</tbody>
</table>
### Metric Description

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>glue.driver.system.cpuSystemLoad</code></td>
<td>The fraction of CPU system load used (scale: 0-1) by the driver, an executor identified by <code>executorId</code>, or ALL executors. Valid dimensions: JobName (the name of the AWS Glue job), JobRunId (the JobRun ID. or ALL), and Type (gauge). Valid Statistics: Average. This metric is reported as an absolute value. Unit: Percentage Can be used to monitor: • Driver CPU load. • Executor CPU load. • Detecting CPU-bound or IO-bound executors or stages in a Job. Some ways to use the data: • DPU capacity Planning along with IO Metrics (Bytes Read/Shuffle Bytes, Task Parallelism) and the number of maximum needed executors metric. • Identify the CPU/IO-bound ratio. This allows for repartitionioning and increasing provisioned capacity for long-running jobs with splittable datasets having lower CPU utilization.</td>
</tr>
<tr>
<td><code>glue.executorId.system.cpuSystemLoad</code></td>
<td></td>
</tr>
<tr>
<td><code>glue.ALL.system.cpuSystemLoad</code></td>
<td></td>
</tr>
</tbody>
</table>

### Dimensions for AWS Glue Metrics

AWS Glue metrics use the AWS Glue namespace and provide metrics for the following dimensions:
### Setting up Amazon CloudWatch alarms on AWS Glue job profiles

AWS Glue metrics are also available in Amazon CloudWatch. You can set up alarms on any AWS Glue metric for scheduled jobs.

A few common scenarios for setting up alarms are as follows:

- **Jobs running out of memory (OOM):** Set an alarm when the memory usage exceeds the normal average for either the driver or an executor for an AWS Glue job.
- **Straggling executors:** Set an alarm when the number of executors falls below a certain threshold for a large duration of time in an AWS Glue job.
- **Data backlog or reprocessing:** Compare the metrics from individual jobs in a workflow using a CloudWatch math expression. You can then trigger an alarm on the resulting expression value (such as the ratio of bytes written by a job and bytes read by a following job).

For detailed instructions on setting alarms, see [Create or Edit a CloudWatch Alarm](https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/alarm.html) in the *Amazon CloudWatch Events User Guide*.

For monitoring and debugging scenarios using CloudWatch, see [Job monitoring and debugging](https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/job-monitoring.html).
Continuous logging for AWS Glue jobs

AWS Glue provides real-time, continuous logging for AWS Glue jobs. You can view real-time Apache Spark job logs in Amazon CloudWatch, including driver logs, executor logs, and an Apache Spark job progress bar. Viewing real-time logs provides you with a better perspective on the running job.

When you start an AWS Glue job, it sends the real-time logging information to CloudWatch (every 5 seconds and before each executor termination) after the Spark application starts running. You can view the logs on the AWS Glue console or the CloudWatch console dashboard.

The continuous logging feature includes the following capabilities:

- Continuous logging with a default filter to reduce high verbosity in the logs
- Continuous logging with no filter
- A custom script logger to log application-specific messages
- A console progress bar to track the running status of the current AWS Glue job

For information about how continuous logging is supported in AWS Glue version 2.0, see Running Spark ETL Jobs with Reduced Startup Times.

You can restrict access to CloudWatch log groups or streams for IAM roles to read the logs. For more details on restricting access, see Using identity-based policies (IAM policies) for CloudWatch Logs in the CloudWatch documentation.

Note

You may incur additional charges when you enable continuous logging and additional CloudWatch log events are created. For more information, see Amazon CloudWatch pricing.

Topics

- Enabling continuous logging for AWS Glue jobs
- Viewing continuous logging for AWS Glue jobs
Enabling continuous logging for AWS Glue jobs

You can enable continuous logging using the AWS Glue console or through the AWS Command Line Interface (AWS CLI).

You can enable continuous logging with either a standard filter or no filter when you create a new job, edit an existing job, or enable it through the AWS CLI. Choosing the **Standard filter** prunes out non-useful Apache Spark driver/executor and Apache Hadoop YARN heartbeat log messages. Choosing **No filter** gives you all the log messages.

You can also specify custom configuration options such as the Amazon CloudWatch log group name, CloudWatch log stream prefix before the AWS Glue job run ID driver/executor ID, and log conversion pattern for log messages. These configurations help you to set aggregate logs in custom CloudWatch log groups with different expiration policies, and analyze them further with custom log stream prefixes and conversions patterns.

**Topics**

- [Using the AWS Management Console](#)
- [Logging application-specific messages using the custom script logger](#)
- [Enabling the progress bar to show job progress](#)
- [Security configuration with continuous logging](#)

**Using the AWS Management Console**

Follow these steps to use the console to enable continuous logging when creating or editing an AWS Glue job.

**To create a new AWS Glue job with continuous logging**

2. In the navigation pane, choose **Jobs**.
3. Choose **Add job**.
4. In **Configure the job properties**, expand the **Monitoring options** section.
5. Select **Continuous logging** to use it for this job.
6. Under **Log filtering**, choose **Standard filter** or **No filter**.
To enable continuous logging for an existing AWS Glue job

2. In the navigation pane, choose Jobs.
3. Choose an existing job from the Jobs list.
5. Expand the Monitoring options section.
6. Select Continuous logging to use it for this job.
7. Under Log filtering, choose Standard filter or No filter.

To enable continuous logging for all newly created AWS Glue jobs

2. In the navigation pane, choose Jobs.
3. In the upper-right corner, choose User preferences.
4. Under the heading Monitoring options, choose Continuous logging.
5. Under Log filtering, choose Standard filter or No filter.

These user preferences are applied to all new jobs unless you override them explicitly when creating an AWS Glue job or by editing an existing job as described previously.

Using the AWS CLI

To enable continuous logging, you pass in job parameters to an AWS Glue job. When you want to use the standard filter, pass the following special job parameters similar to other AWS Glue job parameters. For more information, see AWS Glue job parameters.

```
'--enable-continuous-cloudwatch-log': 'true'
```

When you want no filter, use the following.

```
'--enable-continuous-cloudwatch-log': 'true',
'--enable-continuous-log-filter': 'false'
```

You can specify a custom Amazon CloudWatch log group name. If not specified, the default log group name is /aws-glue/jobs/logs-v2/.
You can specify a custom Amazon CloudWatch log stream prefix. If not specified, the default log stream prefix is the job run ID.

You can specify a custom continuous logging conversion pattern. If not specified, the default conversion pattern is `%d{yy/MM/dd HH:mm:ss} %p %c{1}: %m%n`. Note that the conversion pattern only applies to driver logs and executor logs. It does not affect the AWS Glue progress bar.

Logging application-specific messages using the custom script logger

You can use the AWS Glue logger to log any application-specific messages in the script that are sent in real time to the driver log stream.

The following example shows a Python script.

```python
from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)
logger = glueContext.get_logger()
logger.info("info message")
logger.warn("warn message")
logger.error("error message")
```

The following example shows a Scala script.

```scala
import com.amazonaws.services.glue.log.GlueLogger

object GlueApp {
  def main(sysArgs: Array[String]) {
    val logger = new GlueLogger
    logger.info("info message")
    logger.warn("warn message")
    logger.error("error message")
  }
}
```
Enabling the progress bar to show job progress

AWS Glue provides a real-time progress bar under the JOB_RUN_ID-progress-bar log stream to check AWS Glue job run status. Currently it supports only jobs that initialize glueContext. If you run a pure Spark job without initializing glueContext, the AWS Glue progress bar does not appear.

The progress bar shows the following progress update every 5 seconds.

\[
\text{Stage Number (Stage Name): } \frac{(\text{numCompletedTasks} + \text{numActiveTasks})}{\text{totalNumOfTasksInThisStage}}
\]

Security configuration with continuous logging

If a security configuration is enabled for CloudWatch logs, AWS Glue will create a log group named as follows for continuous logs:

\[
<\text{Log-Group-Name}>-<\text{Security-Configuration-Name}>
\]

The default and custom log groups will be as follows:

- The default continuous log group will be /aws-glue/jobs/logs-v2-<Security-Configuration-Name>
- The custom continuous log group will be <custom-log-group-name>-<Security-Configuration-Name>

You need to add the logs:AssociateKmsKey to your IAM role permissions, if you enable a security configuration with CloudWatch Logs. If that permission is not included, continuous logging will be disabled. Also, to configure the encryption for the CloudWatch Logs, follow the instructions at Encrypt Log Data in CloudWatch Logs Using AWS Key Management Service in the Amazon CloudWatch Logs User Guide.

For more information on creating security configurations, see Working with security configurations on the AWS Glue console.

Viewing continuous logging for AWS Glue jobs

You can view real-time logs using the AWS Glue console or the Amazon CloudWatch console.
To view real-time logs using the AWS Glue console dashboard

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, choose Jobs.
3. Add or start an existing job. Choose Action, Run job.

When you start running a job, you navigate to a page that contains information about the running job:

- The Logs tab shows the older aggregated application logs.
- The Continuous logging tab shows a real-time progress bar when the job is running with glueContext initialized.
- The Continuous logging tab also contains the Driver logs, which capture real-time Apache Spark driver logs, and application logs from the script logged using the AWS Glue application logger when the job is running.

4. For older jobs, you can also view the real-time logs under the Job History view by choosing Logs. This action takes you to the CloudWatch console that shows all Spark driver, executor, and progress bar log streams for that job run.

To view real-time logs using the CloudWatch console dashboard

2. In the navigation pane, choose Log.
3. Choose the /aws-glue/jobs/logs-v2/ log group.
4. In the Filter box, paste the job run ID.

You can view the driver logs, executor logs, and progress bar (if using the Standard filter).

Monitoring with AWS Glue Observability metrics

Note

AWS Glue Observability metrics is available on AWS Glue 4.0 and later versions.
Use AWS Glue Observability metrics to generate insights into what is happening inside your AWS Glue for Apache Spark jobs to improve triaging and analysis of issues. Observability metrics are visualized through Amazon CloudWatch dashboards and can be used to help perform root cause analysis for errors and for diagnosing performance bottlenecks. You can reduce the time spent debugging issues at scale so you can focus on resolving issues faster and more effectively.

AWS Glue Observability provides Amazon CloudWatch metrics categorized in following four groups:

- **Reliability (i.e., Errors Classes)** – easily identify the most common failure reasons at given time range that you may want to address.

- **Performance (i.e., Skewness)** – identify a performance bottleneck and apply tuning techniques. For example, when you experience degraded performance due to job skewness, you may want to enable Spark Adaptive Query Execution and fine-tune the skew join threshold.

- **Throughput (i.e., per source/sink throughput)** – monitor trends of data reads and writes. You can also configure Amazon CloudWatch alarms for anomalies.

- **Resource Utilization (i.e., workers, memory and disk utilization)** – efficiently find the jobs with low capacity utilization. You may want to enable AWS Glue auto-scaling for those jobs.

**Getting started with AWS Glue Observability metrics**

**Note**

The new metrics are enabled by default in the AWS Glue Studio console.

**To configure observability metrics in AWS Glue Studio:**

1. Log in to the AWS Glue console and choose **ETL jobs** from the console menu.
2. Choose a job by clicking on the job name in the **Your jobs** section.
3. Choose the **Job details** tab.
4. Scroll to the bottom and choose **Advanced properties**, then **Job observability metrics**.
To enable AWS Glue Observability metrics using AWS CLI:

- Add to the `--default-arguments` map the following key-value in the input JSON file:

```
--enable-observability-metrics, true
```

Using AWS Glue observability

Because the AWS Glue observability metrics is provided through Amazon CloudWatch, you can use the Amazon CloudWatch console, AWS CLI, SDK or API to query the observability metrics.
Using AWS Glue observability in the Amazon CloudWatch console

To query and visualize metrics in the Amazon CloudWatch console:

1. Open the Amazon CloudWatch console and choose All metrics.
2. Under custom namespaces, choose AWS Glue.
3. Choose Job Observability Metrics, Observability Metrics Per Source, or Observability Metrics Per Sink.
4. Search for the specific metric name, job name, job run ID, and select them.
5. Under the Graphed metrics tab, configure your preferred statistic, period, and other options.

To query an Observability metric using AWS CLI:

1. Create a metric definition JSON file and replace your-Glue-job-name and your-Glue-job-run-id with yours.

```json
$ cat multiplequeries.json
[
  {
    "Id": "avgWorkerUtil_0",
    "MetricStat": {
      "Metric": {
        "Namespace": "Glue",
        "MetricName": "glue.driver.workerUtilization",
        "Dimensions": [
          "Spark and PySpark jobs"]
      }
    }
  }
]```
```json
{
  "Id": "avgWorkerUtil_1",
  "MetricStat": {
    "Metric": {
      "Namespace": "Glue",
      "MetricName": "glue.driver.workerUtilization",
      "Dimensions": [
        {
          "Name": "JobName",
          "Value": "<your-Glue-job-name-B>"
        },
        {
          "Name": "JobRunId",
          "Value": "<your-Glue-job-run-id-B>"
        },
        {
          "Name": "Type",
          "Value": "gauge"
        },
        {
          "Name": "ObservabilityGroup",
          "Value": "resource_utilization"
        }
      ]
    },
    "Period": 1800,
    "Stat": "Minimum",
    "Unit": "None"
  }
}
```
2. Run the `get-metric-data` command:

```
$ aws cloudwatch get-metric-data --metric-data-queries file: //multiplequeries.json
  
  --start-time '2023-10-28T18:20'
  --end-time '2023-10-28T19:10'
  --region us-east-1

{
  "MetricDataResults": [
    {
      "Id": "avgWorkerUtil_0",
      "Label": "<your-label-for-A>",
      "Timestamps": [
        "2023-10-28T18:20:00+00:00"
      ],
      "Values": [
        0.06718750000000001
      ],
      "StatusCode": "Complete"
    },
    {
      "Id": "avgWorkerUtil_1",
      "Label": "<your-label-for-B>",
      "Timestamps": [
        "2023-10-28T18:50:00+00:00"
      ],
      "Values": [
        0.5959183673469387
      ],
      "StatusCode": "Complete"
    }
  ]
}
```
**Observability metrics**

AWS Glue Observability profiles and sends the following metrics to Amazon CloudWatch every 30 seconds, and some of these metrics can be visible in the AWS Glue Studio Job Runs Monitoring Page.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.skewness.stage</td>
<td>Metric Category: job_performance</td>
<td>job_performance</td>
</tr>
<tr>
<td></td>
<td>The spark stages execution Skewness: this metric captures execution skewness, which might be caused by input data skewness or by a transformation (e.g., skewed join). The values of this metric falls into the range of [0, infinity[, where 0 means the ratio of the maximum to median tasks' execution time, among all tasks in the stage is less than a certain stage skewness factor. The default stage skewness factor is <code>5</code> and it be overwritten via spark conf: spark.metrics.conf .driver.source.glue.jobPerformance.skewnessFactor</td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>A stage skewness value of 1 means the ratio is twice the stage skewness factor.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The value of stage skewness is updated every 30 seconds to reflect the current skewness. The value at the end of the stage reflects the final stage skewness.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID, or ALL), Type (gauge), and ObservabilityGroup (job_performance)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valid Statistics: Average, Maximum, Minimum, Percentile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit: Count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------</td>
</tr>
</tbody>
</table>
| glue.driver.skewness.job | Metric Category: job_performance  
Job skewness is the weighted average of the job stages skewness. Weighted average gives more weight to stages that takes longer to execute. This is to avoid the corner case when a very skewwed stage is actually running for very short time relative to other stages (and thus its skewness is not significant for the overall job performance and does not worth the effort to try to address its skewness).  
This metric is updated upon completion of each stage, and thus the last value reflects the actual overall job skewness.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (job_performance)  
Valid Statistics: Average, Maximum, Minimum, Percentile  
Unit: Count | job_performance      |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
</table>
| glue.succeed.ALL | Metric Category: error  
Total number of successful job runs, to complete the picture of failures categories  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (count), and ObservabilityGroup (error)  
Valid Statistics: SUM  
Unit: Count | error    |
| glue.error.ALL  | Metric Category: error  
Total number of job run errors, to complete the picture of failures categories  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (count), and ObservabilityGroup (error)  
Valid Statistics: SUM  
Unit: Count | error    |
**Metric** | **Description** | **Category**
---|---|---
`glue.error.[error category]` | Metric Category: error  
This is actually a set of metrics, that are updated only when a job run fails. The error categorization helps with triaging and debugging. When a job run fails, the error causing the failure is categorized and the corresponding error category metric is set to 1. This helps to perform over time failures analysis, as well as over all jobs error analysis to identify most common failure categories to start addressing them. AWS Glue has 28 error categories, including OUT_OF_MEMORY (driver and executor), PERMISSION, SYNTAX and THROTTLING error categories. Error categories also include COMPILATION, LAUNCH and TIMEOUT error categories.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (count), and ObservabilityGroup (error)  
Valid Statistics: SUM
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
</table>
| glue.driver.workerUtilization | Metric Category: resource_utilization  
The percentage of the allocated workers which are actually used. If not good, auto scaling can help.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average, Maximum, Minimum, Percentile  
Unit: Percentage                                                                 | resource_utilization          |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>`glue.driver.memory.heap.[available</td>
<td>used]`</td>
<td>Metric Category: resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The driver's available / used heap memory during the job run. This helps to understand memory usage trends, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Average</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit: Bytes</td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>----------</td>
</tr>
</tbody>
</table>
| glue.driver.memory.heap.used.percentage | Metric Category: resource_utilization  
The driver's used (%) heap memory during the job run. This helps to understand memory usage trends, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average  
Unit: Percentage | resource_utilization |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.memory.non-heap.[available</td>
<td>used]</td>
<td>Metric Category: resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The driver's available / used non-heap memory during the job run. This helps to understand memory usage trend, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Average</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>Unit: Bytes</td>
<td>resource_utilization</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
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<td>----------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>glue.driver.memory.non-heap.used.percentage</td>
<td>Metric Category: resource_utilization</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The driver's used (%) non-heap memory during the job run. This helps to understand memory usage trends, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
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<tr>
<td></td>
<td>Valid Statistics: Average</td>
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<td></td>
<td>Unit: Percentage</td>
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<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
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<td>--------------------------------------------</td>
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</tr>
</tbody>
</table>
| `glue.driver.memory.total.[available | used]`                                 | Metric Category: `resource_utilization`  
The driver's available / used total memory during the job run. This helps to understand memory usage trends, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.  
Valid dimensions: `JobName` (the name of the AWS Glue Job), `JobRunId` (the JobRun ID. or ALL), `Type` (gauge), and `ObservabilityGroup` (resource_utilization)  
Valid Statistics: Average  
Unit: Bytes                                                                 | `resource_utilization`          |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
</table>
| glue.driver.memory.total.used.percentage | Metric Category: resource_utilization  
The driver's used (%) total memory during the job run. This helps to understand memory usage trends, especially over time, which can help avoid potential failures, in addition to debugging memory related failures.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average  
Unit: Percentage                                                                 | resource_utilization         |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.ALL.memory.heap.[available</td>
<td>Metric Category: resource_utilization</td>
<td>resource_utilization</td>
</tr>
<tr>
<td>available</td>
<td>The executors' available/used heap memory. ALL means all executors.</td>
<td></td>
</tr>
<tr>
<td>used]</td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
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<td>Valid Statistics: Average</td>
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<td>Unit: Bytes</td>
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<tr>
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</tr>
<tr>
<td>glue.ALL.memory.non-heap. [available</td>
<td>used]</td>
<td>Metric Category: resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The executors' available/used non-heap memory. ALL means all executors.</td>
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<td>Unit: Percentage</td>
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</table>

Spark and PySpark jobs
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
</table>
| glue.ALL.memory.total.[available | used] | Metric Category: resource_utilization  
The executors' available/used total memory. ALL means all executors.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average  
Unit: Bytes | resource_utilization |
| glue.ALL.memory.total.used.percentage | Metric Category: resource_utilization  
The executors' used (%) total memory. ALL means all executors.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average  
Unit: Percentage | resource_utilization |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.disk.[available_GB</td>
<td>The driver's available/used disk space during the job run. This helps to understand disk usage trends, especially over time, which can help avoid potential failures, in addition to debugging not enough disk space related failures.</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>[ used_GB]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
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<td></td>
<td>Valid Statistics: Average</td>
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<tr>
<td></td>
<td>Unit: Gigabytes</td>
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<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
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<tr>
<td>--------</td>
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</tr>
</tbody>
</table>
| glue.driver.disk.used.percentage | Metric Category: resource_utilization  
The driver's available/used disk space during the job run. This helps to understand disk usage trends, especially over time, which can help avoid potential failures, in addition to debugging not enough disk space related failures.  
Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)  
Valid Statistics: Average  
Unit: Percentage | resource_utilization |
<table>
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<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.ALL.disk.[available_GB</td>
<td>used_GB]</td>
<td>Metric Category: resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The executors' available/used disk space. ALL means all executors.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
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<tr>
<td></td>
<td>Valid Statistics: Average</td>
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<tr>
<td></td>
<td>Unit: Gigabytes</td>
<td></td>
</tr>
<tr>
<td>glue.ALL.disk.used.percentage</td>
<td>Metric Category: resource_utilization</td>
<td>resource_utilization</td>
</tr>
<tr>
<td></td>
<td>The executors' available/used/used(%) disk space. ALL means all executors.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), and ObservabilityGroup (resource_utilization)</td>
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<td></td>
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<td></td>
<td>Unit: Percentage</td>
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<td>Metric</td>
<td>Description</td>
<td>Category</td>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>glue.driver.bytesRead</td>
<td>Metric Category: throughput The number of bytes read per input source in this job run, as well as for ALL sources. This helps understand the data volume and its changes over time, which helps addressing issues such as data skewness.</td>
<td>throughput</td>
</tr>
<tr>
<td></td>
<td>Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), ObservabilityGroup (resource _utilization), and Source (source data location)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valid Statistics: Average</td>
<td></td>
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<tr>
<td></td>
<td>Unit: Bytes</td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>glue.driver.[recordsRead</td>
<td>The number of records/files read per input source in this job run, as well as well as for ALL sources. This helps understand the data volume and its changes over time, which helps addressing issues such as data skewness.</td>
<td>throughput</td>
</tr>
<tr>
<td>filesRead]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), ObservabilityGroup (resource_utilization), and Source (source data location)

Valid Statistics: Average

Unit: Count
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.partitionsRead</td>
<td>Metric Category: throughput The number of partitions read per Amazon S3 input source in this job run, as well as well as for ALL sources. Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), ObservabilityGroup (resource _utilization), and Source (source data location) Valid Statistics: Average Unit: Count</td>
<td>throughput</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
</tbody>
</table>
| glue.driver.bytesWritten | Metric Category: throughput  
The number of bytes written per output sink in this job run, as well as for ALL sinks. This helps understand the data volume and how it evolves over time, which helps addressing issues such as processing skewness.  

Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), ObservabilityGroup (resource _utilization), and Sink (sink data location)  

Valid Statistics: Average  

Unit: Bytes                                                                 | throughput |
<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue.driver.[recordsWritten</td>
<td>filesWritten]</td>
<td>Metric Category: throughput The number of records/files written per output sink in this job run, as well as for ALL sinks. This helps understand the data volume and how it evolves over time, which helps addressing issues such as processing skewness.</td>
</tr>
</tbody>
</table>

Valid dimensions: JobName (the name of the AWS Glue Job), JobRunId (the JobRun ID. or ALL), Type (gauge), ObservabilityGroup (resource utilization), and Sink (sink data location)

Valid Statistics: Average

Unit: Count

**Error categories**

<table>
<thead>
<tr>
<th>Error categories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPILATION_ERROR</td>
<td>Errors arise during the compilation of Scala code.</td>
</tr>
<tr>
<td>CONNECTION_ERROR</td>
<td>Errors arise during connecting to a service/remote host/database service, etc.</td>
</tr>
<tr>
<td>DISK_NO_SPACE_ERROR</td>
<td>Errors arise when there is no space left in disk on driver/executor.</td>
</tr>
<tr>
<td>Error categories</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>OUT_OF_MEMORY_ERROR</td>
<td>Errors arise when there is no space left in memory on driver/executor.</td>
</tr>
<tr>
<td>IMPORT_ERROR</td>
<td>Errors arise when import dependencies.</td>
</tr>
<tr>
<td>INVALID_ARGUMENT_ERROR</td>
<td>Errors arise when the input arguments are not invalid/illegal.</td>
</tr>
<tr>
<td>PERMISSION_ERROR</td>
<td>Errors arise when lacking the permission to service, data, etc.</td>
</tr>
<tr>
<td>RESOURCE_NOT_FOUND_ERROR</td>
<td>Errors arise when data, location, etc does not exist.</td>
</tr>
<tr>
<td>QUERY_ERROR</td>
<td>Errors arise from Spark SQL query execution.</td>
</tr>
<tr>
<td>SYNTAX_ERROR</td>
<td>Errors arise when there is syntax error in the script.</td>
</tr>
<tr>
<td>THROTTLING_ERROR</td>
<td>Errors arise when hitting service concurrency limitation or exceeding service quota limitation.</td>
</tr>
<tr>
<td>DATA LAKE FRAMEWORK_ERROR</td>
<td>Errors arise from AWS Glue native-supported data lake framework like Hudi, Iceberg, etc.</td>
</tr>
<tr>
<td>UNSUPPORTED_OPERATION_ERROR</td>
<td>Errors arise when making unsupported operation.</td>
</tr>
<tr>
<td>RESOURCES_ALREADY_EXISTS_ERROR</td>
<td>Errors arise when a resource to be created or added already exists.</td>
</tr>
<tr>
<td>GLUE_INTERNAL_SERVICE_ERROR</td>
<td>Errors arise when there is a AWS Glue internal service issue.</td>
</tr>
<tr>
<td>GLUE_OPERATION_TIMEOUT_ERROR</td>
<td>Errors arise when a AWS Glue operation is timeout.</td>
</tr>
</tbody>
</table>
## Error categories

<table>
<thead>
<tr>
<th>Error category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLUE_VALIDATION_ERROR</td>
<td>Errors arise when a required value could not be validated for AWS Glue job.</td>
</tr>
<tr>
<td>GLUE_JOB_BOOKMARK_VERSION_MISMATCH_ERROR</td>
<td>Errors arise when same job ex on the same source bucket and write to the same/different destination concurrently (concurrency &gt;1)</td>
</tr>
<tr>
<td>LAUNCH_ERROR</td>
<td>Errors arise during the AWS Glue job launch phase.</td>
</tr>
<tr>
<td>DYNAMODB_ERROR</td>
<td>Generic errors arise from Amazon DynamoDB service.</td>
</tr>
<tr>
<td>GLUE_ERROR</td>
<td>Generic Errors arise from AWS Glue service.</td>
</tr>
<tr>
<td>LAKEFORMATION_ERROR</td>
<td>Generic Errors arise from AWS Lake Formation service.</td>
</tr>
<tr>
<td>REDSHIFT_ERROR</td>
<td>Generic Errors arise from Amazon Redshift service.</td>
</tr>
<tr>
<td>S3_ERROR</td>
<td>Generic Errors arise from Amazon S3 service.</td>
</tr>
<tr>
<td>SYSTEM_EXIT_ERROR</td>
<td>Generic system exit error.</td>
</tr>
<tr>
<td>TIMEOUT_ERROR</td>
<td>Generic errors arise when job failed by operation time out.</td>
</tr>
<tr>
<td>UNCLASSIFIED_SPARK_ERROR</td>
<td>Generic errors arise from Spark.</td>
</tr>
<tr>
<td>UNCLASSIFIED_ERROR</td>
<td>Default error category.</td>
</tr>
</tbody>
</table>

## Limitations

**Note**

glueContext must be initialized to publish the metrics.
In the Source Dimension, the value is either Amazon S3 path or table name, depending on the source type. In addition, if the source is JDBC and the query option is used, the query string is set in the source dimension. If the value is longer than 500 characters, it is trimmed within 500 characters. The following are limitations in the value:

- Non-ASCII characters will be removed.
- If the source name doesn't contain any ASCII character, it is converted to <non-ASCII input>.

**Limitations and considerations for throughput metrics**

- DataFrame and DataFrame-based DynamicFrame (e.g. JDBC, reading from parquet on Amazon S3) are supported, however, RDD-based DynamicFrame (e.g. reading csv, json on Amazon S3, etc.) is not supported. Technically, all reads and writes visible on Spark UI are supported.
- The `recordsRead` metric will be emitted if the data source is catalog table and the format is JSON, CSV, text, or Iceberg.
- `glue.driver.throughput.recordsWritten`, `glue.driver.throughput.bytesWritten`, and `glue.driver.throughput.filesWritten` metrics are not available in JDBC and Iceberg tables.
- Metrics may be delayed. If the job finishes in about one minute, there may be no throughput metrics in Amazon CloudWatch Metrics.

**Job monitoring and debugging**

You can collect metrics about AWS Glue jobs and visualize them on the AWS Glue and Amazon CloudWatch consoles to identify and fix issues. Profiling your AWS Glue jobs requires the following steps:

1. Enable metrics:
   a. Enable the **Job metrics** option in the job definition. You can enable profiling in the AWS Glue console or as a parameter to the job. For more information see [Defining job properties for Spark jobs](#) or [AWS Glue job parameters](#).
   b. Enable the **AWS Glue Observability metrics** option in the job definition. You can enable Observability in the AWS Glue console or as a parameter to the job. For more information see [Monitoring with AWS Glue Observability metrics](#).
2. Confirm that the job script initializes a GlueContext. For example, the following script snippet initializes a GlueContext and shows where profiled code is placed in the script. This general format is used in the debugging scenarios that follow.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
import time

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
```

```python
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

...  
  ...
```

```python
code-to-profile

...
```

```python
job.commit()
```

3. Run the job.

4. Visualize the metrics:
   a. Visualize job metrics on the AWS Glue console and identify abnormal metrics for the driver or an executor.
   b. Check observability metrics in the Job run monitoring page, job run details page, or on Amazon CloudWatch. For more information, see Monitoring with AWS Glue Observability metrics.

5. Narrow down the root cause using the identified metric.

6. Optionally, confirm the root cause using the log stream of the identified driver or job executor.
Use cases for AWS Glue observability metrics

- Debugging OOM exceptions and job abnormalities
- Debugging demanding stages and straggler tasks
- Monitoring the progress of multiple jobs
- Monitoring for DPU capacity planning
- Using AWS Glue Observability for monitoring resource utilization to reduce cost

Debugging OOM exceptions and job abnormalities

You can debug out-of-memory (OOM) exceptions and job abnormalities in AWS Glue. The following sections describe scenarios for debugging out-of-memory exceptions of the Apache Spark driver or a Spark executor.

- Debugging a driver OOM exception
- Debugging an executor OOM exception

Debugging a driver OOM exception

In this scenario, a Spark job is reading a large number of small files from Amazon Simple Storage Service (Amazon S3). It converts the files to Apache Parquet format and then writes them out to Amazon S3. The Spark driver is running out of memory. The input Amazon S3 data has more than 1 million files in different Amazon S3 partitions.

The profiled code is as follows:

```python
data = spark.read.format("json").option("inferSchema", False).load("s3://input_path")
data.write.format("parquet").save(output_path)
```

Visualize the profiled metrics on the AWS Glue console

The following graph shows the memory usage as a percentage for the driver and executors. This usage is plotted as one data point that is averaged over the values reported in the last minute. You can see in the memory profile of the job that the driver memory crosses the safe threshold of 50 percent usage quickly. On the other hand, the average memory usage across all executors is still less than 4 percent. This clearly shows abnormality with driver execution in this Spark job.
The job run soon fails, and the following error appears in the History tab on the AWS Glue console: Command Failed with Exit Code 1. This error string means that the job failed due to a systemic error—which in this case is the driver running out of memory.

On the console, choose the Error logs link on the History tab to confirm the finding about driver OOM from the CloudWatch Logs. Search for "Error" in the job's error logs to confirm that it was indeed an OOM exception that failed the job:

```
# java.lang.OutOfMemoryError: Java heap space
# -XX:OnOutOfMemoryError="kill -9 %p"
# Executing /bin/sh -c "kill -9 12039"
```
On the **History** tab for the job, choose **Logs**. You can find the following trace of driver execution in the CloudWatch Logs at the beginning of the job. The Spark driver tries to list all the files in all the directories, constructs an InMemoryFileIndex, and launches one task per file. This in turn results in the Spark driver having to maintain a large amount of state in memory to track all the tasks. It caches the complete list of a large number of files for the in-memory index, resulting in a driver OOM.

**Fix the processing of multiple files using grouping**

You can fix the processing of the multiple files by using the *grouping* feature in AWS Glue. Grouping is automatically enabled when you use dynamic frames and when the input dataset has a large number of files (more than 50,000). Grouping allows you to coalesce multiple files together into a group, and it allows a task to process the entire group instead of a single file. As a result, the Spark driver stores significantly less state in memory to track fewer tasks. For more information about manually enabling grouping for your dataset, see [Reading input files in larger groups](#).

To check the memory profile of the AWS Glue job, profile the following code with grouping enabled:

```python
df = glueContext.create_dynamic_frame_from_options("s3", {'paths': ["s3://input_path"], 
"recurse":True, 'groupFiles': 'inPartition'}, format="json")
dataSink = glueContext.write_dynamic_frame.from_options(frame = df, connection_type 
 = "s3", connection_options = {'path': output_path}, format = "parquet", 
transformation_ctx = "datasink")
```

You can monitor the memory profile and the ETL data movement in the AWS Glue job profile.

The driver runs below the threshold of 50 percent memory usage over the entire duration of the AWS Glue job. The executors stream the data from Amazon S3, process it, and write it out to Amazon S3. As a result, they consume less than 5 percent memory at any point in time.
The data movement profile below shows the total number of Amazon S3 bytes that are read and written in the last minute by all executors as the job progresses. Both follow a similar pattern as the data is streamed across all the executors. The job finishes processing all one million files in less than three hours.

**Debugging an executor OOM exception**

In this scenario, you can learn how to debug OOM exceptions that could occur in Apache Spark executors. The following code uses the Spark MySQL reader to read a large table of about 34
million rows into a Spark dataframe. It then writes it out to Amazon S3 in Parquet format. You can provide the connection properties and use the default Spark configurations to read the table.

```scala
val connectionProperties = new Properties()
  connectionProperties.put("user", user)
  connectionProperties.put("password", password)
  connectionProperties.put("Driver", "com.mysql.jdbc.Driver")
val sparkSession = glueContext.sparkSession
val dfSpark = sparkSession.read.jdbc(url, tableName, connectionProperties)
dfSpark.write.format("parquet").save(output_path)
```

**Visualize the profiled metrics on the AWS Glue console**

If the slope of the memory usage graph is positive and crosses 50 percent, then if the job fails before the next metric is emitted, then memory exhaustion is a good candidate for the cause. The following graph shows that within a minute of execution, the average memory usage across all executors spikes up quickly above 50 percent. The usage reaches up to 92 percent and the container running the executor is stopped by Apache Hadoop YARN.

As the following graph shows, there is always a single executor running until the job fails. This is because a new executor is launched to replace the stopped executor. The JDBC data source reads are not parallelized by default because it would require partitioning the table on a column and opening multiple connections. As a result, only one executor reads in the complete table sequentially.
As the following graph shows, Spark tries to launch a new task four times before failing the job. You can see the memory profile of three executors. Each executor quickly uses up all of its memory. The fourth executor runs out of memory, and the job fails. As a result, its metric is not reported immediately.

You can confirm from the error string on the AWS Glue console that the job failed due to OOM exceptions, as shown in the following image.
Job output logs: To further confirm your finding of an executor OOM exception, look at the CloudWatch Logs. When you search for Error, you find the four executors being stopped in roughly the same time windows as shown on the metrics dashboard. All are terminated by YARN as they exceed their memory limits.

Executor 1

18/06/13 16:54:29 WARN YarnAllocator: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:54:29 WARN YarnSchedulerBackend$YarnSchedulerEndpoint: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:54:29 ERROR YarnClusterScheduler: Lost executor 1 on ip-10-1-2-175.ec2.internal: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:54:29 WARN TaskSetManager: Lost task 0.0 in stage 0.0 (TID 0, ip-10-1-2-175.ec2.internal, executor 1): ExecutorLostFailure (executor 1 exited caused by one of the running tasks) Reason: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

Executor 2

18/06/13 16:55:35 WARN YarnAllocator: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:55:35 WARN YarnSchedulerBackend$YarnSchedulerEndpoint: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:55:35 ERROR YarnClusterScheduler: Lost executor 2 on ip-10-1-2-16.ec2.internal: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
18/06/13 16:55:35 WARN TaskSetManager: Lost task 0.1 in stage 0.0 (TID 1, ip-10-1-2-16.ec2.internal, executor 2): ExecutorLostFailure (executor 2 exited caused by one of the running tasks) Reason: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
Executor 3

18/06/13 16:56:37 WARN YarnAllocator: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

18/06/13 16:56:37 WARN YarnSchedulerBackend$YarnSchedulerEndpoint: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

18/06/13 16:56:37 ERROR YarnClusterScheduler: Lost executor 3 on ip-10-1-2-189.ec2.internal: Container killed by YARN for exceeding memory limits. 5.8 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

Executor 4

18/06/13 16:57:18 WARN YarnAllocator: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

18/06/13 16:57:18 WARN YarnSchedulerBackend$YarnSchedulerEndpoint: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

18/06/13 16:57:18 ERROR YarnClusterScheduler: Lost executor 4 on ip-10-1-2-96.ec2.internal: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.

18/06/13 16:57:18 WARN TaskSetManager: Lost task 0.3 in stage 0.0 (TID 3, ip-10-1-2-96.ec2.internal, executor 4): ExecutorLostFailure (executor 4 exited caused by one of the running tasks) Reason: Container killed by YARN for exceeding memory limits. 5.5 GB of 5.5 GB physical memory used. Consider boosting spark.yarn.executor.memoryOverhead.
Fix the fetch size setting using AWS Glue dynamic frames

The executor ran out of memory while reading the JDBC table because the default configuration for the Spark JDBC fetch size is zero. This means that the JDBC driver on the Spark executor tries to fetch the 34 million rows from the database together and cache them, even though Spark streams through the rows one at a time. With Spark, you can avoid this scenario by setting the fetch size parameter to a non-zero default value.

You can also fix this issue by using AWS Glue dynamic frames instead. By default, dynamic frames use a fetch size of 1,000 rows that is a typically sufficient value. As a result, the executor does not take more than 7 percent of its total memory. The AWS Glue job finishes in less than two minutes with only a single executor. While using AWS Glue dynamic frames is the recommended approach, it is also possible to set the fetch size using the Apache Spark fetchsize property. See the Spark SQL, DataFrames and Datasets Guide.

```scala
val (url, database, tableName) = {
  ("jdbc_url", "db_name", "table_name")
}
val source = glueContext.getSource(format, sourceJson)
val df = source.getDynamicFrame
glueContext.write_dynamic_frame.from_options(frame = df, connection_type = "s3",
  connection_options = {"path": output_path}, format = "parquet", transformation_ctx = "datasink")
```

**Normal profiled metrics:** The executor memory with AWS Glue dynamic frames never exceeds the safe threshold, as shown in the following image. It streams in the rows from the database and caches only 1,000 rows in the JDBC driver at any point in time. An out of memory exception does not occur.
Debugging demanding stages and straggler tasks

You can use AWS Glue job profiling to identify demanding stages and straggler tasks in your extract, transform, and load (ETL) jobs. A straggler task takes much longer than the rest of the tasks in a stage of an AWS Glue job. As a result, the stage takes longer to complete, which also delays the total execution time of the job.

Coalescing small input files into larger output files

A straggler task can occur when there is a non-uniform distribution of work across the different tasks, or a data skew results in one task processing more data.

You can profile the following code—a common pattern in Apache Spark—to coalesce a large number of small files into larger output files. For this example, the input dataset is 32 GB of JSON Gzip compressed files. The output dataset has roughly 190 GB of uncompressed JSON files.

The profiled code is as follows:

```java
datasource0 = spark.read.format("json").load("s3://input_path")
df = datasource0.coalesce(1)
df.write.format("json").save(output_path)
```

Visualize the profiled metrics on the AWS Glue console

You can profile your job to examine four different sets of metrics:
ETL data movement: In the ETL Data Movement profile, the bytes are read fairly quickly by all the executors in the first stage that completes within the first six minutes. However, the total job execution time is around one hour, mostly consisting of the data writes.

Data shuffle across executors: The number of bytes read and written during shuffling also shows a spike before Stage 2 ends, as indicated by the Job Execution and Data Shuffle metrics. After the data shuffles from all executors, the reads and writes proceed from executor number 3 only.
Job execution: As shown in the graph below, all other executors are idle and are eventually relinquished by the time 10:09. At that point, the total number of executors decreases to only one. This clearly shows that executor number 3 consists of the straggler task that is taking the longest execution time and is contributing to most of the job execution time.

Memory profile: After the first two stages, only executor number 3 is actively consuming memory to process the data. The remaining executors are simply idle or have been relinquished shortly after the completion of the first two stages.
Fix straggling executors using grouping

You can avoid straggling executors by using the grouping feature in AWS Glue. Use grouping to distribute the data uniformly across all the executors and coalesce files into larger files using all the available executors on the cluster. For more information, see Reading input files in larger groups.

To check the ETL data movements in the AWS Glue job, profile the following code with grouping enabled:

```python
df = glueContext.create_dynamic_frame_from_options("s3", {'paths': ['s3://input_path'], "recurse":True, 'groupFiles': 'inPartition'}, format="json")
datasink = glueContext.write_dynamic_frame.from_options(frame = df, connection_type = "s3", connection_options = {"path": output_path}, format = "json", transformation_ctx = "datasink4")
```

ETL data movement: The data writes are now streamed in parallel with the data reads throughout the job execution time. As a result, the job finishes within eight minutes—much faster than previously.
Data shuffle across executors: As the input files are coalesced during the reads using the grouping feature, there is no costly data shuffle after the data reads.

Job execution: The job execution metrics show that the total number of active executors running and processing data remains fairly constant. There is no single straggler in the job. All executors are active and are not relinquished until the completion of the job. Because there is no intermediate shuffle of data across the executors, there is only a single stage in the job.
Memory profile: The metrics show the active memory consumption across all executors—reconfirming that there is activity across all executors. As data is streamed in and written out in parallel, the total memory footprint of all executors is roughly uniform and well below the safe threshold for all executors.
Monitoring the progress of multiple jobs

You can profile multiple AWS Glue jobs together and monitor the flow of data between them. This is a common workflow pattern, and requires monitoring for individual job progress, data processing backlog, data reprocessing, and job bookmarks.

Topics

- Profiled code
- Visualize the profiled metrics on the AWS Glue console
- Fix the processing of files

Profiled code

In this workflow, you have two jobs: an Input job and an Output job. The Input job is scheduled to run every 30 minutes using a periodic trigger. The Output job is scheduled to run after each successful run of the Input job. These scheduled jobs are controlled using job triggers.

Input job: This job reads in data from an Amazon Simple Storage Service (Amazon S3) location, transforms it using `ApplyMapping`, and writes it to a staging Amazon S3 location. The following code is profiled code for the Input job:

```python
datasource0 = glueContext.create_dynamic_frame.from_options(connection_type="s3", connection_options = {"paths": ["s3://input_path"], "useS3ListImplementation":True,"recurse":True}, format="json")
applymapping1 = ApplyMapping.apply(frame = datasource0, mappings = [map_spec])
datasink2 = glueContext.write_dynamic_frame.from_options(frame = applymapping1, connection_type = "s3", connection_options = {"path": staging_path, "compression": "gzip"}, format = "json")
```

Output job: This job reads the output of the Input job from the staging location in Amazon S3, transforms it again, and writes it to a destination:

```python
datasource0 = glueContext.create_dynamic_frame.from_options(connection_type="s3", connection_options = {"paths": [staging_path], "useS3ListImplementation":True,"recurse":True}, format="json")
```
applymapping1 = ApplyMapping.apply(frame = datasource0, mappings = [map_spec])
datasink2 = glueContext.write_dynamic_frame.from_options(frame = applymapping1,
connection_type = "s3", connection_options = {"path": output_path}, format = "json")

Visualize the profiled metrics on the AWS Glue console

The following dashboard superimposes the Amazon S3 bytes written metric from the Input job
onto the Amazon S3 bytes read metric on the same timeline for the Output job. The timeline
shows different job runs of the Input and Output jobs. The Input job (shown in red) starts every 30
minutes. The Output Job (shown in brown) starts at the completion of the Input Job, with a Max
Concurrency of 1.

In this example, job bookmarks are not enabled. No transformation contexts are used to enable job
bookmarks in the script code.

Job History: The Input and Output jobs have multiple runs, as shown on the History tab, starting
from 12:00 PM.

The Input job on the AWS Glue console looks like this:

The following image shows the Output job:
First job runs: As shown in the Data Bytes Read and Written graph below, the first job runs of the Input and Output jobs between 12:00 and 12:30 show roughly the same area under the curves. Those areas represent the Amazon S3 bytes written by the Input job and the Amazon S3 bytes read by the Output job. This data is also confirmed by the ratio of Amazon S3 bytes read (summed over 30 minutes – the job trigger frequency for the Input job). The data point for the ratio for the Input job run that started at 12:00PM is also 1.

The following graph shows the data flow ratio across all the job runs:

Second job runs: In the second job run, there is a clear difference in the number of bytes read by the Output job compared to the number of bytes written by the Input job. (Compare the area under the curve across the two job runs for the Output job, or compare the areas in the second run of the Input and Output jobs.) The ratio of the bytes read and written shows that the Output Job read about 2.5x the data written by the Input job in the second span of 30 minutes from 12:30 to 13:00. This is because the Output Job reprocessed the output of the first job run of the Input job because job bookmarks were not enabled. A ratio above 1 shows that there is an additional backlog of data that was processed by the Output job.
**Third job runs:** The Input job is fairly consistent in terms of the number of bytes written (see the area under the red curves). However, the third job run of the Input job ran longer than expected (see the long tail of the red curve). As a result, the third job run of the Output job started late. The third job run processed only a fraction of the data accumulated in the staging location in the remaining 30 minutes between 13:00 and 13:30. The ratio of the bytes flow shows that it only processed 0.83 of data written by the third job run of the Input job (see the ratio at 13:00).

**Overlap of Input and Output jobs:** The fourth job run of the Input job started at 13:30 as per the schedule, before the third job run of the Output job finished. There is a partial overlap between these two job runs. However, the third job run of the Output job captures only the files that it listed in the staging location of Amazon S3 when it began around 13:17. This consists of all data output from the first job runs of the Input job. The actual ratio at 13:30 is around 2.75. The third job run of the Output job processed about 2.75x of data written by the fourth job run of the Input job from 13:30 to 14:00.

As these images show, the Output job is reprocessing data from the staging location from all prior job runs of the Input job. As a result, the fourth job run for the Output job is the longest and overlaps with the entire fifth job run of the Input job.

**Fix the processing of files**

You should ensure that the Output job processes only the files that haven't been processed by previous job runs of the Output job. To do this, enable job bookmarks and set the transformation context in the Output job, as follows:

```python
datasource0 = glueContext.create_dynamic_frame.from_options(connection_type="s3", connection_options = {"paths": [staging_path], "useS3ListImplementation":True,"recurse":True}, format="json", transformation_ctx = "bookmark_ctx")
```

With job bookmarks enabled, the Output job doesn't reprocess the data in the staging location from all the previous job runs of the Input job. In the following image showing the data read and written, the area under the brown curve is fairly consistent and similar with the red curves.
The ratios of byte flow also remain roughly close to 1 because there is no additional data processed.

A job run for the Output job starts and captures the files in the staging location before the next Input job run starts putting more data into the staging location. As long as it continues to do this, it processes only the files captured from the previous Input job run, and the ratio stays close to 1.
Suppose that the Input job takes longer than expected, and as a result, the Output job captures files in the staging location from two Input job runs. The ratio is then higher than 1 for that Output job run. However, the following job runs of the Output job don't process any files that are already processed by the previous job runs of the Output job.

**Monitoring for DPU capacity planning**

You can use job metrics in AWS Glue to estimate the number of data processing units (DPUs) that can be used to scale out an AWS Glue job.

**Note**

This page is only applicable to AWS Glue versions 0.9 and 1.0. Later versions of AWS Glue contain cost-saving features that introduce additional considerations when capacity planning.

**Topics**

- Profiled code
- Visualize the profiled metrics on the AWS Glue console
- Determine the optimal DPU capacity
**Profiler code**

The following script reads an Amazon Simple Storage Service (Amazon S3) partition containing 428 gzipped JSON files. The script applies a mapping to change the field names, and converts and writes them to Amazon S3 in Apache Parquet format. You provision 10 DPUs as per the default and run this job.

```python
datasource0 = glueContext.create_dynamic_frame.from_options(connection_type="s3", connection_options = {"paths": [input_path], "useS3ListImplementation":True,"recurse":True}, format="json")
applymapping1 = ApplyMapping.apply(frame = datasource0, mappings = [(map_spec])
datasink2 = glueContext.write_dynamic_frame.from_options(frame = applymapping1, connection_type = "s3", connection_options = {"path": output_path}, format = "parquet")
```

**Visualize the profiled metrics on the AWS Glue console**

**Job run 1**: In this job run we show how to find if there are under-provisioned DPUs in the cluster. The job execution functionality in AWS Glue shows the total number of actively running executors, the number of completed stages, and the number of maximum needed executors.

The number of maximum needed executors is computed by adding the total number of running tasks and pending tasks, and dividing by the tasks per executor. This result is a measure of the total number of executors required to satisfy the current load.

In contrast, the number of actively running executors measures how many executors are running active Apache Spark tasks. As the job progresses, the maximum needed executors can change and typically goes down towards the end of the job as the pending task queue diminishes.

The horizontal red line in the following graph shows the number of maximum allocated executors, which depends on the number of DPUs that you allocate for the job. In this case, you allocate 10 DPUs for the job run. One DPU is reserved for management. Nine DPUs run two executors each and one executor is reserved for the Spark driver. The Spark driver runs inside the primary application. So, the number of maximum allocated executors is 2*9 - 1 = 17 executors.
As the graph shows, the number of maximum needed executors starts at 107 at the beginning of the job, whereas the number of active executors remains 17. This is the same as the number of maximum allocated executors with 10 DPUs. The ratio between the maximum needed executors and maximum allocated executors (adding 1 to both for the Spark driver) gives you the under-provisioning factor: 108/18 = 6x. You can provision 6 (under provisioning ratio) * 9 (current DPU capacity - 1) + 1 DPUs = 55 DPUs to scale out the job to run it with maximum parallelism and finish faster.

The AWS Glue console displays the detailed job metrics as a static line representing the original number of maximum allocated executors. The console computes the maximum allocated executors from the job definition for the metrics. By constrast, for detailed job run metrics, the console computes the maximum allocated executors from the job run configuration, specifically the DPUs allocated for the job run. To view metrics for an individual job run, select the job run and choose View run metrics.
Looking at the Amazon S3 bytes read and written, notice that the job spends all six minutes streaming in data from Amazon S3 and writing it out in parallel. All the cores on the allocated DPUs are reading and writing to Amazon S3. The maximum number of needed executors being 107 also matches the number of files in the input Amazon S3 path—428. Each executor can launch four Spark tasks to process four input files (JSON gzipped).

**Determine the optimal DPU capacity**

Based on the results of the previous job run, you can increase the total number of allocated DPUs to 55, and see how the job performs. The job finishes in less than three minutes—half the time it required previously. The job scale-out is not linear in this case because it is a short running job. Jobs with long-lived tasks or a large number of tasks (a large number of max needed executors) benefit from a close-to-linear DPU scale-out performance speedup.
As the above image shows, the total number of active executors reaches the maximum allocated —107 executors. Similarly, the maximum needed executors is never above the maximum allocated executors. The maximum needed executors number is computed from the actively running and pending task counts, so it might be smaller than the number of active executors. This is because there can be executors that are partially or completely idle for a short period of time and are not yet decommissioned.
This job run uses 6x more executors to read and write from Amazon S3 in parallel. As a result, this job run uses more Amazon S3 bandwidth for both reads and writes, and finishes faster.

**Identify overprovisioned DPUs**

Next, you can determine whether scaling out the job with 100 DPUs (99 * 2 = 198 executors) helps to scale out any further. As the following graph shows, the job still takes three minutes to finish. Similarly, the job does not scale out beyond 107 executors (55 DPUs configuration), and the remaining 91 executors are overprovisioned and not used at all. This shows that increasing the number of DPUs might not always improve performance, as evident from the maximum needed executors.
Compare time differences

The three job runs shown in the following table summarize the job execution times for 10 DPUs, 55 DPUs, and 100 DPUs. You can find the DPU capacity to improve the job execution time using the estimates you established by monitoring the first job run.

<table>
<thead>
<tr>
<th>Job ID</th>
<th>Number of DPUs</th>
<th>Execution time</th>
</tr>
</thead>
<tbody>
<tr>
<td>jr_c894524c8ef5048a4d9...</td>
<td>10</td>
<td>6 min.</td>
</tr>
<tr>
<td>jr_1a466cf2575e7ffe6856...</td>
<td>55</td>
<td>3 min.</td>
</tr>
<tr>
<td>jr_34fa1ed4c6aa9ff0a814...</td>
<td>100</td>
<td>3 min.</td>
</tr>
</tbody>
</table>

Streaming ETL jobs in AWS Glue

You can create streaming extract, transform, and load (ETL) jobs that run continuously, consume data from streaming sources like Amazon Kinesis Data Streams, Apache Kafka, and Amazon Managed Streaming for Apache Kafka (Amazon MSK). The jobs cleanse and transform the data, and then load the results into Amazon S3 data lakes or JDBC data stores.
Additionally, you can produce data for Amazon Kinesis Data Streams streams. This feature is only available when writing AWS Glue scripts. For more information, see the section called “Kinesis connections”.

By default, AWS Glue processes and writes out data in 100-second windows. This allows data to be processed efficiently and permits aggregations to be performed on data arriving later than expected. You can modify this window size to increase timeliness or aggregation accuracy. AWS Glue streaming jobs use checkpoints rather than job bookmarks to track the data that has been read.

Note

AWS Glue bills hourly for streaming ETL jobs while they are running.

This video discusses streaming ETL cost challenges, and cost-saving features in AWS Glue.

Creating a streaming ETL job involves the following steps:

1. For an Apache Kafka streaming source, create an AWS Glue connection to the Kafka source or the Amazon MSK cluster.
2. Manually create a Data Catalog table for the streaming source.
3. Create an ETL job for the streaming data source. Define streaming-specific job properties, and supply your own script or optionally modify the generated script.

For more information, see Streaming ETL in AWS Glue.

When creating a streaming ETL job for Amazon Kinesis Data Streams, you don’t have to create an AWS Glue connection. However, if there is a connection attached to the AWS Glue streaming ETL job that has Kinesis Data Streams as a source, then a virtual private cloud (VPC) endpoint to Kinesis is required. For more information, see Creating an interface endpoint in the Amazon VPC User Guide. When specifying a Amazon Kinesis Data Streams stream in another account, you must setup the roles and policies to allow cross-account access. For more information, see Example: Read From a Kinesis Stream in a Different Account.

AWS Glue streaming ETL jobs can auto-detect compressed data, transparently decompress the streaming data, perform the usual transformations on the input source, and load to the output store.
AWS Glue supports auto-decompression for the following compression types given the input format:

<table>
<thead>
<tr>
<th>Compression type</th>
<th>Avro file</th>
<th>Avro datum</th>
<th>JSON</th>
<th>CSV</th>
<th>Grok</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZIP2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GZIP</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SNAPPY</td>
<td>Yes (raw Snappy)</td>
<td>Yes (framed Snappy)</td>
<td>Yes (framed Snappy)</td>
<td>Yes (framed Snappy)</td>
<td>Yes (framed Snappy)</td>
</tr>
<tr>
<td>XZ</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ZSTD</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DEFLATE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Topics**

- [Creating an AWS Glue connection for an Apache Kafka data stream](#)
- [Creating a Data Catalog table for a streaming source](#)
- [Notes and restrictions for Avro streaming sources](#)
- [Applying grok patterns to streaming sources](#)
- [Defining job properties for a streaming ETL job](#)
- [Streaming ETL notes and restrictions](#)

**Creating an AWS Glue connection for an Apache Kafka data stream**

To read from an Apache Kafka stream, you must create an AWS Glue connection.

**To create an AWS Glue connection for a Kafka source (Console)**

2. In the navigation pane, under **Data catalog**, choose **Connections**.
3. Choose **Add connection**, and on the **Set up your connection's properties** page, enter a connection name.
4. For **Connection type**, choose **Kafka**.

5. For **Kafka bootstrap servers URLs**, enter the host and port number for the bootstrap brokers for your Amazon MSK cluster or Apache Kafka cluster. Use only Transport Layer Security (TLS) endpoints for establishing the initial connection to the Kafka cluster. Plaintext endpoints are not supported.

The following is an example list of hostname and port number pairs for an Amazon MSK cluster.

```
myserver1.kafka.us-east-1.amazonaws.com:9094,myserver2.kafka.us-east-1.amazonaws.com:9094,
myserver3.kafka.us-east-1.amazonaws.com:9094
```

For more information about getting the bootstrap broker information, see [Getting the Bootstrap Brokers for an Amazon MSK Cluster](https://docs.aws.amazon.com/mkms/latest/userguide/Getting-the-Bootstrap-Brokers-for-an-Amazon-MSK-Cluster.html) in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

6. If you want a secure connection to the Kafka data source, select **Require SSL connection**, and for **Kafka private CA certificate location**, enter a valid Amazon S3 path to a custom SSL certificate.

For an SSL connection to self-managed Kafka, the custom certificate is mandatory. It's optional for Amazon MSK.

For more information about specifying a custom certificate for Kafka, see the section called "SSL connection properties".

7. Use AWS Glue Studio or the AWS CLI to specify a Kafka client authentication method. To access AWS Glue Studio select **AWS Glue** from the **ETL** menu in the left navigation pane.

For more information about Kafka client authentication methods, see [AWS Glue Kafka connection properties for client authentication](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-etl-kafka-connections-prop-readme.html).

8. Optionally enter a description, and then choose **Next**.
9. For an Amazon MSK cluster, specify its virtual private cloud (VPC), subnet, and security group. The VPC information is optional for self-managed Kafka.

10. Choose Next to review all connection properties, and then choose Finish.

For more information about AWS Glue connections, see Connecting to data.

AWS Glue Kafka connection properties for client authentication

SASL/GSSAPI (Kerberos) authentication

Choosing this authentication method will allow you to specify Kerberos properties.

Kerberos Keytab

Choose the location of the keytab file. A keytab stores long-term keys for one or more principals. For more information, see MIT Kerberos Documentation: Keytab.

Kerberos krb5.conf file

Choose the krb5.conf file. This contains the default realm (a logical network, similar to a domain, that defines a group of systems under the same KDC) and the location of the KDC server. For more information, see MIT Kerberos Documentation: krb5.conf.

Kerberos principal and Kerberos service name

Enter the Kerberos principal and service name. For more information, see MIT Kerberos Documentation: Kerberos principal.

SASL/SCRAM-SHA-512 authentication

Choosing this authentication method will allow you to specify authentication credentials.

AWS Secrets Manager

Search for your token in the Search box by typing the name or ARN.

Provider username and password directly

Search for your token in the Search box by typing the name or ARN.

SSL client authentication

Choosing this authentication method allows you to select the location of the Kafka client keystore by browsing Amazon S3. Optionally, you can enter the Kafka client keystore password and Kafka client key password.
IAM authentication

This authentication method does not require any additional specifications and is only applicable when the Streaming source is MSK Kafka.

Creating a Data Catalog table for a streaming source

A Data Catalog table that specifies source data stream properties, including the data schema can be manually created for a streaming source. This table is used as the data source for the streaming ETL job.

If you don't know the schema of the data in the source data stream, you can create the table without a schema. Then when you create the streaming ETL job, you can turn on the AWS Glue schema detection function. AWS Glue determines the schema from the streaming data.

Use the AWS Glue console, the AWS Command Line Interface (AWS CLI), or the AWS Glue API to create the table. For information about creating a table manually with the AWS Glue console, see the section called “AWS Glue tables”.

Note

You can't use the AWS Lake Formation console to create the table; you must use the AWS Glue console.

Also consider the following information for streaming sources in Avro format or for log data that you can apply Grok patterns to.

- the section called “Notes and restrictions for Avro streaming sources”
- the section called “Applying grok patterns to streaming sources”

Topics

- Kinesis data source
- Kafka data source
- AWS Glue Schema Registry table source
Kinesis data source

When creating the table, set the following streaming ETL properties (console).

Type of Source

Kinesis

For a Kinesis source in the same account:

Region

The AWS Region where the Amazon Kinesis Data Streams service resides. The Region and Kinesis stream name are together translated to a Stream ARN.

Example: https://kinesis.us-east-1.amazonaws.com

Kinesis stream name

Stream name as described in Creating a Stream in the Amazon Kinesis Data Streams Developer Guide.

For a Kinesis source in another account, refer to this example to set up the roles and policies to allow cross-account access. Configure these settings:

Stream ARN

The ARN of the Kinesis data stream that the consumer is registered with. For more information, see Amazon Resource Names (ARNs) and AWS Service Namespaces in the AWS General Reference.

Assumed Role ARN

The Amazon Resource Name (ARN) of the role to assume.

Session name (optional)

An identifier for the assumed role session.

Use the role session name to uniquely identify a session when the same role is assumed by different principals or for different reasons. In cross-account scenarios, the role session name is visible to, and can be logged by the account that owns the role. The role session name is also used in the ARN of the assumed role principal. This means that subsequent cross-account API requests that use the temporary security credentials will expose the role session name to the external account in their AWS CloudTrail logs.
To set streaming ETL properties for Amazon Kinesis Data Streams (AWS Glue API or AWS CLI)

- To set up streaming ETL properties for a Kinesis source in the same account, specify the streamName and endpointUrl parameters in the StorageDescriptor structure of the CreateTable API operation or the create_table CLI command.

```
"StorageDescriptor": {
    "Parameters": {
        "typeOfData": "kinesis",
        "streamName": "sample-stream",
        "endpointUrl": "https://kinesis.us-east-1.amazonaws.com"
    }
   ...
}
```

Or, specify the streamARN.

**Example**

```
"StorageDescriptor": {
    "Parameters": {
        "typeOfData": "kinesis",
        "streamARN": "arn:aws:kinesis:us-east-1:123456789:stream/sample-stream"
    }
   ...
}
```

- To set up streaming ETL properties for a Kinesis source in another account, specify the streamARN, awsSTSRoleARN and awsSTSSessionName (optional) parameters in the StorageDescriptor structure in the CreateTable API operation or the create_table CLI command.

```
"StorageDescriptor": {
    "Parameters": {
        "typeOfData": "kinesis",
        "awsSTSRoleARN": "arn:aws:iam::123456789:role/sample-assume-role-arn",
        "awsSTSSessionName": "optional-session"
    }
   ...
}
```
Kafka data source

When creating the table, set the following streaming ETL properties (console).

Type of Source

Kafka

For a Kafka source:

Topic name

Topic name as specified in Kafka.

Connection

An AWS Glue connection that references a Kafka source, as described in the section called “Creating a connection for a Kafka data stream”.

AWS Glue Schema Registry table source

To use AWS Glue Schema Registry for streaming jobs, follow the instructions at Use case: AWS Glue Data Catalog to create or update a Schema Registry table.

Currently, AWS Glue Streaming supports only Glue Schema Registry Avro format with schema inference set to false.

Notes and restrictions for Avro streaming sources

The following notes and restrictions apply for streaming sources in the Avro format:

- When schema detection is turned on, the Avro schema must be included in the payload. When turned off, the payload should contain only data.

- Some Avro data types are not supported in dynamic frames. You can't specify these data types when defining the schema with the Define a schema page in the create table wizard in the AWS Glue console. During schema detection, unsupported types in the Avro schema are converted to supported types as follows:
  - EnumType => StringType
- **FixedType** => **BinaryType**
- **UnionType** => **StructType**

If you define the table schema using the **Define a schema** page in the console, the implied root element type for the schema is **record**. If you want a root element type other than **record**, for example **array** or **map**, you can't specify the schema using the **Define a schema** page. Instead you must skip that page and specify the schema either as a table property or within the ETL script.

To specify the schema in the table properties, complete the create table wizard, edit the table details, and add a new key-value pair under **Table properties**. Use the key **avroSchema**, and enter a schema JSON object for the value, as shown in the following screenshot.

![Edit table details](image)

- To specify the schema in the ETL script, modify the **datasource0** assignment statement and add the **avroSchema** key to the **additional_options** argument, as shown in the following Python and Scala examples.
Applying grok patterns to streaming sources

You can create a streaming ETL job for a log data source and use Grok patterns to convert the logs to structured data. The ETL job then processes the data as a structured data source. You specify the Grok patterns to apply when you create the Data Catalog table for the streaming source.

For information about Grok patterns and custom pattern string values, see Writing grok custom classifiers.

To add grok patterns to the Data Catalog table (console)

- Use the create table wizard, and create the table with the parameters specified in the section called “Creating a Data Catalog table for a streaming source”. Specify the data format as Grok, fill in the Grok pattern field, and optionally add custom patterns under Custom patterns (optional).
Press **Enter** after each custom pattern.

**To add grok patterns to the Data Catalog table (AWS Glue API or AWS CLI)**

- Add the `GrokPattern` parameter and optionally the `CustomPatterns` parameter to the `CreateTable` API operation or the `create_table` CLI command.

```json
"Parameters": {
...
   "grokPattern": "string",
   "grokCustomPatterns": "string",
...
},
```

Express `grokCustomPatterns` as a string and use "\n" as the separator between patterns.

The following is an example of specifying these parameters.
Example

```
"parameters": {
  ...
  "grokPattern": "%{USERNAME:username} %{DIGIT:digit:int}\\", 
  "grokCustomPatterns": "digit \d\\", 
  ...
}
```

Defining job properties for a streaming ETL job

When you define a streaming ETL job in the AWS Glue console, provide the following stream-specific properties. For descriptions of additional job properties, see Defining job properties for Spark jobs.

**IAM role**

Specify the AWS Identity and Access Management (IAM) role that is used for authorization to resources that are used to run the job, access streaming sources, and access target data stores.

For access to Amazon Kinesis Data Streams, attach the AmazonKinesisFullAccess AWS managed policy to the role, or attach a similar IAM policy that permits more fine-grained access. For sample policies, see Controlling Access to Amazon Kinesis Data Streams Resources Using IAM.

For more information about permissions for running jobs in AWS Glue, see Identity and access management for AWS Glue.

**Type**

Choose Spark streaming.

**AWS Glue version**

The AWS Glue version determines the versions of Apache Spark, and Python or Scala, that are available to the job. Choose a selection that specifies the version of Python or Scala available to the job. AWS Glue Version 2.0 with Python 3 support is the default for streaming ETL jobs.

**Job timeout**

Optionally enter a duration in minutes. The default value is blank, which means the job might run indefinitely.
Data source

Specify the table that you created in the section called “Creating a Data Catalog table for a streaming source”.

Data target

Do one of the following:

- Choose Create tables in your data target and specify the following data target properties.

  **Data store**

  Choose Amazon S3 or JDBC.

  **Format**

  Choose any format. All are supported for streaming.

- Choose Use tables in the data catalog and update your data target, and choose a table for a JDBC data store.

Output schema definition

Do one of the following:

- Choose Automatically detect schema of each record to turn on schema detection. AWS Glue determines the schema from the streaming data.

- Choose Specify output schema for all records to use the Apply Mapping transform to define the output schema.

Script

Optionally supply your own script or modify the generated script to perform operations that the Apache Spark Structured Streaming engine supports. For information on the available operations, see Operations on streaming DataFrames/Datasets.

Streaming ETL notes and restrictions

Keep in mind the following notes and restrictions:

- Auto-decompression for AWS Glue streaming ETL jobs is only available for the supported compression types. Also note the following:

  - Framed Snappy refers to the official framing format for Snappy.
Deflate is supported in Glue version 3.0, not Glue version 2.0.

When using schema detection, you cannot perform joins of streaming data.

AWS Glue streaming ETL jobs do not support the Union data type for AWS Glue Schema Registry with Avro format.

Your ETL script can use AWS Glue's built-in transforms and the transforms native to Apache Spark Structured Streaming. For more information, see Operations on streaming DataFrames/Datasets on the Apache Spark website or AWS Glue PySpark transforms reference.

AWS Glue streaming ETL jobs use checkpoints to keep track of the data that has been read. Therefore, a stopped and restarted job picks up where it left off in the stream. If you want to reprocess data, you can delete the checkpoint folder referenced in the script.

Job bookmarks aren't supported.

To use enhanced fan-out feature of Kinesis Data Streams in your job, consult the section called “Using enhanced fan-out in Kinesis streaming jobs”.

If you use a Data Catalog table created from AWS Glue Schema Registry, when a new schema version becomes available, to reflect the new schema, you need to do the following:

1. Stop the jobs associated with the table.
2. Update the schema for the Data Catalog table.
3. Restart the jobs associated with the table.

Record matching with AWS Lake Formation FindMatches

Note: Record matching is currently unavailable in the following Regions in the AWS Glue console: Middle East (UAE), Europe (Spain) (eu-south-2), and Europe (Zurich) (eu-central-2).

AWS Lake Formation provides machine learning capabilities to create custom transforms to cleanse your data. There is currently one available transform named FindMatches. The FindMatches transform enables you to identify duplicate or matching records in your dataset, even when the records do not have a common unique identifier and no fields match exactly. This will not require writing any code or knowing how machine learning works. FindMatches can be useful in many different problems, such as:
• **Matching customers**: Linking customer records across different customer databases, even when many customer fields do not match exactly across the databases (e.g. different name spelling, address differences, missing or inaccurate data, etc).

• **Matching products**: Matching products in your catalog against other product sources, such as product catalog against a competitor’s catalog, where entries are structured differently.

• **Improving fraud detection**: Identifying duplicate customer accounts, determining when a newly created account is (or might be) a match for a previously known fraudulent user.

• **Other matching problems**: Match addresses, movies, parts lists, etc etc. In general, if a human being could look at your database rows and determine that they were a match, there is a really good chance that the FindMatches transform can help you.

You can create these transforms when you create a job. The transform that you create is based on a source data store schema and example data from the source data set that you label (we call this process "teaching" a transform). The records that you label must be present in the source dataset. In this process we generate a file which you label and then upload back which the transform would in a manner learn from. After you teach your transform, you can call it from your Spark-based AWS Glue job (PySpark or Scala Spark) and use it in other scripts with a compatible source data store.

After the transform is created, it is stored in AWS Glue. On the AWS Glue console, you can manage the transforms that you create. In the navigation pane under **Data Integration and ETL, Data classification tools > Record Matching**, you can edit and continue to teach your machine learning transform. For more information about managing transforms on the console, see [Working with machine learning transforms on the AWS Glue console](#).

⚠ **Note**

AWS Glue version 2.0 FindMatches jobs use the Amazon S3 bucket `aws-glue-temp-<accountID>-<region>` to store temporary files while the transform is processing data. You can delete this data after the run has completed, either manually or by setting an Amazon S3 Lifecycle rule.

**Types of machine learning transforms**

You can create machine learning transforms to cleanse your data. You can call these transforms from your ETL script. Your data passes from transform to transform in a data structure called a
DynamicFrame, which is an extension to an Apache Spark SQL DataFrame. The DynamicFrame contains your data, and you reference its schema to process your data.

The following types of machine learning transforms are available:

Find matches

Finds duplicate records in the source data. You teach this machine learning transform by labeling example datasets to indicate which rows match. The machine learning transform learns which rows should be matches the more you teach it with example labeled data. Depending on how you configure the transform, the output is one of the following:

- A copy of the input table plus a match_id column filled in with values that indicate matching sets of records. The match_id column is an arbitrary identifier. Any records which have the same match_id have been identified as matching to each other. Records with different match_id's do not match.
- A copy of the input table with duplicate rows removed. If multiple duplicates are found, then the record with the lowest primary key is kept.

Find incremental matches

The Find matches transform can also be configured to find matches across the existing and incremental frames and return as output a column containing a unique ID per match group.

For more information, see: Finding incremental matches

Using the FindMatches transform

You can use the FindMatches transform to find duplicate records in the source data. A labeling file is generated or provided to help teach the transform.

Note

Currently, FindMatches transforms that use a custom encryption key aren't supported in the following Regions:

- Asia Pacific (Osaka) - ap-northeast-3
To get started with the FindMatches transform, you can follow the steps below. For a more advanced and detailed example, see the AWS Big Data Blog: [Harmonize data using AWS Glue and AWS Lake Formation FindMatches ML to build a customer 360 view](https://aws.amazon.com/blogs/big-data/)

Getting started using the Find Matches transform

Follow these steps to get started with the FindMatches transform:

1. Create a table in the AWS Glue Data Catalog for the source data that is to be cleaned. For information about how to create a crawler, see [Working with Crawlers on the AWS Glue Console](https://docs.aws.amazon.com/glue/latest/dg/glue-crawler-workingwith.html).

   If your source data is a text-based file such as a comma-separated values (CSV) file, consider the following:
   - Keep your input record CSV file and labeling file in separate folders. Otherwise, the AWS Glue crawler might consider them as multiple parts of the same table and create tables in the Data Catalog incorrectly.
   - Unless your CSV file includes ASCII characters only, ensure that UTF-8 without BOM (byte order mark) encoding is used for the CSV files. Microsoft Excel often adds a BOM in the beginning of UTF-8 CSV files. To remove it, open the CSV file in a text editor, and resave the file as **UTF-8 without BOM**.

2. On the AWS Glue console, create a job, and choose the **Find matches** transform type.

   > **Important**
   > The data source table that you choose for the job can't have more than 100 columns.

3. Tell AWS Glue to generate a labeling file by choosing **Generate labeling file**. AWS Glue takes the first pass at grouping similar records for each **labeling_set_id** so that you can review those groupings. You label matches in the **label** column.

   - If you already have a labeling file, that is, an example of records that indicate matching rows, upload the file to Amazon Simple Storage Service (Amazon S3). For information about the format of the labeling file, see [Labeling file format](https://docs.aws.amazon.com/glue/latest/dg/gs-findmatches-transform-labeling-file-format.html). Proceed to step 4.

4. Download the labeling file and label the file as described in the [Labeling](https://docs.aws.amazon.com/glue/latest/dg/gs-findmatches-transform-labeling.html) section.

5. Upload the corrected labelled file. AWS Glue runs tasks to teach the transform how to find matches.

   On the **Machine learning transforms** list page, choose the **History** tab. This page indicates when AWS Glue performs the following tasks:
6. To create a better transform, you can iteratively download, label, and upload the labelled file. In the initial runs, a lot more records might be mismatched. But AWS Glue learns as you continue to teach it by verifying the labeling file.

7. Evaluate and tune your transform by evaluating performance and results of finding matches. For more information, see Tuning machine learning transforms in AWS Glue.

Labeling

When FindMatches generates a labeling file, records are selected from your source table. Based on previous training, FindMatches identifies the most valuable records to learn from.

The act of labeling is editing a labeling file (we suggest using a spreadsheet such as Microsoft Excel) and adding identifiers, or labels, into the label column that identifies matching and nonmatching records. It is important to have a clear and consistent definition of a match in your source data. FindMatches learns from which records you designate as matches (or not) and uses your decisions to learn how to find duplicate records.

When a labeling file is generated by FindMatches, approximately 100 records are generated. These 100 records are typically divided into 10 labeling sets, where each labeling set is identified by a unique labeling_set_id generated by FindMatches. Each labeling set should be viewed as a separate labeling task independent of the other labeling sets. Your task is to identify matching and non-matching records within each labeling set.

Tips for editing labeling files in a spreadsheet

When editing the labeling file in a spreadsheet application, consider the following:

- The file might not open with column fields fully expanded. You might need to expand the labeling_set_id and label columns to see content in those cells.
- If the primary key column is a number, such as a Long data type, the spreadsheet might interpret it as a number and change the value. This key value must be treated as text. To correct this problem, format all the cells in the primary key column as Text data.
Labeling file format

The labeling file that is generated by AWS Glue to teach your FindMatches transform uses the following format. If you generate your own file for AWS Glue, it must follow this format as well:

- It is a comma-separated values (CSV) file.
- It must be encoded in UTF-8. If you edit the file using Microsoft Windows, it might be encoded with cp1252.
- It must be in an Amazon S3 location to pass it to AWS Glue.
- Use a moderate number of rows for each labeling task. 10–20 rows per task are recommended, although 2–30 rows per task are acceptable. Tasks larger than 50 rows are not recommended and may cause poor results or system failure.
- If you have already-labeled data consisting of pairs of records labeled as a "match" or a "no-match", this is fine. These labeled pairs can be represented as labeling sets of size 2. In this case label both records with, for instance, a letter "A" if they match, but label one as "A" and one as "B" if they do not match.

**Note**

Because it has additional columns, the labeling file has a different schema from a file that contains your source data. Place the labeling file in a different folder from any transform input CSV file so that the AWS Glue crawler does not consider it when it creates tables in the Data Catalog. Otherwise, the tables created by the AWS Glue crawler might not correctly represent your data.

- The first two columns (labeling_set_id, label) are required by AWS Glue. The remaining columns must match the schema of the data that is to be processed.
- For each labeling_set_id, you identify all matching records by using the same label. A label is a unique string placed in the label column. We recommend using labels that contain simple characters, such as A, B, C, and so on. Labels are case sensitive and are entered in the label column.
- Rows that contain the same labeling_set_id and the same label are understood to be labeled as a match.
- Rows that contain the same labeling_set_id and a different label are understood to be labeled as *not* a match.
• Rows that contain a different `labeling_set_id` are understood to be conveying no information for or against matching.

The following is an example of labeling the data:

<table>
<thead>
<tr>
<th><code>labeling_set_id</code></th>
<th>label</th>
<th><code>first_name</code></th>
<th><code>last_name</code></th>
<th><code>Birthday</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC123</td>
<td>A</td>
<td>John</td>
<td>Doe</td>
<td>04/01/1980</td>
</tr>
<tr>
<td>ABC123</td>
<td>B</td>
<td>Jane</td>
<td>Smith</td>
<td>04/03/1980</td>
</tr>
<tr>
<td>ABC123</td>
<td>A</td>
<td>Johnny</td>
<td>Doe</td>
<td>04/01/1980</td>
</tr>
<tr>
<td>ABC123</td>
<td>A</td>
<td>Jon</td>
<td>Doe</td>
<td>04/01/1980</td>
</tr>
<tr>
<td>DEF345</td>
<td>A</td>
<td>Richard</td>
<td>Jones</td>
<td>12/11/1992</td>
</tr>
<tr>
<td>DEF345</td>
<td>A</td>
<td>Rich</td>
<td>Jones</td>
<td>11/12/1992</td>
</tr>
<tr>
<td>DEF345</td>
<td>B</td>
<td>Sarah</td>
<td>Jones</td>
<td>12/11/1992</td>
</tr>
<tr>
<td>DEF345</td>
<td>C</td>
<td>Richie</td>
<td>Jones Jr.</td>
<td>05/06/2017</td>
</tr>
<tr>
<td>DEF345</td>
<td>B</td>
<td>Sarah</td>
<td>Jones-Walker</td>
<td>12/11/1992</td>
</tr>
<tr>
<td>GHI678</td>
<td>A</td>
<td>Robert</td>
<td>Miller</td>
<td>1/3/1999</td>
</tr>
<tr>
<td>GHI678</td>
<td>A</td>
<td>Bob</td>
<td>Miller</td>
<td>1/3/1999</td>
</tr>
<tr>
<td>XYZABC</td>
<td>A</td>
<td>William</td>
<td>Robinson</td>
<td>2/5/2001</td>
</tr>
<tr>
<td>XYZABC</td>
<td>B</td>
<td>Andrew</td>
<td>Robinson</td>
<td>2/5/1971</td>
</tr>
</tbody>
</table>

• In the above example we identify John/Johnny/Jon Doe as being a match and we teach the system that these records do not match Jane Smith. Separately, we teach the system that Richard and Rich Jones are the same person, but that these records are not a match to Sarah Jones/Jones-Walker and Richie Jones Jr.

• As you can see, the scope of the labels is limited to the `labeling_set_id`. So labels do not cross `labeling_set_id` boundaries. For example, a label "A" in `labeling_set_id` 1 does not have any relation to label "A" in `labeling_set_id` 2.
• If a record does not have any matches within a labeling set, then assign it a unique label. For instance, Jane Smith does not match any record in labeling set ABC123, so it is the only record in that labeling set with the label of B.

• The labeling set "GHI678" shows that a labeling set can consist of just two records which are given the same label to show that they match. Similarly, "XYZABC" shows two records given different labels to show that they do not match.

• Note that sometimes a labeling set may contain no matches (that is, you give every record in the labeling set a different label) or a labeling set might all be "the same" (you gave them all the same label). This is okay as long as your labeling sets collectively contain examples of records that are and are not "the same" by your criteria.

Important

Confirm that the IAM role that you pass to AWS Glue has access to the Amazon S3 bucket that contains the labeling file. By convention, AWS Glue policies grant permission to Amazon S3 buckets or folders whose names are prefixed with `aws-glue-`. If your labeling files are in a different location, add permission to that location in the IAM role.

Tuning machine learning transforms in AWS Glue

You can tune your machine learning transforms in AWS Glue to improve the results of your data-cleansing jobs to meet your objectives. To improve your transform, you can teach it by generating a labeling set, adding labels, and then repeating these steps several times until you get your desired results. You can also tune by changing some machine learning parameters.

For more information about machine learning transforms, see Record matching with AWS Lake Formation FindMatches.

Topics

• Machine learning measurements
• Deciding between precision and recall
• Deciding Between accuracy and cost
• Estimating the quality of matches using match confidence scores
• Teaching the Find Matches transform
Machine learning measurements

To understand the measurements that are used to tune your machine learning transform, you should be familiar with the following terminology:

True positive (TP)

A match in the data that the transform correctly found, sometimes called a *hit*.

True negative (TN)

A nonmatch in the data that the transform correctly rejected.

False positive (FP)

A nonmatch in the data that the transform incorrectly classified as a match, sometimes called a *false alarm*.

False negative (FN)

A match in the data that the transform didn't find, sometimes called a *miss*.

For more information about the terminology that is used in machine learning, see [Confusion matrix](#) in Wikipedia.

To tune your machine learning transforms, you can change the value of the following measurements in the **Advanced properties** of the transform.

- **Precision** measures how well the transform finds true positives among the total number of records that it identifies as positive (true positives and false positives). For more information, see [Precision and recall](#) in Wikipedia.

- **Recall** measures how well the transform finds true positives from the total records in the source data. For more information, see [Precision and recall](#) in Wikipedia.

- **Accuracy** measures how well the transform finds true positives and true negatives. Increasing accuracy requires more machine resources and cost. But it also results in increased recall. For more information, see [Accuracy and precision](#) in Wikipedia.

- **Cost** measures how many compute resources (and thus money) are consumed to run the transform.
Deciding between precision and recall

Each FindMatches transform contains a precision-recall parameter. You use this parameter to specify one of the following:

- If you are more concerned about the transform falsely reporting that two records match when they actually don't match, then you should emphasize precision.
- If you are more concerned about the transform failing to detect records that really do match, then you should emphasize recall.

You can make this trade-off on the AWS Glue console or by using the AWS Glue machine learning API operations.

**When to favor precision**

Favor precision if you are more concerned about the risk that FindMatches results in a pair of records matching when they don't actually match. To favor precision, choose a higher precision-recall trade-off value. With a higher value, the FindMatches transform requires more evidence to decide that a pair of records should be matched. The transform is tuned to bias toward saying that records do not match.

For example, suppose that you're using FindMatches to detect duplicate items in a video catalog, and you provide a higher precision-recall value to the transform. If your transform incorrectly detects that *Star Wars: A New Hope* is the same as *Star Wars: The Empire Strikes Back*, a customer who wants *A New Hope* might be shown *The Empire Strikes Back*. This would be a poor customer experience.

However, if the transform fails to detect that *Star Wars: A New Hope* and *Star Wars: Episode IV —A New Hope* are the same item, the customer might be confused at first but might eventually recognize them as the same. It would be a mistake, but not as bad as the previous scenario.

**When to favor recall**

Favor recall if you are more concerned about the risk that the FindMatches transform results might fail to detect a pair of records that actually do match. To favor recall, choose a lower precision-recall trade-off value. With a lower value, the FindMatches transform requires less evidence to decide that a pair of records should be matched. The transform is tuned to bias toward saying that records do match.
For example, this might be a priority for a security organization. Suppose that you are matching customers against a list of known defrauders, and it is important to determine whether a customer is a defrauder. You are using FindMatches to match the defrauder list against the customer list. Every time FindMatches detects a match between the two lists, a human auditor is assigned to verify that the person is, in fact, a defrauder. Your organization might prefer to choose recall over precision. In other words, you would rather have the auditors manually review and reject some cases when the customer is not a defrauder than fail to identify that a customer is, in fact, on the defrauder list.

How to favor both precision and recall

The best way to improve both precision and recall is to label more data. As you label more data, the overall accuracy of the FindMatches transform improves, thus improving both precision and recall. Nevertheless, even with the most accurate transform, there is always a gray area where you need to experiment with favoring precision or recall, or choose a value in the middle.

Deciding Between accuracy and cost

Each FindMatches transform contains an accuracy-cost parameter. You can use this parameter to specify one of the following:

- If you are more concerned with the transform accurately reporting that two records match, then you should emphasize accuracy.
- If you are more concerned about the cost or speed of running the transform, then you should emphasize lower cost.

You can make this trade-off on the AWS Glue console or by using the AWS Glue machine learning API operations.

When to favor accuracy

Favor accuracy if you are more concerned about the risk that the find matches results won't contain matches. To favor accuracy, choose a higher accuracy-cost trade-off value. With a higher value, the FindMatches transform requires more time to do a more thorough search for correctly matching records. Note that this parameter doesn't make it less likely to falsely call a nonmatching record pair a match. The transform is tuned to bias towards spending more time finding matches.

When to favor cost
Favor cost if you are more concerned about the cost of running the find matches transform and less about how many matches are found. To favor cost, choose a lower accuracy-cost trade-off value. With a lower value, the FindMatches transform requires fewer resources to run. The transform is tuned to bias towards finding fewer matches. If the results are acceptable when favoring lower cost, use this setting.

**How to favor both accuracy and lower cost**

It takes more machine time to examine more pairs of records to determine whether they might be matches. If you want to reduce cost without reducing quality, here are some steps you can take:

- Eliminate records in your data source that you aren't concerned about matching.
- Eliminate columns from your data source that you are sure aren't useful for making a match/no-match decision. A good way of deciding this is to eliminate columns that you don't think affect your own decision about whether a set of records is “the same.”

**Estimating the quality of matches using match confidence scores**

Match confidence scores provide an estimate of the quality of matches found by FindMatches to distinguish between matched records in which the machine learning model is highly confident, uncertain, or unlikely. A match confidence score will be between 0 and 1, where a higher score means higher similarity. Examining match confidence scores lets you distinguish between clusters of matches in which the system is highly confident (which you may decide to merge), clusters about which the system is uncertain (which you may decide to have reviewed by a human), and clusters that the system deems to be unlikely (which you may decide to reject).

You may want to adjust your training data in situations where you see a high match confidence score, but determine there are not matches, or where you see a low score but determine there are, in fact, matches.

Confidence scores are particularly useful when there are large sized industrial datasets, where it is infeasible to review every FindMatches decision.

Match confidence scores are available in AWS Glue version 2.0 or later.

**Generating match confidence scores**

You can generate match confidence scores by setting the Boolean value of computeMatchConfidenceScores to True when calling the FindMatches or FindIncrementalMatches API.
AWS Glue adds a new column `match_confidence_score` to the output.

**Match scoring examples**

For example, consider the following matched records:

**Score >= 0.9**

Summary of matched records:

<table>
<thead>
<tr>
<th>primary_id</th>
<th>match_id</th>
<th>match_confidence_score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3281355037663</td>
<td>85899345947</td>
<td>0.9823658302132061</td>
</tr>
<tr>
<td>1546188247619</td>
<td>85899345947</td>
<td>0.9823658302132061</td>
</tr>
</tbody>
</table>

Details:

From this example, we can see that two records are very similar and share `display_position`, `primary_name`, and `street name`.

**Score >= 0.8 and score < 0.9**

Summary of matched records:

<table>
<thead>
<tr>
<th>primary_id</th>
<th>match_id</th>
<th>match_confidence_score</th>
</tr>
</thead>
<tbody>
<tr>
<td>309237680432</td>
<td>85899345928</td>
<td>0.8309852373674638</td>
</tr>
<tr>
<td>3590592666790</td>
<td>85899345928</td>
<td>0.8309852373674638</td>
</tr>
<tr>
<td>343597390617</td>
<td>85899345928</td>
<td>0.8309852373674638</td>
</tr>
<tr>
<td>249108124906</td>
<td>85899345928</td>
<td>0.8309852373674638</td>
</tr>
<tr>
<td>463856477937</td>
<td>85899345928</td>
<td>0.8309852373674638</td>
</tr>
</tbody>
</table>

Details:
From this example, we can see that these records share the same primary_name, and country.

**Score >= 0.6 and score < 0.7**

Summary of matched records:

<table>
<thead>
<tr>
<th>primary_id</th>
<th>match_id</th>
<th>match_confidence_score</th>
</tr>
</thead>
<tbody>
<tr>
<td>2164663519676</td>
<td>85899345930</td>
<td>0.6971099896480333</td>
</tr>
<tr>
<td>317827595278</td>
<td>85899345930</td>
<td>0.6971099896480333</td>
</tr>
<tr>
<td>472446424341</td>
<td>85899345930</td>
<td>0.6971099896480333</td>
</tr>
<tr>
<td>3118146262932</td>
<td>85899345930</td>
<td>0.6971099896480333</td>
</tr>
<tr>
<td>214748380804</td>
<td>85899345930</td>
<td>0.6971099896480333</td>
</tr>
</tbody>
</table>

Details:

From this example, we can see that these records share only the same primary_name.

For more information, see:

- **Step 5: Add and run a job with your machine learning transform**
- PySpark: **FindMatches class**
- PySpark: **FindIncrementalMatches class**
- Scala: **FindMatches class**
- Scala: **FindIncrementalMatches class**

**Teaching the Find Matches transform**

Each FindMatches transform must be taught what should be considered a match and what should not be considered a match. You teach your transform by adding labels to a file and uploading your choices to AWS Glue.
You can orchestrate this labeling on the AWS Glue console or by using the AWS Glue machine learning API operations.

**How many times should I add labels? How many labels do I need?**

The answers to these questions are mostly up to you. You must evaluate whether FindMatches is delivering the level of accuracy that you need and whether you think the extra labeling effort is worth it for you. The best way to decide this is to look at the “Precision,” “Recall,” and “Area under the precision recall curve” metrics that you can generate when you choose Estimate quality on the AWS Glue console. After you label more sets of tasks, rerun these metrics and verify whether they have improved. If, after labeling a few sets of tasks, you don't see improvement on the metric that you are focusing on, the transform quality might have reached a plateau.

**Why are both true positive and true negative labels needed?**

The FindMatches transform needs both positive and negative examples to learn what you think is a match. If you are labeling FindMatches-generated training data (for example, using the I do not have labels option), FindMatches tries to generate a set of “label set ids” for you. Within each task, you give the same “label” to some records and different “labels” to other records. In other words, the tasks generally are not either all the same or all different (but it's okay if a particular task is all “the same” or all “not the same”).

If you are teaching your FindMatches transform using the Upload labels from S3 option, try to include both examples of matching and nonmatching records. It's acceptable to have only one type. These labels help you build a more accurate FindMatches transform, but you still need to label some records that you generate using the Generate labeling file option.

**How can I enforce that the transform matches exactly as I taught it?**

The FindMatches transform learns from the labels that you provide, so it might generate records pairs that don't respect the provided labels. To enforce that the FindMatches transform respects your labels, select EnforceProvidedLabels in FindMatchesParameter.

**What techniques can you use when an ML transform identifies items as matches that are not true matches?**

You can use the following techniques:

- Increase the precisionRecallTradeoff to a higher value. This eventually results in finding fewer matches, but it should also break up your big cluster when it reaches a high enough value.
• Take the output rows corresponding to the incorrect results and reformat them as a labeling set (removing the match_id column and adding a labeling_set_id and label column). If necessary, break up (subdivide) into multiple labeling sets to ensure that the labeler can keep each labeling set in mind while assigning labels. Then, correctly label the matching sets and upload the label file and append it to your existing labels. This might teach your transformer enough about what it is looking for to understand the pattern.

• (Advanced) Finally, look at that data to see if there is a pattern that you can detect that the system is not noticing. Preprocess that data using standard AWS Glue functions to normalize the data. Highlight what you want the algorithm to learn from by separating data that you know to be differently important into their own columns. Or construct combined columns from columns whose data you know to be related.

**Working with machine learning transforms on the AWS Glue console**

You can use AWS Glue to create custom machine learning transforms that can be used to cleanse your data. You can use these transforms when you create a job on the AWS Glue console.

For information about how to create a machine learning transform, see [Record matching with AWS Lake Formation FindMatches](https://docs.aws.amazon.com/elasticloadbalancing/latest/application/load-balancing-attacks.html).

**Topics**

- [Transform properties](#)
- [Adding and editing machine learning transforms](#)
- [Viewing transform details](#)
- [Teach transforms using labels](#)

**Transform properties**

To view an existing machine learning transform, sign in to the AWS Management Console, and open the AWS Glue console at [https://console.aws.amazon.com/glue/](https://console.aws.amazon.com/glue/). In the navigation pane under **Data Integration and ETL**, choose **Data classification tools > Record Matching**.

The properties for each transform:

**Transform name**

The unique name you gave the transform when you created it.
ID

A unique identifier of the transform.

Label count

The number of labels in the labeling file that was provided to help teach the transform.

Status

Indicates whether the transform is Ready or Needs training. To run a machine learning transform successfully in a job, it must be Ready.

Created

The date the transform was created.

Modified

The date the transform was last updated.

Description

The description supplied for the transform, if one was provided.

AWS Glue version

The version of AWS Glue used.

Run ID

The unique name you gave the transform when you created it.

Task type

The type of machine learning transform; for example, Find matching records.

Status

Indicates the status of the task run. Possible statuses include:

- Starting
- Running
- Stopping
- Stopped
- Succeeded
- Failed
- Timeout

**Error**

If the status is Failed, an error message is displayed describing the reason for the failure.

**Adding and editing machine learning transforms**

You can view, delete, set up and teach, or tune a transform on the AWS Glue console. Select the check box next to the transform in the list, choose **Action**, and then choose the action that you want to take.

**Creating a new ML transform**

To add a new machine learning transform, choose **Create transform**. Follow the instructions in the **Add job** wizard. For more information, see [Record matching with AWS Lake Formation FindMatches](#).

**Step 1. Set transform properties.**

1. Enter the name and description (optional).
2. Optionally, set security configuration. See [Using data encryption with machine learning transforms](#).
3. Optionally, set Task execution settings. Task execution settings allow you to customize how the task is run. Select the Worker type, number of workers, task timeout (in minutes), the number of retries, and the AWS Glue version.
4. Optionally, set Tags. Tags are labels that you can assign to an AWS resource. Each tag consists of a key and an optional value. Tags can be used to search and filter your resource or track your AWS costs.

**Step 2. Choose table and primary key.**

1. Choose the AWS Glue Catalog database and table.
2. Choose a primary key from the selected table. The primary key column typically contains a unique identifier for every record in the data source.
Step 3. Select tuning options.

1. For **Recall vs. precision**, choose the tuning value to tune the transform to favor recall or precision. By default, **Balanced** is selected, but you can choose to favor recall or favor precision, or choose **Custom** and enter a value between 0.0 and 1.0 (inclusive).

2. For **Lower cost vs. accuracy**, choose the tuning value to favor lower cost or accuracy, or choose **Custom** and enter a value between 0.0 and 1.0 (inclusive).

3. For **Match enforcement**, choose **Force output to match labels** if you want to teach the ML transform by forcing the output to match the labels used.

Step 4. Review and create.

1. Review the options for steps 1 – 3.

2. Choose **Edit** for any step that needs to be modified. Choose **Create transform** to complete the create transform wizard.

Using data encryption with machine learning transforms

When adding a machine learning transform to AWS Glue, you can optionally specify a security configuration that is associated with the data source or data target. If the Amazon S3 bucket used to store the data is encrypted with a security configuration, specify the same security configuration when creating the transform.

You can also choose to use server-side encryption with AWS KMS (SSE-KMS) to encrypt the model and labels to prevent unauthorized persons from inspecting it. If you choose this option, you’re prompted to choose the AWS KMS key by name, or you can choose **Enter a key ARN**. If you choose to enter the ARN for the KMS key, a second field appears where you can enter the KMS key ARN.

Note

Currently, ML transforms that use a custom encryption key aren't supported in the following Regions:

- Asia Pacific (Osaka) - ap-northeast-3
Viewing transform details

Viewing transform properties

The Transform properties page includes attributes of your transform. It shows you the details about the transform definition, including the following:

- **Transform name** shows the name of the transform.
- **Type** lists the type of the transform.
- **Status** displays whether the transform is ready to be used in a script or job.
- **Force output to match labels** displays whether the transform forces the output to match the labels provided by the user.
- **Spark version** is related to the AWS Glue version you chose in the Task run properties when adding the transform. AWS Glue 1.0 and Spark 2.4 is recommended for most customers. For more information, see AWS Glue Versions.

History, Estimate quality and Tags tabs

Transform details include the information that you defined when you created the transform. To view the details of a transform, select the transform in the Machine learning transforms list, and review the information on the following tabs:

- History
- Estimate quality
- Tags

History

The History tab shows your transform task run history. Several types of tasks are run to teach a transform. For each task, the run metrics include the following:

- **Run ID** is an identifier created by AWS Glue for each run of this task.
- **Task type** shows the type of task run.
- **Status** shows the success of each task listed with the most recent run at the top.
- **Error** shows the details of an error message if the run was not successful.
- **Start time** shows the date and time (local time) that the task started.
• **End time** shows the date and time (local time) that the task ended.

• **Logs** links to the logs written to stdout for this job run.

  The **Logs** link takes you to Amazon CloudWatch Logs. There you can view the details about the tables that were created in the AWS Glue Data Catalog and any errors that were encountered. You can manage your log retention period on the CloudWatch console. The default log retention is **Never Expire**. For more information about how to change the retention period, see [Change Log Data Retention in CloudWatch Logs](#) in the *Amazon CloudWatch Logs User Guide*.

• **Label file** shows a link to Amazon S3 for a generated labeling file.

**Estimate quality**

The **Estimate quality** tab shows the metrics that you use to measure the quality of the transform. Estimates are calculated by comparing the transform match predictions using a subset of your labeled data against the labels you have provided. These estimates are approximate. You can invoke an **Estimate quality** task run from this tab.

The **Estimate quality** tab shows the metrics from the last **Estimate quality** run including the following properties:

• **Area under the Precision-Recall curve** is a single number estimating the upper bound of the overall quality of the transform. It is independent of the choice made for the precision-recall parameter. Higher values indicate that you have a more attractive precision-recall tradeoff.

• **Precision** estimates how often the transform is correct when it predicts a match.

• **Recall upper limit** estimates that for an actual match, how often the transform predicts the match.

• **F1** estimates the transform's accuracy between 0 and 1, where 1 is the best accuracy. For more information, see [F1 score](#) in Wikipedia.

• The **Column importance** table show the column names and importance score for each column. Column importance helps you understand how columns contribute to your model, by identifying which columns in your records are being used the most to do the matching. This data may prompt you to add to or change your labelset to raise or lower the importance of columns.

  The Importance column provides a numerical score for each column, as a decimal not greater than 1.0.
For information about understanding quality estimates versus true quality, see Quality estimates versus end-to-end (true) quality.

For more information about tuning your transform, see Tuning machine learning transforms in AWS Glue.

Quality estimates versus end-to-end (true) quality

AWS Glue estimates the quality of your transform by presenting the internal machine-learned model with a number of pairs of records that you provided matching labels for but that the model has not seen before. These quality estimates are a function of the quality of the machine-learned model (which is influenced by the number of records that you label to “teach” the transform). The end-to-end, or true recall (which is not automatically calculated by the ML transform) is also influenced by the ML transform filtering mechanism that proposes a wide variety of possible matches to the machine-learned model.

You can tune this filtering method primarily by specifying the Lower Cost-Accuracy tuning value. As the tuning value gets closer to favor Accuracy, the system does a more thorough and expensive search for pairs of records that might be matches. More pairs of records are fed to your machine-learned model, and your ML transform's end-to-end or true recall gets closer to the estimated recall metric. As a result, changes in the end-to-end quality of your matches as a result of changes in the cost/accuracy tradeoff for your matches will typically not be reflected in the quality estimate.

Tags

Tags are labels that you can assign to an AWS resource. Each tag consists of a key and an optional value. Tags can be used to search and filter your resource or track your AWS costs.

Teach transforms using labels

You can teach your ML transform using labels (examples) by choosing Teach transform from the ML transform details page. When you teach your machine learning algorithm by providing examples (called labels), you can choose existing labels to use, or create a labeling file.
Teach the transform using labels

Labeling
Teach your machine learning algorithms by providing examples, called labels. For your transform, provide examples of matching and non-matching records.

- I do not have labels
- I have labels
  ▶ How to label

Generate labeling file
AWS Glue extracts records from your source data and suggests potential matching records. The file will contain approximately 100 data samples for you to work with. You can download the file once it has been generated.

S3 path to store the generated label file

```plaintext
s3://bucket/prefix/object
```

[View](#)  [Browse S3](#)

[Generate labeling file]  [Download labeling file]

Upload labels from S3
The completed labeling file must be in the correct format and in Amazon S3.

S3 path where the label file is stored

```plaintext
s3://bucket/prefix/object
```

[View](#)  [Browse S3](#)

Existing labels

- Append to my existing labels
- Overwrite my existing labels

[Upload labeling file from S3]

- **Labeling** – If you have labels, choose I have labels. If you do not have labels, you can still continue with the next step in generating a labeling file.

- **Generate labeling file** – AWS Glue extracts records from your source data and suggest potential matching records. You choose the Amazon S3 bucket to store the generated label file. Choose Generate labeling file to start the process. When done, choose Download labeling file. The downloaded file will have a column for labels where you can fill in the labels.

- **Upload labels from Amazon S3** – Choose the completed labeling file from the Amazon S3 bucket where the label file is stored. Then, choose to either append the labels to your existing labels or to overwrite your existing labels. Choose Upload labeling file from Amazon S3.

Tutorial: Creating a machine learning transform with AWS Glue

This tutorial guides you through the actions to create and manage a machine learning (ML) transform using AWS Glue. Before using this tutorial, you should be familiar with using the AWS
Glue console to add crawlers and jobs and edit scripts. You should also be familiar with finding and downloading files on the Amazon Simple Storage Service (Amazon S3) console.

In this example, you create a FindMatches transform to find matching records, teach it how to identify matching and nonmatching records, and use it in an AWS Glue job. The AWS Glue job writes a new Amazon S3 file with an additional column named `match_id`.

The source data used by this tutorial is a file named `dblp_acm_records.csv`. This file is a modified version of academic publications (DBLP and ACM) available from the original DBLP ACM dataset. The `dblp_acm_records.csv` file is a comma-separated values (CSV) file in UTF-8 format with no byte-order mark (BOM).

A second file, `dblp_acm_labels.csv`, is an example labeling file that contains both matching and nonmatching records used to teach the transform as part of the tutorial.

Topics

- Step 1: Crawl the source data
- Step 2: Add a machine learning transform
- Step 3: Teach your machine learning transform
- Step 4: Estimate the quality of your machine learning transform
- Step 5: Add and run a job with your machine learning transform
- Step 6: Verify output data from Amazon S3

**Step 1: Crawl the source data**

First, crawl the source Amazon S3 CSV file to create a corresponding metadata table in the Data Catalog.

**Important**

To direct the crawler to create a table for only the CSV file, store the CSV source data in a different Amazon S3 folder from other files.

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, choose Crawlers, Add crawler.
3. Follow the wizard to create and run a crawler named demo-crawl-dblp-acm with output to database demo-db-dblp-acm. When running the wizard, create the database demo-db-dblp-acm if it doesn't already exist. Choose an Amazon S3 include path to sample data in the current AWS Region. For example, for us-east-1, the Amazon S3 include path to the source file is s3://ml-transforms-public-datasets-us-east-1/dblp-acm/records/dblp_acm_records.csv.

If successful, the crawler creates the table dblp_acm_records.csv with the following columns: id, title, authors, venue, year, and source.

**Step 2: Add a machine learning transform**

Next, add a machine learning transform that is based on the schema of your data source table created by the crawler named demo-crawl-dblp-acm.

1. On the AWS Glue console, in the navigation pane under **Data Integration and ETL**, choose **Data classification tools > Record Matching**, then **Add transform**. Follow the wizard to create a Find matches transform with the following properties.
   
a. For **Transform name**, enter `demo-xform-dblp-acm`. This is the name of the transform that is used to find matches in the source data.
   
b. For **IAM role**, choose an IAM role that has permission to the Amazon S3 source data, labeling file, and AWS Glue API operations. For more information, see [Create an IAM Role for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/data-integration-create-iam-role-for-glue.html) in the AWS Glue Developer Guide.
   
c. For **Data source**, choose the table named `dblp_acm_records_csv` in database `demo-db-dblp-acm`.
   
d. For **Primary key**, choose the primary key column for the table, `id`.

2. In the wizard, choose **Finish** and return to the **ML transforms** list.

**Step 3: Teach your machine learning transform**

Next, you teach your machine learning transform using the tutorial sample labeling file.

You can't use a machine language transform in an extract, transform, and load (ETL) job until its status is **Ready for use**. To get your transform ready, you must teach it how to identify matching and nonmatching records by providing examples of matching and nonmatching records. To teach your transform, you can **Generate a label file**, add labels, and then **Upload label file**.
this tutorial, you can use the example labeling file named `dblp_acm_labels.csv`. For more information about the labeling process, see Labeling.

1. On the AWS Glue console, in the navigation pane, choose **Record Matching**.
2. Choose the `demo-xform-dblp-acm` transform, and then choose **Action, Teach**. Follow the wizard to teach your Find matches transform.
3. On the transform properties page, choose **I have labels**. Choose an Amazon S3 path to the sample labeling file in the current AWS Region. For example, for `us-east-1`, upload the provided labeling file from the Amazon S3 path `s3://ml-transforms-public-datasets-us-east-1/dblp-acm/labels/dblp_acm_labels.csv` with the option to overwrite existing labels. The labeling file must be located in Amazon S3 in the same Region as the AWS Glue console.

   When you upload a labeling file, a task is started in AWS Glue to add or overwrite the labels used to teach the transform how to process the data source.

4. On the final page of the wizard, choose **Finish**, and return to the **ML transforms** list.

**Step 4: Estimate the quality of your machine learning transform**

Next, you can estimate the quality of your machine learning transform. The quality depends on how much labeling you have done. For more information about estimating quality, see Estimate quality.

1. On the AWS Glue console, in the navigation pane under **Data Integration and ETL**, choose **Data classification tools > Record Matching**.
2. Choose the `demo-xform-dblp-acm` transform, and choose the **Estimate quality** tab. This tab displays the current quality estimates, if available, for the transform.
3. Choose **Estimate quality** to start a task to estimate the quality of the transform. The accuracy of the quality estimate is based on the labeling of the source data.
4. Navigate to the **History** tab. In this pane, task runs are listed for the transform, including the Estimating quality task. For more details about the run, choose **Logs**. Check that the run status is **Succeeded** when it finishes.
Step 5: Add and run a job with your machine learning transform

In this step, you use your machine learning transform to add and run a job in AWS Glue. When the transform demo-xform-dblp-acm is Ready for use, you can use it in an ETL job.

1. On the AWS Glue console, in the navigation pane, choose Jobs.
2. Choose Add job, and follow the steps in the wizard to create an ETL Spark job with a generated script. Choose the following property values for your transform:
   a. For Name, choose the example job in this tutorial, demo-etl-dblp-acm.
   b. For IAM role, choose an IAM role with permission to the Amazon S3 source data, labeling file, and AWS Glue API operations. For more information, see Create an IAM Role for AWS Glue in the AWS Glue Developer Guide.
   c. For ETL language, choose Scala. This is the programming language in the ETL script.
   d. For Script file name, choose demo-etl-dblp-acm. This is the file name of the Scala script (same as the job name).
   e. For Data source, choose dblp_acm_records_csv. The data source you choose must match the machine learning transform data source schema.
   f. For Transform type, choose Find matching records to create a job using a machine learning transform.
   g. Clear Remove duplicate records. You don't want to remove duplicate records because the output records written have an additional match_id field added.
   h. For Transform, choose demo-xform-dblp-acm, the machine learning transform used by the job.
   i. For Create tables in your data target, choose to create tables with the following properties:
      - Data store type — Amazon S3
      - Format — CSV
      - Compression type — None
      - Target path — The Amazon S3 path where the output of the job is written (in the current console AWS Region)
3. Choose Save job and edit script to display the script editor page.
4. Edit the script to add a statement to cause the job output to the **Target path** to be written to a single partition file. Add this statement immediately following the statement that runs the FindMatches transform. The statement is similar to the following.

```scala
val single_partition = findmatches1.repartition(1)
```

You must modify the `.writeDynamicFrame(findmatches1)` statement to write the output as `.writeDynamicFrame(single_partition)`.

5. After you edit the script, choose **Save**. The modified script looks similar to the following code, but customized for your environment.

```scala
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.ml.FindMatches
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import org.apache.spark.SparkContext
import scala.collection.JavaConverters_

object GlueApp {
  def main(sysArgs: Array[String]) {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    // @params: [JOB_NAME]
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)
    // @type: DataSource
    // @args: [database = "demo-db-dblp-acm", table_name = "dblp_acm_records_csv",
    // @return: datasource0]
    // @inputs: []
    val datasource0 = glueContext.getCatalogSource(database = "demo-db-dblp-acm",
    tableName = "dblp_acm_records_csv", redshiftTmpDir = ",
    transformationContext = "datasource0").getDynamicFrame()
    // @type: FindMatches
    // @args: [transformId = "tfm-123456789012", emitFusion = false,
    // @return: findmatches1]
    // @inputs: [frame = datasource0]
  }
}
```
6. Choose Run job to start the job run. Check the status of the job in the jobs list. When the job finishes, in the ML transform, History tab, there is a new Run ID row added of type ETL job.

7. Navigate to the Jobs, History tab. In this pane, job runs are listed. For more details about the run, choose Logs. Check that the run status is Succeeded when it finishes.

**Step 6: Verify output data from Amazon S3**

In this step, you check the output of the job run in the Amazon S3 bucket that you chose when you added the job. You can download the output file to your local machine and verify that matching records were identified.

1. Open the Amazon S3 console at [https://console.aws.amazon.com/s3/](https://console.aws.amazon.com/s3/).

2. Download the target output file of the job demo-etl-dblp-acm. Open the file in a spreadsheet application (you might need to add a file extension .csv for the file to properly open).

   The following image shows an excerpt of the output in Microsoft Excel.
The data source and target file both have 4,911 records. However, the Find matches transform adds another column named `match_id` to identify matching records in the output. Rows with the same `match_id` are considered matching records. The `match_confidence_score` is a number between 0 and 1 that provides an estimate of the quality of matches found by Find matches.

3. Sort the output file by `match_id` to easily see which records are matches. Compare the values in the other columns to see if you agree with the results of the Find matches transform. If you don’t, you can continue to teach the transform by adding more labels.

You can also sort the file by another field, such as `title`, to see if records with similar titles have the same `match_id`.

Finding incremental matches

The Find matches feature allows you to identify duplicate or matching records in your dataset, even when the records don’t have a common unique identifier and no fields match exactly. The initial release of the Find matches transform identified matching records within a single dataset. When you add new data to the dataset, you had to merge it with the existing clean dataset and rerun matching against the complete merged dataset.

The incremental matching feature makes it simpler to match to incremental records against existing matched datasets. Suppose that you want to match prospects data with existing customer datasets. The incremental match capability provides you the flexibility to match hundreds of thousands of new prospects with an existing database of prospects and customers by merging the results into a single database or table. By matching only between the new and existing datasets, the find incremental matches optimization reduces computation time, which also reduces cost.
The usage of incremental matching is similar to Find matches as described in Tutorial: Creating a machine learning transform with AWS Glue. This topic identifies only the differences with incremental matching.

For more information, see the blog post on Incremental data matching.

**Running an incremental matching job**

For the following procedure, suppose the following:

- You have crawled the existing dataset into the table `first_records`. The `first_records` dataset must be a matched dataset, or the output of the matched job.
- You have created and trained a Find matches transform with AWS Glue version 2.0. This is the only version of AWS Glue that supports incremental matches.
- The ETL language is Scala. Note that Python is also supported.
- The model already generated is called `demo-xform`.

1. Crawl the incremental dataset to the table `second_records`.
2. On the AWS Glue console, in the navigation pane, choose **Jobs**.
3. Choose **Add job**, and follow the steps in the wizard to create an ETL Spark job with a generated script. Choose the following property values for your transform:
   a. For **Name**, choose `demo-etl`.
   b. For **IAM role**, choose an IAM role with permission to the Amazon S3 source data, labeling file, and AWS Glue API operations.
   c. For **ETL language**, choose Scala.
   d. For **Script file name**, choose `demo-etl`. This is the file name of the Scala script.
   e. For **Data source**, choose `first_records`. The data source you choose must match the machine learning transform data source schema.
   f. For **Transform type**, choose **Find matching records** to create a job using a machine learning transform.
   g. Select the incremental matching option, and for **Data Source** select the table named `second_records`.
   h. For **Transform**, choose `demo-xform`, the machine learning transform used by the job.
   i. Choose **Create tables in your data target** or **Use tables in the data catalog and update your data target**.
4. Choose **Save job and edit script** to display the script editor page.

5. Choose **Run job** to start the job run.

### Using FindMatches in a visual job

To use the **FindMatches** transform in AWS Glue Studio, you can use the **Custom Transform** node that invokes the FindMatches API. For more information on how to use a custom transform, see [Creating a custom transformation](#).

#### Note

Currently, the FindMatches API only works with **Glue 2.0**. In order to run a job with the Custom transform that invokes the FindMatches API, ensure the AWS Glue version is **Glue 2.0** in the **Job details** tab. If the version of AWS Glue is not **Glue 2.0**, the job will fail at runtime with the following error message: “cannot import name 'FindMatches' from 'awsglueml.transforms'”.

### Prerequisites

- In order to use the **Find Matches** transform, open the AWS Glue Studio console at [https://console.aws.amazon.com/gluestudio/](https://console.aws.amazon.com/gluestudio/).

- Create a machine learning transform. When created, a transformId is generated. You will need this ID for the steps below. For more information on how to create a machine learning transform, see [Adding and editing machine learning transforms](#).

### Adding a FindMatches transform

**To add a FindMatches transform:**

1. In the AWS Glue Studio job editor, open the Resource panel by clicking on the cross symbol in the upper left-hand corner of the visual job graph and choose a Data source by choosing the **Data tab**. This is the data source you want to check for matches.
2. Choose the data source node, then open the Resource panel by clicking on the cross symbol in the upper left-hand corner of the visual job graph and search for 'custom transform'. Choose the **Custom Transform** node to add it to the graph. The **Custom Transform** is linked to the data source node. If it is not, you can click on the **Custom Transform** node and choose the **Node properties** tab, then under **Node parents**, choose the data source.

3. Click the **Custom Transform** node in the visual graph, then choose the **Node properties** tab and name the custom transform. It is recommended that you rename the transform so that the transform name is easily identifiable in the visual graph.

4. Choose the **Transform** tab, where you can edit the code block. This is where the code to invoke the FindMatches API can be added.
The code block contains pre-populated code to get you started. Overwrite the pre-populated code with the template below. The template has a placeholder for the `transformId`, which you can provide.

```python
def MyTransform(glueContext, dfc) -> DynamicFrameCollection:
    dynf = dfc.select(list(dfc.keys())[0])
    from awsglue.ml.transforms import FindMatches
    findmatches = FindMatches.apply(frame = dynf, transformId = "<your id>")
    return(DynamicFrameCollection({"FindMatches": findmatches}, glueContext))
```

5. Click the **Custom Transform** node in the visual graph, then open the Resource panel by clicking on the cross symbol in the upper left-hand corner of the visual job graph and search for 'Select From Collection'. There is no need to change the default selection since there is only one DynamicFrame in the collection.
6. You can continue adding transformations or store the result, which is now enriched with the find matches additional columns. If you want to reference those new columns in downstream transforms, you need to add them to the transform output schema. The easiest way to do that is to choose the Data preview tab and then in the schema tab choose “Use datapreview schema”.

7. To customize FindMatches, you can add additional parameters to pass to the 'apply' method. See FindMatches class.

Adding a FindMatches incrementally transformation

In the case of incremental matches, the process is the same as Adding a FindMatches transformation with the following differences:

- Instead of a parent node for the custom transform, you need two parent nodes.
- The first parent node should be the dataset.
- The second parent node should be the incremental dataset.

Replace the transformId with your transformId in the template code block:

```python
def MyTransform (glueContext, dfc) -> DynamicFrameCollection:
    dfs = list(dfc.values())
    dynf = dfs[0]
    inc_dynf = dfs[1]
    from awsglueml.transforms import FindIncrementalMatches
    findmatches = FindIncrementalMatches.apply(existingFrame = dynf, incrementalFrame = inc_dynf,
        transformId = "<your id>")
    return(DynamicFrameCollection({"FindMatches": findmatches}, glueContext))
```

- For optional parameters, see FindIncrementalMatches class.

Migrate Apache Spark programs to AWS Glue

Apache Spark is an open-source platform for distributed computing workloads performed on large datasets. AWS Glue leverages Spark’s capabilities to provide an optimized experience for ETL. You can migrate Spark programs to AWS Glue to take advantage of our features. AWS Glue provides the same performance enhancements you would expect from Apache Spark on Amazon EMR.
Run Spark code

Native Spark code can be run in a AWS Glue environment out of the box. Scripts are often developed by iteratively changing a piece of code, a workflow suited for an Interactive Session. However, existing code is more suited to run in a AWS Glue job, which allows you to schedule and consistently get logs and metrics for each script run. You can upload and edit an existing script through the console.

1. Acquire the source to your script. For this example, you will use an example script from the Apache Spark repository. Binarizer Example

2. In the AWS Glue Console, expand the left-side navigation pane and select ETL > Jobs

In the Create job panel, select Spark script editor. An Options section will appear. Under Options, select Upload and edit an existing script.

A File upload section will appear. Under File upload, click Choose file. Your system file chooser will appear. Navigate to the location where you saved binarizer_example.py, select it and confirm your selection.

A Create button will appear on the header for the Create job panel. Click it.
3. Your browser will navigate to the script editor. On the header, click the **Job details** tab. Set the **Name** and **IAM Role**. For guidance around AWS Glue IAM roles, consult the section called “Setting up IAM permissions”.

Optionally - set **Requested number of workers** to 2 and **Number of retries** to 1. These options are valuable when running production jobs, but turning them down will streamline your experience while testing out a feature.

In the title bar, click **Save**, then **Run**

4. Navigate to the **Runs** tab. You will see a panel corresponding to your job run. Wait a few minutes and the page should automatically refresh to show **Succeeded** under **Run status**.
5. You will want to examine your output to confirm that the Spark script ran as intended. This Apache Spark sample script should write a string to the output stream. You can find that by navigating to Output logs under Cloudwatch logs in the panel for the successful job run. Note the job run id, a generated id under the Id label beginning with jr_.

This will open the CloudWatch console, set to visualize the contents of the default AWS Glue log group /aws-glue/jobs/output, filtered to the contents of the log streams for the job run id. Each worker will have generated a log stream, shown as rows under the Log streams. One worker should have run the requested code. You will need to open all the log streams to identify the correct worker. Once you find the right worker, you should see the output of the script, as seen in the following image:
Common procedures needed for migrating Spark programs

Assess Spark version support

AWS Glue release versions define the version of Apache Spark and Python available to the AWS Glue job. You can find our AWS Glue versions and what they support at the section called “AWS Glue versions”. You may need to update your Spark program to be compatible with a newer version of Spark in order to access certain AWS Glue features.

Include third-party libraries

Many existing Spark programs will have dependencies, both on private and public artifacts. AWS Glue supports JAR style dependencies for Scala Jobs as well as Wheel and source pure-Python dependencies for Python jobs.

Python - For information about Python dependencies, see the section called “Python libraries”

Common Python dependencies are provided in the AWS Glue environment, including the commonly requested Pandas library. Dependencies are included in AWS Glue Version 2.0+. For more information about provided modules, see the section called “Python modules already provided in AWS Glue”. If you need to supply a Job with a different version of a dependency
included by default, you can use `--additional-python-modules`. For information about job arguments, see the section called “Job parameters”.

You can supply additional Python dependencies with the `--extra-py-files` job argument. If you are migrating a job from a Spark program, this parameter is a good option because it is functionally equivalent to the `--py-files` flag in PySpark, and is subject to the same limitations. For more information about the `--extra-py-files` parameter, see the section called “Including Python files with PySpark native features”.

For new jobs, you can manage Python dependencies with the `--additional-python-modules` job argument. Using this argument allows for a more thorough dependency management experience. This parameter supports Wheel style dependencies, including those with native code bindings compatible with Amazon Linux 2.

**Scala**

You can supply additional Scala dependencies with the `--extra-jars` Job Argument. Dependencies must be hosted in Amazon S3 and the argument value should be a comma delimited list of Amazon S3 paths with no spaces. You may find it easier to manage your configuration by rebundling your dependencies before hosting and configuring them. AWS Glue JAR dependencies contain Java bytecode, which can be generated from any JVM language. You can use other JVM languages, such as Java, to write custom dependencies.

**Manage data source credentials**

Existing Spark programs may come with complex or custom configuration to pull data from their datasources. Common datasource auth flows are supported by AWS Glue connections. For more information about AWS Glue connections, see Connecting to data.

AWS Glue connections facilitate connecting your Job to a variety of types of data stores in two primary ways: through method calls to our libraries and setting the **Additional network connection** in the AWS console. You may also call the AWS SDK from within your job to retrieve information from a connection.

**Method calls** – AWS Glue Connections are tightly integrated with the AWS Glue Data Catalog, a service that allows you to curate information about your datasets, and the methods available to interact with AWS Glue connections reflect that. If you have an existing auth configuration you would like to reuse, for JDBC connections, you can access your AWS Glue connection configuration through the `extract_jdbc_conf` method on the GlueContext. For more information, see the section called “extract_jdbc_conf”.
**Console configuration** – AWS Glue Jobs use associated AWS Glue connections to configure connections to Amazon VPC subnets. If you directly manage your security materials, you may need to provide a NETWORK type **Additional network connection** in the AWS console to configure routing. For more information about the AWS Glue connection API, see the section called “Connections”.

If your Spark programs has a custom or uncommon auth flow, you may need to manage your security materials in a hands-on fashion. If AWS Glue connections do not seem like a good fit, you can securely host security materials in Secrets Manager and access them through the boto3 or AWS SDK, which are provided in the job.

**Configure Apache Spark**

Complex migrations often alter Spark configuration to accommodate their workloads. Modern versions of Apache Spark allow runtime configuration to be set with the SparkSession. AWS Glue 3.0+ Jobs are provided a SparkSession, which can be modified to set runtime configuration. [Apache Spark Configuration]. Tuning Spark is complex, and AWS Glue does not guarantee support for setting all Spark configuration. If your migration requires substantial Spark-level configuration, contact support.

**Set custom configuration**

Migrated Spark programs may be designed to take custom configuration. AWS Glue allows configuration to be set on the job and job run level, through the job arguments. For information about job arguments, see the section called “Job parameters”. You can access job arguments within the context of a job through our libraries. AWS Glue provides a utility function to provide a consistent view between arguments set on the job and arguments set on the job run. See the section called “getResolvedOptions” in Python and the section called “GlueArgParser” in Scala.

**Migrate Java code**

As explained in the section called “Third-party libraries”, your dependencies can contain classes generated by JVM languages, such as Java or Scala. Your dependencies can include a main method. You can use a main method in a dependency as the entrypoint for a AWS Glue Scala job. This allows you to write your main method in Java, or reuse a main method packaged to your own library standards.

To use a main method from a dependency, perform the following: Clear the contents of the editing pane providing the default GlueApp object. Provide the fully qualified name of a class in a dependency as a job argument with the key `--class`. You should then be able to trigger a Job run.
You cannot configure the order or structure of the arguments AWS Glue passes to the main method. If your existing code needs to read configuration set in AWS Glue, this will likely cause incompatibility with prior code. If you use `getResolvedOptions`, you will also not have a good place to call this method. Consider invoking your dependency directly from a main method generated by AWS Glue. The following AWS Glue ETL script shows an example of this.

```scala
import com.amazonaws.services.glue.util.GlueArgParser

object GlueApp {
  def main(sysArgs: Array[String]) {
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)

    // Invoke static method from JAR. Pass some sample arguments as a String[], one defined inline and one taken from the job arguments, using getResolvedOptions
    com.mycompany.myproject.MyClass.myStaticPublicMethod(Array("string parameter1", args("JOB_NAME")))

    // Alternatively, invoke a non-static public method.
    (new com.mycompany.myproject.MyClass).someMethod()
  }
}
```

**Working with Ray jobs in AWS Glue**

This section provides information about using AWS Glue for Ray jobs. For more information about writing AWS Glue for Ray scripts, consult the [section called “AWS Glue for Ray”](#) section.

**Topics**
- Getting started with AWS Glue for Ray
- Supported Ray runtime environments
- Accounting for workers in Ray jobs
- Using job parameters in Ray jobs
- Monitoring Ray jobs with metrics

**Getting started with AWS Glue for Ray**

To work with AWS Glue for Ray, you use the same AWS Glue jobs and interactive sessions that you use with AWS Glue for Spark. AWS Glue jobs are designed for running the same script on
a recurring cadence, while interactive sessions are designed to let you run snippets of code sequentially against the same provisioned resources.

AWS Glue ETL and Ray are different underneath, so in your script, you have access to different tools, features, and configuration. As a new computation framework managed by AWS Glue, Ray has a different architecture and uses different vocabulary to describe what it does. For more information, see Architecture Whitepapers in the Ray documentation.

**Note**
AWS Glue for Ray is available in US East (N. Virginia), US East (Ohio), US West (Oregon), Asia Pacific (Tokyo), and Europe (Ireland).

**Ray jobs in the AWS Glue Studio console**

On the **Jobs** page in the AWS Glue Studio console, you can select a new option when you're creating a job in AWS Glue Studio—**Ray script editor**. Choose this option to create a Ray job in the console. For more information about jobs and how they're used, see **Building visual ETL jobs with AWS Glue Studio**.

**Ray jobs in the AWS CLI and SDK**

Ray jobs in the AWS CLI use the same SDK actions and parameters as other jobs. AWS Glue for Ray introduces new values for certain parameters. For more information in the Jobs API, see **the section called “Jobs”**.
Supported Ray runtime environments

In Spark jobs, GlueVersion determines the versions of Apache Spark and Python available in an AWS Glue for Spark job. The Python version indicates the version that is supported for jobs of type Spark. This is not how Ray runtime environments are configured.

For Ray jobs, you should set GlueVersion to 4.0 or greater. However, the versions of Ray, Python, and additional libraries that are available in your Ray job are determined by the Runtime field in the job definition.

The Ray2.4 runtime environment will be available for a minimum of 6 months after release. As Ray rapidly evolves, you will be able to incorporate Ray updates and improvements through future runtime environment releases.

Valid values: Ray2.4

<table>
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<th>Ray and Python versions</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Ray 2.4.0</td>
</tr>
<tr>
<td></td>
<td>Python 3.9</td>
</tr>
</tbody>
</table>

Additional information

- For release notes that accompany AWS Glue on Ray releases, see the section called “AWS Glue versions”.
- For Python libraries that are provided in a runtime environment, see the section called “Modules provided with Ray jobs”.

Accounting for workers in Ray jobs

AWS Glue runs Ray jobs on new Graviton-based EC2 worker types, which are only available for Ray jobs. To appropriately provision these workers for the workloads Ray is designed for, we provide a different ratio of compute resources to memory resources from most workers. In order to account for these resources, we use the memory-optimized data processing unit (M-DPU) rather than the standard data processing unit (DPU).

- One M-DPU corresponds to 4 vCPUs and 32 GB of memory.
One DPU corresponds to 4 vCPUs and 16 GB of memory. DPUs are used to account for resources in AWS Glue with Spark jobs and corresponding workers.

Ray jobs currently have access to one worker type, Z.2X. The Z.2X worker maps to 2 M-DPUs (8 vCPUs, 64 GB of memory) and has 128 GB of disk space. A Z.2X machine provides 8 Ray workers (one per vCPU).

The number of M-DPUs that you can use concurrently in an account is subject to a service quota. For more information about your AWS Glue account limits, see AWS Glue endpoints and quotas.

You specify the number of worker nodes that are available to a Ray job with --number-of-workers (NumberOfWorkers) in the job definition. For more information about Ray values in the Jobs API, see the section called “Jobs”.

You can further specify a minimum number of workers that a Ray job must allocate with the --min-workers job parameter. For more information about job parameters, see the section called “Reference”.

Using job parameters in Ray jobs

You set arguments for AWS Glue Ray jobs the same way you set arguments for AWS Glue for Spark jobs. For more information about the AWS Glue API, see the section called “Jobs”. You can configure AWS Glue Ray jobs with different arguments, which are listed in this reference. You can also provide your own arguments.

You can configure a job through the console, on the Job details tab, under the Job Parameters heading. You can also configure a job through the AWS CLI by setting DefaultArguments on a job, or setting Arguments on a job run. Default arguments and job parameters stay with the job through multiple runs.

For example, the following is the syntax for running a job using --arguments to set a special parameter.

```
$ aws glue start-job-run --job-name "CSV to CSV" --arguments='--scriptLocation='s3://my_glue/libraries/test_lib.py",--test-environment="true"
```

After you set the arguments, you can access job parameters from within your Ray job through environment variables. This gives you a way to configure your job for each run. The name of the environment variable will be the job argument name without the -- prefix.
For instance, in the previous example, the variable names would be `scriptLocation` and `test-environment`. You would then retrieve the argument through methods available in the standard library: `test_environment = os.environ.get('test-environment')`. For more information about accessing environment variables with Python, see `os module` in the Python documentation.

**Reference**

Ray jobs recognize the following argument names that you can use to set up the script environment for your Ray jobs and job runs:

- **--min-workers** – The minimum number of worker nodes that are allocated to a Ray job. A worker node can run multiple replicas, one per virtual CPU. Format: integer. Minimum: 0. Maximum: value specified in `--number-of-workers (NumberOfWorkers)` on the job definition. For more information about accounting for worker nodes, see the section called "Accounting for workers in Ray jobs".

- **--object_spilling_config** – AWS Glue for Ray supports using Amazon S3 as a way of extending the space available to Ray's object store. To enable this behavior, you can provide Ray an `object spilling` JSON config object with this parameter. For more information about Ray object spilling configuration, see Object Spilling in the Ray documentation. Format: JSON object.

AWS Glue for Ray only supports spilling to disk or spilling to Amazon S3 at once. You can provide multiple locations for spilling, as long as they respect this limitation. When spilling to Amazon S3, you will also need to add IAM permissions to your job for this bucket.

When providing a JSON object as configuration with the CLI, you must provide it as a string, with the JSON object string-escaped. For example, a string value for spilling to one Amazon S3 path would look like: "{"type": "smart_open", "params": {"uri": "s3path"}}". In AWS Glue Studio, provide this parameter as a JSON object with no extra formatting.

- **--object_store_memory_head** – The memory allocated to the Plasma object store on the Ray head node. This instance runs cluster management services, as well as worker replicas. The value represents a percentage of free memory on the instance after a warm start. You use this parameter to tune memory intensive workloads—defaults are acceptable for most use cases. Format: positive integer. Minimum: 1. Maximum: 100.

For more information about Plasma, see The Plasma In-Memory Object Store in the Ray documentation.
• \--object_store_memory_worker\ – The memory allocated to the Plasma object store on the Ray worker nodes. These instances only run worker replicas. The value represents a percentage of free memory on the instance after a warm start. This parameter is used to tune memory intensive workloads—defaults are acceptable for most use cases. Format: positive integer. Minimum: 1. Maximum: 100.

For more information about Plasma, see The Plasma In-Memory Object Store in the Ray documentation.

• \--pip-install\ – A set of Python packages to be installed. You can install packages from PyPI using this argument. Format: comma-delimited list.

A PyPI package entry is in the format package==version, with the PyPI name and version of your target package. Entries use Python version matching to match the package and version, such as ==, not the single equals =. There are other version-matching operators. For more information, see PEP 440 on the Python website. You can also provide custom modules with \--s3-py-modules\.

• \--s3-py-modules\ – A set of Amazon S3 paths that host Python module distributions. Format: comma-delimited list.

You can use this to distribute your own modules to your Ray job. You can also provide modules from PyPI with \--pip-install\. Unlike with AWS Glue ETL, custom modules are not set up through pip, but are passed to Ray for distribution. For more information, see the section called “Additional Python modules for Ray jobs”.

• \--working-dir\ – A path to a .zip file hosted in Amazon S3 that contains files to be distributed to all nodes running your Ray job. Format: string. For more information, see the section called “Providing files to your Ray job”.

**Monitoring Ray jobs with metrics**

You can monitor Ray jobs using AWS Glue Studio and Amazon CloudWatch. CloudWatch collects and processes raw metrics from AWS Glue with Ray, which makes them available for analysis. These metrics are visualized in the AWS Glue Studio console, so you can monitor your job as it runs.

For a general overview of how to monitor AWS Glue, see the section called “Using CloudWatch metrics”. For a general overview of how to use CloudWatch metrics that are published by AWS Glue, see the section called “Monitoring with CloudWatch”.

Ray job metrics
Monitoring Ray jobs in the AWS Glue console

On the details page for a job run, below the Run details section, you can view pre-built aggregated graphs that visualize your available job metrics. AWS Glue Studio sends job metrics to CloudWatch for every job run. With these, you can build a profile of your cluster and tasks, as well as access detailed information about each node.

For more information about available metrics graphs, see the section called “Viewing Amazon CloudWatch metrics for a Ray job run”.

Overview of Ray jobs metrics in CloudWatch

We publish Ray metrics when detailed monitoring is enabled in CloudWatch. Metrics are published to the Glue/Ray CloudWatch namespace.

- **Instance metrics**

  We publish metrics about the CPU, memory and disk utilization of instances assigned to a job. These metrics are identified by features such as ExecutorId, ExecutorType and host. These metrics are a subset of the standard Linux CloudWatch agent metrics. You can find information about metric names and features in the CloudWatch documentation. For more information, see Metrics collected by the CloudWatch agent.

- **Ray cluster metrics**

  We forward metrics from the Ray processes that run your script to this namespace, then provide those most critical for you. The metrics that are available might differ by Ray version. For more information about which Ray version your job is running, see the section called “AWS Glue versions”.

Ray collects metrics at the instance level. It also provides metrics for tasks and the cluster. For more information about Ray's underlying metric strategy, see Metrics in the Ray documentation.

Note

We don't publish Ray metrics to the Glue/Job Metrics/ namespace, which is only used for AWS Glue ETL jobs.
Python shell jobs in AWS Glue

You can use a Python shell job to run Python scripts as a shell in AWS Glue. With a Python shell job, you can run scripts that are compatible with Python 2.7, Python 3.6, or Python 3.9.

You can't use job bookmarks with Python shell jobs.

The Amazon CloudWatch Logs group for Python shell jobs output is `/aws-glue/python-jobs/output`. For errors, see the log group `/aws-glue/python-jobs/error`.

Topics
- Defining job properties for Python shell jobs
- Supported libraries for Python shell jobs
- Limitations
- Providing your own Python library

Defining job properties for Python shell jobs

These sections describe defining job properties in AWS Glue Studio, or using the AWS CLI.

AWS Glue Studio

When you define your Python shell job in AWS Glue Studio, you provide some of the following properties:

IAM role

Specify the AWS Identity and Access Management (IAM) role that is used for authorization to resources that are used to run the job and access data stores. For more information about permissions for running jobs in AWS Glue, see Identity and access management for AWS Glue.

Type

Choose Python shell to run a Python script with the job command named `pythonshell`.

Python version

Choose the Python version. The default is Python 3.9. Valid versions are Python 3.6 and Python 3.9.
Load common analytics libraries (Recommended)

Choose this option to include common libraries for Python 3.9 in the Python shell.

If your libraries are either custom or they conflict with the pre-installed ones, you can choose not to install common libraries. However, you can install additional libraries besides the common libraries.

When you select this option, the library-set option is set to analytics. When you de-select this option, the library-set option is set to none.

Script filename and Script path

The code in the script defines your job’s procedural logic. You provide the script name and location in Amazon Simple Storage Service (Amazon S3). Confirm that there isn't a file with the same name as the script directory in the path. To learn more about using scripts, see AWS Glue programming guide.

Script

The code in the script defines your job's procedural logic. You can code the script in Python 3.6 or Python 3.9. You can edit a script in AWS Glue Studio.

Data processing units

The maximum number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see AWS Glue pricing.

You can set the value to 0.0625 or 1. The default is 0.0625. In either case, the local disk for the instance will be 20GB.

CLI

You can also create a Python shell job using the AWS CLI, as in the following example.

```
aws glue create-job --name python-job-cli --role Glue_DefaultRole
   --command '{"Name" : "pythonshell", "PythonVersion": "3.9", "ScriptLocation" :
"s3://DOC-EXAMPLE-BUCKET/scriptname.py"}'
   --max-capacity 0.0625
```
Jobs that you create with the AWS CLI default to Python 3. Valid Python versions are 3 (corresponding to 3.6), and 3.9. To specify Python 3.6, add this tuple to the --command parameter: "PythonVersion":"3"

To specify Python 3.9, add this tuple to the --command parameter: "PythonVersion":"3.9"

To set the maximum capacity used by a Python shell job, provide the --max-capacity parameter. For Python shell jobs, the --allocated-capacity parameter can't be used.

**Supported libraries for Python shell jobs**

In Python shell using Python 3.9, you can choose the library set to use pre-packaged library sets for your needs. You can use the library-set option to choose the library set. Valid values are analytics, and none.

The environment for running a Python shell job supports the following libraries:

<table>
<thead>
<tr>
<th>Python version</th>
<th>Python 3.6</th>
<th>Python 3.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library set</td>
<td>N/A</td>
<td>analytics</td>
</tr>
<tr>
<td>avro</td>
<td></td>
<td>1.11.0</td>
</tr>
<tr>
<td>awscli</td>
<td>116.242</td>
<td>1.23.5</td>
</tr>
<tr>
<td>awswrangler</td>
<td></td>
<td>2.15.1</td>
</tr>
<tr>
<td>botocore</td>
<td>1.12.232</td>
<td>1.23.5</td>
</tr>
<tr>
<td>boto3</td>
<td>1.9.203</td>
<td>1.22.5</td>
</tr>
<tr>
<td>elasticsearch</td>
<td></td>
<td>8.2.0</td>
</tr>
<tr>
<td>numpy</td>
<td>1.16.2</td>
<td>1.22.3</td>
</tr>
<tr>
<td>pandas</td>
<td>0.24.2</td>
<td>1.4.2</td>
</tr>
<tr>
<td>psycopg2</td>
<td></td>
<td>2.9.3</td>
</tr>
<tr>
<td>pyathena</td>
<td></td>
<td>2.5.3</td>
</tr>
<tr>
<td>PyGreSQL</td>
<td>5.0.6</td>
<td></td>
</tr>
<tr>
<td>Python version</td>
<td>Python 3.6</td>
<td>Python 3.9</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>PyMySQL</td>
<td></td>
<td>1.0.2</td>
</tr>
<tr>
<td>pyodbc</td>
<td></td>
<td>4.0.32</td>
</tr>
<tr>
<td>pyorc</td>
<td></td>
<td>0.6.0</td>
</tr>
<tr>
<td>redshift-connector</td>
<td></td>
<td>2.0.907</td>
</tr>
<tr>
<td>requests</td>
<td>2.22.0</td>
<td>2.27.1</td>
</tr>
<tr>
<td>scikit-learn</td>
<td>0.20.3</td>
<td>1.0.2</td>
</tr>
<tr>
<td>scipy</td>
<td>1.2.1</td>
<td>1.8.0</td>
</tr>
<tr>
<td>SQLAlchemy</td>
<td></td>
<td>1.4.36</td>
</tr>
<tr>
<td>s3fs</td>
<td></td>
<td>2022.3.0</td>
</tr>
</tbody>
</table>

You can use the NumPy library in a Python shell job for scientific computing. For more information, see [NumPy](https://numpy.org). The following example shows a NumPy script that can be used in a Python shell job. The script prints "Hello world" and the results of several mathematical calculations.

```python
import numpy as np
print("Hello world")

a = np.array([20, 30, 40, 50])
print(a)

b = np.arange(4)
print(b)

c = a - b
print(c)

d = b**2
```
Limitations

Note the following limitations of Python Shell jobs:

- You can't package Python libraries as .egg files in Python 3.9+.
- The --extra-files option cannot be used, because of a limitation on temporary copies of S3 data.

Providing your own Python library

Using PIP

Python shell using Python 3.9 lets you provide additional Python modules or different versions at the job level. You can use the --additional-python-modules option with a list of comma-separated Python modules to add a new module or change the version of an existing module. You cannot provide custom Python modules hosted on Amazon S3 with this parameter when using Python shell jobs.

For example to update or to add a new scikit-learn module use the following key and value: "--additional-python-modules", "scikit-learn==0.21.3".

AWS Glue uses the Python Package Installer (pip3) to install the additional modules. You can pass additional pip3 options inside the --additional-python-modules value. For example, "scikit-learn==0.21.3 -i https://pypi.python.org/simple/". Any incompatibilities or limitations from pip3 apply.

Note

To avoid incompatibilities in the future, we recommend that you use libraries built for Python 3.9.

Using an Egg or Whl file

You might already have one or more Python libraries packaged as an .egg or a .whl file. If so, you can specify them to your job using the AWS Command Line Interface (AWS CLI) under the --extra-py-files flag, as in the following example.
If you aren't sure how to create an .egg or a .whl file from a Python library, use the following steps. This example is applicable on macOS, Linux, and Windows Subsystem for Linux (WSL).

**To create a Python .egg or .whl file**

1. Create an Amazon Redshift cluster in a virtual private cloud (VPC), and add some data to a table.

2. Create an AWS Glue connection for the VPC-SecurityGroup-Subnet combination that you used to create the cluster. Test that the connection is successful.

3. Create a directory named `redshift_example`, and create a file named `setup.py`. Paste the following code into `setup.py`.

   ```python
   from setuptools import setup
   
   setup(
       name="redshift_module",
       version="0.1",
       packages=['redshift_module'],
   )
   ```

4. In the `redshift_example` directory, create a `redshift_module` directory. In the `redshift_module` directory, create the files `__init__.py` and `pygresql_redshift_common.py`.

5. Leave the `__init__.py` file empty. In `pygresql_redshift_common.py`, paste the following code. Replace `port`, `db_name`, `user`, and `password_for_user` with details specific to your Amazon Redshift cluster. Replace `table_name` with the name of the table in Amazon Redshift.

   ```python
   import pg
   
   def get_connection(host):
       rs_conn_string = "host=%s port=%s dbname=%s user=%s password=%s" % (host, port, db_name, user, password_for_user)
   ```
rs_conn = pg.connect(dbname=rs_conn_string)
rs_conn.query("set statement_timeout = 1200000")
return rs_conn

def query(con):
    statement = "Select * from table_name;"
    res = con.query(statement)
    return res

6. If you're not already there, change to the redshift_example directory.

7. Do one of the following:
   - To create an .egg file, run the following command.
     python setup.py bdist_egg
   - To create a .whl file, run the following command.
     python setup.py bdist_wheel

8. Install the dependencies that are required for the preceding command.

9. The command creates a file in the dist directory:
   - If you created an egg file, it's named redshift_module-0.1-py2.7.egg.
   - If you created a wheel file, it's named redshift_module-0.1-py2.7-none-any.whl.

Upload this file to Amazon S3.

In this example, the uploaded file path is either s3://DOC-EXAMPLE-BUCKET/EGG-FILE or s3://DOC-EXAMPLE-BUCKET/WHEEL-FILE.

10. Create a Python file to be used as a script for the AWS Glue job, and add the following code to the file.

    from redshift_module import pygresql_redshift_common as rs_common

    con1 = rs_common.get_connection(redshift_endpoint)
    res = rs_common.query(con1)
print "Rows in the table cities are: "
print res

11. Upload the preceding file to Amazon S3. In this example, the uploaded file path is `s3://DOC-EXAMPLE-BUCKET/scriptname.py`.

12. Create a Python shell job using this script. On the AWS Glue console, on the Job properties page, specify the path to the `.egg`/.whl file in the Python library path box. If you have multiple `.egg`/.whl files and Python files, provide a comma-separated list in this box.

   When modifying or renaming `.egg` files, the file names must use the default names generated by the "python setup.py bdist_egg" command or must adhere to the Python module naming conventions. For more information, see the [Style Guide for Python Code](#).

   Using the AWS CLI, create a job with a command, as in the following example.

   ```
   aws glue create-job --name python-redshift-test-cli --role Role --command 
   '{"Name" : "pythonshell", "ScriptLocation" : "s3://DOC-EXAMPLE-BUCKET/scriptname.py"}'
   ```

   When the job runs, the script prints the rows created in the `table_name` table in the Amazon Redshift cluster.

**Monitoring AWS Glue**

Monitoring is an important part of maintaining the reliability, availability, and performance of AWS Glue and your other AWS solutions. AWS provides monitoring tools that you can use to watch AWS Glue, report when something is wrong, and take action automatically when appropriate:

You can use the following automated monitoring tools to watch AWS Glue and report when something is wrong:

- **Amazon CloudWatch Events** delivers a near real-time stream of system events that describe changes in AWS resources. CloudWatch Events enables automated event-driven computing. You
can write rules that watch for certain events and trigger automated actions in other AWS services when these events occur. For more information, see the Amazon CloudWatch Events User Guide.

- **Amazon CloudWatch Logs** enables you to monitor, store, and access your log files from Amazon EC2 instances, AWS CloudTrail, and other sources. CloudWatch Logs can monitor information in the log files and notify you when certain thresholds are met. You can also archive your log data in highly durable storage. For more information, see the Amazon CloudWatch Logs User Guide.

- **AWS CloudTrail** captures API calls and related events made by or on behalf of your AWS account and delivers the log files to an Amazon S3 bucket that you specify. You can identify which users and accounts call AWS, the source IP address from which the calls are made, and when the calls occur. For more information, see the AWS CloudTrail User Guide.

Additionally, you have access to the following insights in the AWS Glue console to help you debug and profile jobs:

- Spark jobs – you can see a visualization of selected CloudWatch metrics series, and newer jobs have access to the Spark UI. For more information, see the section called “Monitoring Spark jobs”.

- Ray jobs – you can see a visualization of selected CloudWatch metrics series. For more information, see the section called “Ray job metrics”.

**Topics**

- [AWS tags in AWS Glue](#)
- [Automating AWS Glue with CloudWatch Events](#)
- [AWS Glue resource monitoring](#)
- [Logging AWS Glue API calls with AWS CloudTrail](#)

**AWS tags in AWS Glue**

To help you manage your AWS Glue resources, you can optionally assign your own tags to some AWS Glue resource types. A tag is a label that you assign to an AWS resource. Each tag consists of a key and an optional value, both of which you define. You can use tags in AWS Glue to organize and identify your resources. Tags can be used to create cost accounting reports and restrict access to resources. If you're using AWS Identity and Access Management, you can control which users in your AWS account have permission to create, edit, or delete tags. In addition to the permissions to
call the tag-related APIs, you also need the `glue:GetConnection` permission to call tagging APIs on connections, and the `glue:GetDatabase` permission to call tagging APIs on databases. For more information, see [ABAC with AWS Glue](#).

In AWS Glue, you can tag the following resources:

- Blueprint
- Connection
- Database
- Crawler
- Interactive Session
- Job
- Trigger
- Workflow
- Development endpoint
- Machine learning transform
- Stream schemas
- Stream schema registries

⚠️ **Note**

As a best practice, to allow tagging of these AWS Glue resources, always include the `glue:TagResource` action in your policies.

Consider the following when using tags with AWS Glue.

- A maximum of 50 tags are supported per entity.
- In AWS Glue, you specify tags as a list of key-value pairs in the format `{"string":"string" ...}`
- When you create a tag on an object, the tag key is required, and the tag value is optional.
- The tag key and tag value are case sensitive.
- The tag key and the tag value must not contain the prefix `aws`. No operations are allowed on such tags.
The maximum tag key length is 128 Unicode characters in UTF-8. The tag key must not be empty or null.

The maximum tag value length is 256 Unicode characters in UTF-8. The tag value may be empty or null.

**Tagging support for AWS Glue connections**

You can restrict `CreateConnection`, `UpdateConnection`, `GetConnection` and, `DeleteConnection` action permission based on the resource tag. This enables you to implement the least privilege access control on AWS Glue jobs with JDBC data sources which need to fetch JDBC connection information from the Data Catalog.

**Example usage**

Create an AWS Glue connection with the tag "connection-category", "dev-test"].

Specify the tag condition for the `GetConnection` action in the IAM policy.

```json
{
   "Effect": "Allow",
   "Action": [ "glue:GetConnection"
   ],
   "Resource": "*",
   "Condition": {
      "ForAnyValue:StringEquals": {
         "aws:ResourceTag/tagKey": "dev-test"
      }
   }
}
```

**Examples**

The following examples create a job with assigned tags.

**AWS CLI**

```
aws glue create-job --name job-test-tags --role MyJobRole --command Name=glueetl,ScriptLocation=S3://aws-glue-scripts//prod-job1 --tags key1=value1,key2=value2
```
{  
  "Description": "AWS Glue Job Test Tags",
  "Resources": {
    "MyJobRole": {
      "Type": "AWS::IAM::Role",
      "Properties": {
        "AssumeRolePolicyDocument": {
          "Version": "2012-10-17",
          "Statement": [
            {
              "Effect": "Allow",
              "Principal": {
                "Service": ["glue.amazonaws.com"]
              },
              "Action": ["sts:AssumeRole"]
            }
          ]
        },
        "Path": "/",
        "Policies": [  
          {  
            "PolicyName": "root",
            "PolicyDocument": {
              "Version": "2012-10-17",
              "Statement": [
                {
                  "Effect": "Allow",
                  "Action": "*",
                  "Resource": "*"
                }
              ]
            }
          }
        ]
      }
    },
    "MyJob": {
      "Type": "AWS::Glue::Job",
      "Properties": {
        "Role": "MyJobRole",
        "Command": {
          "Name": "glue:batch bringen",
          "ScriptLocation": "s3://my濟ds桶/MyJobScript.py"
        },
        "MaxRetries": 3,
        "MaxTrials": 10,
        "Arguments": ["--input", "s3://inputBucket/inputFile.csv", "--output", "s3://outputBucket/outputFile.csv"]
      }
    }
  }
}

AWS Glue
"Properties": {
    "Command": {
        "Name": "glueetl",
        "ScriptLocation": "s3://aws-glue-scripts//prod-job1"
    },
    "DefaultArguments": {
        "--job-bookmark-option": "job-bookmark-enable"
    },
    "ExecutionProperty": {
        "MaxConcurrentRuns": 2
    },
    "MaxRetries": 0,
    "Name": "cf-job1",
    "Role": {
        "Ref": "MyJobRole",
        "Tags": {
            "key1": "value1",
            "key2": "value2"
        }
    }
}
}

AWS CloudFormation YAML

Description: AWS Glue Job Test Tags
Resources:
MyJobRole:
    Type: AWS::IAM::Role
    Properties:
        AssumeRolePolicyDocument:
            Version: '2012-10-17'
            Statement:
                - Effect: Allow
                    Principal:
                        Service:
                            - glue.amazonaws.com
                    Action:
                        - sts:AssumeRole
            Path: "/"
    Policies:
- PolicyName: root
  PolicyDocument:
    Version: '2012-10-17'
    Statement:
      - Effect: Allow
        Action: "*"
        Resource: "*"

MyJob:
  Type: AWS::Glue::Job
  Properties:
    Command:
      Name: glueetl
      ScriptLocation: s3://aws-glue-scripts//prod-job1
    DefaultArguments:
      "--job-bookmark-option": job-bookmark-enable
    ExecutionProperty:
      MaxConcurrentRuns: 2
    MaxRetries: 0
    Name: cf-job1
    Role:
      Ref: MyJobRole
    Tags:
      key1: value1
      key2: value2

For more information, see [AWS Tagging Strategies](#).

For information about how to control access using tags, see [ABAC with AWS Glue](#).

**Automating AWS Glue with CloudWatch Events**

You can use Amazon CloudWatch Events to automate your AWS services and respond automatically to system events such as application availability issues or resource changes. Events from AWS services are delivered to CloudWatch Events in near real time. You can write simple rules to indicate which events are of interest to you, and what automated actions to take when an event matches a rule. The actions that can be automatically triggered include the following:

- Invoking an AWS Lambda function
- Invoking Amazon EC2 Run Command
- Relaying the event to Amazon Kinesis Data Streams
- Activating an AWS Step Functions state machine
• Notifying an Amazon SNS topic or an Amazon SQS queue

Some examples of using CloudWatch Events with AWS Glue include the following:

• Activating a Lambda function when an ETL job succeeds
• Notifying an Amazon SNS topic when an ETL job fails

The following CloudWatch Events are generated by AWS Glue.

• Events for "detail-type":"Glue Job State Change" are generated for SUCCEEDED, FAILED, TIMEOUT, and STOPPED.
• Events for "detail-type":"Glue Job Run Status" are generated for RUNNING, STARTING, and STOPPING job runs when they exceed the job delay notification threshold. You must set the job delay notification threshold property to receive these events.

Only one event is generated per job run status when the job delay notification threshold is exceeded.

• Events for "detail-type":"Glue Crawler State Change" are generated for Started, Succeeded, and Failed.

• Events for "detail-type":"Glue Data Catalog Database State Change" are generated for CreateDatabase, DeleteDatabase, CreateTable, DeleteTable and BatchDeleteTable. For example, if a table is created or deleted, a notification is sent to CloudWatch Events. Note that you cannot write a program that depends on the order or existence of notification events, as they might be out of sequence or missing. Events are emitted on a best effort basis. In the details of the notification:
  • The typeOfChange contains the name of the API operation.
  • The databaseName contains the name of the affected database.
  • The changedTables contains up to 100 names of affected tables per notification. When table names are long, multiple notifications might be created.

• Events for "detail-type":"Glue Data Catalog Table State Change" are generated for UpdateTable, CreatePartition, BatchCreatePartition, UpdatePartition, DeletePartition, BatchUpdatePartition and BatchDeletePartition. For example, if a table or partition is updated, a notification is sent to CloudWatch Events. Note that you cannot write a program that depends on the order or existence of notification events, as they might
be out of sequence or missing. Events are emitted on a best effort basis. In the details of the notification:

- The `typeOfChange` contains the name of the API operation.
- The `databaseName` contains the name of the database that contains the affected resources.
- The `tableName` contains the name of the affected table.
- The `changedPartitions` specifies up to 100 affected partitions in one notification. When partition names are long, multiple notifications might be created.

For example if there are two partition keys, `Year` and `Month`, then "2018,01", "2018,02" modifies the partition where "Year=2018" and "Month=01" and the partition where "Year=2018" and "Month=02".

```
{
   "version":"0",
   "id":"abcdef00-1234-5678-9abc-def012345678",
   "detail-type":"Glue Data Catalog Table State Change",
   "source":"aws.glue",
   "account":"123456789012",
   "time":"2017-09-07T18:57:21Z",
   "region":"us-west-2",
   "resources": ["arn:aws:glue:us-west-2:123456789012:database/default/foo"],
   "detail":{
      "changedPartitions": ["2018,01", "2018,02"],
      "databaseName": "default",
      "tableName": "foo",
      "typeOfChange": "BatchCreatePartition"
   }
}
```

For more information, see the [Amazon CloudWatch Events User Guide](https://docs.aws.amazon.com/AmazonCloudWatch/latest/events/CloudWatchEventsOverview.html). For events specific to AWS Glue, see [AWS Glue Events](https://docs.aws.amazon.com/glue/latest/dg/glue-events.html).

**AWS Glue resource monitoring**

AWS Glue has service limits to protect customers from unexpected excessive provisioning and from malicious actions intended to increase your bill. The limits also protect the service. Logging into
the AWS Service Quota console, customers can view their current resource limits and request an increase (where appropriate).

AWS Glue allows you to view the service's resource usage as a percentage in Amazon CloudWatch and to configure CloudWatch alarms on it to monitor usage. Amazon CloudWatch provides monitoring for AWS resources and the customer applications running on the Amazon infrastructure. The metrics are free of charge to you. The following metrics are supported:

- Number of workflows per account
- Number of triggers per account
- Number of jobs per account
- Number of concurrent job runs per account
- Number of blueprints per account
- Number of interactive sessions per account

**Configuring and using resource metrics**

To use this feature, you can go to the Amazon CloudWatch console to view the metrics and configure alarms. The metrics are under the AWS/Glue namespace and are a percentage of the actual resource usage count divided by the resource quota. The CloudWatch metrics are delivered to your accounts, which will be no cost for you. For example, if you have 10 workflows created, and your service quota allows you to have 200 workflows in maximum, then your usage is 10/200 = 5%, and in graph, you will see a datapoint of 5 as a percentage. To be more specific:

```
Namespace: AWS/Glue
Metric name: ResourceUsage
Type: Resource
Resource: Workflow (or Trigger, Job, JobRun, Blueprint, InteractiveSession)
Service: Glue
Class: None
```
To create an alarm on a metric in the CloudWatch console:

1. Once you locate the metric, go to **Graphed metrics**.
2. Click **Create alarm** under **Actions**.
3. Configure the alarm as needed.

We emit metrics whenever your resource usage has a change (such as an increase or decrease). But if your resource usage doesn't change, we emit metrics hourly, so that you have a continuous CloudWatch graph. To avoid having missing data points, we do not recommend you to configure a period less than 1 hour.

You can also configure alarms using AWS CloudFormation as in the following example. In this example, once the workflow resource usage reaches 80%, it triggers an alarm to send a message to the existing SNS topic, where you can subscribe to it to get notifications.

```json
{
   "Type": "AWS::CloudWatch::Alarm",
   "Properties": {
      "AlarmName": "WorkflowUsageAlarm",
      "ActionsEnabled": true,
      "OKActions": [],
      "AlarmActions": [
         "arn:aws:sns:af-south-1:085425700061:Default_CloudWatch_Alarms_Topic"
      ],
      "InsufficientDataActions": []
   }
}
```
Logging AWS Glue API calls with AWS CloudTrail

AWS Glue is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in AWS Glue. CloudTrail captures all API calls for AWS Glue as events. The calls captured include calls from the AWS Glue console and code calls to the AWS Glue API operations. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for AWS Glue. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in Event history. Using the information collected by CloudTrail, you can determine the request that was made to AWS Glue, the IP address from which the request was made, who made the request, when it was made, and additional details.

To learn more about CloudTrail, see the AWS CloudTrail User Guide.
AWS Glue information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in AWS Glue, that activity is recorded in a CloudTrail event along with other AWS service events in Event history. You can view, search, and download recent events in your AWS account. For more information, see Viewing Events with CloudTrail Event History.

For an ongoing record of events in your AWS account, including events for AWS Glue, create a trail. A trail enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all AWS Regions. The trail logs events from all Regions in the AWS partition and delivers the log files to the Amazon S3 bucket that you specify. Additionally, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see the following:

- Creating a trail for your AWS account
- CloudTrail supported services and integrations
- Configuring Amazon SNS Notifications for CloudTrail
- Receiving CloudTrail Log Files from Multiple Regions and Receiving CloudTrail Log Files from Multiple Accounts

All AWS Glue actions are logged by CloudTrail and are documented in the AWS Glue API. For example, calls to the CreateDatabase, CreateTable and CreateScript actions generate entries in the CloudTrail log files.

Every event or log entry contains information about who generated the request. The identity information helps you determine the following:

- Whether the request was made with root or IAM user credentials.
- Whether the request was made with temporary security credentials for a role or federated user.
- Whether the request was made by another AWS service.

For more information, see the CloudTrail userIdentity Element.

However, CloudTrail doesn't log all information regarding calls. For example, it doesn't log certain sensitive information, such as the ConnectionProperties used in connection requests, and it logs a null instead of the responses returned by the following APIs:
Understanding AWS Glue log file entries

A trail is a configuration that enables delivery of events as log files to an Amazon S3 bucket that you specify. CloudTrail log files contain one or more log entries. An event represents a single request from any source and includes information about the requested action, the date and time of the action, request parameters, and so on. CloudTrail log files aren't an ordered stack trace of the public API calls, so they don't appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the DeleteCrawler action.

```json
{
    "eventVersion": "1.05",
    "userIdentity": {
        "type": "IAMUser",
        "principalId": "AKIAIOSFODNN7EXAMPLE",
        "arn": "arn:aws:iam::123456789012:user/johndoe",
        "accountId": "123456789012",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "userName": "johndoe"
    },
    "eventTime": "2017-10-11T22:29:49Z",
    "eventSource": "glue.amazonaws.com",
    "eventName": "DeleteCrawler",
    "awsRegion": "us-east-1",
    "sourceIPAddress": "72.21.198.64",
    "userAgent": "aws-cli/1.11.148 Python/3.6.1 Darwin/16.7.0 botocore/1.7.6",
    "requestParameters": {
        "name": "tes-alpha"
    },
    "responseElements": null,
    "requestID": "b16f4050-aed3-11e7-b0b3-75564a46954f",
    "eventID": "e73dd117-cfd1-47d1-9e2f-d1271cad838c"
}
```
This example shows a CloudTrail log entry that demonstrates a `CreateConnection` action.

```json
{
   "eventType": "AwsApiCall",
   "recipientAccountId": "123456789012"
}
```

```json
{
   "eventVersion": "1.05",
   "userIdentity": {
      "type": "IAMUser",
      "principalId": "AKIAIOSFODNN7EXAMPLE",
      "arn": "arn:aws:iam::123456789012:user/johndoe",
      "accountID": "123456789012",
      "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
      "userName": "johndoe"
   },
   "eventTime": "2017-10-13T00:19:19Z",
   "eventSource": "glue.amazonaws.com",
   "eventName": "CreateConnection",
   "awsRegion": "us-east-1",
   "sourceIPAddress": "72.21.198.66",
   "userAgent": "aws-cli/1.11.148 Python/3.6.1 Darwin/16.7.0 botocore/1.7.6",
   "requestParameters": {
      "connectionInput": {
         "name": "test-connection-alpha",
         "connectionType": "JDBC",
         "physicalConnectionRequirements": {
            "subnetId": "subnet-323232",
            "availabilityZone": "us-east-1a",
            "securityGroupIdList": [
               "sg-12121212"
            ]
         }
      }
   },
   "responseElements": null,
   "requestID": "27136ebc-afac-11e7-a7d6-ab217e5c3f19",
   "eventID": "e8b3baeb-c511-4597-880f-c16210c60a4a",
   "eventType": "AwsApiCall",
   "recipientAccountId": "123456789012"
}
```
AWS Glue job run statuses

You can view the status of an AWS Glue extract, transform, and load (ETL) job while it is running or after it has stopped. You can view the status using the AWS Glue console, the AWS Command Line Interface (AWS CLI), or the `GetJobRun` action in the AWS Glue API.

Possible job run statuses are STARTING, RUNNING, STOPPING, STOPPED, SUCCEEDED, FAILED, ERROR, WAITING and TIMEOUT.

The following table lists the statuses that indicate abnormal job termination.

<table>
<thead>
<tr>
<th>Job run status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAILED</td>
<td>The job exceeded its maximum allowed concurrent runs, or terminated with an unknown exit code.</td>
</tr>
<tr>
<td>ERROR</td>
<td>A workflow, schedule trigger, or event trigger attempted to run a deleted job.</td>
</tr>
<tr>
<td>TIMEOUT</td>
<td>The job run time exceeded its specified timeout value.</td>
</tr>
</tbody>
</table>

The WAITING status indicates a job run is waiting for resources. The following table describes wait behavior for different classes of jobs.

<table>
<thead>
<tr>
<th>Job type</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spark jobs (Standard)</td>
<td>Jobs that have not been configured to retry based on your <code>maxRetries</code> configuration may enter the WAITING state. A new job run will be in the WAITING state if the service is not able acquire enough resources to start the run. This may occur due to service quotas for your account or capacity limits in your region encountering one of the following error cases:</td>
</tr>
</tbody>
</table>
### Job type

<table>
<thead>
<tr>
<th>Job type</th>
<th>Behavior</th>
</tr>
</thead>
</table>
|                      | • Max concurrent job runs per account exceeded  
|                      | • Max concurrent job runs per job exceeded (includes the account level service quota as well as the limit you specify on the job with MaxConcurrentRuns)  
|                      | • Max concurrent compute (DPU usage) exceeded  
|                      | • Resource unavailable  
|                      | For more information about AWS Glue service quotas, see [AWS Glue endpoints and quotas](#).  
|                      | The time AWS Glue will wait for resources may differ based on circumstances. A job may transition between non-terminal statuses as it attempts to acquire resources. Eventually, the job will transition to FAILED if it cannot acquire resources. AWS Glue will retry for a maximum of 15 minutes or 10 attempts, whichever comes first. |

**Spark jobs (Flex)**  
A new job run will be in the WAITING state if the service is not able acquire enough resources to start the run, which delays the starting of the run. The run will be in WAITING state for a maximum of 20 minutes (timeout controlled by the service). After 15 minutes, the service will try to do a force start and depending on available capacity the run may start or fail with an appropriate error message.

**Python shell jobs**  
Same behavior as standard jobs using Spark.
AWS Glue Data Quality

AWS Glue Data Quality allows you to measure and monitor the quality of your data so that you can make good business decisions. Built on top of the open-source DeeQu framework, AWS Glue Data Quality provides a managed, serverless experience. AWS Glue Data Quality works with Data Quality Definition Language (DQDL), which is a domain specific language that you use to define data quality rules. To learn more about DQDL and supported rule types, see [Data Quality Definition Language (DQDL) reference](#).

For additional product details and pricing, see the service page for [AWS Glue Data Quality](#).

**Benefits and key features**

Benefits and key features of AWS Glue Data Quality include:

- **Serverless** – there is no installation, patching or maintenance.
- **Get started quickly** – AWS Glue Data Quality quickly analyzes your data and creates data quality rules for you. You can get started with two clicks: “Create Data Quality Rules → Recommend rules”.
- **Detect data quality issues** – Use machine learning (ML) to detect anomalies and hard-to-detect data quality issues.
- **Improvise your rules** – with 25+ out-of-the-box DQ rules to start from, you can create rules that suit your specific needs.
- **Evaluate quality and make confident business decisions** – Once you evaluate the rules, you get a Data Quality score that provides an overview of the health of your data. Use Data Quality score to make confident business decisions.
- **Zero in on bad data** – AWS Glue Data Quality helps you identify the exact records that caused your quality scores to go down. Easily identify them, quarantine and fix them.
- **Pay as you go** – There are no annual licenses you need to use AWS Glue Data Quality.
- **No lock-in** – AWS Glue Data Quality is built on open source DeeQu, allowing you to keep the rules you are authoring in an open language.
- **Data quality checks** – AWS Glue Data Quality You can enforce data quality checks on Data Catalog and AWS Glue ETL pipelines allowing you to manage data quality at rest and in transit.
- **ML-based data quality detection** – Use machine learning (ML) to detect anomalies and hard-to-detect data quality issues.
How it works

There are two entry points for AWS Glue Data Quality: the AWS Glue Data Catalog and AWS Glue ETL jobs. This section provides an overview of the use cases and AWS Glue features that each entry point supports.

Data quality for the AWS Glue Data Catalog

AWS Glue Data Quality evaluates objects that are stored in the AWS Glue Data Catalog. It offers non-coders an easy way to set up data quality rules. These personas include data stewards and business analysts.

You might choose this option for the following use cases:

- You want to perform data quality tasks on data sets that you've already cataloged in the AWS Glue Data Catalog.
- You work on data governance and need to identify or evaluate data quality issues in your data lake on an ongoing basis.

You can manage data quality for the Data Catalog using the following interfaces:

- The AWS Glue management console
- AWS Glue APIs

To get started with AWS Glue Data Quality for the AWS Glue Data Catalog see [Getting started with AWS Glue Data Quality for the Data Catalog](#).

Data quality for AWS Glue ETL jobs

AWS Glue Data Quality for AWS Glue ETL jobs lets you perform proactive data quality tasks. Proactive tasks help you identify and filter out bad data before you load a data set into your data lake.

**Video: Introducing AWS Glue Data Quality for ETL Pipelines**

You might choose data quality for ETL jobs for the following use cases:

- You want to incorporate data quality tasks into your ETL jobs
• You want to write code that defines data quality tasks in ETL scripts
• You want to manage the quality of data that flows in your visual data pipelines

You can manage data quality for ETL jobs using the following interfaces:

• AWS Glue Studio, AWS Glue Studio notebooks, and AWS Glue interactive sessions
• AWS Glue libraries for ETL scripting
• AWS Glue APIs

To get started with data quality for ETL jobs, see Tutorial: Getting started with Data Quality in the AWS Glue Studio User Guide.

**Comparing data quality for the Data Catalog to data quality for ETL jobs**

This table provides an overview of features that each entry point for AWS Glue Data Quality supports.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Data quality for the Data Catalog</th>
<th>Data quality for ETL jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data sources</td>
<td>Amazon S3, Amazon Redshift, JDBC sources compatible with the Data Catalog, and transactional data lake formats such as Apache Iceberg, Apache Hudi, and Delta Lake.</td>
<td>All data sources supported by AWS Glue, including custom connectors and third-party connectors.</td>
</tr>
<tr>
<td>Data Quality rule recommendations</td>
<td>Supported</td>
<td>Not supported</td>
</tr>
<tr>
<td>Author and run DQDL rules</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Auto scaling</td>
<td>Not supported</td>
<td>Supported</td>
</tr>
<tr>
<td>AWS Glue Flex support</td>
<td>Not supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Feature</td>
<td>Data quality for the Data Catalog</td>
<td>Data quality for ETL jobs</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Supported when evaluating Data Quality rules and via Step Functions.</td>
<td>Supported when using Step Functions and workflows.</td>
</tr>
<tr>
<td>Identifying records that failed data quality checks</td>
<td>Not supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Integration with Amazon Eventbridge</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Integration with AWS Cloudwatch</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Writing data quality results to Amazon S3</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>Incremental data quality</td>
<td>Supported via pushdown predicates</td>
<td>Supported via AWS Glue bookmarks</td>
</tr>
<tr>
<td>AWS CloudFormation support</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>ML-based anomaly detection</td>
<td>Not supported</td>
<td>Preview - available for AWS Glue 4.0 only</td>
</tr>
<tr>
<td>Dynamic rules</td>
<td>Not supported</td>
<td>Supported</td>
</tr>
</tbody>
</table>

**Considerations**

Consider the following items before you use AWS Glue Data Quality:

- Data quality rules can't evaluate nested or list-type data sources. See [Flatten nested structs](#).

**Terminology**

The following list defines terms that are related to AWS Glue Data Quality.
Data Quality Definition Language (DQDL)

A domain-specific language that you can use to write AWS Glue Data Quality rules.

To learn more about DQDL, see the Data Quality Definition Language (DQDL) reference guide.

data quality

Describes how well a dataset serves its specific purpose. AWS Glue Data Quality evaluates rules against a dataset to measure data quality. Each rule checks for particular characteristics like data freshness or integrity. To quantify data quality, you can use a data quality score.

data quality score

The percentage of data quality rules that pass (result in true) when you evaluate a ruleset with AWS Glue Data Quality.

rule

A DQDL expression that checks your data for a specific characteristic and returns a Boolean value. For more information, see Rule structure.

analyzer

A DQDL expression that gathers data statistics. An analyzer gathers data statistics that can be used by ML algorithms to detect anomalies and hard-to-detect data quality issues over time.

ruleset

An AWS Glue resource that comprises a set of data quality rules. A ruleset must be associated with a table in the AWS Glue Data Catalog. When you save a ruleset, AWS Glue assigns an Amazon Resource Name (ARN) to the ruleset.

data quality score

The percentage of data quality rules that pass (result in true) when you evaluate a ruleset with AWS Glue Data Quality.

observation

An unconfirmed insight generated by AWS Glue by analyzing data statistics gathered from rules and analyzers over time.

Release notes for AWS Glue Data Quality

This topic describes features introduced in AWS Glue Data Quality.
General availability: new features

The following new features are available with the general availability of AWS Glue Data Quality:

- The ability to identify which records failed data quality checks is now supported in AWS Glue Studio
- New data quality ruletypes such as validating referential integrity of data between two data sets, comparing data between two datasets, and data type checks
- Improved user experience in the AWS Glue Data Catalog
- Support for Apache Iceberg, Apache Hudi and Delta Lake
- Support for Amazon Redshift
- Simplified notification with Amazon Eventbridge
- AWS CloudFormation support for creating rulesets
- Performance improvements: caching option in ETL and AWS Glue Studio for faster performance when evaluating data quality

Nov 27, 2023 (Preview)

- ML-powered anomaly detection capabilities are now available in AWS Glue ETL and AWS Glue Studio. With this, you can now detect anomalies and hard-to-detect data quality issues.
- Dynamic Rules allows you to provide dynamic thresholds (ex: RowCount > avg(last(10))).

Anomaly detection in AWS Glue Data Quality

⚠️ Note
AWS Glue Data Quality is available in preview in the following regions:

- US East (Ohio, N. Virginia)
- US West (Oregon)
- Asia Pacific (Tokyo)
- Europe (Ireland)
AWS Glue Data Quality anomaly detection applies machine learning (ML) algorithms on data statistics over time to detect abnormal patterns and hidden data quality issues that are hard to detect through rules. At present, anomaly detection is only available for AWS Glue 4.0. This feature is currently available only in AWS Glue Studio Visual ETL and AWS Glue ETL. This capability doesn't work on AWS Glue Studio Notebooks, Interactive Sessions and AWS Glue Data Previews.

**How it works**

When evaluating Data Quality rules, AWS Glue captures data statistics needed to determine whether the data conforms with the rules. For example, Data Quality will compute the number of distinct values in a dataset, and then compare that value to the expectation.

The Data Quality rule engine compares the statistic value with the defined thresholds, and evaluates your quality requirements. As these statistics are collected over time, you can enable anomaly detection on your ETL pipelines to let AWS Glue learn from past statistics and report hidden patterns as Observations. Observations are unconfirmed insights that AWS Glue's ML algorithm identifies. They come with recommended Data Quality rules that you can apply to your ruleset for monitoring of the discovered pattern. We recommend running jobs at a regular schedule (for example, hourly and daily). Irregular runs might produce poor insights.
Using analyzers to inspect your data

Sometimes, you might not have the time to author data quality rules. This is where analyzers come in handy. Analyzers are part of your ruleset and are very simple to configure. For example, you can write this in your ruleset:

```
Analyzers = [
    RowCount,
    Completeness "AllColumns"
]
```

This will gather the following statistics:

- Row Count for the entire dataset
- Completeness of every column in your dataset

We recommend using Analyzers because you won't have to worry about the thresholds. You can run your data pipelines and after three runs, AWS Glue Data Quality will start generating observations and rule recommendations when it notices any anomalies. You can review the observations, associated statistics and can easily incorporate the rule recommendations in your ruleset. To get started see Configuring Anomaly detection and generating insights. Note that Analyzers will not impact your data quality scores. They generate statistics that can be analyzed over time to generate observations.

Using the DetectAnomaly Rule

Sometimes, you want your jobs to fail when it detects anomalies. To enforce a constraint, you must configure a rule. Analyzers won't stop a job. Instead, they will gather statistics and analyze the data. Configuring the DetectAnomaly rule in the rules section of the ruleset will confirm that the DQ scan reports the job has failed to pass all the rules in the scan.

Benefits and use cases of Anomaly Detection

Engineers may manage hundreds of data pipelines at any given time. Each pipeline can extract data from different sources and load it into the data lake. Since each pipeline might extract data from a different source and load it into data lake, it is difficult to get immediate feedback on the data – whether its shape has changed significantly, or it has diverged from existing trends.
In the past, upstream data sources have changed without warning to data engineering teams, introducing hard-to-track “data bugs” into this process. By adding Data Quality nodes to jobs, this makes life much easier, as jobs fail when issues are spotted. However, this doesn't remove all the failure modes that data teams are worried about, which keeps the door open for other data bugs to come in.

One failure mode is around data volume. As a company's data store grows over time, the number of records produced by data pipelines may grow exponentially. Every week, data teams may need to manually update ETL jobs to increase each Data Quality rule that sets a limit to the number of rows ingested.

Another failure mode is that some of the data quality rule limits are very wide to accommodate the fact that transaction volume varies by day of the week. On weekends, there are almost no transactions, and on Mondays there are about three times more transaction than on other weekdays. Data teams have two options - either implement logic to change the ruleset on the fly depending on the day, or set a very wide expectation.

Finally, data teams are also concerned with less well-defined data bugs. Models have been trained on data with specific characteristics, and if these start skewing in unexpected ways, the team wants to know. For example, in February a company may expand to Montana, and so transactions started containing the “MT” code appear more frequently. This may break the ML inference, and as a result the models falsely predicted that every single Montana transaction was fraudulent.

This is where Data quality anomaly detection can help solve these problems. Some of the benefits of Data Quality anomaly detection include:

- Scanning of data on a scheduled, event-driven, or manual basis.
- Detection of anomalies that can be indicative of an unintended event, seasonality, or statistical abnormality.
- Offer Rule Recommendations to take action on observations found by Data Quality anomaly detection.

This is useful if you:

- want to detect anomalies on your data automatically without the need to write data quality rules.
- want to catch potential problems in your data that data quality rules alone can't find.
• want to automate some tasks that evolve over time, such as limiting the number of rows ingested for data quality monitoring.

**Configure IAM permissions for AWS Glue Data Quality**

This topic provides information to help you understand the actions and resources that you an IAM administrator can use in an AWS Identity and Access Management (IAM) policy for AWS Glue Data Quality. It also includes sample IAM policies with the minimum permissions you need to use AWS Glue Data Quality with the AWS Glue Data Catalog.

For additional information about security in AWS Glue, see Security in AWS Glue.

**IAM permissions for AWS Glue Data Quality**

The following table lists the permissions that a user needs in order to perform specific AWS Glue Data Quality operations. To set fine-grained authorization for AWS Glue Data Quality, you can specify these actions in the Action element of an IAM policy statement.

**AWS Glue Data Quality actions**

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
<th>Resource types</th>
</tr>
</thead>
<tbody>
<tr>
<td>glue:CreateDataQualityRuleset</td>
<td>Grants permission to create a data quality ruleset.</td>
<td>::dataQualityRuleset/&lt;name&gt;</td>
</tr>
<tr>
<td>glue:DeleteDataQualityRuleset</td>
<td>Grants permission to delete a data quality ruleset.</td>
<td>::dataQualityRuleset/&lt;name&gt;</td>
</tr>
<tr>
<td>glue:GetDataQualityRuleset</td>
<td>Grants permission to retrieve a data quality ruleset.</td>
<td>::dataQualityRuleset/&lt;name&gt;</td>
</tr>
<tr>
<td>glue:GetDataQualityResult</td>
<td>Grants permission to retrieve a data quality task run result.</td>
<td>::dataQualityRuleset/&lt;name&gt;</td>
</tr>
<tr>
<td>glue:ListDataQualityRulesets</td>
<td>Grants permission to retrieve all data quality rulesets.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:UpdateDataQualityRuleset</td>
<td>Grants permission to update a data quality ruleset.</td>
<td>::dataQualityRuleset/&lt;name&gt;</td>
</tr>
<tr>
<td>Action</td>
<td>Description</td>
<td>Resource types</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>glue:ListDataQualityResults</td>
<td>Grants permission to retrieve all data quality task run results.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:CancelDataQualityRuleRecommendationRun</td>
<td>Grants permission to stop an in-progress data quality recommendation task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:GetDataQualityRuleRecommendationRun</td>
<td>Grants permission to retrieve a data quality recommendation task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:ListDataQualityRuleRecommendationRuns</td>
<td>Grants permission to retrieve all data quality recommendation task runs.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:StartDataQualityRuleRecommendationRun</td>
<td>Grants permission to start a data quality recommendation task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:CancelDataQualityRulesetEvaluationRun</td>
<td>Grants permission to stop an in-progress data quality task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:GetDataQualityRulesetEvaluationRun</td>
<td>Grants permission to retrieve a data quality task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:ListDataQualityRulesetEvaluationRuns</td>
<td>Grants permission to retrieve all data quality task runs.</td>
<td>::dataQualityRuleset/*</td>
</tr>
<tr>
<td>glue:StartDataQualityRulesetEvaluationRun</td>
<td>Grants permission to start a data quality task run.</td>
<td>::dataQualityRuleset/*</td>
</tr>
</tbody>
</table>
IAM setup required for scheduling evaluation runs

IAM permissions

To run scheduled Data Quality evaluation runs, you must add the IAM:PassRole action to the permissions policy.

AWS EventBridge Scheduler required permissions

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
<th>Resource types</th>
</tr>
</thead>
<tbody>
<tr>
<td>iam:PassRole</td>
<td>Grants permission for IAM to allow the user to pass the approved roles.</td>
<td>ARN of the role used to call StartDataQualityRulesetEvaluationRun</td>
</tr>
</tbody>
</table>

Without these permissions the following error occurs:

```
"errorCode": "AccessDenied"
"errorMessage": "User: arn:aws:sts::account_id:assumed-role/AWSGlueServiceRole is not authorized to perform: iam:PassRole on resource: arn:aws:iam::account_id:role/service-role/AWSGlueServiceRole because no identity-based policy allows the iam:PassRole action"
```

IAM trusted entities

The AWS Glue and AWS EventBridge Scheduler services need to be listed in the trusted entities in order to create and run a scheduled StartDataQualityEvaluationRun.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
```
Example IAM policies

An IAM role for AWS Glue Data Quality needs the following types of permissions:

- Permissions for AWS Glue Data Quality operations so that you can get recommended data quality rules and run a data quality task against a table in the AWS Glue Data Catalog. The example IAM policies in this section include the minimum permissions required for AWS Glue Data Quality operations.

- Permissions that grant access to your Data Catalog table and the underlying data. These permissions vary depending on your use case. For example, for data that you catalog in Amazon S3, the permissions should include access to Amazon S3.

  Note
  You must configure Amazon S3 permissions in addition to the permissions described in this section.

Minimum permissions to get recommended data quality rules

This example policy includes the permissions you need in order to generate recommended data quality rules.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Service": "glue.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    },
    {
      "Effect": "Allow",
      "Principal": {
        "Service": "scheduler.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```
Example IAM policies

```json
{
    "Sid": "AllowGlueRuleRecommendationRunActions",
    "Effect": "Allow",
    "Action": [
        "glue:GetDataQualityRuleRecommendationRun",
        "glue:PublishDataQuality",
        "glue:CreateDataQualityRuleset"
    ],
},
{
    "Sid": "AllowCatalogPermissions",
    "Effect": "Allow",
    "Action": [
        "glue:GetPartitions",
        "glue:GetTable"
    ],
    "Resource": [
        "*"
    ]
},
{
    "Sid": "AllowS3GetObjectToRunRuleRecommendationTask",
    "Effect": "Allow",
    "Action": [
        "s3:GetObject"
    ],
    "Resource": "arn:aws:s3:::aws-glue-*"
},
{
    // Optional for Logs
    "Sid": "AllowPublishingCloudwatchLogs",
    "Effect": "Allow",
    "Action": [
        "logs:CreateLogStream",
        "logs:CreateLogGroup",
        "logs:PutLogEvents"
    ],
    "Resource": "*"
}
}
```
Minimum permissions to run a data quality task

This example policy includes the permissions you need in order to run a data quality evaluation task.

The following policy statements are optional, depending on your use case:

- **AllowCloudWatchPutMetricDataToPublishTaskMetrics** - Required if you want to publish data quality run metrics to Amazon CloudWatch.
- **AllowS3PutObjectToWriteTaskResults** - Required if you want to write data quality run results to Amazon S3.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "AllowGlueGetDataQualityRuleset",
            "Effect": "Allow",
            "Action": ["glue:GetDataQualityRuleset"],
        },
        {
            "Sid": "AllowGlueRulesetEvaluationRunActions",
            "Effect": "Allow",
            "Action": ["glue:GetDataQualityRulesetEvaluationRun", "glue:PublishDataQuality"],
        },
        {
            "Sid": "AllowCatalogPermissions",
            "Effect": "Allow",
            "Action": ["glue:GetPartitions", "glue:GetTable"],
            "Resource": ["*"]
        }
    ]
}
```
Getting started with AWS Glue Data Quality for the Data Catalog

This getting started section provides instructions to help you get started with AWS Glue Data Quality on the AWS Glue console. You'll learn how to complete essential tasks such as generating data quality rule recommendations and evaluating a ruleset against your data.

**Topics**
Prerequisites

Before you use AWS Glue Data Quality, you should be familiar with using the Data Catalog and crawlers in AWS Glue. With AWS Glue Data Quality, you can evaluate quality for tables in a Data Catalog database. You also need the following:

- A table in the Data Catalog to evaluate your data quality ruleset against.
- An IAM role for AWS Glue that you supply when you generate rule recommendations or run a data quality task. This role must have permission to access resources that various AWS Glue Data Quality processes require to run on your behalf. These resources include AWS Glue, Amazon S3, and CloudWatch. To view example policies that include the minimum permissions for AWS Glue Data Quality, see Example IAM policies.

To learn more about IAM roles for AWS Glue, see Create an IAM policy for the AWS Glue service and Create an IAM role for the AWS Glue service. You can also view a list of all AWS Glue permissions that are specific to data quality in Authorization for AWS Glue Data Quality actions.

- A database with at least one table that contains a variety of data. The table used in this tutorial is named yyz-tickets, with the table tickets. This data is a collection of publicly available information from the City of Toronto for parking citations. If you create your own table, make sure that it's populated with a variety of valid data to get the best set of recommended rules.

Step-by-step example

For a step-by-step example with sample datasets, see the AWS Glue Data Quality blog post.
Generating rule recommendations

Rule recommendations make it easy to get started with data quality without writing code. With AWS Glue Data Quality, you can analyze your data, identify rules, and create a ruleset that you can evaluate in a data quality task. Recommendation runs are automatically deleted after 90 days.

To generate data quality rule recommendations

2. Choose Tables in the navigation pane. Then choose the table that you want to generate data quality rule recommendations for.
3. On the table details page, select the Data quality tab to access AWS Glue Data Quality rules and settings for your table.
4. On the Data quality tab, choose Add rules and monitor data quality.
5. On the Ruleset builder page, an alert at the top of the page will prompt you to start a recommendation task if there are no rule recommendation runs.
6. Choose Recommend rules to open the modal and input your parameters for the recommendation task.
7. Choose an IAM role with access to AWS Glue. This role must have permission to access resources that various AWS Glue Data Quality processes require to run on your behalf.
8. After the fields are completed according to your preferences, choose Recommend rules to start the recommendation task run. If recommendation runs are in progress or completed, you can manage your runs in this alert. You might need to refresh the alert to view the status change. Completed and in-progress recommendation task runs appear in the Run history page that lists all recommendation runs for the past 90 days.

What the recommended rules mean

AWS Glue Data Quality generates rules based on the data from each column of the input table. It uses the rules to identify potential boundaries where data can be filtered to maintain quality requirements. The following list of generated rules includes examples that are useful for understanding what the rules mean and what they might do when applied to your data.

For a full list of the generated Data Quality Definition Language (DQDL) rule types, see DQDL rule type reference.
• IsComplete "SET_FINE_AMOUNT" – The IsComplete rule verifies that the column is filled in for any given row. Use this rule to tag columns as non-optional in data.

• Uniqueness "TICKET_NUMBER" > 0.95 – The Uniqueness rule verifies that the data within the column meets some threshold of uniqueness. In this example, the data that populates any given row for "TICKET_NUMBER" was determined to be at most 95% identical in content to all other rows, which suggests this rule.

• ColumnValues "PROVINCE" in ["ON", "QC", "AB", "NY",...] – The ColumnValues rule defines valid values for the column, based on existing column contents. In this example, the data for each row is a 2-letter license code plate for a state or province.

• ColumnLength "INFRACTION_DESCRIPTION" between 15 and 31 – The ColumnLength rule enforces a length restriction on a column's data. This rule is generated from the sample data based on the minimum and maximum recorded lengths for a column of strings.

### Monitoring rule recommendations

When data quality rule recommendations are running, the **Add rules and monitor data quality** page displays information and additional actions that you can take in the top bar.

When rule recommendations are in progress, you can choose **Stop run** before the recommendation task is complete. While the task is in progress, you will see the status, **in progress**, and the date and time when the run started.

When the rule recommendations are complete, the rule recommendation bar displays the number of rules recommended, the status of the last recommendation run, and the date and timestamp when it finished.

You can add the recommended rules by choosing **Insert Rule Recommendation**. To view previously recommended rules, select a specific date. To run a new recommendation, choose **More actions**, and then choose **Recommended rules**.

Set default settings by choosing **Manage user settings**. You can set the default path for Amazon S3 to store rulesets or to set up a default role to run the Data Catalog.

### Editing recommended rule sets

Because AWS Glue Data Quality generates rules based on existing data that you have available, you might see some unexpected or undesirable rules in the automated suggestions. In order to get the most out of the recommended rulesets, you need to evaluate and modify them. For this step
of the tutorial, you take the rules generated in the previous step and adjust them to enforce more restrictive qualities on some data. You also relax other rules to ensure that correct, unique data can be added later.

**Edit a suggested ruleset**

1. In the AWS Glue console, choose **Data Catalog**, and then choose **Databases tables** in the navigation pane. Choose the table **tickets**.

2. On the table details page, choose the **Data quality** tab to access AWS Glue Data Quality rules and settings for the table.

3. In the **Rulesets** section, select the ruleset generated in [Generating rule recommendations](#).

4. Choose **Actions**, and then choose **Edit** in the console window. The ruleset editor loads in the console. It includes an editing pane for your rules and a quick reference for DQDL.

5. Remove line 2 of the script. This relaxes the requirement that the database size is constrained within a certain number of rows. After the edit, your file should contain the following on lines 1–3:

   ```
   Rules = [
   IsComplete "TAG_NUMBER_MASKED",
   ColumnLength "TAG_NUMBER_MASKED" between 6 and 9,
   ]
   ```

6. Remove line 25 of the script. This relaxes the requirement that 96% of recorded provinces are ON. After the edit, your file should contain the following from line 24 to the end of the ruleset:

   ```
   "VA", "TX", "NF", "MD", "PE", "CT", "NC", "GA", "IN", "OR", "MN", "TN", "WI",
   "UT", "MS", "NM", "ID", "SD", "ND", "AK", "NU", "GO", "WY", "HI"],
   ColumnLength "PROVINCE" = 2
   ]
   ```

7. Change line 14 to the following:

   ```
   IsComplete "TIME_OF_INFRINGEMENT",
   ```

   This **strengthens** the requirement on the column by limiting the database to only tickets that contain a recorded time of infraction. You should always consider tickets without a recorded
time of infraction to be invalid data in this dataset. This is different than situations where partitioning or transformation might be more appropriate for further data use or inspection to determine a quality rule.

8. Choose **Update Ruleset** at the bottom of the console page.

### Creating a new ruleset

A ruleset is a group of data quality rules that you evaluate against your data. In the AWS Glue console, you can author custom rulesets using Data Quality Definition Language (DQDL).

**To create a data quality ruleset**

1. In the AWS Glue console, choose **Data Catalog**, choose **Databases**, and then choose **Tables** in the navigation pane. Select the table **tickets**.

2. Open the **Data quality** tab.

3. In the **Rulesets** section, choose **Create ruleset**. The DQDL editor launches in the console. It has a text area for direct editing, and a quick reference for DQDL rules and the table schema.

4. Start adding rules to the text area of the DQDL editor. You can either write rules directly from this tutorial, or use the **DQDL rule builder** feature of the data quality rules editor.

#### Note

**How to use the DQDL rule builder**

1. Select a rule type from the list, and select the plus sign to insert example syntax into the editor pane.

2. Exchange the placeholder column names with your own column names. Column names from the table are available in the **Schema** tab.

3. Update the expression parameter as you see fit. For a full list of expressions that DQDL supports, see **Expressions**.

As an example, the following rules are constraints for data validation of the **ticket_number** column in the **tickets** table. To add the following rules, use the DQDL rule builder or directly edit your ruleset:
5. Provide a name for your new ruleset in the **Ruleset name** field.

6. Choose **Save ruleset**.

### Evaluating data quality across multiple datasets

You can set up data quality rules across multiple datasets using ReferentialIntegrity and DatasetMatch rulesets. ReferentialIntegrity checks to see if data in the primary dataset is present in other datasets.

To add a reference dataset, choose the **Schema** tab and then choose **Update reference tables**. You will be prompted to select a database and a table. You can add the table and then set up data quality rules. Rule types like AggregateMatch, RowCountMatch, ReferentialIntegrity, SchemaMatch, and DatasetMatch support the ability to perform data quality checks across multiple datasets.

### Running a ruleset to evaluate data quality

When you run a data quality task, AWS Glue Data Quality evaluates a ruleset against your data and calculates a data quality score. This score represents the percentage of data quality rules that passed for the input.

#### To run a data quality task

1. In the AWS Glue console, choose **Data Catalog**, choose **Databases**, and then choose **Tables** in the navigation pane. Select the table tickets.
2. Choose the **Data quality** tab.
3. In the **Rulesets** list, select the ruleset that you want to evaluate against the table. For this step, we recommend using a ruleset that you've written or modified already rather than generated rules. Choose **Run**.
4. In the modal, choose your IAM role. This role must have permission to access resources that various AWS Glue Data Quality processes require to run on your behalf. You can save the IAM role as the default or modify it by going to the **Default Setting** page.
5. Under **Data quality actions**, choose whether you want to **Publish metrics to Amazon CloudWatch**. When this option is selected, AWS Glue Data Quality publishes metrics that
indicate the number of rules that passed and the number of rules that failed. To take action on metrics stored this way, you can use CloudWatch alarms. Key metrics are also published to Amazon EventBridge for you to set up alerts. For more information, see Setting up alerts, deployments, and scheduling.

6. In Run Frequency, choose run on demand or schedule the ruleset. When you schedule a ruleset, you're prompted for a task name. The schedule will be created in Amazon EventBridge. You can edit your schedule in Amazon EventBridge.

7. To save the data quality results in Amazon S3, select a Data quality results location. The IAM role that you previously selected for this task must have write access to this location.

8. Under Additional Configurations, enter the Requested number of workers that you want AWS Glue to allocate for your data quality task.

9. You can optionally set up a filter at the data source. This helps you reduce the data that you're reading. You can also use a filter to run incremental validations by selecting partition information and passing them as parameters via API calls. To improve performance, you can provide a partition predicate.

10. Choose Run. You should see your new task in the Data quality task runs list. When the Run status column for the task shows as Completed, you can view the quality score results. You might need to refresh your console window for the status to update correctly.

11. To view the column for the data quality result details, choose the “+” icon to expand the ruleset. The results show you the rules that passed and failed in the evaluation, and what triggered the rule failure.

Viewing the data quality score and results

To see the latest run on all created rulesets

1. In the AWS Glue console, choose Tables in the navigation pane. Then choose the table that you want to run a data quality task for.

2. Choose the Data quality tab.

3. The Data quality snapshot shows a general trend of runs over time. The last 10 runs over all rulesets are displayed by default. To filter by ruleset, select the desired one from the dropdown list. If there are less than 10 runs, all the completed runs that are available are displayed.

4. In the Data quality table, each ruleset with its latest run (if there is one) is shown, along with the score. Expanding the ruleset displays the rules that are in that ruleset, along with the rule results for that run.
To see the latest run on a particular ruleset

1. In the AWS Glue console, choose Tables in the navigation pane. Then choose the table that you want to run a data quality task for.
2. Choose the Data quality tab.
3. In the Data quality table, choose on a specific ruleset.
4. On the Ruleset details page, choose the Run history tab.

All of the evaluation runs for this particular ruleset are listed in the table within this tab. You can see the history of the scores and the status of the runs.
5. To see more information about a particular run, choose the Run ID to go to the Evaluation run details page. On this page, you can see specifics about the run and more details about the status of individual rule results.

Related topics

- [DQDL rule type reference](#)
- [Data Quality Definition Language (DQDL) reference](#)

Evaluating data quality with AWS Glue Studio

AWS Glue Data Quality evaluates and monitors the quality of your data based on rules that you define. This makes it easy to identify the data that needs action. In AWS Glue Studio, you can add data quality nodes to your visual job to create data quality rules on tables in your Data Catalog. You can then monitor and evaluate changes to your datasets as they evolve over time. For an overview of how to work with AWS Glue Data Quality in AWS Glue Studio, see the following video.

The following are the high-level steps for how you work with AWS Glue Data Quality:

1. **Create data quality rules** – Build a set of data quality rules using the DQDL builder by choosing built-in rulesets that you configure.
2. **Configure a data quality job** – Define actions based on the data quality results and output options.
3. **Save and run a data quality job** – Create and run a job. Saving the job will save the rulesets that you created for the job.
4. **Monitor and review the data quality results** – Review the data quality results after the job run is complete. Optionally, schedule the job for a future date.

**Benefits**

Data analysts, data engineers, and data scientists can use the Evaluate Data Quality node in AWS Glue Studio to analyze, configure, monitor, and improve the quality of data from the visual job editor. The benefits of using the data quality node include the following:

- **You can detect data quality issues** - You can check for issues by creating rules that check characteristics of your datasets.
- **It's easy to get started** - You can start with pre-built rules and actions.
- **Tight integration** - You can use data quality nodes in AWS Glue Studio because AWS Glue Data Quality runs on top of the AWS Glue Data Catalog.

**Evaluating data quality for ETL jobs in AWS Glue Studio**

In this tutorial, you get started with AWS Glue Data Quality in AWS Glue Studio. You will learn how to:

- Create rules using the Data Quality Definition Language (DQDL) rule builder.
- Specify data quality actions, data to output, and the output location of the data quality results.
- Review data quality results.

To practice with an example, review the blog post [Getting started with AWS Glue Data Quality for ETL pipelines](#).

**Step 1: Add the Evaluate Data Quality transform node to the visual job**

In this step, you add the Evaluate Data Quality node to the visual job editor.

**To add the data quality node**

1. In the AWS Glue Studio console, choose **Visual with a source and target** from the **Create job** section, and then choose **Create**.
2. Choose a node that you want to apply the data quality transform to. Typically, this will be a transform node or a data source.
3. Open the resource panel on the left by choosing the "+" icon. Then search for **Evaluate Data Quality** in the search bar and choose **Evaluate Data Quality** from the search results.

4. The visual job editor shows the **Evaluate Data Quality** transform node branching from the node you selected. On the right side of the console, the **Transform** tab is automatically opened. If you need to change the parent node, choose the **Node properties** tab, and then choose the node parent from the dropdown menu.

   When you choose a new node parent, a new connection is made between the parent node and the **Evaluate Data Quality** node. Remove any unwanted parent nodes. Only one parent node can be connected to one **Evaluate Data Quality** node.

5. The **Evaluate Data Quality** transform supports multiple parents so you can validate data quality rules across multiple datasets. Rules that support multiple datasets include **ReferentialIntegrity**, **DatasetMatch**, **SchemaMatch**, **RowCountMatch**, and **AggregateMatch**.

   When you add multiple inputs to the **Evaluate Data Quality** transform, you need to select your “primary” input. Your primary input is the dataset that you want to validate data quality for. All other nodes or inputs are treated as references.

   You can use the **Evaluate Data Quality** transform to identify specific records that failed data quality checks. We recommend that you choose your primary dataset because new columns that flag bad records are added to the primary dataset.

6. You can specify aliases for input data sources. Aliases provide another way to reference the input source when you're using the **ReferentialIntegrity** rule. Because only one data source can be designated as the primary source, each additional data source that you add will require an alias.

   In the following example, the **ReferentialIntegrity** rule specifies the input data source by the alias name and performs a one-to-one comparison to the primary data source.

   ```
   Rules = [
     ReferentialIntegrity "Aliasname.name" = 1
   ]
   ```
Step 2: Create a rule using DQDL

In this step, you create a rule using DQDL. For this tutorial, you create a single rule using the **Completeness** rule type. This rule type checks the percentage of complete (non-null) values in a column against a given expression. For more information about using DQDL, see [DQDL](#).

1. **On the Transform tab**, add a **Rule type** by choosing the **Insert** button. This adds the rule type to the rule editor, where you can enter the parameters for the rule.

   ![Note]
   When you're editing rules, ensure that the rules are within the brackets and that the rules are separated by commas. For example, a complete rule expression will look like the following:

   ```
   Rules= [ 
     Completeness "year">0.8, Completeness "month">0.8 
   ]
   ``

   This example specifies the parameter for completeness for the columns named 'year' and 'month'. For the rule to pass, these columns must be greater than 80% 'complete', or must have data in over 80% of instances for each respective column.

   In this example, search for and insert the **Completeness** rule type. This adds the rule type to the rule editor. This rule type has the following syntax: Completeness <COL_NAME> <EXPRESSION>.

   Most rule types require that you provide an expression as a parameter in order to create a Boolean response. For more information on supported DQDL expressions, see [DQDL expressions](#). Next, you'll add the column name.

2. **In the DQDL rule builder**, choose the **Schema** tab. Use the search bar to locate the column name in the input schema. The input schema displays the column name and data type.

3. **In the rule editor**, click to the right of the rule type to insert the cursor where the column will be inserted. Alternately, you can enter in the name of the column in the rule.
For example, from the list of columns in the input schema list, choose the **Insert** button next to the column (in this example, **year**). This adds the column to the rule.

4. Then, in the rule editor, add an expression to evaluate the rule. Because the **Completeness** rule type checks the percentage of complete (non-null) values in a column against a given expression, enter an expression such as \( \geq 0.8 \). This rule checks the column if it's greater than 80% complete (non-null) values.

**Step 3: Configure data quality outputs**

After creating data quality rules, you can select additional options to specify data quality node output.

1. In **Data quality transform output**, choose from the following options:
   - **Original data** – Choose to output original input data. When you choose this option, a new child node “rowLevelOutcomes” is added to the job. The schema matches the schema of the primary dataset that was passed as input to the transform. This option is useful if you just want to pass the data through and fail the job when quality issues occur.
   
   Another use case is when you want to detect bad records that failed data quality checks. To detect bad records, choose the option **Add new columns to indicate data quality errors**. This action adds four new columns to the schema of the “rowLevelOutcomes” transform.
   - **DataQualityRulesPass** (string array) – Provides an array of rules that passed data quality checks.
   - **DataQualityRulesFail** (string array) – Provides an array of rules that failed data quality checks.
   - **DataQualityRulesSkip** (string array) – Provides an array of rules that were skipped. The following rules cannot identify error records because they're applied at the dataset level.
     - AggregateMatch
     - ColumnCount
     - ColumnExists
     - ColumnNamesMatchPattern
     - CustomSql
     - RowCount
     - RowCountMatch
• StandardDeviation
• Mean
• ColumnCorrelation

• DataQualityEvaluationResult – Provides “Passed” or “Failed” status at the row level. Note that your overall results can be FAIL, but a certain record might pass. For example, the RowCount rule might have failed, but all other rules might have been successful. In such instances, this field status is ‘Passed’.

2. Data quality results – Choose to output configured rules and their pass or fail status. This option is useful if you want to write your results to Amazon S3 or other databases.

3. Data quality output settings (Optional) – Choose Data quality output settings to reveal the Data quality result location field. Then, choose Browse to search for an Amazon S3 location to set as the data quality output target.

Step 4. Configure data quality actions

You can use actions to publish metrics to CloudWatch or to stop jobs based on specific criteria. Actions are only available after you create a rule. When you choose this option, the same metrics are also published to Amazon EventBridge. You can use these options to create alerts for notification.

• On ruleset failure – You can choose what to do if a ruleset fails while the job is running. If you want the job to fail if data quality fails, choose when the job should fail by selecting one of the following options. By default, this action is not selected, and the job completes its run even if data quality rules fail.
  • None – If you choose None (default), the job does not fail and continues to run despite ruleset failures.
  • Fail job after loading data to target – The job fails and no data is saved. In order to save the results, choose an Amazon S3 location where the data quality results will be saved.
  • Fail job without loading to target data – This option fails the job immediately when a data quality error occurs. It does not load any data targets, including the results from the data quality transform.

Step 5: View data quality results

After running the job, view the data quality results by choosing the Data quality tab.
1. For each job run, view the data quality results. Each node displays a data quality status and status detail. Choose a node to view all rules and the status of each rule.

2. Choose **Download results** to download a CSV file that contains information about the job run and data quality results.

3. If you have more than one job run with data quality results, you can filter the results by date and time range. Choose **Filter by a date and time range** to expand the filter window.

4. Choose a relative range or absolute range. For absolute ranges, use the calendar to select a date, and enter values for start time and end time. When you're done, choose **Apply**.

**Data Quality rule builder**

With the Data Quality Definition Language (DQDL) rule builder, you can create data quality rules to evaluate your data. Start by selecting a rule type, and then specify the parameters in the rule editor. The rule editor also shows you any errors and warnings as you create rules.

The **DQDL guide** provides comprehensive documentation on how to construct rules using the DQDL syntax, built-in rule types, and examples.

**Evaluate Data Quality node**

When you're working with the **Evaluate Data Quality** transform node and the DQDL rule builder, you can expand the working space.

- To expand the **Transform** tab to fill the entire screen, choose the expand icon in the upper-right hand corner of the node details panel.
- To expand the DQDL rule editor, choose the **<<** icon to expand the rule editor and collapse the **Rule types** and **Schema** tabs.
Components

There are 26 rule types that are built into AWS Glue Studio. Each rule type has a description and examples of how they can be used.

Data quality rule types

AWS Glue Studio provides built-in rule types for ease in creating a rule. For more information on rule types, see DQDL rule type reference.

Schema

The Schema tab displays the column names and data type from the parent node. Schemas from multiple nodes are displayed. You can view the input schema, search by column name, and insert the column into the rule editor.
The rule editor is a text editor where you can write and edit rules. If you select a rule type from the DQDL rule builder, the rule type is added to the rule editor. You can then specify parameters, add rules, and edit rules as needed by modifying the text. AWS Glue Studio validates the rules in the rule editor and displays errors and warnings if there are any.

Errors and warnings
If a rule doesn't follow the DQDL rule syntax, the rule editor shows several visual indicators that there is an error:

- The rule editor displays an error icon and red color on the line with the error.
- The rule editor displays the number of errors next to the red error icon.
- When you choose the line with the error, descriptions of the error and location (line and column) are displayed at the bottom of the rule editor.
Data quality actions

By default, this action is not selected and the job will complete its run even if the data quality rules fail.

Choose between the following actions. You can use actions to publish results to CloudWatch or stop jobs based on specific criteria. Actions are only available after you create a rule.
• **Publish results to CloudWatch** – When you run a job, add the results to CloudWatch.

• **Fail job when data quality fails** – If data quality rules fail, the job will also fail as a result.

**Data quality transform output**

• **Original data** – Choose to output original input data. This option is ideal if you want to stop the job when quality issues are detected.

• **Data quality metrics** – Choose to output configured rules and their pass or fail status. This option is useful if you want to take a custom action.

**Data quality output settings**

Set the data quality result location by specifying the Amazon S3 location as the data quality output target.

**Configuring Anomaly detection and generating insights**

AWS Glue Data Quality (DQ) evaluates your data based on the data quality rules that you write and provides insights and observations about your data over time so that you can take immediate action. Since DQ scans your data, DQ computes statistical metrics such as row count, maximum or minimum, and then compares them against threshold expressions.

Some of the benefits of Data Quality anomaly detection include:

• continuous automated scanning of data

• detection of anomalies that can be indicative of an unintended event or statistical abnormality

• offer Rule Recommendations to take action on observations found by Data Quality anomaly detection

This is useful if you:

• want to detect anomalies on your data automatically, without the need to write data quality

• want to profile your data and view visual representations of what the data looks like

• want to track how your data changes over time

**What observations can I view about my data?**
DQ identifies outliers in the data statistics gathered, changes in data formats, data drifts and schema changes. Based on observations, DQ recommends data quality rules that users can easily operationalize. Statistics include Completeness, Uniqueness, Mean, Sum, StandardDeviation, Entropy, DistinctValuesCount, and UniqueValueRatio.

**Enabling anomaly detection in AWS Glue Studio**

To enable anomaly detection, you can open a AWS Glue Studio job and toggle on “Enable Anomaly Detection”. Turning this on enables anomaly detection on your data by analyzing your data over time and providing data statistics about your data and observations that you can act on.

**To enable anomaly detection in AWS Glue Studio:**

1. Choose the **Data Quality** node in your job, then choose the **Anomaly detection** tab. Toggle on ‘Enable Anomaly Detection’.

   ![Anomaly detection tab](image)

   - **Anomaly detection scope**: Scope of data statistics configured to be analyzed for anomalies.

2. Define the data to monitor for anomalies by choosing **Add analyzer**. There are two fields you can populate: Statistics and Data.

   Statistics are information about your data’s shape and other properties. You can choose one or more statistics at a time, or choose All statistics. Statistics include: Completeness, Uniqueness, Mean, Sum, StandardDeviation, Entropy, DistinctValuesCount, and UniqueValueRatio.

   Data is the columns in your data set. You can choose all columns or individual columns.
3. Choose **Add anomaly detection scope** to save your changes. When you’ve created analyzers, you can see them in the **Anomaly detection scope** section.

You can also use the **Actions** menu to edit your analyzers, or choose the **Ruleset editor** tab and edit the analyzer directly in the ruleset editor notepad. You will see the analyzers you saved just below any rules you’ve created.

```python
Rules = [
]

Analyzers = [
    Completeness "id"
]
```

With the updated ruleset along with analyzers, Data Quality continuously monitors incoming data, signaling anomalies through alerts or job stops based on your settings.
Observations are generated when a minimum of three values per data statistics are observed in your data set. If there are no observations visible, Data quality does not have enough data to generate an observation. After several job runs, Data quality can provide insights into your data and will display them in the Observations section.

Analyzers generate observations by detecting anomalies in your data and provide you recommendations to progressively build rules. You can view the observations by choosing the Data Quality tab. Observations are specific to each job run. You can view the specific Data Quality node and job run at the top of the Observations section. Choose a new node or job run to view observations specific to that node and job.

**Observation** – each insight is based for a specific job run configured by the rulesets and analyzers you specified.

**Related metrics** – When observations are generated, the Related metrics column shows you the rule and actual and expected values, as well as lower and upper limits.

**Rule recommendations** – AWS Glue then also recommends rules to address this. Each rule that is recommended can be copied by clicking the copy icon. You can copy all recommended rules by clicking the copy icon next to each rule and then clicking Apply copied rules.
**Monitored data** – The Monitored data column provides the column or row that was monitored and triggered the observation.

**Applying a recommend rule to your Data quality node**

After an observation has been generated and a recommended rule is provided, you can apply that rule to your data quality node. To do this:

1. Click the copy icon next to each rule recommendation. This will add the rule recommendation to a notepad that you can retrieve later.
2. Click **Apply rule recommendations**. This opens the notepad where you can view the rules you previously copied.
3. Choose **Copy rules**.
4. Choose **Apply to ruleset editor**. This opens the ruleset editor where you can paste the copied rules.
5. Paste the copied rules to the ruleset editor.

**Data Quality for ETL jobs in AWS Glue Studio notebooks**

In this tutorial, you learn how to use AWS Glue Data Quality for extract, transform, and load (ETL) jobs in AWS Glue Studio notebooks.

You can use notebooks in AWS Glue Studio to edit job scripts and view the output without having to run a full job. You can also add markdown and save notebooks as `.ipynb` files and job scripts. Note that you can start a notebook without installing software locally or managing servers. When you’re satisfied with your code, you can use AWS Glue Studio to easily convert your notebook to an AWS Glue job.

The dataset that you use in this example consists of Medicare Provider payment data that was downloaded from two [Data.CMS.gov](https://data.cms.gov) datasets: "Inpatient Prospective Payment System Provider Summary for the Top 100 Diagnosis-Related Groups - FY2011" and "Inpatient Charge Data FY 2011".

After downloading the data, we modified the dataset to introduce a couple of erroneous records at the end of the file. This modified file is located in a public Amazon S3 bucket at s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv.
Prerequisites

- AWS Glue role with Amazon S3 permission to write to your destination Amazon S3 bucket
- A new notebook (see Getting started with notebooks in AWS Glue Studio)

Creating an ETL job in AWS Glue Studio

To create an ETL job

1. Change the session version to AWS Glue 3.0.

   To do this, remove all boilerplate code cells with the following magic and run the cell. Note that this boilerplate code is automatically provided in the first cell when a new notebook is created.

   ```
   %glue_version 3.0
   ```

2. Copy the following code and run it in the cell.

   ```python
   import sys
   from awsglue.transforms import *
   from awsglue.utils import getResolvedOptions
   from pyspark.context import SparkContext
   from awsglue.context import GlueContext
   from awsglue.job import Job

   sc = SparkContext.getOrCreate()
   glueContext = GlueContext(sc)
   spark = glueContext.spark_session
   job = Job(glueContext)
   ```

3. In the next cell, import the EvaluateDataQuality class that evaluates AWS Glue Data Quality.

   ```
   from awsgluedq.transforms import EvaluateDataQuality
   ```

4. In the next cell, read in the source data by using the .csv file that's stored in the public Amazon S3 bucket.
medicare = spark.read.format("csv").option("header", "true").option("inferSchema", "true").load('s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv')
medicare.printSchema()

5. Convert the data to an AWS Glue DynamicFrame.

from awsglue.dynamicframe import DynamicFrame
medicare_dyf = DynamicFrame.fromDF(medicare, glueContext, "medicare_dyf")

6. Create the ruleset using Data Quality Definition Language (DQDL).

EvaluateDataQuality_ruleset = ""
    Rules = [
        ColumnExists "Provider Id",
        IsComplete "Provider Id",
        ColumnValues " Total Discharges " > 15
    ]
]"

7. Validate the dataset against the ruleset.

EvaluateDataQualityMultiframe = EvaluateDataQuality().process_rows(    frame=medicare_dyf,
    ruleset=EvaluateDataQuality_ruleset,
    publishing_options={
        "dataQualityEvaluationContext": "EvaluateDataQualityMultiframe",
        "enableDataQualityCloudWatchMetrics": False,
        "enableDataQualityResultsPublishing": False,
    },
    additional_options={"performanceTuning.caching": "CACHE_NOTHING"},
)

8. Review the results.
ruleOutcomes = SelectFromCollection.apply(
    dfc=EvaluateDataQualityMultiframe,
    key="ruleOutcomes",
    transformation_ctx="ruleOutcomes",
)

ruleOutcomes.toDF().show(truncate=False)

Output:

--------------------------------------+-
+-------------------------------------------+-
|Rule                                  |Outcome|FailureReason |
|EvaluatedMetrics                           |       |             |
+--------------------------------------+-
|ColumnExists "Provider Id"            |Passed |null         |
|{}                                         |       |             |
|IsComplete "Provider Id"              |Passed |null         |
|{{Column.Provider Id.Completeness -> 1.0}   |       |             |
|ColumnValues " Total Discharges " > 15|Failed |Value: 11.0 does not meet the constraint requirement!|{{Column. Total Discharges .Minimum -> 11.0}|
+--------------------------------------+-
+-------------------------------------------+

9. Filter passed rows and review the failed rows from the Data Quality row-level results.

rowLevelOutcomes = SelectFromCollection.apply(
    dfc=EvaluateDataQualityMultiframe,
    key="rowLevelOutcomes",
    transformation_ctx="rowLevelOutcomes",
)

rowLevelOutcomes_df = rowLevelOutcomes.toDF() # Convert Glue DynamicFrame to SparkSQL DataFrame
rowLevelOutcomes_df_passed = rowLevelOutcomes_df.filter(rowLevelOutcomes_df.DataQualityEvaluationResult == "Passed")  
# Filter only the Passed records.
rowLevelOutcomes_df.filter(rowLevelOutcomes_df.DataQualityEvaluationResult == "Failed").show(5, truncate=False)  
# Review the Failed records

Output:

<table>
<thead>
<tr>
<th>DRG Definition</th>
<th>Provider Id</th>
<th>Provider Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider Street Address</td>
<td>Provider City</td>
<td>Provider State</td>
</tr>
<tr>
<td>Hospital Referral Region Description</td>
<td>Total Discharges</td>
<td>Average Covered Charges</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>039 - EXTRACRANIAL PROCEDURES W/O CC/MCC</td>
<td>10005</td>
<td>MARSHALL MEDICAL CENTER SOUTH</td>
</tr>
<tr>
<td>2505 U S HIGHWAY 431 NORTH</td>
<td>BOAZ</td>
<td>AL</td>
</tr>
</tbody>
</table>
| AL - Birmingham | 14           | $15131.85 $5787.57 $4976.71 [[IsComplete "Provider Id"]]
| [ColumnValues " Total Discharges " > 15] [ColumnExists "Provider Id"] | Failed |
| 039 - EXTRACRANIAL PROCEDURES W/O CC/MCC | 10046       | RIVERVIEW REGIONAL MEDICAL CENTER |
| 600 SOUTH THIRD STREET | GADSDEN | AL | 35901 |
| AL - Birmingham | 14           | $67327.92 $5461.57 $4493.57 [[IsComplete "Provider Id"]]
| [ColumnValues " Total Discharges " > 15] [ColumnExists "Provider Id"] | Failed |
| 039 - EXTRACRANIAL PROCEDURES W/O CC/MCC | 10083       | SOUTH BALDWIN REGIONAL MEDICAL CENTER |
| 1613 NORTH MCKENZIE STREET | FOLEY | AL | 36535 |
Note that AWS Glue Data Quality added four new columns (DataQualityRulesPass, DataQualityRulesFail, DataQualityRulesSkip, and DataQualityEvaluationResult). This indicates the records that passed, the records that failed, rules skipped for row-level evaluation, and the overall row-level results.

10. Write the output to an Amazon S3 bucket to analyze the data and visualize the results.

```python
#Write the Passed records to the destination.

glueContext.write_dynamic_frame.from_options(  
    frame = rowLevelOutcomes_df_passed,  
    connection_type = "s3",  
    connection_options = {"path": "s3://glue-sample-target/output-dir/medicare_parquet"},  
    format = "parquet"
)
```
Data Quality Definition Language (DQDL) reference

Data Quality Definition Language (DQDL) is a domain specific language that you use to define rules for AWS Glue Data Quality.

This guide introduces key DQDL concepts to help you understand the language. It also provides a reference for DQDL rule types with syntax and examples. Before you use this guide, we recommend that you have familiarity with AWS Glue Data Quality. For more information, see AWS Glue Data Quality.

Note

DynamicRules are only supported in AWS Glue ETL.

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  - ColumnCorrelation
  - ColumnCount
  - ColumnDataType
  - ColumnExists
  - ColumnLength
  - ColumnNamesMatchPattern
  - ColumnValues
  - Completeness
A DQDL document is case sensitive and contains a `ruleset`, which groups individual data quality rules together. To construct a ruleset, you must create a list named `Rules` (capitalized), delimited by a pair of square brackets. The list should contain one or more comma-separated DQDL rules like the following example.

```plaintext
Rules = [
    IsComplete "order-id",
    IsUnique "order-id"
]
```
Rule structure

The structure of a DQDL rule depends on the rule type. However, DQDL rules generally fit the following format.

\[
\text{<RuleType> <Parameter> <Parameter> <Expression>}
\]

RuleType is the case-sensitive name of the rule type that you want to configure. For example, IsComplete, IsUnique, or CustomSql. Rule parameters differ for each rule type. For a complete reference of DQDL rule types and their parameters, see DQDL rule type reference.

Rule combination

DQDL supports the following logical operators that you can use to combine rules.

and

The logical and operator results in true if and only if the rules that it connects are true. Otherwise, the combined rule results in false. Each rule that you connect with the and operator must be surrounded by parentheses.

The following example uses the and operator to combine two DQDL rules.

\[
\text{(IsComplete "id") and (IsUnique "id")}
\]

or

The logical or operator results in true if and only if one or more of the rules that it connects are true. Each rule that you connect with the or operator must be surrounded by parentheses.

The following example uses the or operator to combine two DQDL rules.

\[
\text{(RowCount "id" > 100) or (IsPrimaryKey "id")}
\]

You can use the same operator to connect multiple rules, so the following rule combination is allowed.

\[
\text{(Mean "Star_Rating" > 3) and (Mean "Order_Total" > 500) and (IsComplete "Order_Id")}
\]
However, you can’t combine the logical operators into a single expression. For example, the following combination is not allowed.

\[(\text{Mean } \ "\text{Star\_Rating}\) > 3) \text{ and } (\text{Mean } \ "\text{Order\_Total}\) > 500) \text{ or } (\text{IsComplete } \ "\text{Order\_Id}\)\]

**Expressions**

If a rule type doesn’t produce a Boolean response, you must provide an expression as a parameter in order to create a Boolean response. For example, the following rule checks the mean (average) of all the values in a column against an expression to return a true or false result.

\[\text{Mean } \ "\text{colA}\) \text{ between } 80 \text{ and } 100\]

Some rule types such as IsUnique and IsComplete already return a Boolean response.

The following table lists expressions that you can use in DQDL rules.

**Supported DQDL expressions**

<table>
<thead>
<tr>
<th>Expression</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>= x</td>
<td>Resolves to true if the rule type response is equal to x.</td>
<td>Completeness &quot;colA&quot; = 1.0, ColumnValues &quot;colA&quot; = &quot;2022-06-30&quot;</td>
</tr>
<tr>
<td>&gt; x</td>
<td>Resolves to true if the rule type response is greater than x.</td>
<td>ColumnValues &quot;colA&quot; &gt; 10</td>
</tr>
<tr>
<td>&lt; x</td>
<td>Resolves to true if the rule type response is less than x.</td>
<td>ColumnValues &quot;colA&quot; &lt; 1000, ColumnValues &quot;colA&quot; &lt; &quot;2022-06-30&quot;</td>
</tr>
<tr>
<td>&gt;= x</td>
<td>Resolves to true if the rule type response is greater than or equal to x.</td>
<td>ColumnValues &quot;colA&quot; &gt;= 10</td>
</tr>
<tr>
<td>Expression</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>&lt;= x</td>
<td>Resolves to true if the rule type response is less than or equal to x.</td>
<td>ColumnValues &quot;colA&quot; &lt;= 1000</td>
</tr>
<tr>
<td>between x and y</td>
<td>Resolves to true if the rule type response falls in a specified range (exclusive). Only use this expression type for numeric and date types.</td>
<td>Mean &quot;colA&quot; between 8 and 100, ColumnValues &quot;colA&quot; between &quot;2022-05-31&quot; and &quot;2022-06-30&quot;</td>
</tr>
<tr>
<td>in [a, b, c, ...]</td>
<td>Resolves to true if the rule type response is in the specified set.</td>
<td>ColumnValues &quot;colA&quot; in [ 1, 2, 3 ], ColumnValues &quot;colA&quot; in [ &quot;a&quot;, &quot;b&quot;, &quot;c&quot; ]</td>
</tr>
<tr>
<td>matches /ab+c/i</td>
<td>Resolves to true if the rule type response matches a regular expression.</td>
<td>ColumnValues &quot;colA&quot; matches &quot;[a-zA-Z]*&quot;</td>
</tr>
<tr>
<td>now()</td>
<td>Works only with the ColumnValues rule type to create a date expression.</td>
<td>ColumnValues &quot;load_date&quot; &gt; (now() - 3 days)</td>
</tr>
<tr>
<td>matches/in [...] with threshold</td>
<td>Specifies the percentage of values that match the rule conditions. Works only with the ColumnValues and ColumnDataType rule types.</td>
<td>ColumnValues &quot;colA&quot; in [&quot;A&quot;, &quot;B&quot;] with threshold &gt; 0.8, ColumnValues &quot;colA&quot; matches &quot;:[a-zA-Z]*&quot; with threshold between 0.2 and 0.9 ColumnDataType &quot;colA&quot; = &quot;Timestamp&quot; with threshold &gt; 0.9</td>
</tr>
</tbody>
</table>
Dynamic rules

You can now author dynamic rules to compare current metrics produced by your rules with their historical values. These historical comparisons are enabled by using the `last()` operator in expressions. For example, the rule `RowCount > last()` will succeed when the number of rows in the current run is greater than the most recent prior row count for the same dataset. `last()` takes an optional natural number argument describing how many prior metrics to consider; `last(k)` where `k >= 1` will reference the last `k` metrics.

- If no data points are available, `last(k)` will return the default value 0.0.
- If fewer than `k` metrics are available, `last(k)` will return all prior metrics.

To form valid expressions use `last(k)`, where `k > 1` requires an aggregation function to reduce multiple historical results to a single number. For example, `RowCount > avg(last(5))` will check whether the current dataset's row count is strictly greater than the average of the last five row counts for the same dataset. `RowCount > last(5)` will produce an error because the current dataset row count can't be meaningfully compared to a list.

Supported aggregation functions:

- `avg`
- `median`
- `max`
- `min`
- `sum`
- `std` (standard deviation)
- `abs` (absolute value)
- `index(last(k), i)` will allow for selecting the `i`th most recent value out of the last `k`. `i` is zero-indexed, so `index(last(3), 0)` will return the most recent datapoint and `index(last(3), 3)` will result in an error as there are only three datapoints and we attempt to index the 4th most recent one.

Sample expressions

ColumnCorrelation

Syntax
• ColumnCorrelation "colA" "colB" < avg(last(10))

**DistinctValuesCount**

• DistinctValuesCount "colA" between min(last(10))-1 and max(last(10))+1

Most rule types with numeric conditions or thresholds support dynamic rules; see the provided table, [Analyzers and Rules](#), to determine whether dynamic rules are supported for your rule type.

**Analyzers**

DQDL rules use functions called * analyzers * to gather information about your data. This information is employed by a rule's Boolean expression to determine whether the rule should succeed or fail. For example, the RowCount rule RowCount > 5 will use a row count analyzer to discover the number of rows in your dataset, and compare that count with the expression > 5 to check whether more than five rows exist in the current dataset.

Sometimes, instead of authoring rules, we recommend creating analyzers and then have them generate statistics that can be used to detect anomalies. For such instances, you can create analyzers. Analyzers differ from rules in the following ways.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Analyzers</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part of ruleset</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Generates statistics</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Generates observations</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can evaluate and assert a condition</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>You can configure actions such as stop the jobs on failure, continue processing job</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Analyzers can independently exist without rules, so you can quickly configure them and progressively build data quality rules.

Some rule types can be input in the Analyzers block of your ruleset to run the rules required for analyzers and gather information without applying checks for any condition. Some analyzers aren't associated with rules and can only be input in the Analyzers block. The following table indicates whether each item is supported as a rule or a standalone analyzer, along with additional details for each rule type.

**Example Ruleset with Analyzer**

The following ruleset uses:

- a dynamic rule to check whether a dataset is growing over its trailing average for the last three job runs
- a `DistinctValuesCount` analyzer to record the number of distinct values in the dataset's `Name` column
- a `ColumnLength` analyzer to track minimum and maximum `Name` size over time

Analyzer metric results can be viewed in the Data Quality tab for your job run.

```plaintext
Rules = [
    RowCount > avg(last(3))
],
Analyzers = [
    DistinctValuesCount "Name",
    ColumnLength "Name"
]
```

**DQDL rule type reference**

This section provides a reference for each rule type that AWS Glue Data Quality supports.

**Note**

- DQDL doesn't currently support nested or list-type column data.
- Bracketed values in the below table will be replaced with the information provided in rule arguments.
- Rules typically require an additional argument for expression

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Match</td>
<td>Checks if two datasets match by comparing summary metrics like total sales amount. Useful for financial institutions to compare if all data is ingested from source systems.</td>
<td>One or more aggregations</td>
<td>When first and second aggregation column names match: Column. [Column].AggregateMatch</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>When first and second aggregation column names different: Column. [Column].AggregateMatch</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>column1, column2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
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</tr>
<tr>
<td>AllStatistics</td>
<td>Standalone analyzer to gather multiple metrics for the provided column, or all columns in a dataset.</td>
<td>A single column name, OR &quot;AllColumns&quot;</td>
<td>For columns of all types: Dataset.RowCount, Column.[Column].Completeness, Column.[Column].Uniqueness. Additional metrics for string-valued columns: ColumnLength, metrics</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ruletype</td>
<td>Description</td>
<td>Arguments</td>
<td>Reported Metrics</td>
<td>Supported as Rule?</td>
<td>Supported as Analyzer?</td>
<td>Returns row-level Results?</td>
<td>Dynamic rule support?</td>
<td>Generates Observations</td>
</tr>
<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>ColumnCorrelation</td>
<td>Checks how well two columns are correlated.</td>
<td>Exactly two column names</td>
<td>Multicolumn. ColumnCorrelation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ColumnCount</td>
<td>Checks if any columns are dropped.</td>
<td>None</td>
<td>Dataset.ColumnCount</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
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<td>------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>ColumnDataType</td>
<td>Checks if a column is compliant with a datatype.</td>
<td>Exactly one column name</td>
<td>Column. [Column].ColumnDataType.Compliance</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>ColumnExists</td>
<td>Checks if columns exist in a dataset. This allows customers building self service data platforms to ensure certain columns are made available.</td>
<td>Exactly one column name</td>
<td>N/A</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rule Type</td>
<td>Description</td>
<td>Arguments</td>
<td>Reported Metrics</td>
<td>Supported as Rule?</td>
<td>Supported as Analyzer?</td>
<td>Returns row-level Results?</td>
<td>Dynamic rule support?</td>
<td>Generates Observations</td>
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</tr>
<tr>
<td>ColumnLength</td>
<td>Checks if length of data is consistent.</td>
<td>Exactly one column name</td>
<td>Column. [Column].MaximumLength, Column. [Column].MinimumLength</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, when row-level threshold provided</td>
<td>No</td>
<td>Yes. Only generates observations by analyzing Minimum and Maximum length</td>
</tr>
</tbody>
</table>

**ColumnLength Checks**
- Checks if length of data is consistent.
- Args: Exactly one column name.
- Rules:
  - Column. [Column].MaximumLength
  - Column. [Column].MinimumLength
- Additional metric when row-level threshold provided:
  - Column. [Column].ColumnValues.Compliance
<table>
<thead>
<tr>
<th>Ruletype</th>
<th>Description</th>
<th>Arguments</th>
<th>Reported Metrics</th>
<th>Supported as Rule?</th>
<th>Supported as Analyzer?</th>
<th>Returns row-level Results?</th>
<th>Dynamic rule support?</th>
<th>Generates Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ColumnNamesMatchPattern</td>
<td>Checks if column names match defined patterns. Useful for governance teams to enforce column name consistency.</td>
<td>A regex for column names</td>
<td>Dataset.*.ColumnNamesPatternMatchRatio</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ruletype</td>
<td>Description</td>
<td>Argument</td>
<td>Reported Metrics</td>
<td>Supported as Rule?</td>
<td>Supported as Analyzer?</td>
<td>Returns row-level Results?</td>
<td>Dynamic rule support?</td>
<td>Generates Observations</td>
</tr>
<tr>
<td>-------------------</td>
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<td>------------------------</td>
</tr>
<tr>
<td>ColumnValues</td>
<td>Checks if data is consistent per defined values. This rule supports regular expressions.</td>
<td>Exactly one column name</td>
<td>Column. [Column]. Maximum Column. [Column]. Minimum Additional metric when row-level threshold provided:</td>
<td>Yes</td>
<td>No</td>
<td>Yes, when row-level threshold provided</td>
<td>No</td>
<td>Yes. Only generates observations by analyzing Minimum and Maximum values</td>
</tr>
<tr>
<td>Completeness</td>
<td>Checks for any blank or NULLs in data.</td>
<td>Exactly one column name</td>
<td>Column. [Column]. Completeness Column. [Column]. Completeness</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>CustomSql</td>
<td>Customer can implement almost any type of data quality checks in SQL.</td>
<td>A SQL statement (Optional) A row-level threshold</td>
<td>Dataset.<em>.CustomSql.</em>.compliance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, when row-level threshold provided</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>DataFreshness</td>
<td>Checks if data is fresh.</td>
<td>Exactly one column name</td>
<td>[Column].DataFreshness.compliance</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
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</tr>
<tr>
<td>DatasetMatch</td>
<td>Compares two datasets and identifies if they are in synch.</td>
<td>Name of a reference dataset and a column mapping (Optional) Columns to check for matches</td>
<td>Dataset [Reference DatasetAlias].DatasetMatch</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>DistinctValuesCount</td>
<td>Checks for duplicate values.</td>
<td>Exactly one column name</td>
<td>Column.[Column].DistinctValuesCount</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DetectAnomalies</td>
<td>Checks for anomalies in another rule type's reported metrics.</td>
<td>A rule type Metric(s) reported by the rule type argument</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ruletype</td>
<td>Description</td>
<td>Arguments</td>
<td>Reported Metrics</td>
<td>Supports as Rule?</td>
<td>Supports as Analyzer?</td>
<td>Returns row-level Results?</td>
<td>Dynamic rule support?</td>
<td>Generates Observations</td>
</tr>
<tr>
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</tr>
<tr>
<td>Entropy</td>
<td>Checks for entropy of the data.</td>
<td>Exactly one column name</td>
<td>Column.[Column].Entropy</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>IsComplete</td>
<td>Checks if 100% of the data is complete.</td>
<td>Exactly one column name</td>
<td>Column.[Column].Completeness</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>IsPrimary Key</td>
<td>Checks if a column is a primary key (not NULL and unique).</td>
<td>Exactly one column name</td>
<td>For single column: Column.[Column].Uniqueness; For multiple columns: Multicolumn[Comma delimited columns].Uniqueness</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
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</tr>
<tr>
<td>IsUnique</td>
<td>Checks if 100% of the data is unique.</td>
<td>Exactly one column name</td>
<td>Column.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mean</td>
<td>Checks if the mean matches the set threshold.</td>
<td>Exactly one column name</td>
<td>Column.</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ReferentialIntegrity</td>
<td>Checks if two datasets have referential integrity.</td>
<td>One or more column names from dataset</td>
<td>Column.</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
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</tr>
<tr>
<td>RowCount</td>
<td>Checks if record counts match a threshold.</td>
<td>None</td>
<td>Dataset.RowCount</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>RowCountMatch</td>
<td>Checks if record counts between two datasets match.</td>
<td>Reference dataset alias</td>
<td>Dataset [Reference DatasetAlias].RowCountMatch</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>StandardDeviation</td>
<td>Checks if standard deviation matches the threshold.</td>
<td>Exactly one column name</td>
<td>Column.[Column].StandardDeviation</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
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</tr>
<tr>
<td>SchemaMatch</td>
<td>Checks if schema between two datasets match.</td>
<td>Reference dataset alias</td>
<td>Dataset</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sum</td>
<td>Checks if sum matches a set threshold.</td>
<td>Exactly one column name</td>
<td>Column.</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Uniqueness</td>
<td>Checks if uniqueness of dataset matches threshold.</td>
<td>Exactly one column name</td>
<td>Column.</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>UniqueValueRatio</td>
<td>Checks if the unique value matches threshold.</td>
<td>Exactly one column name</td>
<td>Column.</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Topics

- AggregateMatch
- ColumnCorrelation
- ColumnCount
- ColumnDataType
- ColumnExists
- ColumnLength
- ColumnNamesMatchPattern
- ColumnValues
- Completeness
- CustomSQL
- DataFreshness
- DatasetMatch
- DistinctValuesCount
- Entropy
- IsComplete
- IsPrimaryKey
- IsUnique
- Mean
- ReferentialIntegrity
- RowCount
- RowCountMatch
- StandardDeviation
- Sum
- SchemaMatch
- Uniqueness
- UniqueValueRatio
- DetectAnomalies
AggregateMatch

Checks the ratio of two column aggregations against a given expression. This ruletype works on multiple datasets. The two column aggregations are evaluated and a ratio is produced by dividing the result of the first column aggregation with the result of the second column aggregation. The ratio is checked against the provided expression to produce a boolean response.

Syntax

Column aggregation

```
ColumnExists <AGG_OPERATION> (<OPTIONAL_REFERENCE_ALIAS>.<COL_NAME>)
```

- **AGG_OPERATION** – The operation to use for the aggregation. Currently, sum and avg are supported.

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **OPTIONAL_REFERENCE_ALIAS** – This parameter needs to be provided if the column is from a reference dataset and not the primary dataset. If you are using this rule in the AWS Glue Data Catalog, your reference alias must follow the format "<database_name>.<table_name>.<column_name>

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **COL_NAME** – The name of the column to aggregate.

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

Example: Average

```
"avg(rating)"
```

Example: Sum

```
"sum(amount)"
```

Example: Average of column in reference dataset

```
"avg(reference.rating)"
```
Rule

AggregateMatch <AGG_EXP_1> <AGG_EXP_2> <EXPRESSION>

- **AGG_EXP_1** – The first column aggregation.
  
  Supported column types: Byte, Decimal, Double, Float, Integer, Long, Short

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **AGG_EXP_2** – The second column aggregation.
  
  Supported column types: Byte, Decimal, Double, Float, Integer, Long, Short

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

**Example: Aggregate Match using sum**

The following example rule checks whether the sum of the values in the `amount` column is exactly equal to the sum of the values in the `total_amount` column.

```
AggregateMatch "sum(amount)" "sum(total_amount)" = 1.0
```

**Example: Aggregate Match using average**

The following example rule checks whether the average of the values in the `ratings` column is equal to at least 90% of the average of the values in the `ratings` column in the reference dataset. The reference dataset is provided as an additional data source in the ETL or Data Catalog experience.

In AWS Glue ETL, you can use:

```
AggregateMatch "avg(ratings)" "avg(reference.ratings)" >= 0.9
```

In the AWS Glue Data Catalog, you can use:

```
AggregateMatch "avg(ratings)" "avg(database_name.tablename.ratings)" >= 0.9
```
ColumnCorrelation

Checks the correlation between two columns against a given expression. AWS Glue Data Quality uses the Pearson correlation coefficient to measure the linear correlation between two columns. The result is a number between -1 and 1 that measures the strength and direction of the relationship.

Syntax

```
ColumnCorrelation <COL_1_NAME> <COL_2_NAME> <EXPRESSION>
```

- **COL_1_NAME** – The name of the first column that you want to evaluate the data quality rule against.
  
  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **COL_2_NAME** – The name of the second column that you want to evaluate the data quality rule against.
  
  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

Example: Column correlation

The following example rule checks whether the correlation coefficient between the columns height and weight has a strong positive correlation (a coefficient value greater than 0.8).

```
ColumnCorrelation "height" "weight" > 0.8
```

Sample dynamic rules

- ColumnCorrelation "colA" "colB" between min(last(10)) and max(last(10))
- ColumnCorrelation "colA" "colB" < avg(last(5)) + std(last(5))

ColumnCount

Checks the column count of the primary dataset against a given expression. In the expression, you can specify the number of columns or a range of columns using operators like > and <.
Syntax

ColumnCount `<EXPRESSION>`

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

Example: Column count numeric check

The following example rule checks whether the column count is within a given range.

```
ColumnCount between 10 and 20
```

Sample dynamic rules

- ColumnCount >= avg(last(10))
- ColumnCount between min(last(10))-1 and max(last(10))+1

**ColumnDataType**

Checks the inherent data type of the values in a given column against the provided expected type. Accepts a with threshold expression to check for a subset of the values in the column.

Syntax

ColumnDataType `<COL_NAME>` = `<EXPECTED_TYPE>`

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  Supported column types: String type

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPECTED_TYPE** – The expected type of the values in the column.

  Supported values: Boolean, Date, Timestamp, Integer, Double, Float, Long

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short
• **EXPRESSION** – An optional expression to specify the percentage of values that should be of the expected type.

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

**Example: Column data type integers as strings**

The following example rule checks whether the values in the given column, which is of type string, are actually integers.

```plaintext
ColumnDataType "colA" = "INTEGER"
```

**Example: Column data type integers as strings check for a subset of the values**

The following example rule checks whether more than 90% of the values in the given column, which is of type string, are actually integers.

```plaintext
ColumnDataType "colA" = "INTEGER" with threshold > 0.9
```

**ColumnExists**

Checks whether a column exists.

**Syntax**

```plaintext
ColumnExists <COL_NAME>
```

• **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types:** Any column type

**Example: Column exists**

The following example rule checks whether the column named Middle_Name exists.

```plaintext
ColumnExists "Middle_Name"
```

**ColumnLength**

Checks whether the length of each row in a column conforms to a given expression.
**Syntax**

ColumnLength `<COL_NAME>` `<EXPRESSION>`

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types**: String

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

**Example: Column row length**

The following example rule checks whether the value in each row in the column named `Postal_Code` is 5 characters long.

```sql
ColumnLength "Postal_Code" = 5
```

**ColumnNamesMatchPattern**

Checks whether the names of all columns in the primary dataset match the given regular expression.

**Syntax**

ColumnNamesMatchPattern `<PATTERN>`

- **PATTERN** – The pattern you want to evaluate the data quality rule against.

  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

**Example: Column names match pattern**

The following example rule checks whether all columns start with the prefix "aws_"

```sql
ColumnNamesMatchPattern "aws_.*"
```

**ColumnValues**

Runs an expression against the values in a column.
Syntax

ColumnValues <COL_NAME> <EXPRESSION>

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.
  
  **Supported column types**: Any column type

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

**Example: Allowed values**

The following example rule checks whether each value in the specified column is in a set of allowed values.

ColumnValues "Country" in [ "US", "CA", "UK" ]

**Example: Regular expression**

The following example rule checks the values in a column against a regular expression.

ColumnValues "First_Name" matches "[a-zA-Z]*"

**Example: Date values**

The following example rule checks the values in a date column against a date expression.

ColumnValues "Load_Date" > (now() - 3 days)

**Example: Numeric values**

The following example rule checks whether the column values match a certain numeric constraint.

ColumnValues "Customer_ID" between 1 and 2000

**Completeness**

Checks the percentage of complete (non-null) values in a column against a given expression.

**Syntax**

Rule type reference

998
Completeness `<COL_NAME>` `<EXPRESSION>`

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.
- **Supported column types**: Any column type
- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

**Example: Null value percentage**

The following example rules check if more than 95 percent of the values in a column are complete.

 Completeness "First_Name" > 0.95

**Sample dynamic rules**

- Completeness "colA" between min(last(5)) - 1 and max(last(5)) + 1
- Completeness "colA" <= avg(last(10))

**CustomSQL**

This rule type has been extended to support two use cases:

- Run a custom SQL statement against a dataset and checks the return value against a given expression.
- Run a custom SQL statement where you specify a column name in your SELECT statement against which you compare with some condition to get row-level results.

**Syntax**

 CustomSql `<SQL_STATEMENT>` `<EXPRESSION>`

- **SQL_STATEMENT** – A SQL statement that returns a single numeric value, surrounded by double quotes.
- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.
Example: Custom SQL to retrieve an overall rule outcome

This example rule uses a SQL statement to retrieve the record count for a data set. The rule then checks that the record count is between 10 and 20.

```sql
CustomSql "select count(*) from primary" between 10 and 20
```

Example: Custom SQL to retrieve row-level results

This example rule uses a SQL statement wherein you specify a column name in your SELECT statement against which you compare with some condition to get row level results. A threshold condition expression defines a threshold of how many records should fail for the entire rule to fail. Note that a rule may not contain both a condition and keyword together.

```sql
CustomSql "select Name from primary where Age > 18"
```

or

```sql
CustomSql "select Name from primary where Age > 18" with threshold > 3
```

⚠️ Important

The primary alias stands in for the name of the data set that you want to evaluate. When you work with visual ETL jobs on the console, primary always represents the DynamicFrame being passed to the EvaluateDataQuality.apply() transform. When you use the AWS Glue Data Catalog to run data quality tasks against a table, primary represents the table.

If you are in AWS Glue Data Catalog, you can also use the actual table names:

```sql
CustomSql "select count(*) from database.table" between 10 and 20
```

You can also join multiple tables to compare different data elements:

```sql
CustomSql "select count(*) from database.table inner join database.table2 on id1 = id2" between 10 and 20
```
In AWS Glue ETL, CustomSQL can identify records that failed the data quality checks. For this to work, you will need to return records that are part of the primary table that you are evaluating data quality. Records that are returned as part of the query are considered successful and records that are not returned are considered failed.

The following rule will ensure that records with age < 100 are identified as successful and records that are above are marked as failed.

```
CustomSql "select id from primary where age < 100"
```

This CustomSQL rule will pass when 50% of the records have age > 10 and will also identify records that failed. The records returned by this CustomSQL will be considered passed while the ones not returned will be considered failed.

```
CustomSQL "select ID, CustomerID from primary where age > 10" with threshold > 0.5
```

Note: CustomSQL rule will fail if you return records that are not available in the dataset.

**DataFreshness**

Checks the freshness of data in a column by evaluating the difference between the current time and the values of a date column. You can specify a time-based expression for this rule type to make sure that column values are up to date.

**Syntax**

```
DataFreshness <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.
- **Supported column types**: Date
- **EXPRESSION** – A numeric expression in hours or days. You must specify the time unit in your expression.

**Example: Data freshness**

The following example rules check for data freshness.

```
DataFreshness "Order_Date" <= 24 hours
```
DatasetMatch

Checks if the data in the primary dataset matches the data in a reference dataset. The two datasets are joined using the provided key column mappings. Additional column mappings can be provided should you wish to check for the equality of the data in only those columns. Note that for DatasetMatch to work, your join keys should be unique and should not be NULL (must be a primary key). If you don’t satisfy these conditions, you will get the error message, “Provided key map not suitable for given data frames”. In cases where you can’t have joined keys that are unique, consider using other ruletypes such as AggregateMatch to match on summary data.

Syntax

DatasetMatch <REFERENCE_DATASET_ALIAS> <JOIN CONDITION WITH MAPPING> <OPTIONAL_MATCH_COLUMN_MAPPINGS> <EXPRESSION>

- **REFERENCE_DATASET_ALIAS** – The alias of the reference dataset with which you compare data from the primary dataset.
- **KEY_COLUMN_MAPPINGS** – A comma-separated list of column names that form a key in the datasets. If the column names are not the same in both datasets, you must separated them with a ->
- **OPTIONAL_MATCH_COLUMN_MAPPINGS** – You can supply this parameter if you want to check for matching data only in certain columns. It uses the same syntax as the key column mappings. If this parameter is not provided, we will match the data in all remaining columns. The remaining, non-key columns must have the same names in both datasets.
- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

Example: Match set datasets using ID column

The following example rule checks that more than 90% of the primary dataset matches the reference dataset, using the "ID" column to join the two datasets. It compares all columns in this case.

DatasetMatch "reference" "ID" >= 0.9

Example: Match set datasets using multiple key columns
In the following example, the primary dataset and the reference dataset have different names for the key columns. ID_1 and ID_2 together form a composite key in the primary dataset. ID_ref1 and ID_ref2 together form a composite key in the reference dataset. In this scenario, you can use the special syntax to supply the column names.

```
DatasetMatch "reference" "ID_1->ID_ref1,ID_ref2->ID_ref2" >= 0.9
```

**Example: Match set datasets using multiple key columns and check that specific column matches**

This example builds on the previous example. We want to check that only the column containing the amounts match. This column is named Amount1 in the primary dataset and Amount2 in the reference dataset. You want an exact match.

```
DatasetMatch "reference" "ID_1->ID_ref1,ID_ref2->ID_ref2" "Amount1->Amount2" >= 0.9
```

**DistinctValuesCount**

Checks the number of distinct values in a column against a given expression.

**Syntax**

```
DistinctValuesCount <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types**: Any column type

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

**Example: Distinct column value count**

The following example rule checks that the column named State contains more than 3 distinct values.

```
DistinctValuesCount "State" > 3
```

**Sample dynamic rules**
DistinctValuesCount "colA" between avg(last(10))-1 and avg(last(10))+1
DistinctValuesCount "colA" <= index(last(10),2) + std(last(5))

Entropy

Checks whether the entropy value of a column matches a given expression. Entropy measures the level of information that's contained in a message. Given the probability distribution over values in a column, entropy describes how many bits are required to identify a value.

Syntax

Entropy `<COL_NAME>` `<EXPRESSION>`

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.
- **Supported column types**: Any column type
- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

Example: Column entropy

The following example rule checks that the column named Feedback has an entropy value greater than one.

Entropy "Star_Rating" > 1

Sample dynamic rules

- Entropy "colA" < max(last(10))
- Entropy "colA" between min(last(10)) and max(last(10))

IsComplete

Checks whether all of the values in a column are complete (non-null).

Syntax

IsComplete `<COL_NAME>`
• **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types**: Any column type

**Example: Null values**

The following example checks whether all of the values in a column named `email` are non-null.

```
IsComplete "email"
```

**IsPrimaryKey**

Checks whether a column contains a primary key. A column contains a primary key if all of the values in the column are unique and complete (non-null).

**Syntax**

```
IsPrimaryKey <COL_NAME>
```

• **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types**: Any column type

**Example: Primary key**

The following example rule checks whether the column named `Customer_ID` contains a primary key.

```
IsPrimaryKey "Customer_ID"
```

**Example: Primary key with multiple columns. Any of the following examples are valid.**

```
IsPrimaryKey "colA" "colB"
IsPrimaryKey "colA" "colB" "colC"
IsPrimaryKey colA "colB" "colC"
```

**IsUnique**

Checks whether all of the values in a column are unique, and returns a Boolean value.
Syntax

IsUnique <COL_NAME>

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types:** Any column type

Example: Unique column values

The following example rule checks whether all of the values in a column named `email` are unique.

IsUnique "email"

Mean

Checks whether the mean (average) of all the values in a column matches a given expression.

Syntax

Mean <COL_NAME> <EXPRESSION>

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

Example: Average value

The following example rule checks whether the average of all of the values in a column exceeds a threshold.

Mean "Star_Rating" > 3

Sample dynamic rules

- Mean "colA" > avg(last(10)) + std(last(2))
- Mean "colA" between min(last(5)) - 1 and max(last(5)) + 1
**ReferentialIntegrity**

Checks to what extent the values of a set of columns in the primary dataset are a subset of the values of a set of columns in a reference dataset.

**Syntax**

ReferentialIntegrity <PRIMARY_COLS> <REFERENCE_DATASET_COLS> <EXPRESSION>

- **PRIMARY_COLS** – A comma-separated list of column names in the primary dataset.
  
  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **REFERENCE_DATASET_COLS** – This parameter contains two parts separated by a period. The first part is the alias of the reference dataset. The second part is the comma-separated list of column names in the reference dataset enclosed in braces.
  
  **Supported column types**: Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

**Example: Check the referential integrity of a zip code column**

The following example rule checks that more than 90% of the values in the zipcode column in the primary dataset, are present in the zipcode column in the reference dataset.

ReferentialIntegrity "zipcode" "reference.zipcode" >= 0.9

**Example: Check the referential integrity of the city and state columns**

In the following example, columns containing city and state information exist in the primary dataset and the reference dataset. The names of the columns are different in both datasets. The rule checks if the set of values of the columns in the primary dataset is exactly equal to the set of values of the columns in the reference dataset.

ReferentialIntegrity "city,state" "reference.{ref_city,ref_state}" = 1.0

**Sample dynamic rules**
- ReferentialIntegrity "city, state" "reference.{ref_city, ref_state}" > avg(last(10))
- ReferentialIntegrity "city, state" "reference.{ref_city, ref_state}" between min(last(10)) - 1 and max(last(10)) + 1

**RowCount**

Checks the row count of a dataset against a given expression. In the expression, you can specify the number of rows or a range of rows using operators like > and <.

**Syntax**

```
RowCount <EXPRESSION>
```

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

**Example: Row count numeric check**

The following example rule checks whether the row count is within a given range.

```
RowCount between 10 and 100
```

**Sample dynamic rules**

```
RowCount > avg(lats(10)) * 0.8
```

**RowCountMatch**

Checks the ratio of the row count of the primary dataset and the row count of a reference dataset against the given expression.

**Syntax**

```
RowCountMatch <REFERENCE_DATASET_ALIAS> <EXPRESSION>
```

- **REFERENCE_DATASET_ALIAS** – The alias of the reference dataset against which to compare row counts.
**Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

### Example: Row count check against a reference dataset

The following example rule checks whether the row count of the primary dataset is at least 90% of the row count of the reference dataset.

```
RowCountMatch "reference" >= 0.9
```

### StandardDeviation

Checks the standard deviation of all of the values in a column against a given expression.

#### Syntax

```
StandardDeviation <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

### Example: Standard deviation

The following example rule checks whether the standard deviation of the values in a column named `colA` is less than a specified value.

```
StandardDeviation "Star_Rating" < 1.5
```

### Sample dynamic rules

- StandardDeviation "colA" > avg(last(10)) + 0.1
- StandardDeviation "colA" between min(last(10)) - 1 and max(last(10)) + 1
Sum

Checks the sum of all the values in a column against a given expression.

Syntax

```
Sum <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types:** Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

Example: Sum

The following example rule checks whether the sum of all of the values in a column exceeds a given threshold.

```
Sum "transaction_total" > 500000
```

Sample dynamic rules

- Sum "ColA" > avg(last(10))
- Sum "colA" between min(last(10)) - 1 and max(last(10)) + 1

SchemaMatch

Checks if the schema of the primary dataset matches the schema of a reference dataset. The schema check is done column by column. The schema of two columns match if the names are identical and the types are identical. The order of the columns does not matter.

Syntax

```
SchemaMatch <REFERENCE_DATASET_ALIAS> <EXPRESSION>
```

- **REFERENCE_DATASET_ALIAS** – The alias of the reference dataset against which to compare schemas.
Supported column types: Byte, Decimal, Double, Float, Integer, Long, Short

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

**Example: SchemaMatch**

The following example rule checks whether the schema of the primary dataset exactly matches the schema of a reference dataset.

```
SchemaMatch "reference" = 1.0
```

**Uniqueness**

Checks the percentage of unique values in a column against a given expression. Unique values occur exactly once.

**Syntax**

```
Uniqueness  <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  Supported column types: Any column type

  - **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see Expressions.

**Example: Uniqueness percentage**

The following example rule checks whether the percentage of unique values in a column matches certain numeric criteria.

```
Uniqueness "email" = 1.0
```

**Sample dynamic rules**

- Uniqueness "colA" between min(last(10)) and max(last(10))
- Uniqueness "colA" >= avg(last(10))
UniqueValueRatio

Checks the *unique value ratio* of a column against a given expression. A unique value ratio is the fraction of unique values divided by the number of all distinct values in a column. Unique values occur exactly one time, while distinct values occur *at least* once.

For example, the set \([a, a, b]\) contains one unique value (b) and two distinct values (a and b). So the unique value ratio of the set is \(\frac{1}{2} = 0.5\).

**Syntax**

```
UniqueValueRatio <COL_NAME> <EXPRESSION>
```

- **COL_NAME** – The name of the column that you want to evaluate the data quality rule against.

  **Supported column types**: Any column type

- **EXPRESSION** – An expression to run against the rule type response in order to produce a Boolean value. For more information, see [Expressions](#).

**Example: Unique value ratio**

This example checks the unique value ratio of a column against a range of values.

```
UniqueValueRatio "test_score" between 0 and 0.5
```

**Sample dynamic rules**

- UniqueValueRatio "colA" > avg(last(10))
- UniqueValueRatio "colA" <= index(last(10),2) + std(last(5))

**DetectAnomalies**

Detects anomalies for a given Deequ rule. Every execution of DetectAnomalies rule result in saving evaluated value for the given rule. When there is enough data gathered, anomaly detection algorithm takes all historical data for that given rule and runs anomaly detection. DetectAnomalies rule fails when anomaly is detected. More info about what anomaly was detected can be obtained from Observations.
Syntax

DetectAnomalies <RULE_NAME> <RULE_PARAMETERS>

RULE_NAME – The name of the rule that you want to evaluate and detect anomalies for. Supported rules:

- "RowCount"
- "Completeness"
- "Uniqueness"
- "Mean"
- "Sum"
- "StandardDeviation"
- "Entropy"
- "DistinctValuesCount"
- "UniqueValueRatio"
- "ColumnLength"
- "ColumnValues"
- "ColumnCorrelation"
- "CustomSql"

RULE_PARAMETERS – some rules require additional parameters to run. Refer to the given rule documentation to see required parameters.

Example: Anomalies for RowCount

For example, if we want to detect RowCount anomalies, we provide RowCount as a rule name.

DetectAnomalies "RowCount"

Example: Anomalies for ColumnLength

For example, if we want to detect ColumnLength anomalies, we provide ColumnLength as a rule name and the column name.
Using APIs to measure and manage data quality

This topic describes how to use APIs to measure and manage data quality.

Contents

- Prerequisites
- Working with AWS Glue Data Quality recommendations
- Working with AWS Glue Data Quality rulesets
- Working with AWS Glue Data Quality runs
- Working with AWS Glue Data Quality results

Prerequisites

- Make sure your boto3 version is up to date so that it includes the latest AWS Glue Data Quality API.
- Make sure your AWS CLI version is up to date, so as to include the latest CLI.

If you’re using an AWS Glue job to run these APIs, you can use the following option to update the boto3 library to the latest version:

```
--additional-python-modules boto3==<version>
```

Working with AWS Glue Data Quality recommendations

To start an AWS Glue Data Quality recommendation run:

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions.""
    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client
```
def start_data_quality_rule_recommendation_run(self, database_name, table_name, role_arn):
    ""
    Starts a recommendation run that is used to generate rules when you don't
    know what rules to write. AWS Glue Data Quality analyzes the data and comes up with
    recommendations for a potential ruleset. You can then triage the ruleset and modify
    the generated ruleset to your liking.
    
    :param database_name: The name of the AWS Glue database which contains the
    dataset.
    :param table_name: The name of the AWS Glue table against which we want a
    recommendation
    :param role_arn: The Amazon Resource Name (ARN) of an AWS Identity and Access
    Management (IAM) role that grants permission to let AWS Glue access the resources it
    needs.
    ""
    try:
        response = self.client.start_data_quality_rule_recommendation_run(
            DataSource={
                'GlueTable': {
                    'DatabaseName': database_name,
                    'TableName': table_name
                }
            },
            Role=role_arn
        )
    except ClientError as err:
        logger.error("Couldn't start data quality recommendation run %s. Here's why: %s:
        %s", name, err.response['Error']['Code'], err.response['Error']['Message'])
        raise
    else:
        return response['RunId']

For a recommendation run, you are able to use your pushDownPredicates or
catalogPartitionPredicates to improve performance and run recommendations only on
specific partitions of your catalog sources.

client.start_data_quality_rule_recommendation_run(
    DataSource={
        'GlueTable': {

To get results of an AWS Glue Data Quality recommendation run:

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions.""
    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def get_data_quality_rule_recommendation_run(self, run_id):
        """
        Gets the specified recommendation run that was used to generate rules.

        :param run_id: The id of the data quality recommendation run
        """
        try:
            response =
            self.client.get_data_quality_rule_recommendation_run(RunId=run_id)
        except ClientError as err:
            logger.error(  
                "Couldn't get data quality recommendation run %. Here's why: %s: %s",
                run_id,  
                err.response['Error']['Code'], err.response['Error']['Message'])
            raise
        else:
            return response
```

From the above response object, you can extract the RuleSet that was recommended by the run, to use in further steps:
print(response['RecommendedRuleset'])

Rules = [
    RowCount between 2000 and 8000,
    IsComplete "col1",
    IsComplete "col2",
    StandardDeviation "col3" between 58138330.8 and 64258155.09,
    ColumnValues "col4" between 1000042965 and 1214474826,
    IsComplete "col5"
]

To get a list of all your recommendation runs that can be filtered and listed:

response = client.list_data_quality_rule_recommendation_runs(
    Filter={
        'DataSource': {
            'GlueTable': {
                'DatabaseName': '<database_name>',
                'TableName': '<table_name>'
            }
        }
    }
)

To cancel existing AWS Glue Data Quality recommendation tasks:

response = client.cancel_data_quality_rule_recommendation_run(
    RunId='dqrun-d4b6b01957fdd79e59866365bf9cb0e40fxxxxxxxx'
)

Working with AWS Glue Data Quality rulesets

To create an AWS Glue Data Quality ruleset:

response = client.create_data_quality_ruleset(
    Name='<ruleset_name>',
    Ruleset='Rules = [IsComplete "col1", IsPrimaryKey "col2", RowCount between 2000 and 8000]',
    TargetTable={
        'TableName': '<table_name>',
        'DatabaseName': '<database_name>'
    }
)
To get a data quality ruleset:

```python
response = client.get_data_quality_ruleset(
    Name='<ruleset_name>'
)
print(response)
```

You can use this API to then extract the rule set:

```python
print(response['Ruleset'])
```

To list all the data quality rulesets for a table:

```python
response = client.list_data_quality_rulesets()
```

You can use the filter condition within the API to filter all rulesets attached to a specific database or table:

```python
response = client.list_data_quality_rulesets(
    Filter={
        'TargetTable': {
            'TableName': '<table_name>',
            'DatabaseName': '<database_name>'
        }
    },
)
```

To update a data quality ruleset:

```python
class GlueWrapper:
    ""
    """Encapsulates AWS Glue actions.""
    ""
    def __init__(self, glue_client):
        ""
        """:param glue_client: A Boto3 AWS Glue client."
        ""
        self.glue_client = glue_client
    ""
    def update_data_quality_ruleset(self, ruleset_name, ruleset_string):
```

Working with AWS Glue Data Quality rulesets
Update an AWS Glue Data Quality Ruleset

:param ruleset_name: The name of the AWS Glue Data Quality ruleset to update
:param ruleset_string: The DQDL ruleset string to update the ruleset with

try:
    response = self.client.update_data_quality_ruleset(
        Name=ruleset_name,
        Ruleset=ruleset_string
    )
except ClientError as err:
    logger.error("Couldn't update the AWS Glue Data Quality ruleset. Here's why: %s: %s",
                   err.response['Error']['Code'], err.response['Error']['Message'])
    raise
else:
    return response

To delete a data quality ruleset:

class GlueWrapper:
    
    """Encapsulates AWS Glue actions.""
    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def delete_data_quality_ruleset(self, ruleset_name):
        """
        Delete a AWS Glue Data Quality Rulest
        :param ruleset_name: The name of the AWS Glue Data Quality ruleset to delete
        """
        try:
            response = self.client.delete_data_quality_ruleset(
                Name=ruleset_name
            )
        except ClientError as err:
logger.error(  "Couldn't delete the AWS Glue Data Quality ruleset. Here's why: %s: %s",  err.response['Error']['Code'], err.response['Error']['Message'])
raise
else:
    return response

Working with AWS Glue Data Quality runs

To start an AWS Glue Data Quality run:

class GlueWrapper:
    """Encapsulates AWS Glue actions."""
    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

        def start_data_quality_ruleset_evaluation_run(self, database_name, table_name, role_name, ruleset_list):
            """
            Start an AWS Glue Data Quality evaluation run
            """
            :param database_name: The name of the AWS Glue database which contains the dataset.
            :param table_name: The name of the AWS Glue table against which we want to evaluate.
            :param role_arn: The Amazon Resource Name (ARN) of an AWS Identity and Access Management (IAM) role that grants permission to let AWS Glue access the resources it needs.
            :param ruleset_list: The list of AWS Glue Data Quality ruleset names to evaluate.
            """
            try:
                response = client.start_data_quality_ruleset_evaluation_run(
                    DataSource={
                        'GlueTable': {
                            'DatabaseName': database_name,
                            'TableName': table_name
                        }
                    }"""
Remember that you can pass a `pushDownPredicate` or `catalogPartitionPredicate` parameter to ensure your data quality run only targets a specific set of partition within your catalog table. For example:

```python
response = client.start_data_quality_ruleset_evaluation_run(
    DataSource={
        'GlueTable': {
            'DatabaseName': '<database_name>',
            'TableName': '<table_name>',
            'AdditionalOptions': {
                'pushDownPredicate': 'year=2023'
            }
        }
    },
    Role='<role_name>',
    NumberOfWorkers=5,
    Timeout=123,
    AdditionalRunOptions={
        'CloudWatchMetricsEnabled': False
    },
    RulesetNames=['<ruleset_name>',
    ]
)
```

To get information about an AWS Glue Data Quality run:

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions.""
    def __init__(self, glue_client):
```
To get the results from an AWS Glue Data Quality run:

For a given AWS Glue Data Quality run, you can extract the results of the run's evaluation using the following method:

```python
response = client.get_data_quality_ruleset_evaluation_run(
    RunId='d4b6b01957fdd79e59866365bf9cb0e40fxxxxxxx'
)
resultID = response['ResultIds'][0]
response = client.get_data_quality_result(
    ResultId=resultID
)
print(response['RuleResults'])
```

To list all your AWS Glue Data Quality runs:
class GlueWrapper:
    """Encapsulates AWS Glue actions."""
    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def list_data_quality_ruleset_evaluation_runs(self, database_name, table_name):
        """
        Lists all the AWS Glue Data Quality runs against a given table
        
        :param database_name: The name of the database where the data quality runs were created
        :param table_name: The name of the table against which the data quality runs were created
        """
        try:
            response = self.client.list_data_quality_ruleset_evaluation_runs(
                Filter={
                    'DataSource': {
                        'GlueTable': {
                            'DatabaseName': database_name,
                            'TableName': table_name
                        }
                    }
                }
            )
        except ClientError as err:
            logger.error(
                "Couldn't list the AWS Glue Quality runs. Here's why: %s: %s",
                err.response['Error']['Code'], err.response['Error']['Message'])
            raise
        else:
            return response

You can modify the filter clause to only show results between specific times or running against specific tables.

**To stop an ongoing AWS Glue Data Quality run:**

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""
```
```python
def __init__(self, glue_client):
    
    
    self.glue_client = glue_client

def cancel_data_quality_ruleset_evaluation_run(self, result_id):
    
    Cancels a given AWS Glue Data Quality run

    :param result_id: The result id of a AWS Glue Data Quality run to cancel
    
    try:
        response = self.client.cancel_data_quality_ruleset_evaluation_run(
            ResultId=result_id
        )
    except ClientError as err:
        logger.error(
            "Couldn't cancel the AWS Glue Data Quality run. Here's why: %s: %s",
            err.response['Error']['Code'], err.response['Error']['Message'])
        raise
    else:
        return response
```
To cancel existing AWS Glue Data Quality recommendation tasks:

Given an AWS Glue Data Quality run ID, you can extract the result ID to then get the actual results, as shown below:

```python
response = client.get_data_quality_ruleset_evaluation_run(
    RunId='dqrun-abca77ee126abe1378c1da1ae0750xxxxxxxx'
)
resultID = response['ResultIds'][0]
response = client.get_data_quality_result(
    ResultId=resultID
)
print(resp['RuleResults'])
```

Setting up alerts, deployments, and scheduling

This topic describes how to set up alerts, deployments, and scheduling for AWS Glue Data Quality.

Contents

- Setting up alerts and notifications in Amazon EventBridge integration
  - Additional configuration options for the event pattern
  - Formatting notifications as emails
- Set up alerts and notifications in CloudWatch integration
• Querying data quality results to build dashboards
• Deploying data quality rules using AWS CloudFormation
• Scheduling data quality rules

**Setting up alerts and notifications in Amazon EventBridge integration**

AWS Glue Data Quality supports the publishing of EventBridge events, which are emitted upon completion of a Data Quality ruleset evaluation run. With this, you can easily setup alerts when data quality rules fail.

Here is a sample event when you evaluate data quality rulesets in the Data Catalog. With this information, you can review the data that is made available with Amazon EventBridge. You can issue additional API calls to get more details. For example, call the `get_data_quality_result` API with the result ID to get the details of a particular execution.

```json
{
    "version": "0",
    "id": "abcdef00-1234-5678-9abc-def012345678",
    "detail-type": "Data Quality Evaluation Results Available",
    "source": "aws.glue",
    "account": "123456789012",
    "time": "2017-09-07T18:57:21Z",
    "region": "us-west-2",
    "resources": [],
    "detail": {
        "context": {
            "contextType": "GLUE_DATA_CATALOG",
            "runId": "dqrun-12334567890",
            "databaseName": "db-123",
            "tableName": "table-123",
            "catalogId": "123456789012"
        },
        "resultID": "dqresult-12334567890",
        "rulesetNames": ["rulset1"],
        "state": "SUCCEEDED",
        "score": 1.00,
        "rulesSucceeded": 100,
        "rulesFailed": 0,
        "rulesSkipped": 0
    }
}
```
Here is a sample event that gets published when you evaluate data quality rulesets in AWS Glue ETL or AWS Glue Studio notebooks.

```
{
    "version": "0",
    "id": "abcdef00-1234-5678-9abc-def012345678",
    "detail-type": "Data Quality Evaluation Results Available",
    "source": "aws.glue.dataquality",
    "account": "123456789012",
    "time": "2017-09-07T18:57:21Z",
    "region": "us-west-2",
    "resources": [],
    "detail": {
        "context": {
            "contextType": "GLUE_JOB",
            "jobId": "jr-12334567890",
            "jobName": "dq-eval-job-1234",
            "evaluationContext": "",
        }
        "resultID": "dqresult-12334567890",
        "rulesetNames": ["rulset1"],
        "state": "SUCCEEDED",
        "score": 1.00
        "rulesSucceeded": 100,
        "rulesFailed": 0,
        "rulesSkipped": 0
    }
}
```

For Data Quality evaluation runs both in the Data Catalog and in ETL jobs, the Publish metrics to Amazon Cloudwatch option, which is selected by default, must remain selected for EventBridge publishing to work.

Setting up EventBridge notifications
To receive the emitted events and define targets, you must configure Amazon EventBridge rules. To create rules:

1. Open the Amazon EventBridge console.
2. Choose **Rules** under the **Buses** section of the navigation bar.
3. Choose **Create Rule**.
4. On **Define Rule Detail**:
   a. For Name, enter myDQRule.
   b. Enter the description (optional).
   c. For event bus, select your event bus. If you don’t have one, leave it as default.
   d. For Rule type select **Rule with an event pattern** then choose **Next**.
5. On **Build Event Pattern**:
   a. For event source select **AWS events or EventBridge partner events**.
   b. Skip the sample event section.
   c. For creation method select **Use pattern form**.
   d. For event pattern:
      i. Select **AWS services** for Event source.
      ii. Select **Glue Data Quality** for AWS service.
      iii. Select **Data Quality Evaluation Results Available** for Event type.
      iv. Select **FAILED** for Specific state(s). Then you see an event pattern similar to the following:

```json
{
    "source": ["aws.glue-dataquality"],
    "detail-type": ["Data Quality Evaluation Results Available"],
    "detail": {
        "state": ["FAILED"]
    }
}
```
v. For more configuration options see Additional configuration options for the event pattern.

6. On Select Target(s):
   a. For Target Types select AWS service.
   b. Use the Select a target dropdown to choose your desired AWS service to connect to (SNS, Lambda, SQS, etc.), then choose Next.

7. On Configure tag(s) click Add new tags to add optional tags then choose Next.

8. You see a summary page of all the selections. Choose Create rule at the bottom.

Additional configuration options for the event pattern

In addition to filtering your event on success or failure, you may want to further filter events on different parameters.

To do this, go to the Event Pattern section, and select Edit pattern to specify additional parameters. Note that fields in the event pattern are case sensitive. The following are examples of configuring the event pattern.

To capture events from a particular table evaluating specific rulesets use this type of pattern:

```json
{
   "source": ["aws.glue-dataquality"],
   "detail-type": ["Data Quality Evaluation Results Available"],
   "detail": {
      "context": {
         "contextType": ["GLUE_DATA_CATALOG"],
         "databaseName": "db-123",
         "tableName": "table-123",
      },
      "rulesetNames": ["ruleset1", "ruleset2"],
      "state": ["FAILED"]
   }
}
```

To capture events from specific jobs in the ETL experience use this type of pattern:

```json
{
}
```
To capture events with a score under a specific threshold (e.g. 70%):

```
{
    "source": ["aws.glue-dataquality"],
    "detail-type": ["Data Quality Evaluation Results Available"],
    "detail": {
        "score": [{
            "numeric": ["<=", 0.7]
        }]
    }
}
```

**Formatting notifications as emails**

Sometimes you need to send a well-formatted email notification to your business teams. You can use Amazon EventBridge and AWS Lambda to achieve this.
The following sample code can be used to format your data quality notifications to generate emails.

```python
import boto3
import json
from datetime import datetime

sns_client = boto3.client('sns')
glue_client = boto3.client('glue')

sns_topic_arn = 'arn:aws:sns:<region-code>:<account-id>:<sns-topic-name>'

def lambda_handler(event, context):
    log_metadata = {}
```
message_text = ""
subject_text = ""

if event['detail']['context']['contextType'] == 'GLUE_DATA_CATALOG':
    log_metadata['ruleset_name'] = str(event['detail']['rulesetNames'][0])
    log_metadata['tableName'] = str(event['detail']['context']['tableName'])
    log_metadata['databaseName'] = str(event['detail']['context']['databaseName'])
    log_metadata['runId'] = str(event['detail']['context']['runId'])
    log_metadata['resultId'] = str(event['detail']['resultId'])
    log_metadata['state'] = str(event['detail']['state'])
    log_metadata['score'] = str(event['detail']['score'])
    log_metadata['numRulesSucceeded'] = str(event['detail']['numRulesSucceeded'])
    log_metadata['numRulesFailed'] = str(event['detail']['numRulesFailed'])
    log_metadata['numRulesSkipped'] = str(event['detail']['numRulesSkipped'])

    message_text += "Glue Data Quality run details:
    ruleset_name: {}
    glue_table_name: {}
    glue_database_name: {}
    run_id: {}
    result_id: {}
    state: {}
    score: {}
    numRulesSucceeded: {}
    numRulesFailed: {}
    numRulesSkipped: {}"

    subject_text = "Glue Data Quality ruleset {} run
details".format(log_metadata['ruleset_name'])
else:
    log_metadata['ruleset_name'] = str(event['detail']['rulesetNames'][0])
    log_metadata['jobName'] = str(event['detail']['context']['jobName'])
    log_metadata['jobId'] = str(event['detail']['context']['jobId'])
    log_metadata['resultId'] = str(event['detail']['resultId'])
    log_metadata['state'] = str(event['detail']['state'])
    log_metadata['score'] = str(event['detail']['score'])

    log_metadata['numRulesSucceeded'] = str(event['detail']['numRulesSucceeded'])
    log_metadata['numRulesFailed'] = str(event['detail']['numRulesFailed'])
    log_metadata['numRulesSkipped'] = str(event['detail']['numRulesSkipped'])

    message_text += "Glue Data Quality run details:\n"
message_text += "ruleset_name: {}
".format(log_metadata['ruleset_name'])
message_text += "glue_job_name: {}
".format(log_metadata['jobName'])
message_text += "job_id: {}
".format(log_metadata['jobId'])
message_text += "result_id: {}
".format(log_metadata['resultId'])
message_text += "state: {}
".format(log_metadata['state'])
message_text += "score: {}
".format(log_metadata['score'])
message_text += "numRulesSucceeded: {}
".format(log_metadata['numRulesSucceeded'])
message_text += "numRulesFailed: {}
".format(log_metadata['numRulesFailed'])
message_text += "numRulesSkipped: {}
".format(log_metadata['numRulesSkipped'])

subject_text = "Glue Data Quality ruleset {} run
details".format(log_metadata['ruleset_name'])

resultID = str(event['detail']['resultId'])
response = glue_client.get_data_quality_result(ResultId=resultID)
RuleResults = response['RuleResults']
message_text += "\n\nruleset details evaluation steps results:\n\n"
subresult_info = []

for dic in RuleResults:
    subresult = "Name: {}		Result: {}		Description: 	{}
".format(dic['Name'], dic['Result'], dic['Description'])
    if 'EvaluationMessage' in dic:
        subresult += "		EvaluationMessage: {}
".format(dic['EvaluationMessage'])
    subresult_info.append({
        'Name': dic['Name'],
        'Result': dic['Result'],
        'Description': dic['Description'],
        'EvaluationMessage': dic.get('EvaluationMessage', '')
    })
message_text += "\n" + subresult

log_metadata['resultrun'] = subresult_info

sns_client.publish(
    TopicArn=sns_topic_arn,
    Message=message_text,
    Subject=subject_text
)

return {
Set up alerts and notifications in CloudWatch integration

Our recommended approach is to set up data quality alerts using Amazon EventBridge, because Amazon EventBridge requires a one-time setup to alert customers. However, some customers prefer Amazon CloudWatch due to familiarity. For such customers, we offer integration with Amazon CloudWatch.

Each AWS Glue Data Quality evaluation emits a pair of metrics named `glue.data.quality.rules.passed` (indicating a number of rules that passed) and `glue.data.quality.rules.failed` (indicating the number of failed rules) per data quality run. You can use this emitted metric to create alarms to alert users if a given data quality run falls below a threshold. To get started with setting up an alarm that would send an email via an Amazon SNS notification, follow the steps below:

To get started with setting up an alarm that would send an email via an Amazon SNS notification, follow the steps below:

1. Open the Amazon CloudWatch console.
2. Choose All metrics under Metrics. You will see an additional namespace under Custom namespaces titled Glue Data Quality.

   **Note**
   
   When starting an AWS Glue Data Quality run, make sure the Publish metrics to Amazon CloudWatch checkbox is enabled. Otherwise, metrics for that particular run will not be published to Amazon CloudWatch.

Under the Glue Data Quality namespace, you can see metrics being emitted per table, per ruleset. For the purpose of this topic, we will use the `glue.data.quality.rules.failed` rule and alarm if this value goes over 1 (indicating that, if we see a number of failed rule evaluations greater than 1, we want to be notified).

3. To create the alarm, choose All alarms under Alarms.
4. Choose **Create alarm**.

5. Choose **Select metric**.

6. Select the `glue.data.quality.rules.failed` metric corresponding to the table you've created, then choose **Select metric**.

7. Under the **Specify metric and conditions** tab, under the **Metrics** section:
   a. For **Statistic**, choose **Sum**.
   b. For **Period**, choose **1 minute**.

8. Under the **Conditions** section:
   a. For **Threshold type**, choose **Static**.
   b. For **Whenever glue.data.quality.rules.failed is...**, select **Greater/Equal**.
   c. For **than...**, enter **1** as the threshold value.

   These selections imply that if the `glue.data.quality.rules.failed` metric emits a value greater than or equal to 1, we will trigger an alarm. However, if there is no data, we will treat it as acceptable.

9. Choose **Next**.

10. On **Configure actions**:
   a. For the **Alarm state trigger** section, choose **In alarm**.
   b. For **Send a notification to the following SNS topic** section, choose **Create a new topic to send a notification via a new SNS topic**.
   c. For **Email endpoints that will receive the notification** enter your email address. Then click **Create Topic**.
   d. Choose **Next**.

11. For **Alarm name**, enter **myFirstDQAlarm**, then choose **Next**.

12. You see a summary page of all the selections. Choose **Create alarm** at the bottom.

You can now see the alarm being created from the Amazon CloudWatch alarms dashboard.

**Querying data quality results to build dashboards**

You may want to build a dashboard to display your data quality results. There are two ways to do this:

**Set up Amazon EventBridge with the following code to write the data to Amazon S3:**
```python
import boto3
import json
from datetime import datetime

s3_client = boto3.client('s3')
glue_client = boto3.client('glue')

s3_bucket = 's3-bucket-name'

def write_logs(log_metadata):
    try:
        filename = datetime.now().strftime("%m%d%Y%H%M%S") + ".json"
        key_opts = {
            'year': datetime.now().year,
            'month': "{:02d}".format(datetime.now().month),
            'day': "{:02d}".format(datetime.now().day),
            'filename': filename
        }
        s3key = "gluedataqualitylogs/year={year}/month={month}/day={day}/
        {filename}".format(**key_opts)
        s3_client.put_object(Bucket=s3_bucket, Key=s3key,
        Body=json.dumps(log_metadata))
    except Exception as e:
        print(f'Error writing logs to S3: {e}')

def lambda_handler(event, context):
    log_metadata = {}
    message_text = ""
    subject_text = ""

    if event['detail']['context']['contextType'] == 'GLUE_DATA_CATALOG':
        log_metadata['ruleset_name'] = str(event['detail']['rulesetNames'][0])
        log_metadata['tableName'] = str(event['detail']['context']['tableName'])
        log_metadata['databaseName'] = str(event['detail']['context']['databaseName'])
        log_metadata['runId'] = str(event['detail']['context']['runId'])
        log_metadata['resultId'] = str(event['detail']['resultId'])
        log_metadata['state'] = str(event['detail']['state'])
        log_metadata['score'] = str(event['detail']['score'])
        log_metadata['numRulesSucceeded'] = str(event['detail']['numRulesSucceeded'])
        log_metadata['numRulesFailed'] = str(event['detail']['numRulesFailed'])
```

Querying data quality results
log_metadata['numRulesSkipped'] = str(event['detail']['numRulesSkipped'])

message_text += "Glue Data Quality run details:
message_text += "ruleset_name: {}".format(log_metadata['ruleset_name'])
message_text += "glue_table_name: {}".format(log_metadata['tableName'])
message_text += "glue_database_name: {}".format(log_metadata['databaseName'])
message_text += "run_id: {}".format(log_metadata['runId'])
message_text += "result_id: {}".format(log_metadata['resultId'])
message_text += "state: {}".format(log_metadata['state'])
message_text += "score: {}".format(log_metadata['score'])
message_text += "numRulesSucceeded: {}".format(log_metadata['numRulesSucceeded'])
message_text += "numRulesFailed: {}".format(log_metadata['numRulesFailed'])
message_text += "numRulesSkipped: {}".format(log_metadata['numRulesSkipped'])

subject_text = "Glue Data Quality ruleset {} run
details".format(log_metadata['ruleset_name'])

else:
    log_metadata['ruleset_name'] = str(event['detail']['rulesetNames'][0])
    log_metadata['jobName'] = str(event['detail']['context']['jobName'])
    log_metadata['jobId'] = str(event['detail']['context']['jobId'])
    log_metadata['resultId'] = str(event['detail']['resultId'])
    log_metadata['state'] = str(event['detail']['state'])
    log_metadata['score'] = str(event['detail']['score'])

    log_metadata['numRulesSucceeded'] = str(event['detail']['numRulesSucceeded'])
    log_metadata['numRulesFailed'] = str(event['detail']['numRulesFailed'])
    log_metadata['numRulesSkipped'] = str(event['detail']['numRulesSkipped'])

    message_text += "Glue Data Quality run details:
message_text += "ruleset_name: {}".format(log_metadata['ruleset_name'])
message_text += "glue_job_name: {}".format(log_metadata['jobName'])
message_text += "job_id: {}".format(log_metadata['jobId'])
message_text += "result_id: {}".format(log_metadata['resultId'])
message_text += "state: {}".format(log_metadata['state'])
message_text += "score: {}".format(log_metadata['score'])
message_text += "numRulesSucceeded:
{}".format(log_metadata['numRulesSucceeded'])
message_text += "numRulesFailed: {}
message_text += "numRulesSkipped: {}".format(log_metadata['numRulesSkipped'])

subject_text = "Glue Data Quality ruleset {} run
details".format(log_metadata['ruleset_name'])
resultID = str(event['detail']['resultId'])
response = glue_client.get_data_quality_result(ResultId=resultID)
RuleResults = response['RuleResults']
message_text += "ruleset details evaluation steps results:

subresult_info = []

for dic in RuleResults:
    subresult = "Name: {}		Result: {}		Description: 	{}
    
    ".
    if 'EvaluationMessage' in dic:
        subresult += "		EvaluationMessage: {}
    
    subresult_info.append({
        'Name': dic['Name'],
        'Result': dic['Result'],
        'Description': dic['Description'],
        'EvaluationMessage': dic.get('EvaluationMessage', '')
    })

    message_text += " + subresult

log_metadata['resultrun'] = subresult_info
write_logs(log_metadata)

return {
    'statusCode': 200,
    'body': json.dumps('Message published to SNS topic')
}

After writing to Amazon S3, you can use AWS Glue crawlers to register to Athena and query the tables.

**Configure an Amazon S3 location during a data quality evaluation:**

When running data quality tasks in the AWS Glue Data Catalog or AWS Glue ETL, you can provide an Amazon S3 location to write the data quality results to Amazon S3. You can use the syntax below to create a table by referencing the target to read the data quality results.

Note that you must run the CREATE EXTERNAL TABLE and MSCK REPAIR TABLE queries separately.
CREATE EXTERNAL TABLE <my_table_name>(
  catalogid string,
  databasename string,
  tablename string,
  dqrunid string,
  evaluationstartedon timestamp,
  evaluationcompletedon timestamp,
  rule string,
  outcome string,
  failurereason string,
  evaluatedmetrics string)
PARTITIONED BY (``year`` string,
  `month` string,
  `day` string)
ROW FORMAT SERDE 'org.openx.data.jsonserde.JsonSerDe'
WITH SERDEPROPERTIES (
  'paths'='catalogId,databaseName,dqRunId,evaluatedMetrics,evaluationCompletedOn,evaluationStartedOn,failureReason,outcome,rule,tableName')
STORED AS INPUTFORMAT 'org.apache.hadoop.mapred.TextInputFormat'
OUTPUTFORMAT 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat'
LOCATION 's3://glue-s3-dq-bucket-us-east-2-results/'
TBLPROPERTIES (``classification``='json',
  `compressionType`='none',
  `typeOfData`='file');

MSCK REPAIR TABLE <my_table_name>;

Once you create the above table, you can run analytical queries using Amazon Athena.

**Deploying data quality rules using AWS CloudFormation**

You can use AWS CloudFormation to create data quality rules. For more information, see [AWS CloudFormation for AWS Glue](#).

**Scheduling data quality rules**

You can schedule data quality rules using the following methods:
• Schedule data quality rules from the Data Catalog: no code users can use this option to easily schedule their data quality scans. AWS Glue Data Quality will create the schedule in Amazon EventBridge. To schedule data quality rules:

  • Navigate to the ruleset and click Run.

  • In the Run frequency, select the desired schedule and provide a Task Name. This Task Name is the name of your schedule in EventBridge.

• Use Amazon EventBridge and AWS Step Functions to orchestrate evaluations and recommendations for data quality rules.

### Troubleshooting AWS Glue Data Quality errors

If you encounter errors in AWS Glue Data Quality, use the following solutions to help you find the source of the problems and fix them.

**Contents**

• Error: missing AWS Glue Data Quality module

• Error: insufficient AWS Lake Formation permissions

• Error: rulesets are not uniquely named

• Error: tables with special characters

• Error: overflow error with a large ruleset

• Error: overall rule status is failed

• AnalysisException: Unable to verify existence of default database

• Error Message: Provided key map not suitable for given data frames

• Exception in User Class: java.lang.RuntimeException : Failed to fetch data. Check the logs in CloudWatch to get more details

• LAUNCH ERROR: Error downloading from S3 for bucket

• InvalidInputException (status: 400): DataQuality rules cannot be parsed

• Error: Eventbridge is not triggering Glue DQ jobs based on the schedule I setup

• CustomSQL errors

• Dynamic Rules
Error: missing AWS Glue Data Quality module

Error message: No module named 'awsgluedq'.

Resolution: This error occurs when you run AWS Glue Data Quality in an unsupported version. AWS Glue Data Quality is supported only in Glue version 3.0 and later.

Error: insufficient AWS Lake Formation permissions

Error message: Exception in User Class: com.amazonaws.services.glue.model.AccessDeniedException: Insufficient Lake Formation permission(s) on impact_sdg_involvement (Service: AWS Glue; Status Code: 400; Error Code: AccessDeniedException; Request ID: 465ae693-b7ba-4df0-a4e4-6b17xxxxxxxx; Proxy: null).

Resolution: You must provide sufficient permissions in AWS Lake Formation.

Error: rulesets are not uniquely named

Error message: Exception in User Class: ...services.glue.model.AlreadyExistsException: Another ruleset with the same name already exists.

Resolution: Rulesets are global and must be unique.

Error: tables with special characters

Error message: Exception in User Class: org.apache.spark.sql.AnalysisException: cannot resolve "C" given input columns: [primary.data_end_time, primary.data_start_time, primary.end_time, primary.last_updated, primary.message, primary.process_date, primary.rowhash, primary.run_by, primary.run_id, primary.start_time, primary.status]; line 1 pos 44;.

Resolution: There is a current limitation that AWS Glue Data Quality cannot be executed on tables that have special characters such as ".".

Error: overflow error with a large ruleset


Resolution: If you have a large ruleset of greater than 2K rules, you may encounter this issue. Break your rules into multiple rulesets.
**Error: overall rule status is failed**

**Error condition:** My Ruleset is successful, but my overall rule status is failed.

**Resolution:** This error most likely occurred because you chose the option to publish metrics to Amazon CloudWatch while publishing. If your dataset is in a VPC, your VPC may not allow AWS Glue to publish metrics to Amazon CloudWatch. In this case, you must set up an endpoint for your VPC to access Amazon CloudWatch.

**AnalysisException: Unable to verify existence of default database**

**Error condition:** AnalysisException: Unable to verify existence of default database: com.amazonaws.services.glue.model.AccessDeniedException: Insufficient Lake Formation permission(s) on default (Service: AWS Glue; Status Code: 400; Error Code: AccessDeniedException; Request ID: XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXXX; Proxy: null)

**Resolution:** In AWS Glue job’s catalog integration, AWS Glue always tries to check whether default database exists or not using AWS Glue GetDatabase API. When the DESCRIBE Lake Formation permission is not granted, or GetDatabase IAM permission is granted, then the job fails when verifying existence of the default database.

To resolve:

1. Add the DESCRIBE permission in Lake Formation for the default database.
2. Configure the IAM role attached to the AWS Glue job as Database Creator in Lake Formation. This will automatically create a default database and grant required Lake Formation permissions for the role.
3. Disable --enable-data-catalog option. (It is shown as **Use Data Catalog as the Hive metastore** in AWS Glue Studio).

   If you do not need Spark SQL Data Catalog integration in the job, you can disable it.

**Error Message: Provided key map not suitable for given data frames**

**Error condition:** Provided key map not suitable for given data frames.

**Resolution:** You are using **DataSetMatch** ruletype and the join keys have duplicates. Your join keys must be unique and must not be NULL. In cases where you can’t have join keys that are unique, consider using other ruletypes such as **AggregateMatch** to match on summary data.
Exception in User Class: java.lang.RuntimeException : Failed to fetch data. Check the logs in CloudWatch to get more details

Error condition: Exception in User Class: java.lang.RuntimeException : Failed to fetch data. Check the logs in CloudWatch to get more details.

Resolution: This happens when you are creating DQ rules on an Amazon S3-based table that compares against Amazon RDS or Amazon Redshift. In these cases, AWS Glue cannot load the connection. Instead, try to set up DQ rule on the Amazon Redshift or Amazon RDS dataset. This is a known bug.

LAUNCH ERROR: Error downloading from S3 for bucket


Resolution: The permissions in the role passed to AWS Glue Data Quality must permit reading from the preceding Amazon S3 location. This IAM policy should be attached to the role:

```json
{
    "Sid": "allowS3",
    "Effect": "Allow",
    "Action": "s3:GetObject",
}
```

Refer to Data Quality authorization for detailed permissions. These libraries are required to evaluate data quality for your datasets.

InvalidInputException (status: 400): DataQuality rules cannot be parsed

Error condition: InvalidInputException (status: 400): DataQuality rules cannot be parsed.

Resolution: There are many possibilities for this error. One possibility is that your rules may have single quotes. Verify that they are in double quotes. For example:

```java
Rules = [
```
Change this to:

```
Rules = [
  (ColumnValues "tipovinculo" in [ "CODO", "DOCO", "COCO", "DODO"] AND (ColumnValues "categoria" = "ES")
   AND (ColumnValues "codbandera" = "CEP")
]
```

**Error: Eventbridge is not triggering Glue DQ jobs based on the schedule I setup**

**Error condition:** Eventbridge is not triggering AWS Glue Data Quality jobs based on the schedule I setup.

**Resolution:** The role triggering the job may not have the right permissions. Make sure that the role that you are using to start the jobs has the permissions mentioned in [IAM setup required for scheduling evaluation runs](#).

**CustomSQL errors**

**Error condition:** The output from CustomSQL must contain at least one column that matches the input dataset for AWS Glue Data Quality to provide row level results. The SQL query is a valid query but no columns from the SQL result are present in the Input Dataset. Ensure that matching columns are returned from the SQL.

**Resolution:** The SQL query is valid but verify that you’re selecting only columns from the primary table. Selecting aggregate functions like sum, count on the columns from the primary can result in this error.

**Error condition:** There was a problem when executing your SQL statement: cannot resolve "Col".

**Resolution:** This column is not present in the primary table.
Error condition: The columns that are returned from the SQL statement should only belong to the primary table. "In this case, some columns ( Col ) belong to reference table".

Resolution: In SQL queries when you’re joining the primary table with other reference tables, verify that your select statement has only column names from your primary table to generate row level results for the primary table.

Dynamic Rules

Error condition: Dynamic rules require job context, and cannot be evaluated in interactive session or data preview..

Cause: This error message might appear in your data preview results, or in other interactive sessions, when dynamic DQ rules are present in your ruleset. Dynamic rules reference historical metrics associated with a particular job name and evaluation context, so they can't be evaluated in interactive sessions.

Resolution: Running your AWS Glue job will produce historical metrics, which can be referenced in later job runs for the same job.

Error condition:

- [RuleType] rule only supports simple atomic operands in thresholds..
- Function last not yet implemented for [RuleType] rule.

Resolution: Dynamic rules are generally supported for all DQDL ruletypes in numeric expressions (see DQDL Reference). However, some rules that produce multiple metrics, ColumnValues and ColumnLength, are not yet supported.

Error condition: Binary expression operands must resolve to a single number..

Cause: Dynamic rules support binary expressions, like RowCount > avg(last(5)) * 0.9. Here, the binary expression is avg(last(5)) * 0.9. This rule is valid because both operands avg(last(5)) and 0.9 resolve to a single number. An incorrect example is RowCount > last(5) * 0.9, because last(5) will produce a list that can't be meaningfully compared to the current row count.

Resolution: Use aggregation functions to reduce a list-valued operand to a single number.
**Error condition:**

- Rule threshold results in list, and a single value is expected. Use aggregation functions to produce a single value. Valid example: \( \text{sum(last(10))}, \text{avg(last(10))} \).
- Rule threshold results in empty list, and a single value is expected.

**Cause:** Dynamic rules can be used to compare some feature of your dataset with its historical values. The last function allows for the retrieval of multiple historical values, if a positive integer argument is provided. For example, \( \text{last(5)} \) will retrieve the last five most recent values observed in job runs for your rule.

**Resolution:** An aggregation function must be used to reduce these values to a single number to make a meaningful comparison with the value observed in the current job run.

Valid examples:

- \( \text{RowCount} \geq \text{avg(last(5))} \)
- \( \text{RowCount} > \text{last(1)} \)
- \( \text{RowCount} < \text{last()} \)

Invalid example: \( \text{RowCount} > \text{last(5)} \).

**Error condition:**

- Function index used in threshold requires positive integer argument.
- Index argument must be an integer. Valid syntax example: \( \text{RowCount} > \text{index(last(10, 2))} \), which means \( \text{RowCount} \) must be greater than third most recent execution from last 10 job runs.

**Resolution:** When authoring dynamic rules, you can use the index aggregation function to select one historical value from a list. For example, \( \text{RowCount} > \text{index(last(5), 1)} \) will check whether the row count observed in the current job is strictly greater than the second most recent row count observed for your job. index is zero-indexed.

**Error condition:** IllegalArgumentException: Parsing Error: Rule Type: DetectAnomalies is not valid.
Resolution: Anomaly detection is only available in AWS Glue 4.0.

Error condition: IllegalArgumentException: Parsing Error: Unexpected condition for rule of type ... no viable alternative at input ....

Note: ... is dynamic. Example: IllegalArgumentException: Parsing Error: Unexpected condition for rule of type RowCount with number return type, line 4:19 no viable alternative at input '>last'.

Resolution: Anomaly detection is only available in AWS Glue 4.0.
Orchestration in AWS Glue

The following sections provide information on orchestration of jobs in AWS Glue.

Topics

- Starting jobs and crawlers using triggers
- Performing complex ETL activities using blueprints and workflows in AWS Glue
- Developing blueprints in AWS Glue

Starting jobs and crawlers using triggers

In AWS Glue, you can create Data Catalog objects called triggers, which you can use to either manually or automatically start one or more crawlers or extract, transform, and load (ETL) jobs. Using triggers, you can design a chain of dependent jobs and crawlers.

Note
You can accomplish the same thing by defining workflows. Workflows are preferred for creating complex multi-job ETL operations. For more information, see the section called “Performing complex ETL activities using blueprints and workflows”.

Topics

- AWS Glue triggers
- Adding triggers
- Activating and deactivating triggers

AWS Glue triggers

When fired, a trigger can start specified jobs and crawlers. A trigger fires on demand, based on a schedule, or based on a combination of events.
A trigger can exist in one of several states. A trigger is either CREATED, ACTIVATED, or DEACTIVATED. There are also transitional states, such as ACTIVATING. To temporarily stop a trigger from firing, you can deactivate it. You can then reactivate it later.

There are three types of triggers:

**Scheduled**

A time-based trigger based on cron.

You can create a trigger for a set of jobs or crawlers based on a schedule. You can specify constraints, such as the frequency that the jobs or crawlers run, which days of the week they run, and at what time. These constraints are based on cron. When you're setting up a schedule for a trigger, consider the features and limitations of cron. For example, if you choose to run your crawler on day 31 each month, keep in mind that some months don't have 31 days. For more information about cron, see [Time-based schedules for jobs and crawlers](#).

**Conditional**

A trigger that fires when a previous job or crawler or multiple jobs or crawlers satisfy a list of conditions.

When you create a conditional trigger, you specify a list of jobs and a list of crawlers to watch. For each watched job or crawler, you specify a status to watch for, such as succeeded, failed, timed out, and so on. The trigger fires if the watched jobs or crawlers end with the specified statuses. You can configure the trigger to fire when any or all of the watched events occur.

For example, you could configure a trigger T1 to start job J3 when both job J1 and job J2 successfully complete, and another trigger T2 to start job J4 if either job J1 or job J2 fails.

The following table lists the job and crawler completion states (events) that triggers watch for.
### Job completion states

<table>
<thead>
<tr>
<th>Completion State</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUCCEEDED</td>
</tr>
<tr>
<td>STOPPED</td>
</tr>
<tr>
<td>FAILED</td>
</tr>
<tr>
<td>TIMEOUT</td>
</tr>
</tbody>
</table>

### Crawler completion states

<table>
<thead>
<tr>
<th>Completion State</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUCCEEDED</td>
</tr>
<tr>
<td>FAILED</td>
</tr>
<tr>
<td>CANCELLED</td>
</tr>
</tbody>
</table>

---

**On-demand**

A trigger that fires when you activate it. On-demand triggers never enter the ACTIVATED or DEACTIVATED state. They always remain in the CREATED state.

So that they are ready to fire as soon as they exist, you can set a flag to activate scheduled and conditional triggers when you create them.

---

⚠️ **Important**

Jobs or crawlers that run as a result of other jobs or crawlers completing are referred to as dependent. Dependent jobs or crawlers are only started if the job or crawler that completes was started by a trigger. All jobs or crawlers in a dependency chain must be descendants of a single scheduled or on-demand trigger.

---

**Passing job parameters with triggers**

A trigger can pass parameters to the jobs that it starts. Parameters include job arguments, timeout value, security configuration, and more. If the trigger starts multiple jobs, the parameters are passed to each job.

The following are the rules for job arguments passed by a trigger:

- If the key in the key-value pair matches a default job argument, the passed argument overrides the default argument. If the key doesn’t match a default argument, then the argument is passed as an additional argument to the job.
- If the key in the key-value pair matches a non-overridable argument, the passed argument is ignored.
For more information, see the section called “Triggers” in the AWS Glue API.

Adding triggers

You can add a trigger using the AWS Glue console, the AWS Command Line Interface (AWS CLI), or the AWS Glue API.

Note

Currently, the AWS Glue console supports only jobs, not crawlers, when working with triggers. You can use the AWS CLI or AWS Glue API to configure triggers with both jobs and crawlers.

To add a trigger (console)

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under ETL, choose Triggers. Then choose Add trigger.
3. Provide the following properties:
   
   **Name**
   
   Give your trigger a unique name.

   **Trigger type**
   
   Specify one of the following:

   - **Schedule**: The trigger fires at a specific frequency and time.
   - **Job events**: A conditional trigger. The trigger fires when any or all jobs in the list match their designated statuses. For the trigger to fire, the watched jobs must have been started by triggers. For any job you choose, you can only watch one job event (completion status).
   - **On-demand**: The trigger fires when it is activated.

4. Complete the trigger wizard. On the Review page, you can activate Schedule and Job events (conditional) triggers immediately by selecting Enable trigger on creation.
To add a trigger (AWS CLI)

- Enter a command similar to the following.

```bash
aws glue create-trigger --name MyTrigger --type SCHEDULED --schedule "cron(0 12 * * ? *)" --actions CrawlerName=MyCrawler --start-on-creation
```

This command creates a schedule trigger named MyTrigger, which runs every day at 12:00pm UTC and starts a crawler named MyCrawler. The trigger is created in the activated state.

For more information, see the section called “AWS Glue triggers”.

Time-based schedules for jobs and crawlers

You can define a time-based schedule for your crawlers and jobs in AWS Glue. The definition of these schedules uses the Unix-like `cron` syntax. You specify time in Coordinated Universal Time (UTC), and the minimum precision for a schedule is 5 minutes.

To learn more about configuring jobs and crawlers to run using a schedule, see Starting jobs and crawlers using triggers.

Cron expressions

Cron expressions have six required fields, which are separated by white space.

Syntax

```
cron(Minutes Hours Day-of-month Month Day-of-week Year)
```

<table>
<thead>
<tr>
<th>Fields</th>
<th>Values</th>
<th>Wildcards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
<td>0–59</td>
<td>,,- */</td>
</tr>
<tr>
<td>Hours</td>
<td>0–23</td>
<td>,,- */</td>
</tr>
<tr>
<td>Day-of-month</td>
<td>1–31</td>
<td>,,- *? / L W</td>
</tr>
<tr>
<td>Month</td>
<td>1–12 or JAN-DEC</td>
<td>,,- */</td>
</tr>
</tbody>
</table>
Wildcards

- The , (comma) wildcard includes additional values. In the Month field, JAN, FEB, MAR would include January, February, and March.
- The - (dash) wildcard specifies ranges. In the Day field, 1–15 would include days 1 through 15 of the specified month.
- The * (asterisk) wildcard includes all values in the field. In the Hours field, * would include every hour.
- The / (forward slash) wildcard specifies increments. In the Minutes field, you could enter 1/10 to specify every 10th minute, starting from the first minute of the hour (for example, the 11th, 21st, and 31st minute).
- The ? (question mark) wildcard specifies one or another. In the Day-of-month field you could enter 7, and if you didn't care what day of the week the seventh was, you could enter ? in the Day-of-week field.
- The L wildcard in the Day-of-month or Day-of-week fields specifies the last day of the month or week.
- The W wildcard in the Day-of-month field specifies a weekday. In the Day-of-month field, 3W specifies the day closest to the third weekday of the month.

Limits

- You can't specify the Day-of-month and Day-of-week fields in the same cron expression. If you specify a value in one of the fields, you must use a ? (question mark) in the other.
- Cron expressions that lead to rates faster than 5 minutes are not supported.

Examples

When creating a schedule, you can use the following sample cron strings.
### Adding triggers

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Hours</th>
<th>Day of month</th>
<th>Month</th>
<th>Day of week</th>
<th>Year</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>*</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run at 10:00 am (UTC) every day</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>*</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run at 12:15 pm (UTC) every day</td>
</tr>
<tr>
<td>0</td>
<td>18</td>
<td>?</td>
<td>*</td>
<td>MON-FRI</td>
<td>*</td>
<td>Run at 6:00 pm (UTC) every Monday through Friday</td>
</tr>
<tr>
<td>0</td>
<td>8</td>
<td>1</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run at 8:00 am (UTC) every first day of the month</td>
</tr>
<tr>
<td>0/15</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run every 15 minutes</td>
</tr>
<tr>
<td>0/10</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>MON-FRI</td>
<td>*</td>
<td>Run every 10 minutes Monday through Friday</td>
</tr>
</tbody>
</table>
For example to run on a schedule of every day at 12:15 UTC, specify:

```
cron(15 12 * * ? *)
```

**Activating and deactivating triggers**

You can activate or deactivate a trigger using the AWS Glue console, the AWS Command Line Interface (AWS CLI), or the AWS Glue API.

**Note**

Currently, the AWS Glue console supports only jobs, not crawlers, when working with triggers. You can use the AWS CLI or AWS Glue API to configure triggers with both jobs and crawlers.

**To activate or deactivate a trigger (console)**

2. In the navigation pane, under **ETL**, choose **Triggers**.
3. Select the check box next to the desired trigger, and on the **Action** menu choose **Enable trigger** to activate the trigger or **Disable trigger** to deactivate the trigger.
To activate or deactivate a trigger (AWS CLI)

- Enter one of the following commands.

  ```
  aws glue start-trigger --name MyTrigger
  aws glue stop-trigger --name MyTrigger
  ```

Starting a trigger activates it, and stopping a trigger deactivates it. When you activate an on-demand trigger, it fires immediately.

For more information, see the section called “AWS Glue triggers”.

**Performing complex ETL activities using blueprints and workflows in AWS Glue**

Some of your organization's complex extract, transform, and load (ETL) processes might best be implemented by using multiple, dependent AWS Glue jobs and crawlers. Using AWS Glue workflows, you can design a complex multi-job, multi-crawler ETL process that AWS Glue can run and track as single entity. After you create a workflow and specify the jobs, crawlers, and triggers in the workflow, you can run the workflow on demand or on a schedule.

**Topics**

- [Overview of workflows in AWS Glue](#)
- [Creating and building out a workflow manually in AWS Glue](#)
- [Starting an AWS Glue workflow with an Amazon EventBridge event](#)
- [Viewing the EventBridge events that started a workflow](#)
- [Running and monitoring a workflow in AWS Glue](#)
- [Stopping a workflow run](#)
- [Repairing and resuming a workflow run](#)
- [Getting and setting workflow run properties in AWS Glue](#)
- [Querying workflows using the AWS Glue API](#)
- [Blueprint and workflow restrictions in AWS Glue](#)
- [Troubleshooting blueprint errors in AWS Glue](#)
Overview of workflows in AWS Glue

In AWS Glue, you can use workflows to create and visualize complex extract, transform, and load (ETL) activities involving multiple crawlers, jobs, and triggers. Each workflow manages the execution and monitoring of all its jobs and crawlers. As a workflow runs each component, it records execution progress and status. This provides you with an overview of the larger task and the details of each step. The AWS Glue console provides a visual representation of a workflow as a graph.

You can create a workflow from an AWS Glue blueprint, or you can manually build a workflow a component at a time using the AWS Management Console or the AWS Glue API. For more information about blueprints, see the section called “Overview of blueprints”.

Triggers within workflows can start both jobs and crawlers and can be fired when jobs or crawlers complete. By using triggers, you can create large chains of interdependent jobs and crawlers. In addition to triggers within a workflow that define job and crawler dependencies, each workflow has a start trigger. There are three types of start triggers:

- **Schedule** – The workflow is started according to a schedule that you define. The schedule can be daily, weekly, monthly, and so on, or can be a custom schedule based on a cron expression.
- **On demand** – The workflow is started manually from the AWS Glue console, API, or AWS CLI.
- **EventBridge event** – The workflow is started upon the occurrence of a single Amazon EventBridge event or a batch of Amazon EventBridge events. With this trigger type, AWS Glue can be an event consumer in an event-driven architecture. Any EventBridge event type can start a workflow. A common use case is the arrival of a new object in an Amazon S3 bucket (the S3 PutObject operation).

Starting a workflow with a batch of events means waiting until a specified number of events have been received or until a specified amount of time has passed. When you create the EventBridge event trigger, you can optionally specify batch conditions. If you specify batch conditions, you must specify the batch size (number of events), and can optionally specify a batch window (number of seconds). The default and maximum batch window is 900 seconds (15 minutes). The batch condition that is met first starts the workflow. The batch window starts when the first event arrives. If you don’t specify batch conditions when creating a trigger, the batch size defaults to 1.
When the workflow starts, the batch conditions are reset and the event trigger begins watching for the next batch condition to be met to start the workflow again.

The following table shows how batch size and batch window operate together to trigger a workflow.

<table>
<thead>
<tr>
<th>Batch size</th>
<th>Batch window</th>
<th>Resulting triggering condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>The workflow is triggered upon the arrival of 10 EventBridge events, or 15 minutes after the arrival of the first event, whichever occurs first. (If windows size isn't specified, it defaults to 15 minutes.)</td>
</tr>
<tr>
<td>10</td>
<td>2 mins</td>
<td>The workflow is triggered upon the arrival of 10 EventBridge events, or 2 minutes after the arrival of the first event, whichever occurs first.</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>The workflow is triggered upon the arrival of the first event. Window size is irrelevant. The batch size defaults to 1 if you don't specify batch conditions when you create the EventBridge event trigger.</td>
</tr>
</tbody>
</table>

The GetWorkflowRun API operation returns the batch condition that triggered the workflow.

Regardless of how a workflow is started, you can specify the maximum number of concurrent workflow runs when you create the workflow.

If an event or batch of events starts a workflow run that eventually fails, that event or batch of events is no longer considered for starting a workflow run. A new workflow run is started only when the next event or batch of events arrives.

⚠️ Important

Limit the total number of jobs, crawlers, and triggers within a workflow to 100 or less. If you include more than 100, you might get errors when trying to resume or stop workflow runs.
A workflow run will not be started if it would exceed the concurrency limit set for the workflow, even though the event condition is met. It's advisable to adjust workflow concurrency limits based on the expected event volume. AWS Glue does not retry workflow runs that fail due to exceeded concurrency limits. Likewise, it’s advisable to adjust concurrency limits for jobs and crawlers within workflows based on expected event volume.

**Workflow run properties**

To share and manage state throughout a workflow run, you can define default workflow run properties. These properties, which are name/value pairs, are available to all the jobs in the workflow. Using the AWS Glue API, jobs can retrieve the workflow run properties and modify them for jobs that come later in the workflow.

**Workflow graph**

The following image shows the graph of a very basic workflow on the AWS Glue console. Your workflow could have dozens of components.

![Workflow graph](image)

This workflow is started by a schedule trigger, **Month-close1**, which starts two jobs, **De-duplicate** and **Fix phone numbers**. Upon successful completion of both jobs, an event trigger, **Fix/De-dupe succeeded**, starts a crawler, **Update schema**.
Static and dynamic workflow views

For each workflow, there is the notion of *static view* and *dynamic view*. The static view indicates the design of the workflow. The dynamic view is a runtime view that includes the latest run information for each of the jobs and crawlers. Run information includes success status and error details.

When a workflow is running, the console displays the dynamic view, graphically indicating the jobs that have completed and that are yet to be run. You can also retrieve a dynamic view of a running workflow using the AWS Glue API. For more information, see [Querying workflows using the AWS Glue API](#).

See also

- the section called “Creating a workflow from a blueprint”
- the section called “Creating and building out a workflow manually”
- Workflows (for the workflows API)

Creating and building out a workflow manually in AWS Glue

You can use the AWS Glue console to manually create and build out a workflow one node at a time.

A workflow contains jobs, crawlers, and triggers. Before manually creating a workflow, create the jobs and crawlers that the workflow is to include. It's best to specify run-on-demand crawlers for workflows. You can create new triggers while you are building out your workflow, or you can *clone* existing triggers into the workflow. When you clone a trigger, all the catalog objects associated with the trigger—the jobs or crawlers that fire it and the jobs or crawlers that it starts—are added to the workflow.

**Important**

Limit the total number of jobs, crawlers, and triggers within a workflow to 100 or less. If you include more than 100, you might get errors when trying to resume or stop workflow runs.
You build out your workflow by adding triggers to the workflow graph, and defining the watched events and actions for each trigger. You begin with a start trigger, which can be either an on-demand or schedule trigger, and complete the graph by adding event (conditional) triggers.

**Step 1: Create the workflow**

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, under ETL, choose Workflows.
3. Choose Add workflow and complete the Add a new ETL workflow form.

   Any optional default run properties that you add are made available as arguments to all jobs in the workflow. For more information, see Getting and setting workflow run properties in AWS Glue.
4. Choose Add workflow.

   The new workflow appears in the list on the Workflows page.

**Step 2: Add a start trigger**

1. On the Workflows page, select your new workflow. Then, at the bottom of the page, ensure that the Graph tab is selected.
2. Choose Add trigger, and in the Add trigger dialog box, do one of the following:
   - Choose Clone existing, and choose a trigger to clone. Then choose Add.

      The trigger appears on the graph, along with the jobs and crawlers that it watches and the jobs and crawlers that it starts.

      If you mistakenly selected the wrong trigger, select the trigger on the graph, and then choose Remove.
   - Choose Add new, and complete the Add trigger form.

      1. For Trigger type, select Schedule, On demand, or EventBridge event.

         For trigger type Schedule, choose one of the Frequency options. Choose Custom to enter a cron expression.
For trigger type **EventBridge event**, enter **Number of events** (batch size), and optionally enter **Time delay** (batch window). If you omit **Time delay**, the batch window defaults to 15 minutes. For more information, see [Overview of workflows in AWS Glue](#).

2. Choose **Add**.

The trigger appears on the graph, along with a placeholder node (labeled **Add node**). In the example below, the start trigger is a schedule trigger named **Month-close1**.

At this point, the trigger isn’t saved yet.

3. If you added a new trigger, complete these steps:

   a. Do one of the following:

      - Choose the placeholder node (**Add node**).
      - Ensure that the start trigger is selected, and on the **Action** menu above the graph, choose **Add jobs/crawlers to trigger**.

   b. In the **Add jobs(s) and crawler(s) to trigger** dialog box, select one or more jobs or crawlers, and then choose **Add**.

      The trigger is saved, and the selected jobs or crawlers appear on the graph with connectors from the trigger.
If you mistakenly added the wrong jobs or crawlers, you can select either the trigger or a connector and choose Remove.

**Step 3: Add more triggers**

Continue to build out your workflow by adding more triggers of type Event. To zoom in or out or to enlarge the graph canvas, use the icons to the right of the graph. For each trigger to add, complete the following steps:

---

**Note**

There is no action to save the workflow. After you add your last trigger and assign actions to the trigger, the workflow is complete and saved. You can always come back later and add more nodes.

---

1. Do one of the following:
   - To clone an existing trigger, ensure that no node on the graph is selected, and on the Action menu, choose Add trigger.
   - To add a new trigger that watches a particular job or crawler on the graph, select the job or crawler node, and then choose the Add trigger placeholder node.

   You can add more jobs or crawlers to watch for this trigger in a later step.

2. In the Add trigger dialog box, do one of the following:
   - Choose Add new, and complete the Add trigger form. Then choose Add.

   The trigger appears on the graph. You will complete the trigger in a later step.
   - Choose Clone existing, and choose a trigger to clone. Then choose Add.

   The trigger appears on the graph, along with the jobs and crawlers that it watches and the jobs and crawlers that it starts.

   If you mistakenly chose the wrong trigger, select the trigger on the graph, and then choose Remove.

3. If you added a new trigger, complete these steps:
a. Select the new trigger.

As the following graph shows, the trigger De-dupe/fix succeeded is selected, and placeholder nodes appear for (1) events to watch and (2) actions.

b. (Optional if the trigger already watches an event and you want to add more jobs or crawlers to watch.) Choose the events-to-watch placeholder node, and in the Add job(s) and crawler(s) to watch dialog box, select one or more jobs or crawlers. Choose an event to watch (SUCCEEDED, FAILED, etc.), and choose Add.

c. Ensure that the trigger is selected, and choose the actions placeholder node.

d. In the Add job(s) and crawler(s) to watch dialog box, select one or more jobs or crawlers, and choose Add.

The selected jobs and crawlers appear on the graph, with connectors from the trigger.

For more information on workflows and blueprints, see the following topics.

- Overview of workflows in AWS Glue
- Running and monitoring a workflow in AWS Glue
- Creating a workflow from a blueprint in AWS Glue
Starting an AWS Glue workflow with an Amazon EventBridge event

Amazon EventBridge, also known as CloudWatch Events, enables you to automate your AWS services and respond automatically to system events such as application availability issues or resource changes. Events from AWS services are delivered to EventBridge in near real time. You can write simple rules to indicate which events are of interest to you, and what automated actions to take when an event matches a rule.

With EventBridge support, AWS Glue can serve as an event producer and consumer in an event-driven architecture. For workflows, AWS Glue supports any type of EventBridge event as a consumer. The likely most common use case is the arrival of a new object in an Amazon S3 bucket. If you have data arriving in irregular or undefined intervals, you can process this data as close to its arrival as possible.

Note
AWS Glue does not provide guaranteed delivery of EventBridge messages. AWS Glue performs no deduplication if EventBridge delivers duplicate messages. You must manage idempotency based on your use case.
Be sure to configure EventBridge rules correctly to avoid sending unwanted events.

Before you begin

If you want to start a workflow with Amazon S3 data events, you must ensure that events for the S3 bucket of interest are logged to AWS CloudTrail and EventBridge. To do so, you must create a CloudTrail trail. For more information, see Creating a trail for your AWS account.

To start a workflow with an EventBridge event

Note
In the following commands, replace:

- `<workflow-name>` with the name to assign to the workflow.
- `<trigger-name>` with the name to assign to the trigger.
- `<bucket-name>` with the name of the Amazon S3 bucket.
- `<account-id>` with a valid AWS account ID.
1. Ensure that you have AWS Identity and Access Management (IAM) permissions to create and view EventBridge rules and targets. The following is a sample policy that you can attach. You might want to scope it down to put limits on the operations and resources.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "events:PutRule",
                "events:DisableRule",
                "events:DeleteRule",
                "events:PutTargets",
                "events:RemoveTargets",
                "events:EnableRule",
                "events:List*",
                "events:Describe*"
            ],
            "Resource": "*"
        }
    ]
}
```

2. Create an IAM role that the EventBridge service can assume when passing an event to AWS Glue.
   a. On the Create role page of the IAM console, choose AWS Service. Then choose the service CloudWatch Events.
   b. Complete the Create role wizard. The wizard automatically attaches the CloudWatchEventsBuiltInTargetExecutionAccess and CloudWatchEventsInvocationAccess policies.
   c. Attach the following inline policy to the role. This policy allows the EventBridge service to direct events to AWS Glue.

```
{

}
```
3. Enter the following command to create the workflow.

See create-workflow in the AWS CLI Command Reference for information about additional optional command-line parameters.

```bash
aws glue create-workflow --name <workflow-name>
```

4. Enter the following command to create an EventBridge event trigger for the workflow. This will be the start trigger for the workflow. Replace `<actions>` with the actions to perform (the jobs and crawlers to start).

See create-trigger in the AWS CLI Command Reference for information about how to code the actions argument.

```bash
aws glue create-trigger --workflow-name <workflow-name> --type EVENT --name <trigger-name> --actions <actions>
```

If you want the workflow to be triggered by a batch of events instead of a single EventBridge event, enter the following command instead.

```bash
aws glue create-trigger --workflow-name <workflow-name> --type EVENT --name <trigger-name> --event-batching-condition BatchSize=<number-of-events>,BatchWindow=<seconds> --actions <actions>
```

For the event-batching-condition argument, BatchSize is required and BatchWindow is optional. If BatchWindow is omitted, the window defaults to 900 seconds, which is the maximum window size.
Example

The following example creates a trigger that starts the eventtest workflow after three EventBridge events have arrived, or five minutes after the first event arrives, whichever comes first.

```bash
aws glue create-trigger --workflow-name eventtest --type EVENT --name objectArrival --event-batching-condition BatchSize=3,BatchWindow=300 --actions JobName=test1
```

5. Create a rule in Amazon EventBridge.

   a. Create the JSON object for the rule details in your preferred text editor.

      The following example specifies Amazon S3 as the event source, PutObject as the event name, and the bucket name as a request parameter. This rule starts a workflow when a new object arrives in the bucket.

      ```json
      {
        "source": [
          "aws.s3"
        ],
        "detail-type": [
          "AWS API Call via CloudTrail"
        ],
        "detail": {
          "eventSource": [
            "s3.amazonaws.com"
          ],
          "eventName": [
            "PutObject"
          ],
          "requestParameters": {
            "bucketName": [
              "<bucket-name>"
            ]
          }
        }
      }
      
      To start the workflow when a new object arrives in a folder within the bucket, you can substitute the following code for `requestParameters`.
b. Use your preferred tool to convert the rule JSON object to an escaped string.

```json
{
  "source": ["aws.s3"],
  "detail-type": ["AWS API Call via CloudTrail"],
  "detail": {
    "eventSource": ["s3.amazonaws.com"],
    "eventName": ["PutObject"],
    "requestParameters": {
      "bucketName": [<bucket-name>]
    }
  }
}
```

c. Run the following command to create a JSON parameter template that you can edit to specify input parameters to a subsequent `put-rule` command. Save the output in a file. In this example, the file is called `ruleCommand`.

```
aws events put-rule --name <rule-name> --generate-cli-skeleton >ruleCommand
```

For more information about the `--generate-cli-skeleton` parameter, see Generating AWS CLI skeleton and input parameters from a JSON or YAML input file in the AWS Command Line Interface User Guide.

The output file should look like the following.

```json
{
  "Name": "",
  "ScheduleExpression": "",
  "EventPattern": "",
  "State": "ENABLED",
  "Description": "",
  "RoleArn": "",
  "Tags": [
    {
      "Key": "",
      "Value": ""
    }
  ],
  "EventBusName": ""
}
```
d. Edit the file to optionally remove parameters and to specify at a minimum the Name, EventPattern, and State parameters. For the EventPattern parameter, provide the escaped string for the rule details that you created in a previous step.

```json
{
   "Name": "<rule-name>",
   "EventPattern": "{\n     "source": ["aws.s3"],
     "detail-type": ["AWS API Call via CloudTrail"],
     "detail": {
       "eventSource": ["s3.amazonaws.com"],
       "eventName": ["PutObject"],
       "requestParameters": {
         "bucketName": "<bucket-name>"
       }
     }
   },
   "State": "DISABLED",
   "Description": "Start an AWS Glue workflow upon new file arrival in an Amazon S3 bucket"
}
```

**Note**

It is best to leave the rule disabled until you finish building out the workflow.

e. Enter the following `put-rule` command, which reads input parameters from the file `ruleCommand`.

```
aws events put-rule --name <rule-name> --cli-input-json file://ruleCommand
```

The following output indicates success.

```json
{
   "RuleArn": "<rule-arn>"
}
```

6. Enter the following command to attach the rule to a target. The target is the workflow in AWS Glue. Replace `<role-name>` with the role that you created at the beginning of this procedure.

```
aws events put-targets --rule <rule-name> --targets
   "Id":"1","Arn":"arn:aws:glue:<region>:<account-id>:workflow/<workflow-name>","RoleArn":"arn:aws:iam::<account-id>:role/<role-name>" --region <region>
```
The following output indicates success.

```json
{
    "FailedEntryCount": 0,
    "FailedEntries": []
}
```

7. Confirm successful connection of the rule and target by entering the following command.

```
aws events list-rule-names-by-target --target-arn arn:aws:glue:<region>:<account-id>:workflow/<workflow-name>
```

The following output indicates success, where `<rule-name>` is the name of the rule that you created.

```json
{
    "RuleNames": [
        "<rule-name>"
    ]
}
```

8. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.

9. Select the workflow, and verify that the start trigger and its actions—the jobs or crawlers that it starts—appear on the workflow graph. Then continue with the procedure in Step 3: Add more triggers. Or add more components to the workflow by using the AWS Glue API or AWS Command Line Interface.

10. When the workflow is completely specified, enable the rule.

```
aws events enable-rule --name <rule-name>
```

The workflow is now ready to be started by an EventBridge event or event batch.

---

**See also**

- [Amazon EventBridge User Guide](#)
- [Overview of workflows in AWS Glue](#)
Creating and building out a workflow manually in AWS Glue

Viewing the EventBridge events that started a workflow

You can view the event ID of the Amazon EventBridge event that started your workflow. If your workflow was started by a batch of events, you can view the event IDs of all events in the batch.

For workflows with a batch size greater than one, you can also see which batch condition started the workflow: the arrival of the number of events in the batch size, or the expiration of the batch window.

To view the EventBridge events that started a workflow (console)

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. In the navigation pane, choose Workflows.
3. Select the workflow. Then at the bottom, choose the History tab.
4. Select a workflow run, and then choose View run details.
5. On the run details page, locate the Run properties field, and look for the aws:eventIds key.

   The value for that key is a list of EventBridge event IDs.

To view the EventBridge events that started a workflow (AWS API)

- Include the following code in your Python script.

```python
workflow_params = glue_client.get_workflow_run_properties(Name=workflow_name, RunId=workflow_run_id)
batched_events = workflow_params['aws:eventIds']
```

batched_events will be a list of strings, where each string is an event ID.

See also

- Amazon EventBridge User Guide
Running and monitoring a workflow in AWS Glue

If the start trigger for a workflow is an on-demand trigger, you can start the workflow from the AWS Glue console. Complete the following steps to run and monitor a workflow. If the workflow fails, you can view the run graph to determine the node that failed. To help troubleshoot, if the workflow was created from a blueprint, you can view the blueprint run to see the blueprint parameter values that were used to create the workflow. For more information, see the section called “Viewing blueprint runs”.

You can run and monitor a workflow by using the AWS Glue console, API, or AWS Command Line Interface (AWS CLI).

To run and monitor a workflow (console)

2. In the navigation pane, under ETL, choose Workflows.
4. Check the Last run status column in the workflows list. Choose the refresh button to view ongoing workflow status.
5. While the workflow is running or after it has completed (or failed), view the run details by completing the following steps.
   a. Ensure that the workflow is selected, and choose the History tab.
   b. Choose the current or most recent workflow run, and then choose View run details.
      The workflow runtime graph shows the current run status.
   c. Choose any node in the graph to view details and status of the node.
To run and monitor a workflow (AWS CLI)

1. Enter the following command. Replace `<workflow-name>` with the workflow to run.

   ```bash
   aws glue start-workflow-run --name <workflow-name>
   ```

   If the workflow is successfully started, the command returns the run ID.

2. View workflow run status by using the `get-workflow-run` command. Supply the workflow name and run ID.

   ```bash
   aws glue get-workflow-run --name myWorkflow --run-id wr_d2af14217e8eae775ba7b1fc6fc7a42c795aed3c6cd8763f9415452e2dcb8705
   ```

   The following is sample command output.

   ```json
   {
     "Run": {
       "Name": "myWorkflow",
       "WorkflowRunId": "wr_d2af14217e8eae775ba7b1fc6fc7a42c795aed3c6cd8763f9415452e2dcb8705",
       "WorkflowRunProperties": {
         "run_state": "COMPLETED",
         "unique_id": "fee63f30-c512-4742-a9b1-7c8183bdaae2"
       },
       "StartedOn": 1578556843.049,
       "CompletedOn": 1578558649.928,
       "Status": "COMPLETED"
     }
   }
   ```
"Statistics": {  "TotalActions": 11,  "TimeoutActions": 0,  "FailedActions": 0,  "StoppedActions": 0,  "SucceededActions": 9,  "RunningActions": 0,  "ErroredActions": 0  }

See also:

- the section called “Overview of workflows”
- the section called “Overview of blueprints”

Stopping a workflow run

You can use the AWS Glue console, AWS Command Line Interface (AWS CLI) or AWS Glue API to stop a workflow run. When you stop a workflow run, all running jobs and crawlers are immediately terminated, and jobs and crawlers that are not yet started never start. It might take up to a minute for all running jobs and crawlers to stop. The workflow run status goes from Running to Stopping, and when the workflow run is completely stopped, the status goes to Stopped.

After the workflow run is stopped, you can view the run graph to see which jobs and crawlers completed and which never started. You can then determine if you must perform any steps to ensure data integrity. Stopping a workflow run causes no automatic rollback operations to be performed.

To stop a workflow run (console)

2. In the navigation pane, under ETL, choose Workflows.
3. Choose a running workflow, and then choose the History tab.
4. Choose the workflow run, and then choose Stop run.
The run status changes to **Stopping**.

5. (Optional) Choose the workflow run, choose **View run details**, and review the run graph.

### To stop a workflow run (AWS CLI)

- Enter the following command. Replace `<workflow-name>` with the name of the workflow and `<run-id>` with the run ID of the workflow run to stop.

```bash
aws glue stop-workflow-run --name <workflow-name> --run-id <run-id>
```

The following is an example of the `stop-workflow-run` command.

```bash
aws glue stop-workflow-run --name my-workflow --run-id wr_137b88917411d128081069901e4a80595d97f719282094b7f271d09576770354
```

### Repairing and resuming a workflow run

If one or more nodes (jobs or crawlers) in a workflow do not successfully complete, this means that the workflow only partially ran. After you find the root causes and make corrections, you can select one or more nodes to resume the workflow run from, and then resume the workflow run. The selected nodes and all nodes that are downstream from those nodes are then run.

**Topics**

- [Resuming a workflow run: How it works](#)
- [Resuming a workflow run](#)
- [Notes and limitations for resuming workflow runs](#)

### Resuming a workflow run: How it works

Consider the workflow W1 in the following diagram.
The workflow run proceeds as follows:

1. Trigger T1 starts job J1.
2. Successful completion of J1 fires triggers T2 and T3, which run jobs J2 and J3, respectively.
4. Triggers T4 and T5 depend on the successful completion of J2 and J3, so they don't fire, and jobs J4 and J5 don't run. Workflow W1 is only partially run.

Now assume that the issues that caused J2 and J3 to fail are corrected. J2 and J3 are selected as the starting points to resume the workflow run from.

The workflow run resumes as follows:

1. Jobs J2 and J3 run successfully.
2. Triggers T4 and T5 fire.
3. Jobs J4 and J5 run successfully.

The resumed workflow run is tracked as a separate workflow run with a new run ID. When you view the workflow history, you can view the previous run ID for any workflow run. In the example in the following screenshot, the workflow run with run ID \textit{wr\_c7a22} \ldots (the second row) had a node that did not complete. The user fixed the problem and resumed the workflow run, which resulted in run ID \textit{wr\_a07e55} \ldots (the first row).
Resumed workflow run graph

In a resumed workflow run, although only a subset of nodes are run, the run graph is a complete graph. That is, the nodes that didn't run in the resumed workflow are copied from the run graph of the original workflow run. Copied job and crawler nodes that ran in the original workflow run include run details.

Consider again the workflow W1 in the previous diagram. When the workflow run is resumed starting with J2 and J3, the run graph for the resumed workflow run shows all jobs, J1 though J5, and all triggers, T1 through T5. The run details for J1 are copied from the original workflow run.

Workflow run snapshots

When a workflow run is started, AWS Glue takes a snapshot of the workflow design graph at that point in time. That snapshot is used for the duration of the workflow run. If you make changes to any triggers after the run starts, those changes don't affect the current workflow run. Snapshots ensure that workflow runs proceed in a consistent manner.

Snapshots make only triggers immutable. Changes that you make to downstream jobs and crawlers during the workflow run take effect for the current run.

Resuming a workflow run

Follow these steps to resume a workflow run. You can resume a workflow run by using the AWS Glue console, API, or AWS Command Line Interface (AWS CLI).
To resume a workflow run (console)

1. Open the AWS Glue console at https://console.aws.amazon.com/glue/. Sign in as a user who has permissions to view workflows and resume workflow runs.

   ! Note
   
   To resume workflow runs, you need the glue:ResumeWorkflowRun AWS Identity and Access Management (IAM) permission.

2. In the navigation pane, choose Workflows.

3. Select a workflow, and then choose the History tab.

4. Select the workflow run that only partially ran, and then choose View run details.

5. In the run graph, select the first (or only) node that you want to restart and that you want to resume the workflow run from.

6. In the details pane to the right of the graph, select the Resume check box.

   ![Graph](image)

   The node changes color and shows a small resume icon at the upper right.
7. Complete the previous two steps for any additional nodes to restart.

8. Choose **Resume run**.

**To resume a workflow run (AWS CLI)**

1. Ensure that you have the `glue:ResumeWorkflowRun` IAM permission.

2. Retrieve the node IDs for the nodes that you want to restart.
   
   a. Run the `get-workflow-run` command for the original workflow run. Supply the workflow name and run ID, and add the `--include-graph` option, as shown in the following example. Get the run ID from the **History** tab on the console, or by running the `get-workflow` command.

   ```bash
   aws glue get-workflow-run --name cloudtrailtest1 --run-id wr_a07e55f2087afdd415a404403f644a4265278f68b13ba3da08c71924ebe3c3a8 --include-graph
   ```

   The command returns the nodes and edges of the graph as a large JSON object.

   b. Locate the nodes of interest by the Type and Name properties of the node objects.

   The following is an example node object from the output.

   ```json
   {
      "Type": "JOB",
      "Name": "test1_post_failure_4592978",
      "UniqueId": "wnode_d1b2563c503078b153142ee76ce545fe5cee66e053628a786ddd74a05da86fd",
   }
   ```
c. Get the node ID from the `UniqueId` property of the node object.

3. Run the `resume-workflow-run` command. Provide the workflow name, run ID, and list of node IDs separated by spaces, as shown in the following example.

```bash
aws glue resume-workflow-run --name cloudtrailtest1 --run-id wr_a07e55f2087afdd415a404403f644a4265278f68b13ba3da08c71924ebe3c3a8 --node-ids wnode_ca1f63e918fb855e063aed2f42ec5762ccf71b80082ae2eb5daeb8052442f2f3 wnode_d1b2563c503078b153142ee76ce545fe5ceef66e053628a786ddd74a05da86fd
```

The command outputs the run ID of the resumed (new) workflow run and a list of nodes that will be started.

```json
{
  "RunId": "wr_2ada0d3209a262fc1156e4291134b3bd643491bcfb0ceead30bd3e4efac24de9",
  "NodeIds": [
    "wnode_ca1f63e918fb855e063aed2f42ec5762ccf71b80082ae2eb5daeb8052442f2f3"
  ]
}
```
Note that although the example `resume-workflow-run` command listed two nodes to restart, the example output indicated that only one node would be restarted. This is because one node was downstream of the other node, and the downstream node would be restarted anyway by the normal flow of the workflow.

**Notes and limitations for resuming workflow runs**

Keep the following notes and limitations in mind when resuming workflow runs.

- You can resume a workflow run only if it's in the **COMPLETED** state.

  **Note**
  Even if one ore more nodes in a workflow run don't complete, the workflow run state is shown as **COMPLETED**. Be sure to check the run graph to discover any nodes that didn't successfully complete.

- You can resume a workflow run from any job or crawler node that the original workflow run attempted to run. You can't resume a workflow run from a trigger node.
- Restarting a node does not reset its state. Any data that was partially processed is not rolled back.
- You can resume the same workflow run multiple times. If a resumed workflow run only partially runs, you can address the issue and resume the resumed run.
- If you select two nodes to restart and they're dependent upon each other, the upstream node is run before the downstream node. In fact, selecting the downstream node is redundant, because it will be run according to the normal flow of the workflow.

**Getting and setting workflow run properties in AWS Glue**

Use workflow run properties to share and manage state among the jobs in your AWS Glue workflow. You can set default run properties when you create the workflow. Then, as your jobs run, they can retrieve the run property values and optionally modify them for input to jobs that are later in the workflow. When a job modifies a run property, the new value exists only for the workflow run. The default run properties aren't affected.

If your AWS Glue job is not part of a workflow, these properties will not be set.
The following sample Python code from an extract, transform, and load (ETL) job demonstrates how to get the workflow run properties.

```python
import sys
import boto3
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from awsglue.context import GlueContext
from pyspark.context import SparkContext

glue_client = boto3.client("glue")
args = getResolvedOptions(sys.argv, ['JOB_NAME','WORKFLOW_NAME', 'WORKFLOW_RUN_ID'])
workflow_name = args['WORKFLOW_NAME']
workflow_run_id = args['WORKFLOW_RUN_ID']
workflow_params = glue_client.get_workflow_run_properties(Name=workflow_name, RunId=workflow_run_id)['RunProperties']

target_database = workflow_params['target_database']
target_s3_location = workflow_params['target_s3_location']
```

The following code continues by setting the target_format run property to 'csv'.

```python
workflow_params['target_format'] = 'csv'

 glue_client.put_workflow_run_properties(Name=workflow_name, RunId=workflow_run_id, RunProperties=workflow_params)
```

For more information, see the following:

- GetWorkflowRunProperties action (Python: get_workflow_run_properties)
- PutWorkflowRunProperties action (Python: put_workflow_run_properties)

## Querying workflows using the AWS Glue API

AWS Glue provides a rich API for managing workflows. You can retrieve a static view of a workflow or a dynamic view of a running workflow using the AWS Glue API. For more information, see Workflows.

### Topics

- Querying static views
- Querying dynamic views
Querying static views

Use the GetWorkflow API operation to get a static view that indicates the design of a workflow. This operation returns a directed graph consisting of nodes and edges, where a node represents a trigger, a job, or a crawler. Edges define the relationships between nodes. They are represented by connectors (arrows) on the graph in the AWS Glue console.

You can also use this operation with popular graph-processing libraries such as NetworkX, igraph, JGraphT, and the Java Universal Network/Graph (JUNG) Framework. Because all these libraries represent graphs similarly, minimal transformations are needed.

The static view returned by this API is the most up-to-date view according to the latest definition of triggers associated with the workflow.

Graph definition

A workflow graph G is an ordered pair (N, E), where N is a set of nodes and E a set of edges. Node is a vertex in the graph identified by a unique number. A node can be of type trigger, job, or crawler. For example: {name:T1, type:Trigger, uniqueId:1}, {name:J1, type:Job, uniqueId:2}.

Edge is a 2-tuple of the form (src, dest), where src and dest are nodes and there is a directed edge from src to dest.

Example of querying a static view

Consider a conditional trigger T, which triggers job J2 upon completion of job J1.

```
J1 ---> T ---> J2
```

Nodes: J1, T, J2

Edges: (J1, T), (T, J2)

Querying dynamic views

Use the GetWorkflowRun API operation to get a dynamic view of a running workflow. This operation returns the same static view of the graph along with metadata related to the workflow run.
For run, nodes representing jobs in the `GetWorkflowRun` call have a list of job runs initiated as part of the latest run of the workflow. You can use this list to display the run status of each job in the graph itself. For downstream dependencies that are not yet run, this field is set to `null`. The graphed information makes you aware of the current state of any workflow at any point of time.

The dynamic view returned by this API is based on the static view that was present when the workflow run was started.

**Runtime nodes example:**

```
{name:T1, type: Trigger, uniqueId:1},
{name:J1, type:Job, uniqueId:2, jobDetails:{jobRuns}},
{name:C1, type:Crawler, uniqueId:3, crawlerDetails:{crawls}}
```

**Example 1: Dynamic view**

The following example illustrates a simple two-trigger workflow.

- Nodes: t1, j1, t2, j2
- Edges: (t1, j1), (j1, t2), (t2, j2)

The `GetWorkflow` response contains the following.

```json
{
  Nodes : [
    {
      "type" : Trigger,
      "name" : "t1",
      "uniqueId" : 1
    },
    {
      "type" : Job,
      "name" : "j1",
      "uniqueId" : 2
    },
    {
      "type" : Trigger,
      "name" : "t2",
      "uniqueId" : 3
    },
    {
      "type" : Job,
      "name" : "j2",
      "uniqueId" : 4
    }
  ]
}```
The GetWorkflowRun response contains the following.

```json
{
  Nodes: [
    {
      "type": "Trigger",
      "name": "t1",
      "uniqueId": 1,
      "jobDetails": null,
      "crawlerDetails": null
    },
    {
      "type": "Job",
      "name": "j1",
      "uniqueId": 2,
      "jobDetails": [
        {
          "id": "jr_12334",
          "jobRunState": "SUCCEEDED",
          "errorMessage": "error string"
        }
      ],
      "crawlerDetails": null
    }
  ],
  Edges: [
    {
      "sourceId": 1,
      "destinationId": 2
    },
    {
      "sourceId": 2,
      "destinationId": 3
    },
    {
      "sourceId": 3,
      "destinationId": 4
    }
  ]
}```
Example 2: Multiple jobs with a conditional trigger

The following example shows a workflow with multiple jobs and a conditional trigger (t3).

Consider Flow:

```
T(t1) --> J(j1) --> T(t2) --> J(j2) -->+----> T(t3) <--++
```

Querying workflows using the AWS Glue API
Graph generated:
Nodes: t1, t2, t3, j1, j2, j3
Edges: (t1, j1), (j1, t2), (t2, j2), (j1, t3), (j2, t3), (t3, j3)

**Blueprint and workflow restrictions in AWS Glue**

The following are restrictions for blueprints and workflows.

**Blueprint restrictions**

Keep the following blueprint restrictions in mind:

- The blueprint must be registered in the same AWS Region where the Amazon S3 bucket resides in.
- To share blueprints across AWS accounts you must give the read permissions on the blueprint ZIP archive in Amazon S3. Customers who have read permission on a blueprint ZIP archive can register the blueprint in their AWS account and use it.
- The set of blueprint parameters is stored as a single JSON object. The maximum length of this object is 128 KB.
- The maximum uncompressed size of the blueprint ZIP archive is 5 MB. The maximum compressed size is 1 MB.
- Limit the total number of jobs, crawlers, and triggers within a workflow to 100 or less. If you include more than 100, you might get errors when trying to resume or stop workflow runs.

**Workflow restrictions**

Keep the following workflow restrictions in mind. Some of these comments are directed more at a user creating workflows manually.

- The maximum batch size for an Amazon EventBridge event trigger is 100. The maximum window size is 900 seconds (15 minutes).
- A trigger can be associated with only one workflow.
- Only one starting trigger (on-demand or schedule) is permitted.
• If a job or crawler in a workflow is started by a trigger that is outside the workflow, any triggers inside the workflow that depend on job or crawler completion (succeeded or otherwise) do not fire.

• Similarly, if a job or crawler in a workflow has triggers that depend on job or crawler completion (succeeded or otherwise) both within the workflow and outside the workflow, and if the job or crawler is started from within a workflow, only the triggers inside the workflow fire upon job or crawler completion.

Troubleshooting blueprint errors in AWS Glue

If you encounter errors when using AWS Glue blueprints, use the following solutions to help you find the source of the problems and fix them.

Topics

• Error: missing PySpark module
• Error: missing blueprint config file
• Error: missing imported file
• Error: not authorized to perform iamPassRole on resource
• Error: invalid cron schedule
• Error: a trigger with the same name already exists
• Error: workflow with name: foo already exists.
• Error: module not found in specified layoutGenerator path
• Error: validation error in Connections field

Error: missing PySpark module

AWS Glue returns the error "Unknown error executing layout generator function ModuleNotFoundError: No module named 'pyspark'".

When you unzip the blueprint archive it could be like either of the following:

$ unzip compaction.zip
Archive:  compaction.zip
    creating: compaction/
    inflating: compaction/blueprint.cfg
    inflating: compaction/layout.py
In the first case, all the files related to the blueprint were placed under a folder named compaction and it was then converted into a zip file named `compaction.zip`.

In the second case, all the files required for the blueprint were not included into a folder and were added as root files under the zip file `compaction.zip`.

Creating a file in either of the above formats is allowed. However make sure that `blueprint.cfg` has the correct path to the name of the function in the script that generates the layout.

**Examples**

In case 1: `blueprint.cfg` should have `layoutGenerator` as the following:

```
layoutGenerator": "compaction.layout.generate_layout"
```

In case 2: `blueprint.cfg` should have `layoutGenerator` as the following

```
layoutGenerator": "layout.generate_layout"
```

If this path is not included correctly, you could see an error as indicated. For example, if you have the folder structure as mentioned in case 2 and you have the `layoutGenerator` indicated as in case 1, you can see the above error.

**Error: missing blueprint config file**

AWS Glue returns the error "Unknown error executing layout generator function

```
FileNotFoundError: [Errno 2] No such file or directory: '/tmp/compaction/blueprint.cfg''.
```

The blueprint.cfg should be placed at the root level of the ZIP archive or within a folder which has the same name as the ZIP archive.
When we extract the blueprint ZIP archive, blueprint.cfg is expected to be found in one of the following paths. If it is not found in one of the following paths, you can see the above error.

```
$ unzip compaction.zip
Archive:  compaction.zip
    creating: compaction/
    inflating: compaction/blueprint.cfg

$ unzip compaction.zip
Archive:  compaction.zip
    inflating: blueprint.cfg
```

### Error: missing imported file

AWS Glue returns the error "Unknown error executing layout generator function
FileNotFoundError: [Errno 2] No such file or directory:* *'demo-project/foo.py".".

If your layout generation script has functionality to read other files, make sure you give a full path for the file to be imported. For example, the Conversion.py script may be referenced in Layout.py. For more information, see [Sample blueprint Project](#).

### Error: not authorized to perform iamPassRole on resource

AWS Glue returns the error "User: arn:aws:sts::123456789012:assumed-role/AWSGlueServiceRole/GlueSession is not authorized to perform: iam:PassRole on resource: arn:aws:iam::123456789012:role/AWSGlueServiceRole"

If the jobs and crawlers in the workflow assume the same role as the role passed to create workflow from the blueprint, then the blueprint role needs to include the `iam:PassRole` permission on itself.

If the jobs and crawlers in the workflow assume a role other than the role passed to create the entities of the workflow from the blueprint, then the blueprint role needs to include the `iam:PassRole` permission on that other role instead of on the blueprint role.

For more information, see [Permissions for blueprint Roles](#).

### Error: invalid cron schedule

AWS Glue returns the error "The schedule cron(0 0 * * *) is invalid."
Provide a valid `cron` expression. For more information, see Time-Based Schedules for Jobs and Crawlers.

**Error: a trigger with the same name already exists**

AWS Glue returns the error "Trigger with name 'foo_starting_trigger' already submitted with different configuration".

A blueprint does not require you to define triggers in the layout script for workflow creation. Trigger creation is managed by the blueprint library based on the dependencies defined between two actions.

The naming for the triggers is as follows:

- For the starting trigger in the workflow the naming is `<workflow_name>_starting_trigger`.
- For a node(job/crawler) in the workflow that depends on the completion of either one or multiple upstream nodes; AWS Glue defines a trigger with the name `<workflow_name>_<node_name>_trigger`

This error means a trigger with same name already exists. You can delete the existing trigger and re-run the workflow creation.

**Note**

Deleting a workflow doesn’t delete the nodes within the workflow. It is possible that though the workflow is deleted, triggers are left behind. Due to this, you may not receive a 'workflow already exists' error, but you may receive a ‘trigger already exists’ error in a case where you create a workflow, delete it and then try to re-create it with the same name from same blueprint.

**Error: workflow with name: foo already exists.**

The workflow name should be unique. Please try with a different name.

**Error: module not found in specified layoutGenerator path**

AWS Glue returns the error "Unknown error executing layout generator function ModuleNotFoundError: No module named 'crawl_s3_locations'".
For example, if you have the above layoutGenerator path, then when you unzip the blueprint archive, it needs to look like the following:

```
$ unzip crawl_s3_locations.zip
Archive: crawl_s3_locations.zip
  creating: crawl_s3_locations/
  inflating: crawl_s3_locations/blueprint.cfg
  inflating: crawl_s3_locations/layout.py
  inflating: crawl_s3_locations/README.md
```

When you unzip the archive, if the blueprint archive looks like the following, then you can get the above error.

```
$ unzip crawl_s3_locations.zip
Archive: crawl_s3_locations.zip
  inflating: blueprint.cfg
  inflating: layout.py
  inflating: README.md
```

You can see that there is no folder named `crawl_s3_locations` and when the `layoutGenerator` path refers to the layout file via the module `crawl_s3_locations`, you can get the above error.

**Error: validation error in Connections field**

AWS Glue returns the error "Unknown error executing layout generator function TypeError: Value ['foo'] for key Connections should be of type <class 'dict'>!".

This is a validation error. The `Connections` field in the `Job` class is expecting a dictionary and instead a list of values are provided causing the error.

User input was list of values

```
Connections= ['string']
```

Should be a dict like the following

```
Connections*=*{'Connections': ['string']}
```
To avoid these run time errors while creating a workflow from a blueprint, you can validate the workflow, job and crawler definitions as outlined in Testing a blueprint.

Refer to the syntax in AWS Glue blueprint Classes Reference for defining the AWS Glue job, crawler and workflow in the layout script.

Permissions for personas and roles for AWS Glue blueprints

The following are the typical personas and suggested AWS Identity and Access Management (IAM) permissions policies for personas and roles for AWS Glue blueprints.

Topics
- Blueprint personas
- Permissions for blueprint personas
- Permissions for blueprint roles

Blueprint personas

The following are the personas typically involved in the lifecycle of AWS Glue blueprints.

<table>
<thead>
<tr>
<th>Persona</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Glue developer</td>
<td>Develops, tests, and publishes blueprints.</td>
</tr>
<tr>
<td>AWS Glue administrator</td>
<td>Registers, maintains, and grants permissions on blueprints.</td>
</tr>
<tr>
<td>Data analyst</td>
<td>Runs blueprints to create workflows.</td>
</tr>
</tbody>
</table>

For more information, see the section called “Overview of blueprints”.

Permissions for blueprint personas

The following are the suggested permissions for each blueprint persona.

AWS Glue developer permissions for blueprints

The AWS Glue developer must have write permissions on the Amazon S3 bucket that is used to publish the blueprint. Often, the developer registers the blueprint after uploading it. In that
case, the developer needs the permissions listed in the section called “AWS Glue administrator permissions for blueprints”. Additionally, if the developer wishes to test the blueprint after its registered, he or she also needs the permissions listed in the section called “Data analyst permissions for blueprints”.

AWS Glue administrator permissions for blueprints

The following policy grants permissions to register, view, and maintain AWS Glue blueprints.

⚠️ Important
In the following policy, replace `<s3-bucket-name>` and `<prefix>` with the Amazon S3 path to uploaded blueprint ZIP archives to register.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:CreateBlueprint",
        "glue:UpdateBlueprint",
        "glue:DeleteBlueprint",
        "glue:GetBlueprint",
        "glue:ListBlueprints",
        "glue:BatchGetBlueprints"
      ],
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": [
        "s3:GetObject"
      ],
      "Resource": "arn:aws:s3:::<s3-bucket-name>/<prefix>/*"
    }
  ]
}
```
**Data analyst permissions for blueprints**

The following policy grants permissions to run blueprints and to view the resulting workflow and workflow components. It also grants `PassRole` on the role that AWS Glue assumes to create the workflow and workflow components.

The policy grants permissions on any resource. If you want to configure fine-grained access to individual blueprints, use the following format for blueprint ARNs:

```
arn:aws:glue:<region>:<account-id>:blueprint/<blueprint-name>
```

⚠️ **Important**  
In the following policy, replace `<account-id>` with a valid AWS account and replace `<role-name>` with the name of the role used to run a blueprint. See the section called “Permissions for blueprint roles” for the permissions that this role requires.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "glue:ListBlueprints",
        "glue:GetBlueprint",
        "glue:StartBlueprintRun",
        "glue:GetBlueprintRun",
        "glue:GetBlueprintRuns",
        "glue:GetCrawler",
        "glue:ListTriggers",
        "glue:ListJobs",
        "glue:BatchGetCrawlers",
        "glue:GetTrigger",
        "glue:BatchGetWorkflows",
        "glue:BatchGetTriggers",
        "glue:BatchGetJobs",
        "glue:BatchGetBlueprints",
        "glue:GetWorkflowRun",
        "glue:GetWorkflowRuns",
        "glue:ListCrawlers",
      ]
    }
  ]
}
```
Permissions for blueprint roles

The following are the suggested permissions for the IAM role used to create a workflow from a blueprint. The role has to have a trust relationship with glue.amazonaws.com.

⚠️ **Important**

In the following policy, replace `<account-id>` with a valid AWS account, and replace `<role-name>` with the name of the role.
"glue:GetWorkflow",
"glue:CreateCrawler"
],
"Resource": "*"
},
{
"Effect": "Allow",
"Action": "iam:PassRole",
"Resource": "arn:aws:iam::<account-id>:role/<role-name>"
}
] ]

Note

If the jobs and crawlers in the workflow assume a role other than this role, this policy must include the `iam:PassRole` permission on that other role instead of on the blueprint role.

Developing blueprints in AWS Glue

Your organization might have a set of similar ETL use cases that could benefit from being able to parametrize a single workflow to handle them all. To address this need, AWS Glue enables you to define blueprints, which you can use to generate workflows. A blueprint accepts parameters, so that from a single blueprint, a data analyst can create different workflows to handle similar ETL use cases. After you create a blueprint, you can reuse it for different departments, teams, and projects.

Topics

- [Overview of blueprints in AWS Glue](#)
- [Developing blueprints in AWS Glue](#)
- [Registering a blueprint in AWS Glue](#)
- [Viewing blueprints in AWS Glue](#)
- [Updating a blueprint in AWS Glue](#)
- [Creating a workflow from a blueprint in AWS Glue](#)
- [Viewing blueprint runs in AWS Glue](#)
Overview of blueprints in AWS Glue

Note

The blueprints feature is currently unavailable in the following Regions in the AWS Glue console: Asia Pacific (Jakarta) and Middle East (UAE).

AWS Glue blueprints provide a way to create and share AWS Glue workflows. When there is a complex ETL process that could be used for similar use cases, rather than creating an AWS Glue workflow for each use case, you can create a single blueprint.

The blueprint specifies the jobs and crawlers to include in a workflow, and specifies parameters that the workflow user supplies when they run the blueprint to create a workflow. The use of parameters enables a single blueprint to generate workflows for the various similar use cases. For more information about workflows, see Overview of workflows in AWS Glue.

The following are example use cases for blueprints:

- You want to partition an existing dataset. The input parameters to the blueprint are Amazon Simple Storage Service (Amazon S3) source and target paths and a list of partition columns.
- You want to snapshot an Amazon DynamoDB table into a SQL data store like Amazon Redshift. The input parameters to the blueprint are the DynamoDB table name and an AWS Glue connection, which designates an Amazon Redshift cluster and destination database.
- You want to convert CSV data in multiple Amazon S3 paths to Parquet. You want the AWS Glue workflow to include a separate crawler and job for each path. The input parameters are the destination database in the AWS Glue Data Catalog and a comma-delimited list of Amazon S3 paths. Note that in this case, the number of crawlers and jobs that the workflow creates is variable.

Blueprint components

A blueprint is a ZIP archive that contains the following components:

- A Python layout generator script

  Contains a function that specifies the workflow layout—the crawlers and jobs to create for the workflow, the job and crawler properties, and the dependencies between the jobs and crawlers.
The function accepts blueprint parameters and returns a workflow structure (JSON object) that AWS Glue uses to generate the workflow. Because you use a Python script to generate the workflow, you can add your own logic that is suitable for your use cases.

- **A configuration file**

  Specifies the fully qualified name of the Python function that generates the workflow layout. Also specifies the names, data types, and other properties of all blueprint parameters used by the script.

- **(Optional) ETL scripts and supporting files**

  As an advanced use case, you can parameterize the location of the ETL scripts that your jobs use. You can include job script files in the ZIP archive and specify a blueprint parameter for an Amazon S3 location where the scripts are to be copied to. The layout generator script can copy the ETL scripts to the designated location and specify that location as the job script location property. You can also include any libraries or other supporting files, provided that your script handles them.

---

**Blueprint runs**

When you create a workflow from a blueprint, AWS Glue runs the blueprint, which starts an asynchronous process to create the workflow and the jobs, crawlers, and triggers that the workflow encapsulates. AWS Glue uses the blueprint run to orchestrate the creation of the workflow and its components. You view the status of the creation process by viewing the blueprint run status. The blueprint run also stores the values that you supplied for the blueprint parameters.
You can view blueprint runs using the AWS Glue console or AWS Command Line Interface (AWS CLI). When viewing or troubleshooting a workflow, you can always return to the blueprint run to view the blueprint parameter values that were used to create the workflow.

**Lifecycle of a blueprint**

Blueprints are developed, tested, registered with AWS Glue, and run to create workflows. There are typically three personas involved in the blueprint lifecycle.

<table>
<thead>
<tr>
<th>Persona</th>
<th>Tasks</th>
</tr>
</thead>
</table>
| AWS Glue developer       | • Writes the workflow layout script and creates the configuration file.  
                          | • Tests the blueprint locally using libraries provided by the AWS Glue service.   
                          | • Creates a ZIP archive of the script, configuration file, and supporting files and publishes the archive to a location in Amazon S3.  
                          | • Adds a bucket policy to the Amazon S3 bucket that grants read permissions on bucket objects to the AWS Glue administrator's AWS account.  
                          | • Grants IAM read permissions on the ZIP archive in Amazon S3 to the AWS Glue administrator. |
| AWS Glue administrator    | • Registers the blueprint with AWS Glue. AWS Glue makes a copy of the ZIP archive into a reserved Amazon S3 location. |
See also

- Developing blueprints in AWS Glue
- Creating a workflow from a blueprint in AWS Glue
- Permissions for personas and roles for AWS Glue blueprints

Developing blueprints in AWS Glue

As an AWS Glue developer, you can create and publish blueprints that data analysts can use to generate workflows.

Topics

- Overview of developing blueprints
- Prerequisites for developing blueprints
- Writing the blueprint code
- Sample blueprint project
- Testing a blueprint
- Publishing a blueprint
- AWS Glue blueprint classes reference
- Blueprint samples
Overview of developing blueprints

The first step in your development process is to identify a common use case that would benefit from a blueprint. A typical use case involves a recurring ETL problem that you believe should be solved in a general manner. Next, design a blueprint that implements the generalized use case, and define the blueprint input parameters that together can define a specific use case from the generalized use case.

A blueprint consists of a project that contains a blueprint parameter configuration file and a script that defines the layout of the workflow to generate. The layout defines the jobs and crawlers (or entities in blueprint script terminology) to create.

You do not directly specify any triggers in the layout script. Instead you write code to specify the dependencies between the jobs and crawlers that the script creates. AWS Glue generates the triggers based on your dependency specifications. The output of the layout script is a workflow object, which contains specifications for all workflow entities.

You build your workflow object using the following AWS Glue blueprint libraries:

- `awsglue.blueprint.base_resource` – A library of base resources used by the libraries.
- `awsglue.blueprint.workflow` – A library for defining a Workflow class.
- `awsglue.blueprint.job` – A library for defining a Job class.
- `awsglue.blueprint.crawler` – A library for defining a Crawler class.

The only other libraries that are supported for layout generation are those libraries that are available for the Python shell.

Before publishing your blueprint, you can use methods defined in the blueprint libraries to test the blueprint locally.

When you're ready to make the blueprint available to data analysts, you package the script, the parameter configuration file, and any supporting files, such as additional scripts and libraries, into
a single deployable asset. You then upload the asset to Amazon S3 and ask an administrator to register it with AWS Glue.

For information about more sample blueprint projects, see Sample blueprint project and Blueprint samples.

**Prerequisites for developing blueprints**

To develop blueprints, you should be familiar with using AWS Glue and writing scripts for Apache Spark ETL jobs or Python shell jobs. In addition, you must complete the following setup tasks.

- Download four AWS Python libraries to use in your blueprint layout scripts.
- Set up the AWS SDKs.
- Set up the AWS CLI.

**Download the Python libraries**

Download the following libraries from GitHub, and install them into your project:


**Set up the AWS Java SDK**

For the AWS Java SDK, you must add a `jar` file that includes the API for blueprints.

1. If you haven’t already done so, set up the AWS SDK for Java.
   - For Java 1.x, follow the instructions in Set up the AWS SDK for Java in the AWS SDK for Java Developer Guide.
   - For Java 2.x, follow the instructions in Setting up the AWS SDK for Java 2.x in the AWS SDK for Java 2.x Developer Guide.

2. Download the client `jar` file that has access to the APIs for blueprints.
3. Add the client jar to the front of the Java classpath to override the AWS Glue client provided by the AWS Java SDK.

   ```
   export CLASSPATH=<path-to-preview-client-jar>:$CLASSPATH
   ```

4. (Optional) Test the SDK with the following Java application. The application should output an empty list.

   Replace accessKey and secretKey with your credentials, and replace us-east-1 with your Region.

   ```java
import com.amazonaws.auth.AWSCredentials;
import com.amazonaws.auth.AWSCredentialsProvider;
import com.amazonaws.auth.AWSStaticCredentialsProvider;
import com.amazonaws.auth.BasicAWSCredentials;
import com.amazonaws.services.glue.AWSGlue;
import com.amazonaws.services.glue.AWSGlueClientBuilder;
import com.amazonaws.services.glue.model.ListBlueprintsRequest;

public class App{
    public static void main(String[] args) {
        AWSCredentials credentials = new BasicAWSCredentials("accessKey", "secretKey");
        AWSCredentialsProvider provider = new
        AWSStaticCredentialsProvider(credentials);
        AWSGlue glue = AWSGlueClientBuilder.standard().withCredentials(provider)
            .withRegion("us-east-1").build();
        ListBlueprintsRequest request = new
        ListBlueprintsRequest().withMaxResults(2);
        System.out.println(glue.listBlueprints(request));
    }
}
```
Set up the AWS Python SDK

The following steps assume that you have Python version 2.7 or later, or version 3.6 or later installed on your computer.

1. Download the following boto3 wheel file. If prompted to open or save, save the file. s3://awsglue-custom-blueprints-preview-artifacts/aws-python-sdk-preview/boto3-1.17.31-py2.py3-none-any.whl

2. Download the following botocore wheel file: s3://awsglue-custom-blueprints-preview-artifacts/aws-python-sdk-preview/botocore-1.20.31-py2.py3-none-any.whl

3. Check your Python version.

   python --version

4. Depending on your Python version, enter the following commands (for Linux):

   • For Python 2.7 or later.

     python3 -m pip install --user virtualenv
     source env/bin/activate

   • For Python 3.6 or later.

     python3 -m venv python-sdk-test
     source python-sdk-test/bin/activate

5. Install the botocore wheel file.

   python3 -m pip install <download-directory>/botocore-1.20.31-py2.py3-none-any.whl

6. Install the boto3 wheel file.

   python3 -m pip install <download-directory>/boto3-1.17.31-py2.py3-none-any.whl

7. Configure your credentials and default region in the ~/.aws/credentials and ~/.aws/config files. For more information, see Configuring the AWS CLI in the AWS Command Line Interface User Guide.

8. (Optional) Test your setup. The following commands should return an empty list.

    Replace us-east-1 with your Region.
*$ python
>>> import boto3
>>> glue = boto3.client('glue', 'us-east-1')
>>> glue.list_blueprints()*$

**Set up the preview AWS CLI**

1. If you haven't already done so, install and/or update the AWS Command Line Interface (AWS CLI) on your computer. The easiest way to do this is with `pip`, the Python installer utility:

```
pip install awscli --upgrade --user
```

   You can find complete installation instructions for the AWS CLI here: [Installing the AWS Command Line Interface](#).

2. Download the AWS CLI wheel file from: `s3://awsglue-custom-blueprints-preview-artifacts/awscli-preview-build/awscli-1.19.31-py2.py3-none-any.whl`

3. Install the AWS CLI wheel file.

```
python3 -m pip install awscli-1.19.31-py2.py3-none-any.whl
```

4. Run the `aws configure` command. Configure your AWS credentials (including access key, and secret key) and AWS Region. You can find information on configuring the AWS CLI here: [Configuring the AWS CLI](#).

5. Test the AWS CLI. The following command should return an empty list.

   Replace `us-east-1` with your Region.

```
aws glue list-blueprints --region us-east-1
```

**Writing the blueprint code**

Each blueprint project that you create must contain at a minimum the following files:

- A Python layout script that defines the workflow. The script contains a function that defines the entities (jobs and crawlers) in a workflow, and the dependencies between them.
- A configuration file, `blueprint.cfg`, which defines:
• The full path of the workflow layout definition function.
• The parameters that the blueprint accepts.

Topics
• Creating the blueprint layout script
• Creating the configuration file
• Specifying blueprint parameters

Creating the blueprint layout script

The blueprint layout script must include a function that generates the entities in your workflow. You can name this function whatever you like. AWS Glue uses the configuration file to determine the fully qualified name of the function.

Your layout function does the following:

• (Optional) Instantiates the Job class to create Job objects, and passes arguments such as Command and Role. These are job properties that you would specify if you were creating the job using the AWS Glue console or API.
• (Optional) Instantiates the Crawler class to create Crawler objects, and passes name, role, and target arguments.
• To indicate dependencies between the objects (workflow entities), passes the DependsOn and WaitForDependencies additional arguments to Job() and Crawler(). These arguments are explained later in this section.
• Instantiates the Workflow class to create the workflow object that is returned to AWS Glue, passing a Name argument, an Entities argument, and an optional OnSchedule argument. The Entities argument specifies all of the jobs and crawlers to include in the workflow. To see how to construct an Entities object, see the sample project later in this section.
• Returns the Workflow object.

For definitions of the Job, Crawler, and Workflow classes, see AWS Glue blueprint classes reference.

The layout function must accept the following input arguments.
### Argument | Description
--- | ---
user_params | Python dictionary of blueprint parameter names and values. For more information, see [Specifying blueprint parameters](#).

system_params | Python dictionary containing two properties: `region` and `accountId`.

Here is a sample layout generator script in a file named `Layout.py`:

```python
import argparse
import sys
import os
import json
from awsglue.blueprintworkflow import *
from awsglue.blueprintjob import *
from awsglue.blueprintcrawler import *

def generate_layout(user_params, system_params):
    etl_job = Job(Name="{}_etl_job".format(user_params['WorkflowName']),
                  Command={
                    "Name": "glueetl",
                    "ScriptLocation": user_params['ScriptLocation'],
                    "PythonVersion": "2"
                  },
                  Role=user_params['PassRole'])
    post_process_job = Job(Name="{}_post_process".format(user_params['WorkflowName']),
                            Command={
                              "Name": "pythonshell",
                              "ScriptLocation": user_params['ScriptLocation'],
                              "PythonVersion": "2"
                            },
                            Role=user_params['PassRole'],
                            DependsOn={
                              etl_job: "SUCCEEDED"
                            },
                            WaitForDependencies="AND")
    sample_workflow = Workflow(Name=user_params['WorkflowName'],
                                Entities=Entities(Jobs=[etl_job, post_process_job]))
```
The sample script imports the required blueprint libraries and includes a `generate_layout` function that generates a workflow with two jobs. This is a very simple script. A more complex script could employ additional logic and parameters to generate a workflow with many jobs and crawlers, or even a variable number of jobs and crawlers.

### Using the `DependsOn` argument

The `DependsOn` argument is a dictionary representation of a dependency that this entity has on other entities within the workflow. It has the following form.

```
DependsOn = {dependency1 : state, dependency2 : state, ...}
```

The keys in this dictionary represent the object reference, not the name, of the entity, while the values are strings that correspond to the state to watch for. AWS Glue infers the proper triggers. For the valid states, see [Condition Structure](#).

For example, a job might depend on the successful completion of a crawler. If you define a crawler object named `crawler2` as follows:

```python
crawler2 = Crawler(Name="my_crawler", ...)
```

Then an object depending on `crawler2` would include a constructor argument such as:

```python
DependsOn = {crawler2 : "SUCCEEDED"}
```

For example:

```python
job1 = Job(Name="Job1", ..., DependsOn = {crawler2 : "SUCCEEDED", ...})
```

If `DependsOn` is omitted for an entity, that entity depends on the workflow start trigger.

### Using the `WaitForDependencies` argument

The `WaitForDependencies` argument defines whether a job or crawler entity should wait until *all* entities on which it depends complete or until *any* completes.
The allowable values are "AND" or "ANY".

**Using the OnSchedule argument**

The `OnSchedule` argument for the `Workflow` class constructor is a `cron` expression that defines the starting trigger definition for a workflow.

If this argument is specified, AWS Glue creates a schedule trigger with the corresponding schedule. If it isn't specified, the starting trigger for the workflow is an on-demand trigger.

**Creating the configuration file**

The blueprint configuration file is a required file that defines the script entry point for generating the workflow, and the parameters that the blueprint accepts. The file must be named `blueprint.cfg`.

Here is a sample configuration file.

```json
{
    "layoutGenerator": "DemoBlueprintProject.Layout.generate_layout",
    "parameterSpec": {
        "WorkflowName": {
            "type": "String",
            "collection": false
        },
        "WorkerType": {
            "type": "String",
            "collection": false,
            "allowedValues": ["G1.X", "G2.X"],
            "defaultValue": "G1.X"
        },
        "Dpu": {
            "type": "Integer",
            "allowedValues": [2, 4, 6],
            "defaultValue": 2
        },
        "DynamoDBTableName": {
            "type": "String",
            "collection": false
        },
        "ScriptLocation": {
            "type": "String",
            "collection": false
        }
    }
}
```
The `layoutGenerator` property specifies the fully qualified name of the function in the script that generates the layout.

The `parameterSpec` property specifies the parameters that this blueprint accepts. For more information, see [Specifying blueprint parameters](#).

⚠️ **Important**

Your configuration file must include the workflow name as a blueprint parameter, or you must generate a unique workflow name in your layout script.

---

### Specifying blueprint parameters

The configuration file contains blueprint parameter specifications in a `parameterSpec` JSON object. `parameterSpec` contains one or more parameter objects.

```json
"parameterSpec": {
    "<parameter_name>": {
        "type": "<parameter-type>",
        "collection": true|false,
        "description": "<parameter-description>",
        "defaultValue": "<default value for the parameter if value not specified>",
        "allowedValues": "<list of allowed values>"
    },
    "<parameter_name>": {
        ...
    }
}
```

The following are the rules for coding each parameter object:

- The parameter name and type are mandatory. All other properties are optional.
- If you specify the `defaultValue` property, the parameter is optional. Otherwise the parameter is mandatory and the data analyst who is creating a workflow from the blueprint must provide a value for it.
- If you set the collection property to true, the parameter can take a collection of values. Collections can be of any data type.
- If you specify allowedValues, the AWS Glue console displays a dropdown list of values for the data analyst to choose from when creating a workflow from the blueprint.

The following are the permitted values for type:

<table>
<thead>
<tr>
<th>Parameter data type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>-</td>
</tr>
<tr>
<td>Integer</td>
<td>-</td>
</tr>
<tr>
<td>Double</td>
<td>-</td>
</tr>
<tr>
<td>Boolean</td>
<td>Possible values are true and false. Generates a check box on the Create a workflow from &lt;blueprint&gt; page on the AWS Glue console.</td>
</tr>
<tr>
<td>S3Uri</td>
<td>Complete Amazon S3 path, beginning with s3://. Generates a text field and Browse button on the Create a workflow from &lt;blueprint&gt; page.</td>
</tr>
<tr>
<td>S3Bucket</td>
<td>Amazon S3 bucket name only. Generates a bucket picker on the Create a workflow from &lt;blueprint&gt; page.</td>
</tr>
<tr>
<td>IAMRoleArn</td>
<td>Amazon Resource Name (ARN) of an AWS Identity and Access Management (IAM) role. Generates a role picker on the Create a workflow from &lt;blueprint&gt; page.</td>
</tr>
<tr>
<td>IAMRoleName</td>
<td>Name of an IAM role. Generates a role picker on the Create a workflow from &lt;blueprint&gt; page.</td>
</tr>
</tbody>
</table>

**Sample blueprint project**

Data format conversion is a frequent extract, transform, and load (ETL) use case. In typical analytic workloads, column-based file formats like Parquet or ORC are preferred over text formats like CSV or JSON. This sample blueprint enables you to convert data from CSV/JSON/etc. into Parquet for files on Amazon S3.
This blueprint takes a list of S3 paths defined by a blueprint parameter, converts the data to Parquet format, and writes it to the S3 location specified by another blueprint parameter. The layout script creates a crawler and job for each path. The layout script also uploads the ETL script in Conversion.py to an S3 bucket specified by another blueprint parameter. The layout script then specifies the uploaded script as the ETL script for each job. The ZIP archive for the project contains the layout script, the ETL script, and the blueprint configuration file.

For information about more sample blueprint projects, see [Blueprint samples](https://docs.aws.amazon.com/glue/latest/dg/samples-blueprints.html).

The following is the layout script, in the file `Layout.py`.

```python
from awsglue.blueprint.workflow import *
from awsglue.blueprint.job import *
from awsglue.blueprint.crawler import *
import boto3

s3_client = boto3.client('s3')

# Ingesting all the S3 paths as Glue table in parquet format
def generate_layout(user_params, system_params):
    #Always give the full path for the file
    with open("ConversionBlueprint/Conversion.py", "rb") as f:
        s3_client.upload_fileobj(f, user_params['ScriptsBucket'], "Conversion.py")
    etlScriptLocation = "s3://{}/Conversion.py".format(user_params['ScriptsBucket'])

    crawlers = []
    jobs = []

    workflowName = user_params['WorkflowName']
    for path in user_params['S3Paths']:
        tablePrefix = "source_"
        crawler = Crawler(Name="{}_{}/crawler".format(workflowName),
                           Role=user_params['PassRole'],
                           DatabaseName=user_params['TargetDatabase'],
                           TablePrefix=tablePrefix,
                           Targets= {{"S3Targets": ["Path": path]}})
        crawlers.append(crawler)
        transform_job = Job(Name="{}_{}/transform_job".format(workflowName),
                            Command={"Name": "glueetl",
                                "ScriptLocation": etlScriptLocation,
                                "PythonVersion": "3"},
                            Role=user_params['PassRole'],
                            DefaultArguments={"--database_name":
                                user_params['TargetDatabase'],
                                "--glue_string": "{}_{}/Transformation".format(workflowName),
                                "--glue_root_dir": "ConversionBlueprint"})
        jobs.append(transform_job)

    return workflowName, crawlers, jobs
```

Developing blueprints
The following is the corresponding blueprint configuration file blueprint.cfg.

```json
{
    "layoutGenerator": "ConversionBlueprint.Layout.generate_layout",
    "parameterSpec": {
        "WorkflowName": {
            "type": "String",
            "collection": false,
            "description": "Name for the workflow."
        },
        "S3Paths": {
            "type": "S3Uri",
            "collection": true,
            "description": "List of Amazon S3 paths for data ingestion."
        },
        "PassRole": {
            "type": "IAMRoleName",
            "collection": false,
            "description": "Choose an IAM role to be used in running the job/crawler"
        },
        "TargetDatabase": {
            "type": "String",
            "collection": false,
            "description": "Choose a database in the Data Catalog."
        },
        "TargetS3Location": {
            "type": "S3Uri",
            "collection": false,
            "description": "Choose an Amazon S3 output path: ex:s3://<target_path>/."
        },
        "ScriptsBucket": {
            "type": "S3Bucket",
            "description": ""
The following script in the file `Conversion.py` is the uploaded ETL script. Note that it preserves the partitioning scheme during conversion.

```python
import sys
from pyspark.sql.functions import *
from pyspark.context import SparkContext
from awsglue.transforms import *
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions
import boto3

args = getResolvedOptions(sys.argv, [
    'JOB_NAME',
    'region_name',
    'database_name',
    'table_prefix',
    'output_path'])

databaseName = args['database_name']
tablePrefix = args['table_prefix']
outputPath = args['output_path']

glue = boto3.client('glue', region_name=args['region_name'])

glue_context = GlueContext(SparkContext.getOrCreate())
spark = glue_context.spark_session
job = Job(glue_context)
job.init(args['JOB_NAME'], args)

def get_tables(database_name, table_prefix):
    tables = []
    paginator = glue.get_paginator('get_tables')
    for page in paginator.paginate(DatabaseName=database_name, Expression=table_prefix + '*):
        tables.extend(page['TableList'])
    return tables
```
for table in get_tables(databaseName, tablePrefix):
    tableName = table['Name']
    partitionList = table['PartitionKeys']
    partitionKeys = []
    for partition in partitionList:
        partitionKeys.append(partition['Name'])

    # Create DynamicFrame from Catalog
    dyf = glue_context.create_dynamic_frame.from_catalog(
        name_space=databaseName,
        table_name=tableName,
        additional_options={
            'useS3ListImplementation': True
        },
        transformation_ctx='dyf'
    )

    # Resolve choice type with make_struct
    dyf = ResolveChoice.apply(
        frame=dyf,
        choice='make_struct',
        transformation_ctx='resolvechoice_' + tableName
    )

    # Drop null fields
    dyf = DropNullFields.apply(
        frame=dyf,
        transformation_ctx='dropnullfields_' + tableName
    )

    # Write DynamicFrame to S3 in glueparquet
    sink = glue_context.getSink(
        connection_type="s3",
        path=outputPath,
        enableUpdateCatalog=True,
        partitionKeys=partitionKeys
    )
    sink.setFormat("glueparquet")
    sink.setCatalogInfo(
        catalogDatabase=databaseName,
        catalogTable=tableName[len(tablePrefix):]
    )
sink.writeFrame(dyf)

job.commit()

**Note**

Only two Amazon S3 paths can be supplied as an input to the sample blueprint. This is because AWS Glue triggers are limited to invoking only two crawler actions.

---

**Testing a blueprint**

While you develop your code, you should perform local testing to verify that the workflow layout is correct.

Local testing doesn't generate AWS Glue jobs, crawlers, or triggers. Instead, you run the layout script locally and use the `to_json()` and `validate()` methods to print objects and find errors. These methods are available in all three classes defined in the libraries.

There are two ways to handle the `user_params` and `system_params` arguments that AWS Glue passes to your layout function. Your test-bench code can create a dictionary of sample blueprint parameter values and pass that to the layout function as the `user_params` argument. Or, you can remove the references to `user_params` and replace them with hardcoded strings.

If your code makes use of the `region` and `accountId` properties in the `system_params` argument, you can pass in your own dictionary for `system_params`.

**To test a blueprint**

1. Start a Python interpreter in a directory with the libraries, or load the blueprint files and the supplied libraries into your preferred integrated development environment (IDE).
2. Ensure that your code imports the supplied libraries.
3. Add code to your layout function to call `validate()` or `to_json()` on any entity or on the `Workflow` object. For example, if your code creates a `Crawler` object named `mycrawler`, you can call `validate()` as follows.

   ```python
   mycrawler.validate()
   ```

   You can print `mycrawler` as follows:
If you call `to_json()` on an object, there is no need to also call `validate()`, because `to_json()` calls `validate()`.

It is most useful to call these methods on the workflow object. Assuming that your script names the workflow object `my_workflow`, validate and print the workflow object as follows.

```
print(my_workflow.to_json())
```

For more information about `to_json()` and `validate()`, see [Class methods](#).

You can also import `pprint` and pretty-print the workflow object, as shown in the example later in this section.

4. Run the code, fix errors, and finally remove any calls to `validate()` or `to_json()`.

**Example**

The following example shows how to construct a dictionary of sample blueprint parameters and pass it in as the `user_params` argument to layout function `generate_compaction_workflow`. It also shows how to pretty-print the generated workflow object.

```python
from pprint import pprint
from awsglue.blueprint.workflow import *
from awsglue.blueprint.job import *
from awsglue.blueprint.crawler import *

USER_PARAMS = {
    "WorkflowName": "compaction_workflow",
    "ScriptLocation": "s3://awsexamplebucket1/scripts/threaded-compaction.py",
    "PassRole": "arn:aws:iam::111122223333:role/GlueRole-ETL",
    "DatabaseName": "cloudtrial",
    "TableName": "ct_cloudtrail",
    "CoalesceFactor": 4,
    "MaxThreadWorkers": 200
}

def generate_compaction_workflow(user_params: dict, system_params: dict) -> Workflow:
    compaction_job = Job(Name=f"{user_params['WorkflowName']}_etl_job",
```
Publishing a blueprint

After you develop a blueprint, you must upload it to Amazon S3. You must have write permissions on the Amazon S3 bucket that you use to publish the blueprint. You must also make sure that the AWS Glue administrator, who will register the blueprint, has read access to the Amazon S3 bucket. For the suggested AWS Identity and Access Management (IAM) permissions policies for personas and roles for AWS Glue blueprints, see Permissions for personas and roles for AWS Glue blueprints.
To publish a blueprint

1. Create the necessary scripts, resources, and blueprint configuration file.

2. Add all files to a ZIP archive and upload the ZIP file to Amazon S3. Use an S3 bucket that is in the same Region as the Region in which users will register and run the blueprint.

You can create a ZIP file from the command line using the following command.

```
zip -r folder.zip folder
```

3. Add a bucket policy that grants read permissions to the AWS desired account. The following is a sample policy.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Principal": {
            "AWS": "arn:aws:iam::111122223333:root"
         },
         "Action": "s3:GetObject",
         "Resource": "arn:aws:s3:::my-blueprints/*"
      }
   ]
}
```

4. Grant the IAM `s3:GetObject` permission on the Amazon S3 bucket to the AWS Glue administrator or to whoever will be registering blueprints. For a sample policy to grant to administrators, see [AWS Glue administrator permissions for blueprints](#).

After you have completed local testing of your blueprint, you may also want to test a blueprint on AWS Glue. To test a blueprint on AWS Glue, it must be registered. You can limit who sees the registered blueprint using IAM authorization, or by using separate testing accounts.

**See also:**

- [Registering a blueprint in AWS Glue](#)
AWS Glue blueprint classes reference

The libraries for AWS Glue blueprints define three classes that you use in your workflow layout script: Job, Crawler, and Workflow.

Topics

- Job class
- Crawler class
- Workflow class
- Class methods

Job class

The Job class represents an AWS Glue ETL job.

Mandatory constructor arguments

The following are mandatory constructor arguments for the Job class.

<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>str</td>
<td>Name to assign to the job. AWS Glue adds a randomly generated suffix to the name to distinguish the job from those created by other blueprint runs.</td>
</tr>
<tr>
<td>Role</td>
<td>str</td>
<td>Amazon Resource Name (ARN) of the role that the job should assume while executing.</td>
</tr>
<tr>
<td>Command</td>
<td>dict</td>
<td>Job command, as specified in the JobCommand structure in the API documentation.</td>
</tr>
</tbody>
</table>

Optional constructor arguments

The following are optional constructor arguments for the Job class.
<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DependsOn</td>
<td>dict</td>
<td>List of workflow entities that the job depends on. For more information, see <a href="#">Using the DependsOn argument</a>.</td>
</tr>
<tr>
<td>WaitForDependencies</td>
<td>str</td>
<td>Indicates whether the job should wait until all entities on which it depends complete before executing or until any completes. For more information, see <a href="#">Using the WaitForDependencies argument</a>. Omit if the job depends on only one entity.</td>
</tr>
<tr>
<td>(Job properties)</td>
<td>-</td>
<td>Any of the job properties listed in <a href="#">Job structure</a> in the AWS Glue API documentation (except CreatedOn and LastModifiedOn).</td>
</tr>
</tbody>
</table>

**Crawler class**

The Crawler class represents an AWS Glue crawler.

**Mandatory constructor arguments**

The following are mandatory constructor arguments for the Crawler class.

<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>str</td>
<td>Name to assign to the crawler. AWS Glue adds a randomly generated suffix to the name to distinguish the crawler from those created by other blueprint runs.</td>
</tr>
<tr>
<td>Role</td>
<td>str</td>
<td>ARN of the role that the crawler should assume while running.</td>
</tr>
<tr>
<td>Targets</td>
<td>dict</td>
<td>Collection of targets to crawl. Targets class constructor arguments are defined in the <a href="#">CrawlerTargets structure</a> in the API documentation</td>
</tr>
</tbody>
</table>
### Optional constructor arguments

The following are optional constructor arguments for the `Crawler` class.

<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DependsOn</td>
<td>dict</td>
<td>List of workflow entities that the crawler depends on. For more information, see <a href="#">Using the DependsOn argument</a>.</td>
</tr>
<tr>
<td>WaitForDependencies</td>
<td>str</td>
<td>Indicates whether the crawler should wait until all entities on which it depends complete before running or until any completes. For more information, see <a href="#">Using the WaitForDependencies argument</a>. Omit if the crawler depends on only one entity.</td>
</tr>
<tr>
<td>(Crawler properties)</td>
<td>-</td>
<td>Any of the crawler properties listed in <a href="#">Crawler structure</a> in the AWS Glue API documentation, with the following exceptions:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• State</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CrawlElapsedTime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CreationTime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LastUpdated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LastCrawl</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Version</td>
</tr>
</tbody>
</table>
**Workflow class**

The *Workflow* class represents an AWS Glue workflow. The workflow layout script returns a *Workflow* object. AWS Glue creates a workflow based on this object.

**Mandatory constructor arguments**

The following are mandatory constructor arguments for the *Workflow* class.

<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>str</td>
<td>Name to assign to the workflow.</td>
</tr>
<tr>
<td>Entities</td>
<td>Entities</td>
<td>A collection of entities (jobs and crawlers) to include in the workflow. The Entities class constructor accepts a Jobs argument, which is a list of Job objects, and a Crawlers argument, which is a list of Crawler objects.</td>
</tr>
</tbody>
</table>

**Optional constructor arguments**

The following are optional constructor arguments for the *Workflow* class.

<table>
<thead>
<tr>
<th>Argument name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>str</td>
<td>See <a href="#">Workflow structure</a>.</td>
</tr>
<tr>
<td>DefaultRunProperties</td>
<td>dict</td>
<td>See <a href="#">Workflow structure</a>.</td>
</tr>
<tr>
<td>OnSchedule</td>
<td>str</td>
<td>A cron expression.</td>
</tr>
</tbody>
</table>

**Class methods**

All three classes include the following methods.
validate()

Validates the properties of the object and if errors are found, outputs a message and exits. Generates no output if there are no errors. For the Workflow class, calls itself on every entity in the workflow.

to_json()

Serializes the object to JSON. Also calls validate(). For the Workflow class, the JSON object includes job and crawler lists, and a list of triggers generated by the job and crawler dependency specifications.

Blueprint samples

There are a number of sample blueprint projects available on the AWS Glue blueprint Github repository. These samples are for reference only and are not intended for production use.

The titles of the sample projects are:

- Compaction: this blueprint creates a job that compacts input files into larger chunks based on desired file size.
- Conversion: this blueprint converts input files in various standard file formats into Apache Parquet format, which is optimized for analytic workloads.
- Crawling Amazon S3 locations: this blueprint crawls multiple Amazon S3 locations to add metadata tables to the Data Catalog.
- Custom connection to Data Catalog: this blueprint accesses data stores using AWS Glue custom connectors, reads the records, and populates the table definitions in the AWS Glue Data Catalog based on the record schema.
- Encoding: this blueprint converts your non-UTF files into UTF encoded files.
- Partitioning: this blueprint creates a partitioning job that places output files into partitions based on specific partition keys.
- Importing Amazon S3 data into a DynamoDB table: this blueprint imports data from Amazon S3 into a DynamoDB table.
- Standard table to governed: this blueprint imports an AWS Glue Data Catalog table into a Lake Formation table.
Registering a blueprint in AWS Glue

After the AWS Glue developer has coded the blueprint and uploaded a ZIP archive to Amazon Simple Storage Service (Amazon S3), an AWS Glue administrator must register the blueprint. Registering the blueprint makes it available for use.

When you register a blueprint, AWS Glue copies the blueprint archive to a reserved Amazon S3 location. You can then delete the archive from the upload location.

To register a blueprint, you need read permissions on the Amazon S3 location that contains the uploaded archive. You also need the AWS Identity and Access Management (IAM) permission glue:CreateBlueprint. For the suggested permissions for an AWS Glue administrator who must register, view, and maintain blueprints, see AWS Glue administrator permissions for blueprints.

You can register a blueprint by using the AWS Glue console, AWS Glue API, or AWS Command Line Interface (AWS CLI).

To register a blueprint (console)

1. Ensure that you have read permissions (s3:GetObject) on the blueprint ZIP archive in Amazon S3.
2. Open the AWS Glue console at https://console.aws.amazon.com/glue/.
   
   Sign in as a user that has permissions to register a blueprint. Switch to the same AWS Region as the Amazon S3 bucket that contains the blueprint ZIP archive.
3. In the navigation pane, choose blueprints. Then on the blueprints page, choose Add blueprint.
4. Enter a blueprint name and optional description.
5. For ZIP archive location (S3), enter the Amazon S3 path of the uploaded blueprint ZIP archive. Include the archive file name in the path and begin the path with s3://.
6. (Optional) Add tag one or more tags.
7. Choose Add blueprint.

   The blueprints page returns and shows that the blueprint status is CREATING. Choose the refresh button until the status changes to ACTIVE or FAILED.
8. If the status is FAILED, select the blueprint, and on the Actions menu, choose View.
The detail page shows the reason for the failure. If the error message is "Unable to access object at location..." or "Access denied on object at location...", review the following requirements:

- The user that you are signed in as must have read permission on the blueprint ZIP archive in Amazon S3.
- The Amazon S3 bucket that contains the ZIP archive must have a bucket policy that grants read permission on the object to your AWS account ID. For more information, see Developing blueprints in AWS Glue.
- The Amazon S3 bucket that you're using must be in the same Region as the Region that you're signed into on the console.

9. Ensure that data analysts have permissions on the blueprint.

The suggested IAM policy for data analysts is shown in Data analyst permissions for blueprints. This policy grants glue:GetBlueprint on any resource. If your policy is more fine-grained at the resource level, then grant data analysts permissions on this newly created resource.

To register a blueprint (AWS CLI)

1. Enter the following command.

   ```sh/aws glue create-blueprint --name <blueprint-name> [--description <description>] --blueprint-location s3://<s3-path>/<archive-filename>
   ```

2. Enter the following command to check the blueprint status. Repeat the command until the status goes to ACTIVE or FAILED.

   ```sh/aws glue get-blueprint --name <blueprint-name>
   ```

If the status is FAILED and the error message is "Unable to access object at location..." or "Access denied on object at location...", review the following requirements:

- The user that you are signed in as must have read permission on the blueprint ZIP archive in Amazon S3.
- The Amazon S3 bucket containing the ZIP archive must have a bucket policy that grants read permission on the object to your AWS account ID. For more information, see Publishing a blueprint.
• The Amazon S3 bucket that you're using must be in the same Region as the Region that you're signed into on the console.

⚠️ See also:

• Overview of blueprints in AWS Glue

Viewing blueprints in AWS Glue

View a blueprint to review the blueprint description, status, and parameter specifications, and to download the blueprint ZIP archive.

You can view a blueprint by using the AWS Glue console, AWS Glue API, or AWS Command Line Interface (AWS CLI).

To view a blueprint (console)

2. In the navigation pane, choose blueprints.
3. On the blueprints page, select a blueprint. Then on the Actions menu, choose View.

To view a blueprint (AWS CLI)

• Enter the following command to view just the blueprint name, description, and status. Replace <blueprint-name> with the name of the blueprint to view.

  aws glue get-blueprint --name <blueprint-name>

The command output looks something like the following.

```json
{
    "Blueprint": {
        "Name": "myDemoBP",
        "CreatedOn": 1587414516.92,
        "LastModifiedOn": 1587428838.671,
        "BlueprintLocation": "s3://awsexamplebucket1/demo/DemoBlueprintProject.zip",
```
Enter the following command to also view the parameter specifications.

```
aws glue get-blueprint --name <blueprint-name> --include-parameter-spec
```

The command output looks something like the following.

```
{
    "Blueprint": {
        "Name": "myDemoBP",
        "CreatedOn": 1587414516.92,
        "LastModifiedOn": 1587428838.671,
        "ParameterSpec": "{\"WorkflowName\":{\"type\":\"String\",\"collection\":false,\"description\":null,\"defaultValue\":null,\"allowedValues\":null},\"PassRole\":{\"type\":\"String\",\"collection\":false,\"description\":null,\"defaultValue\":null,\"allowedValues\":null},\"DynamoDBTableName\":{\"type\":\"String\",\"collection\":false,\"description\":null,\"defaultValue\":null,\"allowedValues\":null},\"ScriptLocation\":{\"type\":\"String\",\"collection\":false,\"description\":null,\"defaultValue\":null,\"allowedValues\":null}}",
        "BlueprintLocation": "s3://awsexamplebucket1/demo/DemoBlueprintProject.zip",
        "Status": "ACTIVE"
    }
}
```

Add the `--include-blueprint` argument to include a URL in the output that you can paste into your browser to download the blueprint ZIP archive that AWS Glue stored.

See also:

- [Overview of blueprints in AWS Glue](#)
Updating a blueprint in AWS Glue

You can update a blueprint if you have a revised layout script, a revised set of blueprint parameters, or revised supporting files. Updating a blueprint creates a new version.

Updating a blueprint doesn't affect existing workflows created from the blueprint.

You can update a blueprint by using the AWS Glue console, AWS Glue API, or AWS Command Line Interface (AWS CLI).

The following procedure assumes that the AWS Glue developer has created and uploaded an updated blueprint ZIP archive to Amazon S3.

To update a blueprint (console)

1. Ensure that you have read permissions (s3:GetObject) on the blueprint ZIP archive in Amazon S3.
2. Open the AWS Glue console at https://console.aws.amazon.com/glue/.
   Sign in as a user that has permissions to update a blueprint. Switch to the same AWS Region as the Amazon S3 bucket that contains the blueprint ZIP archive.
3. In the navigation pane, choose blueprints.
4. On the blueprints page, select a blueprint, and on the Actions menu, choose Edit.
5. On the Edit a blueprint page, update the blueprint Description or ZIP archive location (S3). Be sure to include the archive file name in the path.
6. Choose Save.
   The blueprints page returns and shows that the blueprint status is UPDATING. Choose the refresh button until the status changes to ACTIVE or FAILED.
7. If the status is FAILED, select the blueprint, and on the Actions menu, choose View.
   The detail page shows the reason for the failure. If the error message is "Unable to access object at location..." or "Access denied on object at location...", review the following requirements:
   • The user that you are signed in as must have read permission on the blueprint ZIP archive in Amazon S3.
• The Amazon S3 bucket that contains the ZIP archive must have a bucket policy that grants read permission on the object to your AWS account ID. For more information, see Publishing a blueprint.

• The Amazon S3 bucket that you're using must be in the same Region as the Region that you're signed into on the console.

**Note**

If the update fails, the next blueprint run uses the latest version of the blueprint that was successfully registered or updated.

---

**To update a blueprint (AWS CLI)**

1. Enter the following command.

   ```bash
   aws glue update-blueprint --name <blueprint-name> [--description <description>] --blueprint-location s3://<s3-path>/<archive-filename>
   ```

2. Enter the following command to check the blueprint status. Repeat the command until the status goes to **ACTIVE** or **FAILED**.

   ```bash
   aws glue get-blueprint --name <blueprint-name>
   ```

   If the status is **FAILED** and the error message is "Unable to access object at location..." or "Access denied on object at location...", review the following requirements:

   • The user that you are signed in as must have read permission on the blueprint ZIP archive in Amazon S3.

   • The Amazon S3 bucket containing the ZIP archive must have a bucket policy that grants read permission on the object to your AWS account ID. For more information, see Publishing a blueprint.

   • The Amazon S3 bucket that you're using must be in the same Region as the Region that you're signed into on the console.
Creating a workflow from a blueprint in AWS Glue

You can create an AWS Glue workflow manually, adding one component at a time, or you can create a workflow from an AWS Glue blueprint. AWS Glue includes blueprints for common use cases. Your AWS Glue developers can create additional blueprints.

⚠️ Important

Limit the total number of jobs, crawlers, and triggers within a workflow to 100 or less. If you include more than 100, you might get errors when trying to resume or stop workflow runs.

When you use a blueprint, you can quickly generate a workflow for a specific use case based on the generalized use case defined by the blueprint. You define the specific use case by providing values for the blueprint parameters. For example, a blueprint that partitions a dataset could have the Amazon S3 source and target paths as parameters.

AWS Glue creates a workflow from a blueprint by running the blueprint. The blueprint run saves the parameter values that you supplied, and is used to track the progress and outcome of the creation of the workflow and its components. When troubleshooting a workflow, you can view the blueprint run to determine the blueprint parameter values that were used to create a workflow.

To create and view workflows, you require certain IAM permissions. For a suggested IAM policy, see Data analyst permissions for blueprints.

You can create a workflow from a blueprint by using the AWS Glue console, AWS Glue API, or AWS Command Line Interface (AWS CLI).

To create a workflow from a blueprint (console)


Sign in as a user that has permissions to create a workflow.
2. In the navigation pane, choose **blueprints**.

3. Select a blueprint, and on the **Actions** menu, choose **Create workflow**.

4. On the **Create a workflow from <blueprint-name>** page, enter the following information:

   **Blueprint parameters**

   These vary depending on the blueprint design. For questions about the parameters, see the developer. blueprints typically include a parameter for the workflow name.

   **IAM role**

   The role that AWS Glue assumes to create the workflow and its components. The role must have permissions to create and delete workflows, jobs, crawlers, and triggers. For a suggested policy for the role, see [Permissions for blueprint roles](#).

5. Choose **Submit**.

   The **Blueprint Details** page appears, showing a list of blueprint runs at the bottom.

6. In the blueprint runs list, check the topmost blueprint run for workflow creation status.

   The initial status is **RUNNING**. Choose the refresh button until the status goes to **SUCCEEDED** or **FAILED**.

7. Do one of the following:

   - If the completion status is **SUCCEEDED**, you can go to the **Workflows** page, select the newly created workflow, and run it. Before running the workflow, you can review the design graph.
   - If the completion status is **FAILED**, select the blueprint run, and on the **Actions** menu, choose **View** to see the error message.

For more information on workflows and blueprints, see the following topics.

- [Overview of workflows in AWS Glue](#)
- [Updating a blueprint in AWS Glue](#)
- [Creating and building out a workflow manually in AWS Glue](#)

### Viewing blueprint runs in AWS Glue

View a blueprint run to see the following information:
• Name of the workflow that was created.
• blueprint parameter values that were used to create the workflow.
• Status of the workflow creation operation.

You can view a blueprint run by using the AWS Glue console, AWS Glue API, or AWS Command Line Interface (AWS CLI).

To view a blueprint run (console)

2. In the navigation pane, choose blueprints.
3. On the blueprints page, select a blueprint. Then on the Actions menu, choose View.
4. At the bottom of the Blueprint Details page, select a blueprint run, and on the Actions menu, choose View.

To view a blueprint run (AWS CLI)

• Enter the following command. Replace <blueprint-name> with the name of the blueprint. Replace <blueprint-run-id> with the blueprint run ID.

```
aws glue get-blueprint-run --blueprint-name <blueprint-name> --run-id <blueprint-run-id>
```

See also:

• Overview of blueprints in AWS Glue
AWS CloudFormation for AWS Glue

AWS CloudFormation is a service that can create many AWS resources. AWS Glue provides API operations to create objects in the AWS Glue Data Catalog. However, it might be more convenient to define and create AWS Glue objects and other related AWS resource objects in an AWS CloudFormation template file. Then you can automate the process of creating the objects.

AWS CloudFormation provides a simplified syntax—either JSON (JavaScript Object Notation) or YAML (YAML Ain't Markup Language)—to express the creation of AWS resources. You can use AWS CloudFormation templates to define Data Catalog objects such as databases, tables, partitions, crawlers, classifiers, and connections. You can also define ETL objects such as jobs, triggers, and development endpoints. You create a template that describes all the AWS resources you want, and AWS CloudFormation takes care of provisioning and configuring those resources for you.

For more information, see What Is AWS CloudFormation? and Working with AWS CloudFormation Templates in the AWS CloudFormation User Guide.

If you plan to use AWS CloudFormation templates that are compatible with AWS Glue, as an administrator, you must grant access to AWS CloudFormation and to the AWS services and actions on which it depends. To grant permissions to create AWS CloudFormation resources, attach the following policy to users that work with AWS CloudFormation:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "cloudformation:*"
            ],
            "Resource": "*"
        }
    ]
}
```

The following table contains the actions that an AWS CloudFormation template can perform on your behalf. It includes links to information about the AWS resource types and their property types that you can add to an AWS CloudFormation template.
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To get started, use the following sample templates and customize them with your own metadata. Then use the AWS CloudFormation console to create an AWS CloudFormation stack to add objects to AWS Glue and any associated services. Many fields in an AWS Glue object are optional. These templates illustrate the fields that are required or are necessary for a working and functional AWS Glue object.
An AWS CloudFormation template can be in either JSON or YAML format. In these examples, YAML is used for easier readability. The examples contain comments (#) to describe the values that are defined in the templates.

AWS CloudFormation templates can include a Parameters section. This section can be changed in the sample text or when the YAML file is submitted to the AWS CloudFormation console to create a stack. The Resources section of the template contains the definition of AWS Glue and related objects. AWS CloudFormation template syntax definitions might contain properties that include more detailed property syntax. Not all properties might be required to create an AWS Glue object. These samples show example values for common properties to create an AWS Glue object.

Sample AWS CloudFormation template for an AWS Glue database

An AWS Glue database in the Data Catalog contains metadata tables. The database consists of very few properties and can be created in the Data Catalog with an AWS CloudFormation template. The following sample template is provided to get you started and to illustrate the use of AWS CloudFormation stacks with AWS Glue. The only resource created by the sample template is a database named cfn-mysampledatabase. You can change it by editing the text of the sample or changing the value on the AWS CloudFormation console when you submit the YAML.

The following shows example values for common properties to create an AWS Glue database. For more information about the AWS CloudFormation database template for AWS Glue, see AWS::Glue::Database.

---
AWSTemplateFormatVersion: '2010-09-09'

# Sample CloudFormation template in YAML to demonstrate creating a database named mysampledatabase
# The metadata created in the Data Catalog points to the flights public S3 bucket
#
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:
  CFNDatabaseName:
    Type: String
    Default: cfn-mysampledatabse

# Resources section defines metadata for the Data Catalog
Resources:
# Create an AWS Glue database
CFNDatabaseFlights:
  Type: AWS::Glue::Database
  Properties:
    # The database is created in the Data Catalog for your account
    CatalogId: !Ref AWS::AccountId
    DatabaseInput:
      # The name of the database is defined in the Parameters section above
      Name: !Ref CFNDatabaseName
      Description: Database to hold tables for flights data
      LocationUri: s3://crawler-public-us-east-1/flight/2016/csv/
    #Parameters: Leave AWS database parameters blank

Sample AWS CloudFormation template for an AWS Glue database, table, and partition

An AWS Glue table contains the metadata that defines the structure and location of data that you want to process with your ETL scripts. Within a table, you can define partitions to parallelize the processing of your data. A partition is a chunk of data that you defined with a key. For example, using month as a key, all the data for January is contained in the same partition. In AWS Glue, databases can contain tables, and tables can contain partitions.

The following sample shows how to populate a database, a table, and partitions using an AWS CloudFormation template. The base data format is csv and delimited by a comma (,). Because a database must exist before it can contain a table, and a table must exist before partitions can be created, the template uses the DependsOn statement to define the dependency of these objects when they are created.

The values in this sample define a table that contains flight data from a publicly available Amazon S3 bucket. For illustration, only a few columns of the data and one partitioning key are defined. Four partitions are also defined in the Data Catalog. Some fields to describe the storage of the base data are also shown in the StorageDescriptor fields.

---
AWSTemplateFormatVersion: '2010-09-09'
# Sample CloudFormation template in YAML to demonstrate creating a database, a table, and partitions
# The metadata created in the Data Catalog points to the flights public S3 bucket
Parameters substituted in the Resources section
These parameters are names of the resources created in the Data Catalog

Parameters:
- CFNDatabaseName:
  Type: String
  Default: cfn-database-flights-1
- CFNTableName1:
  Type: String
  Default: cfn-manual-table-flights-1

Resources to create metadata in the Data Catalog

Resources:

###
# Create an AWS Glue database
CFNDatabaseFlights:
  Type: AWS::Glue::Database
  Properties:
    CatalogId: !Ref AWS::AccountId
    DatabaseInput:
      Name: !Ref CFNDatabaseName
      Description: Database to hold tables for flights data

###
# Create an AWS Glue table
CFNTableFlights:
  DependsOn: CFNDatabaseFlights
  Type: AWS::Glue::Table
  Properties:
    CatalogId: !Ref AWS::AccountId
    DatabaseName: !Ref CFNDatabaseName
    TableInput:
      Name: !Ref CFNTableName1
      Description: Define the first few columns of the flights table
      TableType: EXTERNAL_TABLE
      Parameters: {
        "classification": "csv"
      }
      # ViewExpandedText: String
      PartitionKeys:
      # Data is partitioned by month
      - Name: mon
        Type: bigint
    StorageDescriptor:
      OutputFormat: org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat
Columns:
- Name: year
  Type: bigint
- Name: quarter
  Type: bigint
- Name: month
  Type: bigint
- Name: day_of_month
  Type: bigint

InputFormat: org.apache.hadoop.mapred.TextInputFormat
Location: s3://crawler-public-us-east-1/flight/2016/csv/

SerdeInfo:
  Parameters:
    field.delim: ","
    SerializationLibrary: org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe

# Partition 1
# Create an AWS Glue partition
CFNPartitionMon1:
  DependsOn: CFNTableFlights
  Type: AWS::Glue::Partition
  Properties:
    CatalogId: !Ref AWS::AccountId
    DatabaseName: !Ref CFNDatabaseName
    TableName: !Ref CFNTableName1
    PartitionInput:
      Values:
      - 1
    StorageDescriptor:
      OutputFormat: org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat
      Columns:
      - Name: mon
        Type: bigint
      InputFormat: org.apache.hadoop.mapred.TextInputFormat
      Location: s3://crawler-public-us-east-1/flight/2016/csv/mon=1/
      SerdeInfo:
        Parameters:
          field.delim: ","
          SerializationLibrary: org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe

# Partition 2
# Create an AWS Glue partition
CFNPartitionMon2:
  DependsOn: CFNTableFlights
  Type: AWS::Glue::Partition
  Properties:
CatalogId: !Ref AWS::AccountId
DatabaseName: !Ref CFNDatabaseName
TableName: !Ref CFNTableName1
PartitionInput:
  Values:
  - 2
StorageDescriptor:
  OutputFormat: org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat
  Columns:
  - Name: mon
    Type: bigint
  InputFormat: org.apache.hadoop.mapred.TextInputFormat
  Location: s3://crawler-public-us-east-1/flight/2016/csv/mon=2/
  SerdeInfo:
    Parameters:
    field.delim: ","
    SerializationLibrary: org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe

# Partition 3
# Create an AWS Glue partition
CFNPartitionMon3:
  DependsOn: CFNTableFlights
  Type: AWS::Glue::Partition
  Properties:
    CatalogId: !Ref AWS::AccountId
    DatabaseName: !Ref CFNDatabaseName
    TableName: !Ref CFNTableName1
    PartitionInput:
      Values:
      - 3
    StorageDescriptor:
      OutputFormat: org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat
      Columns:
      - Name: mon
        Type: bigint
      InputFormat: org.apache.hadoop.mapred.TextInputFormat
      Location: s3://crawler-public-us-east-1/flight/2016/csv/mon=3/
      SerdeInfo:
        Parameters:
        field.delim: ","
        SerializationLibrary: org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe

# Partition 4
# Create an AWS Glue partition
CFNPartitionMon4:
  DependsOn: CFNTableFlights
Sample AWS CloudFormation template for an AWS Glue grok classifier

An AWS Glue classifier determines the schema of your data. One type of custom classifier uses a grok pattern to match your data. If the pattern matches, then the custom classifier is used to create your table's schema and set the classification to the value set in the classifier definition.

This sample creates a classifier that creates a schema with one column named `message` and sets the classification to `greedy`.

```yaml
---
AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a classifier
#
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:

# The name of the classifier to be created
CFNClassifierName:
```
Sample AWS CloudFormation template for an AWS Glue JSON classifier

An AWS Glue classifier determines the schema of your data. One type of custom classifier uses a JsonPath string defining the JSON data for the classifier to classify. AWS Glue supports a subset of the operators for JsonPath, as described in Writing JsonPath Custom Classifiers.

If the pattern matches, then the custom classifier is used to create your table's schema.

This sample creates a classifier that creates a schema with each record in the Records3 array in an object.

---

AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a JSON classifier
#
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:

# The name of the classifier to be created
Sample AWS CloudFormation template for an AWS Glue XML classifier

An AWS Glue classifier determines the schema of your data. One type of custom classifier specifies an XML tag to designate the element that contains each record in an XML document that is being parsed. If the pattern matches, then the custom classifier is used to create your table's schema and set the classification to the value set in the classifier definition.

This sample creates a classifier that creates a schema with each record in the Record tag and sets the classification to XML.

```yaml
---
AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating an XML classifier
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:

# The name of the classifier to be created
CFNClassifierName:
    Type: String
    Default: cfn-classifier-json-one-column-1

# Resources section defines metadata for the Data Catalog
Resources:
# Create classifier that uses a JSON pattern.
CFNClassifierFlights:
    Type: AWS::Glue::Classifier
    Properties:
        JSONClassifier:
            #JSON classifier
            Name: !Ref CFNClassifierName
            JsonPath: $.Records3[*]
```
Sample AWS CloudFormation template for an AWS Glue crawler for Amazon S3

An AWS Glue crawler creates metadata tables in your Data Catalog that correspond to your data. You can then use these table definitions as sources and targets in your ETL jobs.

This sample creates a crawler, the required IAM role, and an AWS Glue database in the Data Catalog. When this crawler is run, it assumes the IAM role and creates a table in the database for the public flights data. The table is created with the prefix "cfn_sample_1__". The IAM role created by this template allows global permissions; you might want to create a custom role. No custom classifiers are defined by this classifier. AWS Glue built-in classifiers are used by default.

When you submit this sample to the AWS CloudFormation console, you must confirm that you want to create the IAM role.
CFNCrawlerName:
  Type: String
  Default: cfn-crawler-flights-1
CFNDatabaseName:
  Type: String
  Default: cfn-database-flights-1
CFNTablePrefixName:
  Type: String
  Default: cfn_sample_1_

# Resources section defines metadata for the Data Catalog
Resources:
# Create IAM Role assumed by the crawler. For demonstration, this role is given all permissions.
CFNRoleFlights:
  Type: AWS::IAM::Role
  Properties:
    AssumeRolePolicyDocument:
      Version: "2012-10-17"
      Statement:
        -
          Effect: "Allow"
          Principal:
            Service:
              - "glue.amazonaws.com"
          Action:
            - "sts:AssumeRole"
          Path: "/
          Policies:
            -
              PolicyName: "root"
              PolicyDocument:
                Version: "2012-10-17"
                Statement:
                  -
                    Effect: "Allow"
                    Action: "*"
                    Resource: "*"

# Create a database to contain tables created by the crawler
CFNDatabaseFlights:
  Type: AWS::Glue::Database
  Properties:
    CatalogId: !Ref AWS::AccountName
DatabaseInput:
  Name: !Ref CFNDatabaseName
  Description: "AWS Glue container to hold metadata tables for the flights crawler"

# Create a crawler to crawl the flights data on a public S3 bucket
CFNCrawlerFlights:
  Type: AWS::Glue::Crawler
  Properties:
    Name: !Ref CFNCrawlerName
    Role: !GetAtt CFNRoleFlights.Arn
    # Classifiers: none, use the default classifier
    Description: AWS Glue crawler to crawl flights data
    # Schedule: none, use default run-on-demand
    DatabaseName: !Ref CFNDatabaseName
    Targets:
        S3Targets:
            # Public S3 bucket with the flights data
            - Path: "s3://crawler-public-us-east-1/flight/2016/csv"
    TablePrefix: !Ref CFNTablePrefixName
    SchemaChangePolicy:
        UpdateBehavior: "UPDATE_IN_DATABASE"
        DeleteBehavior: "LOG"
    Configuration: "{"Version":1.0,"CrawlerOutput":{"Partitions":{"AddOrUpdateBehavior":"InheritFromTable"},"Tables":{"AddOrUpdateBehavior":"MergeNewColumns"}}}"}

Sample AWS CloudFormation template for an AWS Glue connection

An AWS Glue connection in the Data Catalog contains the JDBC and network information that is required to connect to a JDBC database. This information is used when you connect to a JDBC database to crawl or run ETL jobs.

This sample creates a connection to an Amazon RDS MySQL database named devdb. When this connection is used, an IAM role, database credentials, and network connection values must also be supplied. See the details of necessary fields in the template.

---

AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a connection
Parameters section contains names that are substituted in the Resources section
These parameters are the names the resources created in the Data Catalog

Parameters:

# The name of the connection to be created
CFNConnectionName:
  Type: String
  Default: cfn-connection-mysql-flights-1

CFNJDBCString:
  Type: String
  Default: "jdbc:mysql://xxx-mysql.yyyyyyyyyyyyy.us-east-1.rds.amazonaws.com:3306/devdb"

CFNJDBCUser:
  Type: String
  Default: "master"

CFNJDBCPassword:
  Type: String
  Default: "12345678"
  NoEcho: true

Resources section defines metadata for the Data Catalog

Resources:

CFNConnectionMySQL:
  Type: AWS::Glue::Connection
  Properties:
    CatalogId: !Ref AWS::AccountId
    ConnectionInput:
      Description: "Connect to MySQL database."
      ConnectionType: "JDBC"
      #MatchCriteria: none
      PhysicalConnectionRequirements:
        AvailabilityZone: "us-east-1d"
        SecurityGroupIdList:
          - "sg-7d52b812"
        SubnetId: "subnet-84f326ee"
    ConnectionProperties: {
      "JDBC_CONNECTION_URL": !Ref CFNJDBCString,
      "USERNAME": !Ref CFNJDBCUser,
      "PASSWORD": !Ref CFNJDBCPassword
    }
  Name: !Ref CFNConnectionName
Sample AWS CloudFormation template for an AWS Glue crawler for JDBC

An AWS Glue crawler creates metadata tables in your Data Catalog that correspond to your data. You can then use these table definitions as sources and targets in your ETL jobs.

This sample creates a crawler, required IAM role, and an AWS Glue database in the Data Catalog. When this crawler is run, it assumes the IAM role and creates a table in the database for the public flights data that has been stored in a MySQL database. The table is created with the prefix "cfn_jdbc_1_". The IAM role created by this template allows global permissions; you might want to create a custom role. No custom classifiers can be defined for JDBC data. AWS Glue built-in classifiers are used by default.

When you submit this sample to the AWS CloudFormation console, you must confirm that you want to create the IAM role.

```yaml
---
AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a crawler
#
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:
  # The name of the crawler to be created
  CFNCrawlerName:
    Type: String
    Default: cfn-crawler-jdbc-flights-1
  # The name of the database to be created to contain tables
  CFNDatabaseName:
    Type: String
    Default: cfn-database-jdbc-flights-1
  # The prefix for all tables crawled and created
  CFNTablePrefixName:
    Type: String
    Default: cfn_jdbc_1_
  # The name of the existing connection to the MySQL database
  CFNConnectionName:
    Type: String
    Default: cfn-connection-mysql-flights-1
```
# The name of the JDBC path (database/schema/table) with wildcard (%) to crawl
CFNJDBCPath:
  Type: String
  Default: saldev/%

#

# Resources section defines metadata for the Data Catalog
Resources:
#Create IAM Role assumed by the crawler. For demonstration, this role is given all permissions.
CFNRoleFlights:
  Type: AWS::IAM::Role
  Properties:
    AssumeRolePolicyDocument:
      Version: "2012-10-17"
      Statement:
        -
          Effect: "Allow"
          Principal:
            Service:
              - "glue.amazonaws.com"
          Action:
            - "sts:AssumeRole"
          Path: "/"
      Policies:
        -
          PolicyName: "root"
          PolicyDocument:
            Version: "2012-10-17"
            Statement:
              -
                Effect: "Allow"
                Action: "*"
                Resource: "*"

# Create a database to contain tables created by the crawler
CFNDatabaseFlights:
  Type: AWS::Glue::Database
  Properties:
    CatalogId: !Ref AWS::AccountId
    DatabaseInput:
      Name: !Ref CFNDatabaseName
      Description: "AWS Glue container to hold metadata tables for the flights crawler"

#Create a crawler to crawl the flights data in MySQL database
Sample AWS CloudFormation template for an AWS Glue job for Amazon S3 to Amazon S3

An AWS Glue job in the Data Catalog contains the parameter values that are required to run a script in AWS Glue.

This sample creates a job that reads flight data from an Amazon S3 bucket in csv format and writes it to an Amazon S3 Parquet file. The script that is run by this job must already exist. You can generate an ETL script for your environment with the AWS Glue console. When this job is run, an IAM role with the correct permissions must also be supplied.

Common parameter values are shown in the template. For example, AllocatedCapacity (DPUs) defaults to 5.
# Sample CFN YAML to demonstrate creating a job using the public flights S3 table in a public bucket

# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog

Parameters:

# The name of the job to be created
CFNJobName:
  Type: String
  Default: cfn-job-S3-to-S3-2

# The name of the IAM role that the job assumes. It must have access to data, script, temporary directory
CFNIAMRoleName:
  Type: String
  Default: AWSGlueServiceRoleGA

# The S3 path where the script for this job is located
CFNScriptLocation:
  Type: String
  Default: s3://aws-glue-scripts-123456789012-us-east-1/myid/sal-job-test2

Resources:

# Resources section defines metadata for the Data Catalog

Resources:

# Create job to run script which accesses flightscsv table and write to S3 file as parquet.
# The script already exists and is called by this job
CFNJobFlights:
  Type: AWS::Glue::Job
  Properties:
    Role: !Ref CFNIAMRoleName
    #DefaultArguments: JSON object
    # If script written in Scala, then set DefaultArguments={"--job-language": 'scala', --class': 'your scala class'}
    #Connections:  No connection needed for S3 to S3 job
    #  ConnectionsList
    #MaxRetries: Double
    Description: Job created with CloudFormation
    #LogUri: String
    Command:
      Name: glueetl
      ScriptLocation: !Ref CFNScriptLocation
      # for access to directories use proper IAM role with permission to buckets and folders that begin with "aws-glue-"
# Sample AWS CloudFormation template for an AWS Glue job for JDBC to Amazon S3

An AWS Glue job in the Data Catalog contains the parameter values that are required to run a script in AWS Glue.

This sample creates a job that reads flight data from a MySQL JDBC database as defined by the connection named `cfn-connection-mysql-flights-1` and writes it to an Amazon S3 Parquet file. The script that is run by this job must already exist. You can generate an ETL script for your environment with the AWS Glue console. When this job is run, an IAM role with the correct permissions must also be supplied.

Common parameter values are shown in the template. For example, `AllocatedCapacity` (DPUs) defaults to 5.

```yaml
AWSTemplateFormatVersion: '2010-09-09'

# Sample CFN YAML to demonstrate creating a job using a MySQL JDBC DB with the flights data to an S3 file

# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog

Parameters:

# The name of the job to be created
CFNJobName:
  Type: String
  Default: cfn-job-JDBC-to-S3-1

# The name of the IAM role that the job assumes. It must have access to data, script, temporary directory
CFNIAMRoleName:
  Type: String
```

```yaml
# script uses temp directory from job definition if required (temp directory not used S3 to S3)
# script defines target for output as s3://aws-glue-target/sal
AllocatedCapacity: 5
ExecutionProperty:
  MaxConcurrentRuns: 1
Name: !Ref CFNJobName
```
# The S3 path where the script for this job is located
CFNScriptLocation:
  Type: String
  Default: s3://aws-glue-scripts-123456789012-us-east-1/myid/sal-job-dec4a

# The name of the connection used for JDBC data source
CFNConnectionName:
  Type: String
  Default: cfn-connection-mysql-flights-1

# Resources section defines metadata for the Data Catalog
Resources:
# Create job to run script which accesses JDBC flights table via a connection and write
# to S3 file as parquet.
# The script already exists and is called by this job
CFNJobFlights:
  Type: AWS::Glue::Job
  Properties:
    Role: !Ref CFNIAMRoleName
    # DefaultArguments: JSON object
    # For example, if required by script, set temporary directory as
    DefaultArguments={'--TempDir': 's3://aws-glue-temporary-xyc/sal'}
    Connections:
      - !Ref CFNConnectionName
    #MaxRetries: Double
    Description: Job created with CloudFormation using existing script
    #LogUri: String
    Command:
      Name: glueetl
      ScriptLocation: !Ref CFNScriptLocation
      # for access to directories use proper IAM role with permission to buckets
      and folders that begin with "aws-glue-
      # if required, script defines temp directory as argument TempDir and used
      in script like redshift_tmp_dir = args["TempDir"]
      # script defines target for output as s3://aws-glue-target/sal
    AllocatedCapacity: 5
    ExecutionProperty:
      MaxConcurrentRuns: 1
    Name: !Ref CFNJobName
Sample AWS CloudFormation template for an AWS Glue on-demand trigger

An AWS Glue trigger in the Data Catalog contains the parameter values that are required to start a job run when the trigger fires. An on-demand trigger fires when you enable it.

This sample creates an on-demand trigger that starts one job named cfn-job-S3-to-S3-1.

---

AWSTemplateFormatVersion: '2010-09-09'

# Sample CFN YAML to demonstrate creating an on-demand trigger

# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog

Parameters:

# The existing job to be started by this trigger
CFNJobName:
  Type: String
  Default: cfn-job-S3-to-S3-1

# The name of the trigger to be created
CFNTriggerName:
  Type: String
  Default: cfn-trigger-ondemand-flights-1

# Resources section defines metadata for the Data Catalog
# Sample CFN YAML to demonstrate creating an on-demand trigger for a job

Resources:

# Create trigger to run an existing job (CFNJobName) on an on-demand schedule.
CFNTriggerSample:
  Type: AWS::Glue::Trigger
  Properties:
    Name:
      Ref: CFNTriggerName
    Description: Trigger created with CloudFormation
    Type: ON_DEMAND
    Actions:
      - JobName: !Ref CFNJobName
    # Arguments: JSON object
    # Schedule:
    # Predicate:
Sample AWS CloudFormation template for an AWS Glue scheduled trigger

An AWS Glue trigger in the Data Catalog contains the parameter values that are required to start a job run when the trigger fires. A scheduled trigger fires when it is enabled and the cron timer pops.

This sample creates a scheduled trigger that starts one job named cfn-job-S3-to-S3-1. The timer is a cron expression to run the job every 10 minutes on weekdays.

---

```
AWSTemplateFormatVersion: "2010-09-09"

# Sample CFN YAML to demonstrate creating a scheduled trigger

# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog

Parameters:
  # The existing job to be started by this trigger
  CFNJobName:
    Type: String
    Default: cfn-job-S3-to-S3-1
  # The name of the trigger to be created
  CFNTriggerName:
    Type: String
    Default: cfn-trigger-scheduled-flights-1

# Resources section defines metadata for the Data Catalog
# Sample CFN YAML to demonstrate creating a scheduled trigger for a job

Resources:
  # Create trigger to run an existing job (CFNJobName) on a cron schedule.
  TriggerSample1CFN:
    Type: AWS::Glue::Trigger
    Properties:
      Name:
        Ref: CFNTriggerName
      Description: Trigger created with CloudFormation
      Type: SCHEDULED
      Actions:
        - JobName: !Ref CFNJobName
          # Arguments: JSON object
          # # Run the trigger every 10 minutes on Monday to Friday
```
Sample AWS CloudFormation template for an AWS Glue conditional trigger

An AWS Glue trigger in the Data Catalog contains the parameter values that are required to start a job run when the trigger fires. A conditional trigger fires when it is enabled and its conditions are met, such as a job completing successfully.

This sample creates a conditional trigger that starts one job named cfn-job-S3-to-S3-1. This job starts when the job named cfn-job-S3-to-S3-2 completes successfully.

```yaml
---
AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a conditional trigger for a job, which starts when another job completes
#
# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:
    # The existing job to be started by this trigger
CFNJobName:
    Type: String
    Default: cfn-job-S3-to-S3-1

    # The existing job that when it finishes causes trigger to fire
CFNJobName2:
    Type: String
    Default: cfn-job-S3-to-S3-2

    # The name of the trigger to be created
CFNTriggerName:
    Type: String
    Default: cfn-trigger-conditional-1

# Resources:
# Create trigger to run an existing job (CFNJobName) when another job completes (CFNJobName2).
CFNTriggerSample:
    Type: AWS::Glue::Trigger
    Properties:
```

Schedule: cron(0/10 * ? * MON-FRI *)
# Predicate:
Sample AWS CloudFormation template for an AWS Glue development endpoint

An AWS Glue machine learning transform is a custom transform to cleanse your data. There is currently one available transform named FindMatches. The FindMatches transform enables you to identify duplicate or matching records in your dataset, even when the records do not have a common unique identifier and no fields match exactly.

This sample creates a machine learning transform. For more information about the parameters that you need to create a machine learning transform, see Record matching with AWS Lake Formation FindMatches.

---

AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a machine learning transform
# Resources section defines metadata for the machine learning transform
Resources:
  MyMLTransform:
    Type: "AWS::Glue::MLTransform"
    Condition: "isGlueMLGARegion"
    Properties:
      Name: !Sub "MyTransform"
      Description: "The bestest transform ever"
Role: !ImportValue MyMLTransformUserRole
GlueVersion: "1.0"
WorkerType: "Standard"
NumberOfWorkers: 5
Timeout: 120
MaxRetries: 1
InputRecordTables:
  GlueTables:
    - DatabaseName: !ImportValue MyMLTransformDatabase
      TableName: !ImportValue MyMLTransformTable
TransformParameters:
  TransformType: "FIND_MATCHES"
  FindMatchesParameters:
    PrimaryKeyColumnName: "testcolumn"
    PrecisionRecallTradeoff: 0.5
    AccuracyCostTradeoff: 0.5
    EnforceProvidedLabels: True
Tags:
  key1: "value1"
  key2: "value2"
TransformEncryption:
  TaskRunSecurityConfigurationName: !ImportValue MyMLTransformSecurityConfiguration
MLUserDataEncryption:
  MLUserDataEncryptionMode: "SSE-KMS"
  KmsKeyId: !ImportValue MyMLTransformEncryptionKey

Sample AWS CloudFormation template for an AWS Glue Data Quality ruleset

An AWS Glue Data Quality ruleset contains rules that can be evaluated on a table within the Data Catalog. Once the ruleset is placed on your targeted table you can go into the Data Catalog and run an evaluation which runs your data against those rules within the ruleset. These rules can vary from evaluating the row count to evaluating referential integrity on your data.

The following sample is a CloudFormation template which creates a ruleset with a variety of rules on the specified target table.

AWSTemplateFormatVersion: '2010-09-09'
# Sample CFN YAML to demonstrate creating a DataQualityRuleset
#
Parameters:

# The name of the ruleset to be created
RulesetName:
  Type: String
  Default: "CFNRulesetName"

RulesetDescription:
  Type: String
  Default: "CFN DataQualityRuleset"

# Rules that will be associated with this ruleset
Rules:
  Type: String
  Default: 'Rules = [
          RowCount > 100,
          IsUnique "id",
          IsComplete "nametype"
      ]'

# Name of database and table within Data Catalog which the ruleset will
# be applied too
DatabaseName:
  Type: String
  Default: "ExampleDatabaseName"

TableName:
  Type: String
  Default: "ExampleTableName"

# Resources section defines metadata for the Data Catalog
Resources:

# Creates a Data Quality ruleset under specified rules
DQRuleset:
  Type: AWS::Glue::DataQualityRuleset
  Properties:
    Name: !Ref RulesetName
    Description: !Ref RulesetDescription
    # The String within rules must be formatted in DQDL, a language
    # used specifically to make rules
    Ruleset: !Ref Rules
    # The targeted table must exist within Data Catalog alongside
    # the correct database
    TargetTable:
      DatabaseName: !Ref DatabaseName
Sample AWS CloudFormation template for an AWS Glue Data Quality ruleset with EventBridge scheduler

An AWS Glue Data Quality ruleset contains rules that can be evaluated on a table within the Data Catalog. Once the ruleset is placed on your targeted table you can go into the Data Catalog and run an evaluation which runs your data against those rules within the ruleset. Instead of having to manually go into the Data Catalog to evaluate the ruleset, you can also add an EventBridge Scheduler within our CloudFormation template to schedule these ruleset evaluations for you on a timed interval.

The following sample is a CloudFormation template which creates a Data Quality ruleset and an EventBridge Scheduler to evaluate the aforementioned ruleset every five minutes.

```yaml
AWSTemplateFormatVersion: '2010-09-09'

# Sample CFN YAML to demonstrate creating a DataQualityRuleset

# Parameters section contains names that are substituted in the Resources section
# These parameters are the names the resources created in the Data Catalog
Parameters:

  # The name of the ruleset to be created
  RulesetName:
    Type: String
    Default: "CFNRulesetName"

  # Rules that will be associated with this Ruleset
  Rules:
    Type: String
    Default: 'Rules = [
      RowCount > 100,
      IsUnique "id",
      IsComplete "nametype"
    ]'

  # The name of the Schedule to be created
  ScheduleName:
    Type: String
    Default: "ScheduleDQRulsetEvaluation"

  # This expression determines the rate at which the Schedule will evaluate
  # your data using the above ruleset
  ScheduleRate:
```
Type: String
Default: "rate(5 minutes)"

# The Request that being sent must match the details of the Data Quality Ruleset
ScheduleRequest:
  Type: String
  Default: '{ "DataSource": { "GlueTable": { "DatabaseName": "ExampleDatabaseName", "TableName": "ExampleTableName" } }, "Role": "role/AWSGlueServiceRoleDefault", "RulesetNames": [ "CFNRulesetName" ] }'  

# Resources section defines metadata for the Data Catalog
Resources:
  # Creates a Data Quality ruleset under specified rules
DQRuleset:
  Type: AWS::Glue::DataQualityRuleset
  Properties:
    Name: !Ref RulesetName
    Description: "CFN DataQualityRuleset"
    # The String within rules must be formatted in DQDL, a language
    # used specifically to make rules
    Ruleset: !Ref Rules
    # The targeted table must exist within Data Catalog alongside
    # the correct database
    TargetTable:
      DatabaseName: "ExampleDatabaseName"
      TableName: "ExampleTableName"

  # Create a Scheduler to schedule evaluation runs on the above ruleset
ScheduleDQEval:
  Type: AWS::Scheduler::Schedule
  Properties:
    Name: !Ref ScheduleName
    Description: "Schedule DataQualityRuleset Evaluations"
    FlexibleTimeWindow:
      Mode: "OFF"
    ScheduleExpression: !Ref ScheduleRate
    ScheduleExpressionTimezone: "America/New_York"
    State: "ENABLED"
    Target:
      # The ARN is the API that will be run, since we want to evaluate our ruleset
      # we want this specific ARN
      # Your RoleArn must have approval to schedule
Sample AWS CloudFormation template for an AWS Glue development endpoint

An AWS Glue development endpoint is an environment that you can use to develop and test your AWS Glue scripts.

This sample creates a development endpoint with the minimal network parameter values required to successfully create it. For more information about the parameters that you need to set up a development endpoint, see Setting up networking for development for AWS Glue.

You provide an existing IAM role ARN (Amazon Resource Name) to create the development endpoint. Supply a valid RSA public key and keep the corresponding private key available if you plan to create a notebook server on the development endpoint.

Note

For any notebook server that you create that is associated with a development endpoint, you manage it. Therefore, if you delete the development endpoint, to delete the notebook server, you must delete the AWS CloudFormation stack on the AWS CloudFormation console.
# The name of the crawler to be created
CFNEndpointName:
    Type: String
    Default: cfn-devendpoint-1
CFNIAMRoleArn:
    Type: String
    Default: arn:aws:iam::123456789012/role/AWSGlueServiceRoleGA

# Resources section defines metadata for the Data Catalog

Resources:
CFNDevEndpoint:
    Type: AWS::Glue::DevEndpoint
    Properties:
        EndpointName: !Ref CFNEndpointName
        #ExtraJarsS3Path: String
        #ExtraPythonLibsS3Path: String
        NumberOfNodes: 5
        PublicKey: ssh-rsa public.....key myuserid-key
        RoleArn: !Ref CFNIAMRoleArn
        SecurityGroupIds:
            - sg-64986c0b
        SubnetId: subnet-c67cccac
AWS Glue programming guide

A script contains the code that extracts data from sources, transforms it, and loads it into targets. AWS Glue runs a script when it starts a job.

AWS Glue ETL scripts are coded in Python or Scala. While all job types can be written in Python, AWS Glue for Spark jobs can be written in Scala as well. When you automatically generate the source code logic for your job in AWS Glue Studio, a script is created. You can edit this script, or you can provide your own script to process your ETL work.

Providing your own custom scripts

Scripts perform the extract, transform, and load (ETL) work in AWS Glue. A script is created when you automatically generate the source code logic for a job. You can either edit this generated script, or you can provide your own custom script.

To provide your own custom script in AWS Glue, follow these general steps:

1. Sign in to the AWS Management Console and open the AWS Glue console at https://console.aws.amazon.com/glue/.
2. Choose the ETL Jobs tab, and then view the Create job section. Choose a script editor option.
3. Under This job runs, choose one of the following:
   - Create a new script with boilerplate code
   - Upload and edit an existing script
4. On the Job details page, choose the IAM role that is required for your custom script to run. For more information, see Identity and access management for AWS Glue.
5. Choose any connections that your script references. These objects are needed to connect to the necessary JDBC data stores.

An elastic network interface is a virtual network interface that you can attach to an instance in a virtual private cloud (VPC). Choose the elastic network interface that is required to connect to the data store that's used in the script.

6. Provide additional configuration, including parameters, specific to your job type. For more information about configuration for your job type, see the Building visual ETL jobs with AWS Glue Studio section.
7. On the **Script** tab, paste or write your custom script.

Use the content in this section to guide the process of writing your custom script.

For more information about adding jobs in AWS Glue, see *Building visual ETL jobs with AWS Glue Studio*.

For step-by-step guidance, see the **Add job** tutorial in the AWS Glue console.

### Programming Spark scripts

AWS Glue makes it easy to write or autogenerate extract, transform, and load (ETL) scripts, in addition to testing and running them. This section describes the extensions to Apache Spark that AWS Glue has introduced, and provides examples of how to code and run ETL scripts in Python and Scala.

**Important**

Different versions of AWS Glue support different versions of Apache Spark. Your custom script must be compatible with the supported Apache Spark version. For information about AWS Glue versions, see the [Glue version job property](https://docs.aws.amazon.com/glue/latest/dg/properties.html).

**Topics**

- [Tutorial: Writing an AWS Glue for Spark script](#)
- [Program AWS Glue ETL scripts in PySpark](#)
- [Programming AWS Glue ETL scripts in Scala](#)
- [Features and optimizations for programming AWS Glue for Spark ETL scripts](#)

**Tutorial: Writing an AWS Glue for Spark script**

This tutorial introduces you to the process of writing AWS Glue scripts. You can run scripts on a schedule with jobs, or interactively with interactive sessions. For more information about jobs, see *Building visual ETL jobs with AWS Glue Studio*. For more information about interactive sessions, see the section called “Overview of AWS Glue interactive sessions”.

AWS Glue for Spark
The AWS Glue Studio visual editor offers a graphical, no-code interface for building AWS Glue jobs. AWS Glue scripts back visual jobs. They give you access to the expanded set of tools available to work with Apache Spark programs. You can access native Spark APIs, as well as AWS Glue libraries that facilitate extract, transform, and load (ETL) workflows from within an AWS Glue script.

In this tutorial, you extract, transform, and load a dataset of parking tickets. The script that does this work is identical in form and function to the one generated in Making ETL easier with AWS Glue Studio on the AWS Big Data Blog, which introduces the AWS Glue Studio visual editor. By running this script in a job, you can compare it to visual jobs and see how AWS Glue ETL scripts work. This prepares you to use additional functionalities that aren't yet available in visual jobs.

You use the Python language and libraries in this tutorial. Similar functionality is available in Scala. After going through this tutorial, you should be able to generate and inspect a sample Scala script to understand how to perform the Scala AWS Glue ETL script writing process.

**Prerequisites**

This tutorial has the following prerequisites:

- The same prerequisites as the AWS Glue Studio blog post, which instructs you to run a AWS CloudFormation template.

  This template uses the AWS Glue Data Catalog to manage the parking ticket dataset available in s3://aws-bigdata-blog/artifacts/gluestudio/. It creates the following resources which will be referenced:

  - **AWS Glue StudioRole** – IAM role to run AWS Glue jobs
  - **AWS Glue StudioAmazon S3Bucket** – Name of the Amazon S3 bucket to store blog-related files
  - **AWS Glue StudioTicketsYYZDB** – AWS Glue Data Catalog database
  - **AWS Glue StudioTableTickets** – Data Catalog table to use as a source
  - **AWS Glue StudioTableTrials** – Data Catalog table to use as a source
  - **AWS Glue StudioParkingTicketCount** – Data Catalog table to use as the destination
  - The script generated in the AWS Glue Studio blog post. If the blog post changes, the script is also available in the following text.

**Generate a sample script**

You can use the AWS Glue Studio visual editor as a powerful code generation tool to create a scaffold for the script you want to write. You will use this tool to create a sample script.
If you want to skip these steps, the script is provided.

**Tutorial sample script**

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

args = getResolvedOptions(sys.argv, ["JOB_NAME"])
sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args["JOB_NAME"], args)

# Script generated for node S3 bucket
S3bucket_node1 = glueContext.create_dynamic_frame.from_catalog(
    database="yyz-tickets", table_name="tickets", transformation_ctx="S3bucket_node1"
)

# Script generated for node ApplyMapping
ApplyMapping_node2 = ApplyMapping.apply(
    frame=S3bucket_node1,
    mappings=[
        ("tag_number_masked", "string", "tag_number_masked", "string"),
        ("date_of_infraction", "string", "date_of_infraction", "string"),
        ("ticket_date", "string", "ticket_date", "string"),
        ("ticket_number", "decimal", "ticket_number", "float"),
        ("officer", "decimal", "officer_name", "decimal"),
        ("infraction_code", "decimal", "infraction_code", "decimal"),
        ("infraction_description", "string", "infraction_description", "string"),
        ("set_fine_amount", "decimal", "set_fine_amount", "float"),
        ("time_of_infraction", "decimal", "time_of_infraction", "decimal"),
    ],
    transformation_ctx="ApplyMapping_node2",
)

# Script generated for node S3 bucket
S3bucket_node3 = glueContext.write_dynamic_frame.from_options(
    frame=ApplyMapping_node2,
    connection_type="s3",
)"
To generate a sample script

1. Complete the AWS Glue Studio tutorial. To complete this tutorial, see [Getting Started with AWS Glue Studio](#).

2. Navigate to the **Script** tab on the job page, as shown in the following screenshot:

```
# Script generated for node S3 bucket
S3bucket_node1 = glueContext.create_dynamic_frame_from_catalog(
    database='yzz-tickets',
    table_name='tickets',
    transformation_ctx='S3bucket_node33',
)

# Script generated for node ApplyMapping
ApplyMapping_node1 = ApplyMapping.applyC
```

3. Copy the complete contents of the **Script** tab. By setting the script language in **Job details**, you can switch back and forth between generating Python or Scala code.
Step 1. Create a job and paste your script

In this step, you create an AWS Glue job in the AWS Management Console. This sets up a configuration that allows AWS Glue to run your script. It also creates a place for you to store and edit your script.

To create a job

1. In the AWS Management Console, navigate to the AWS Glue landing page.
2. In the side navigation pane, choose Jobs.
3. Choose Spark script editor in Create job, and then choose Create.
4. Optional - Paste the full text of your script into the Script pane. Alternatively, you can follow along with the tutorial.

Step 2. Import AWS Glue libraries

You need to set your script up to interact with code and configuration that are defined outside of the script. This work is done behind the scenes in AWS Glue Studio.

In this step, you perform the following actions.

• Import and initialize a GlueContext object. This is the most important import, from the script writing perspective. This exposes standard methods for defining source and target datasets, which is the starting point for any ETL script. To learn more about the GlueContext class, see GlueContext class.

• Initialize a SparkContext and SparkSession. These allow you to configure the Spark engine available inside the AWS Glue job. You won’t need to use them directly within introductory AWS Glue scripts.

• Call getResolvedOptions to prepare your job arguments for use within the script. For more information about resolving job parameters, see the section called “getResolvedOptions”.

• Initialize a Job. The Job object sets configuration and tracks the state of various optional AWS Glue features. Your script can run without a Job object, but the best practice is to initialize it so that you don’t encounter confusion if those features are later integrated.

One of these features is job bookmarks, which you can optionally configure in this tutorial. You can learn about job bookmarks in the following section, the section called “Optional - Enable job bookmarks”.
In this procedure, you write the following code. This code is a portion of the generated sample script.

```python
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

e = getResolvedOptions(sys.argv, ["JOB_NAME"])
sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(e["JOB_NAME"], e)
```

**To import AWS Glue libraries**

- Copy this section of code and paste it into the **Script** editor.

**Note**

You might consider copying code to be a bad engineering practice. In this tutorial, we suggest this to encourage you to consistently name your core variables across all AWS Glue ETL scripts.

**Step 3. Extract data from a source**

In any ETL process, you first need to define a source dataset that you want to change. In the AWS Glue Studio visual editor, you provide this information by creating a **Source** node.

In this step, you provide the `create_dynamic_frame.from_catalog` method a database and `table_name` to extract data from a source configured in the AWS Glue Data Catalog.

In the previous step, you initialized a GlueContext object. You use this object to find methods that are used to configure sources, such as `create_dynamic_frame.from_catalog`.

In this procedure, you write the following code using `create_dynamic_frame.from_catalog`. This code is a portion of the generated sample script.
S3bucket_node1 = glueContext.create_dynamic_frame.from_catalog(
    database="yyz-tickets", table_name="tickets", transformation_ctx="S3bucket_node1"
)

To extract data from a source

1. Examine the documentation to find a method on GlueContext to extract data from a source defined in the AWS Glue Data Catalog. These methods are documented in the section called “GlueContext”. Choose the create_dynamic_frame.from_catalog method. Call this method on glueContext.

2. Examine the documentation for create_dynamic_frame.from_catalog. This method requires database and table_name parameters. Provide the necessary parameters to create_dynamic_frame.from_catalog.

   The AWS Glue Data Catalog stores information about the location and format of your source data, and was set up in the prerequisite section. You don't have to directly provide your script with that information.

3. Optional – Provide the transformation_ctx parameter to the method in order to support job bookmarks. You can learn about job bookmarks in the following section, the section called “Optional - Enable job bookmarks”.

Note

Common methods for extracting data

The section called “create_dynamic_frame_from_catalog” is used to connect to tables in the AWS Glue Data Catalog.

If you need to directly provide your job with configuration that describes the structure and location of your source, see the the section called “create_dynamic_frame_from_options” method. You will need to provide more detailed parameters describing your data than when using create_dynamic_frame.from_catalog.

Refer to the supplemental documentation about format_options and connection_parameters to identify your required parameters. For an explanation of how to provide your script information about your source data format, see the section called “Data format options”. For an explanation of how to provide your script information about your source data location, see the section called “Connection parameters”.

Tutorial: Writing a Spark script
If you're reading information from a streaming source, you provide your job with source information through the `create_data_frame_from_catalog` or `create_data_frame_from_options` methods. Note that these methods return Apache Spark DataFrames. Our generated code calls `create_dynamic_frame.from_catalog` while the reference documentation refers to `create_dynamic_frame_from_catalog`. These methods ultimately call the same code, and are included so you can write cleaner code. You can verify this by viewing the source for our Python wrapper, available at [aws-glue-libs](https://aws-glue-libs).

Step 4. Transform data with AWS Glue

After extracting source data in an ETL process, you need to describe how you want to change your data. You provide this information by creating a Transform node in the AWS Glue Studio visual editor.

In this step, you provide the ApplyMapping method with a map of current and desired field names and types to transform your DynamicFrame.

You perform the following transformations.

- Drop the four location and province keys.
- Change the name of officer to officer_name.
- Change the type of ticket_number and set_fine_amount to float.

`create_dynamic_frame.from_catalog` provides you with a DynamicFrame object. A DynamicFrame represents a dataset in AWS Glue. AWS Glue transforms are operations that change DynamicFrames.

**Note**

What is a DynamicFrame?

A DynamicFrame is an abstraction that allows you to connect a dataset with a description of the names and types of entries in the data. In Apache Spark, a similar abstraction exists called a DataFrame. For an explanation of DataFrames, see [Spark SQL Guide](https://spark.apache.org/docs/latest/sql-pdf/).

With DynamicFrames, you can describe dataset schemas dynamically. Consider a dataset with a price column, where some entries store price as a string, and others store price as
a double. AWS Glue computes a schema on-the-fly—it creates a self-describing record for each row.

Inconsistent fields (like price) are explicitly represented with a type (ChoiceType) in the schema for the frame. You can address your inconsistent fields by dropping them with DropFields or resolving them with ResolveChoice. These are transforms that are available on the DynamicFrame. You can then write your data back to your data lake with writeDynamicFrame.

You can call many of the same transforms from methods on the DynamicFrame class, which can lead to more readable scripts. For more information about DynamicFrame, see the section called “DynamicFrame”.

In this procedure, you write the following code using ApplyMapping. This code is a portion of the generated sample script.

```python
ApplyMapping_node2 = ApplyMapping.apply(
    frame=S3bucket_node1,
    mappings=[
        ("tag_number_masked", "string", "tag_number_masked", "string"),
        ("date_of_infraction", "string", "date_of_infraction", "string"),
        ("ticket_date", "string", "ticket_date", "string"),
        ("ticket_number", "decimal", "ticket_number", "float"),
        ("officer", "decimal", "officer_name", "decimal"),
        ("infraction_code", "decimal", "infraction_code", "decimal"),
        ("infraction_description", "string", "infraction_description", "string"),
        ("set_fine_amount", "decimal", "set_fine_amount", "float"),
        ("time_of_infraction", "decimal", "time_of_infraction", "decimal"),
    ],
    transformation_ctx="ApplyMapping_node2",
)
```

To transform data with AWS Glue

1. Examine the documentation to identify a transform to change and drop fields. For details, see the section called “GlueTransform”. Choose the ApplyMapping transform. For more information about ApplyMapping, see the section called “ApplyMapping”. Call apply on the ApplyMapping transform object.
Note

What is ApplyMapping?

ApplyMapping takes a DynamicFrame and transforms it. It takes a list of tuples that represent transformations on fields—a "mapping". The first two tuple elements, a field name and type, are used to identify a field in the frame. The second two parameters are also a field name and type.

ApplyMapping converts the source field to the target name and type in a new DynamicFrame, which it returns. Fields that aren’t provided are dropped in the return value.

Rather than calling apply, you can call the same transform with the apply_mapping method on the DynamicFrame to create more fluent, readable code. For more information, see the section called “apply_mapping”.

2. Examine the documentation for ApplyMapping to identify required parameters. See the section called “ApplyMapping”. You will find that this method requires frame and mappings parameters. Provide the necessary parameters to ApplyMapping.

3. Optional – Provide transformation_ctx to the method to support job bookmarks. You can learn about job bookmarks in the following section, the section called “Optional - Enable job bookmarks”.

Note

Apache Spark functionality

We provide transforms to streamline ETL workflows within your job. You also have access to the libraries that are available in a Spark program in your job, built for more general purposes. In order to use them, you convert between DynamicFrame and DataFrame. You can create a DataFrame with the section called “toDF”. Then, you can use methods available on the DataFrame to transform your dataset. For more information on these methods, see DataFrame. You can then convert backwards with the section called “fromDF” to use AWS Glue operations for loading your frame to a target.
Step 5. Load data into a target

After you transform your data, you typically store the transformed data in a different place from the source. You perform this operation by creating a target node in the AWS Glue Studio visual editor.

In this step, you provide the write_dynamic_frame.from_options method a connection_type, connection_options, format, and format_options to load data into a target bucket in Amazon S3.

In Step 1, you initialized a GlueContext object. In AWS Glue, this is where you will find methods that are used to configure targets, much like sources.

In this procedure, you write the following code using write_dynamic_frame.from_options. This code is a portion of the generated sample script.

```python
S3bucket_node3 = glueContext.write_dynamic_frame.from_options(
    frame=ApplyMapping_node2,
    connection_type="s3",
    format="glueparquet",
    connection_options={"path": "s3://DOC-EXAMPLE-BUCKET", "partitionKeys": []},
    format_options={"compression": "gzip"},
    transformation_ctx="S3bucket_node3",
)
```

To load data into a target

1. Examine the documentation to find a method to load data into a target Amazon S3 bucket. These methods are documented in the section called “GlueContext”. Choose the the section called “write_dynamic_frame_from_options” method. Call this method on glueContext.

**Note**

Common methods for loading data

write_dynamic_frame.from_options is the most common method used to load data. It supports all targets that are available in AWS Glue.

If you're writing to a JDBC target defined in an AWS Glue connection, use the the section called “write_dynamic_frame_from_jdbc_conf” method. AWS Glue connections store information about how to connect to a data source. This removes the need to
provide that information in connection_options. However, you still need to use connection_options to provide dbtable. write_dynamic_frame.from_catalog is not a common method for loading data. This method updates the AWS Glue Data Catalog without updating the underlying dataset, and is used in combination with other processes that change the underlying dataset. For more information, see the section called “Creating tables, updating the schema, and adding new partitions in the Data Catalog from AWS Glue ETL jobs”.

2. Examine the documentation for the section called “write_dynamic_frame_from_options”. This method requires frame, connection_type, format, connection_options, and format_options. Call this method on glueContext.

   a. Refer to the supplemental documentation about format_options and format to identify the parameters you need. For an explanation of data formats, see the section called “Data format options”.

   b. Refer to the supplemental documentation about connection_type and connection_options to identify the parameters you need. For an explanation of connections, see the section called “Connection parameters”.

   c. Provide the necessary parameters to write_dynamic_frame.from_options. This method has a similar configuration to create_dynamic_frame.from_options.

3. Optional – Provide transformation_ctx to write_dynamic_frame.from_options to support job bookmarks. You can learn about job bookmarks in the following section, the section called “Optional - Enable job bookmarks”.

Step 6. Commit the Job object

You initialized a Job object in Step 1. You need to manually conclude its lifecycle at the end of your script. Certain optional features need this to function properly. This work is done behind the scenes in AWS Glue Studio.

In this step, call the commit method on the Job object.

In this procedure, you write the following code. This code is a portion of the generated sample script.

```python
ejob.commit()```

```python```
To commit the Job object

1. If you have not yet done this, perform the optional steps outlined in previous sections to include transformation_ctx.
2. Call commit.

Optional - Enable job bookmarks

In every prior step, you have been instructed to set transformation_ctx parameters. This is related to a feature called job bookmarks.

With job bookmarks, you can save time and money with jobs that run on a recurring basis, against datasets where previous work can easily be tracked. Job bookmarks track the progress of an AWS Glue transform across a dataset from previous runs. By tracking where previous runs ended, AWS Glue can limit its work to rows it hasn't processed before. For more information about job bookmarks, see the section called “Tracking processed data using job bookmarks”.

To enable job bookmarks, first add the transformation_ctx statements into our provided functions, as described in the previous examples. Job bookmark state is persisted across runs. transformation_ctx parameters are keys used to access that state. On their own, these statements will do nothing. You also need to activate the feature in the configuration for your job.

In this procedure, you enable job bookmarks using the AWS Management Console.

To enable job bookmarks

1. Navigate to the Job details section of your corresponding job.
2. Set Job bookmark to Enable.

Step 7. Run your code as a job

In this step, you run your job to verify that you successfully completed this tutorial. This is done with the click of a button, as in the AWS Glue Studio visual editor.

To run your code as a job

1. Choose Untitled job on the title bar to edit and set your job name.
2. Navigate to the **Job details** tab. Assign your job an **IAM Role**. You can use the one created by the AWS CloudFormation template in the prerequisites for the AWS Glue Studio tutorial. If you have completed that tutorial, it should be available as **AWS Glue StudioRole**.

3. Choose **Save** to save your script.

4. Choose **Run** to run your job.

5. Navigate to the **Runs** tab to verify that your job completes.

6. Navigate to **DOC-EXAMPLE-BUCKET**, the target for `write_dynamic_frame.from_options`. Confirm that the output matches your expectations.

For more information about configuring and managing jobs, see the section called “Providing your own custom scripts”.

**More information**

Apache Spark libraries and methods are available in AWS Glue scripts. You can look at the Spark documentation to understand what you can do with those included libraries. For more information, see the examples section of the Spark source repository.

AWS Glue 2.0+ includes several common Python libraries by default. There are also mechanisms for loading your own dependencies into an AWS Glue job in a Scala or Python environment. For information about Python dependencies, see the section called “Python libraries”.

For more examples of how to use AWS Glue features in Python, see the section called “Python samples”. Scala and Python jobs have feature parity, so our Python examples should give you some thoughts about how to perform similar work in Scala.

**Program AWS Glue ETL scripts in PySpark**

You can find Python code examples and utilities for AWS Glue in the AWS Glue samples repository on the GitHub website.

**Using Python with AWS Glue**

AWS Glue supports an extension of the PySpark Python dialect for scripting extract, transform, and load (ETL) jobs. This section describes how to use Python in ETL scripts and with the AWS Glue API.

- **Setting up to use Python with AWS Glue**
AWS Glue PySpark extensions

AWS Glue has created the following extensions to the PySpark Python dialect.

- **Accessing parameters using `getResolvedOptions`**
- **PySpark extension types**
- **DynamicFrame class**
- **DynamicFrameCollection class**
- **DynamicFrameWriter class**
- **DynamicFrameReader class**
- **GlueContext class**

AWS Glue PySpark transforms

AWS Glue has created the following transform Classes to use in PySpark ETL operations.

- **GlueTransform base class**
- **ApplyMapping class**
- **DropFields class**
- **DropNullFields class**
- **ErrorsAsDynamicFrame class**
- **FillMissingValues class**
- **Filter class**
- **FindIncrementalMatches class**
- **FindMatches class**
- **FlatMap class**
- **Join class**
- **Map class**
ETL in PySpark

Setting up to use Python with AWS Glue

Use Python to develop your ETL scripts for Spark jobs. The supported Python versions for ETL jobs depend on the AWS Glue version of the job. For more information on AWS Glue versions, see the Glue version job property.

To set up your system for using Python with AWS Glue

Follow these steps to install Python and to be able to invoke the AWS Glue APIs.

1. If you don’t already have Python installed, download and install it from the Python.org download page.
2. Install the AWS Command Line Interface (AWS CLI) as documented in the AWS CLI documentation.

   The AWS CLI is not directly necessary for using Python. However, installing and configuring it is a convenient way to set up AWS with your account credentials and verify that they work.
3. Install the AWS SDK for Python (Boto 3), as documented in the Boto3 Quickstart.

   Boto 3 resource APIs are not yet available for AWS Glue. Currently, only the Boto 3 client APIs can be used.

   For more information about Boto 3, see AWS SDK for Python (Boto3) Getting Started.
You can find Python code examples and utilities for AWS Glue in the AWS Glue samples repository on the GitHub website.

**Calling AWS Glue APIs in Python**

Note that Boto 3 resource APIs are not yet available for AWS Glue. Currently, only the Boto 3 client APIs can be used.

**AWS Glue API names in Python**

AWS Glue API names in Java and other programming languages are generally CamelCased. However, when called from Python, these generic names are changed to lowercase, with the parts of the name separated by underscore characters to make them more "Pythonic". In the AWS Glue API reference documentation, these Pythonic names are listed in parentheses after the generic CamelCased names.

However, although the AWS Glue API names themselves are transformed to lowercase, their parameter names remain capitalized. It is important to remember this, because parameters should be passed by name when calling AWS Glue APIs, as described in the following section.

**Passing and accessing Python parameters in AWS Glue**

In Python calls to AWS Glue APIs, it's best to pass parameters explicitly by name. For example:

```python
job = glue.create_job(Name='sample', Role='Glue_DefaultRole',
                      Command={'Name': 'glueetl',
                               'ScriptLocation': 's3://my_script_bucket/scripts/my_etl_script.py'})
```

It is helpful to understand that Python creates a dictionary of the name/value tuples that you specify as arguments to an ETL script in a Job structure or JobRun structure. Boto 3 then passes them to AWS Glue in JSON format by way of a REST API call. This means that you cannot rely on the order of the arguments when you access them in your script.

For example, suppose that you're starting a JobRun in a Python Lambda handler function, and you want to specify several parameters. Your code might look something like the following:

```python
from datetime import datetime, timedelta
client = boto3.client('glue')
```

ETL in PySpark
def lambda_handler(event, context):
    last_hour_date_time = datetime.now() - timedelta(hours = 1)
    day_partition_value = last_hour_date_time.strftime("%Y-%m-%d")
    hour_partition_value = last_hour_date_time.strftime("%-H")

    response = client.start_job_run(
        JobName = 'my_test_Job',
        Arguments = {
            '--day_partition_key':   'partition_0',
            '--hour_partition_key':  'partition_1',
            '--day_partition_value':  day_partition_value,
            '--hour_partition_value': hour_partition_value } )

To access these parameters reliably in your ETL script, specify them by name using AWS Glue's getResolvedOptions function and then access them from the resulting dictionary:

```python
import sys
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv,
                          ['JOB_NAME',
                           'day_partition_key',
                           'hour_partition_key',
                           'day_partition_value',
                           'hour_partition_value'])

print "The day partition key is: ", args['day_partition_key']
print "and the day partition value is: ", args['day_partition_value']
```

If you want to pass an argument that is a nested JSON string, to preserve the parameter value as it gets passed to your AWS Glue ETL job, you must encode the parameter string before starting the job run, and then decode the parameter string before referencing it your job script. For example, consider the following argument string:

```python
glue_client.start_job_run(JobName = "gluejobname", Arguments={
    "-m-curly_braces_string": '{"a": {"b": {"c": [{"d": {"e": 42}}]}}}'
})
```

To pass this parameter correctly, you should encode the argument as a Base64 encoded string.

```python
import base64
...
```
Example: Create and run a job

The following example shows how to call the AWS Glue APIs using Python, to create and run an ETL job.

To create and run a job

1. Create an instance of the AWS Glue client:

   ```python
   import boto3
   glue = boto3.client(service_name='glue', region_name='us-east-1',
                       endpoint_url='https://glue.us-east-1.amazonaws.com')
   ```

2. Create a job. You must use `glueetl` as the name for the ETL command, as shown in the following code:

   ```python
   myJob = glue.create_job(Name='sample', Role='Glue_DefaultRole',
                           Command={'Name': 'glueetl',
                                     'ScriptLocation': 's3://my_script_bucket/
                                              scripts/my_etl_script.py'})
   ```

3. Start a new run of the job that you created in the previous step:

   ```python
   myNewJobRun = glue.start_job_run(JobName=myJob['Name'])
   ```

4. Get the job status:

   ```python
   status = glue.get_job_run(JobName=myJob['Name'], RunId=myNewJobRun['JobRunId'])
   ```
5. Print the current state of the job run:

```python
print(status['JobRun']['JobRunState'])
```

Using Python libraries with AWS Glue

AWS Glue lets you install additional Python modules and libraries for use with AWS Glue ETL.

Topics

- Installing additional Python modules with pip in AWS Glue 2.0+
- Including Python files with PySpark native features
- Python modules already provided in AWS Glue
- Zipping libraries for inclusion
- Loading Python libraries in a development endpoint
- Using Python libraries in a job or JobRun

Installing additional Python modules with pip in AWS Glue 2.0+

AWS Glue uses the Python Package Installer (pip3) to install additional modules to be used by AWS Glue ETL. You can use the `--additional-python-modules` parameter with a list of comma-separated Python modules to add a new module or change the version of an existing module. You can install custom distributions of a library by uploading the distribution to Amazon S3, then include the path to the Amazon S3 object in your list of modules.

You can pass additional options to pip3 with the `--python-modules-installer-option` parameter. For example, you could pass `--upgrade` to upgrade the packages specified by `--additional-python-modules`. For more examples, see [Building Python modules from a wheel for Spark ETL workloads using AWS Glue 2.0](#).

If your Python dependencies transitively depend on native, compiled code, you may run against the following limitation: AWS Glue does not support compiling native code in the job environment. However, AWS Glue jobs run within an Amazon Linux 2 environment. You may be able to provide your native dependencies in a compiled form through a Wheel distributable.

For example to update or to add a new scikit-learn module use the following key/value: `--additional-python-modules`, "scikit-learn==0.21.3".
Also, within the `--additional-python-modules` option you can specify an Amazon S3 path to a Python wheel module. For example:

```bash
--additional-python-modules s3://aws-glue-native-spark/tests/j4.2/ephem-3.7.7.1-cp37-cp37m-linux_x86_64.whl,s3://aws-glue-native-spark/tests/j4.2/fbprophet-0.6-py3-none-any.whl,scikit-learn==0.21.3
```

You specify the `--additional-python-modules` in the **Job parameters** field of the AWS Glue console or by altering the job arguments in the AWS SDK. For more information about setting job parameters, see the section called “Job parameters”.

**Including Python files with PySpark native features**

AWS Glue uses PySpark to include Python files in AWS Glue ETL jobs. You will want to use `--additional-python-modules` to manage your dependencies when available. You can use the `--extra-py-files` job parameter to include Python files. Dependencies must be hosted in Amazon S3 and the argument value should be a comma delimited list of Amazon S3 paths with no spaces. This functionality behaves like the Python dependency management you would use with Spark. For more information on Python dependency management in Spark, see Using PySpark Native Features page in Apache Spark documentation. `--extra-py-files` is useful in cases where your additional code is not packaged, or when you are migrating a Spark program with an existing toolchain for managing dependencies. For your dependency tooling to be maintainable, you will have to bundle your dependencies before submitting.

**Python modules already provided in AWS Glue**

To change the version of these provided modules, provide new versions with the `--additional-python-modules` job parameter.

**AWS Glue version 2.0**

AWS Glue version 2.0 includes the following Python modules out of the box:

- `avro-python3==1.10.0`
- `awscli==1.27.60`
- `boto3==1.12.4`
- `botocore==1.15.4`
- `certifi==2019.11.28`
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- chardet==3.0.4
- click==8.1.3
- colorama==0.4.4
- cycler==0.10.0
- Cython==0.29.15
- docutils==0.15.2
- enum34==1.1.9
- fsspec==0.6.2
- idna==2.9
- importlib-metadata==6.0.0
- jmespath==0.9.4
- joblib==0.14.1
- kiwisolver==1.1.0
- matplotlib==3.1.3
- mpmath==1.1.0
- nltk==3.5
- numpy==1.18.1
- pandas==1.0.1
- patsy==0.5.1
- pmdarima==1.5.3
- ptvsd==4.3.2
- pyarrow==0.16.0
- pyasn1==0.4.8
- pydevd==1.9.0
- pyhocon==0.3.54
- PyMySQL==0.9.3
- pyparsing==2.4.6
- python-dateutil==2.8.1
- pytz==2019.3
AWS Glue version 3.0 includes the following Python modules out of the box:

- aiobotocore==1.4.2
- aiohttp==3.8.3
- aioitertools==0.11.0
- aiosignal==1.3.1
- async-timeout==4.0.2
- asynctest==0.13.0
- attrs==22.2.0
- avro-python3==1.10.2
- boto3==1.18.50
- botocore==1.21.50
- certifi==2021.5.30
- chardet==3.0.4
- charset-normalizer==2.1.1
- click==8.1.3
- cycler==0.10.0
- Cython==0.29.4
- docutils==0.17.1
- enum34==1.1.10
- frozenlist==1.3.3
- fsspec==2021.8.1
- idna==2.10
- importlib-metadata==6.0.0
- jmespath==0.10.0
- joblib==1.0.1
- kiwisolver==1.3.2
- matplotlib==3.4.3
- mpmath==1.2.1
- multidict==6.0.4
- nltk==3.6.3
- numpy==1.19.5
- packaging==23.0
- pandas==1.3.2
- patsy==0.5.1
- Pillow==9.4.0
- pip==23.0
- pmdarima==1.8.2
- ptvsd==4.3.2
- pyarrow==5.0.0
- pydevd==2.5.0
- pyhocon==0.3.58
- PyMySQL==1.0.2
- pyparsing==2.4.7
- python-dateutil==2.8.2
- pytz==2021.1
- PyYAML==5.4.1
- regex==2022.10.31
- requests==2.23.0
- s3fs==2021.8.1
- s3transfer==0.5.0
- scikit-learn==0.24.2
- scipy==1.7.1
- six==1.16.0
- Spark==1.0
- statsmodels==0.12.2
- subprocess32==3.5.4
- sympy==1.8
- tbats==1.1.0
- threadpoolctl==3.1.0
- tqdm==4.64.1
- typing_extensions==4.4.0
- urllib3==1.25.11
- wheel==0.37.0
- wrapt==1.14.1
- yarl==1.8.2
AWS Glue version 4.0

AWS Glue version 4.0 includes the following Python modules out of the box:

- aiobotocore==2.4.1
- aiohttp==3.8.3
- aioitertools==0.11.0
- aiosignal==1.3.1
- async-timeout==4.0.2
- asynctest==0.13.0
- attrs==22.2.0
- avro-python3==1.10.2
- boto3==1.24.70
- botocore==1.27.59
- certifi==2021.5.30
- chardet==3.0.4
- charset-normalizer==2.1.1
- click==8.1.3
- cycler==0.10.0
- Cython==0.29.32
- docutils==0.17.1
- enum34==1.1.10
- frozenlist==1.3.3
- fsspec==2021.8.1
- idna==2.10
- importlib-metadata==5.0.0
- jmespath==0.10.0
- joblib==1.0.1
- kiwisolver==1.4.4
- matplotlib==3.4.3
- mpmath==1.2.1
- multidict==6.0.4
- nltk==3.7
- numpy==1.23.5
- packaging==23.0
- pandas==1.5.1
- patsy==0.5.1
- Pillow==9.4.0
- pip==23.0.1
- pmdarima==2.0.1
- ptvsd==4.3.2
- pyarrow==10.0.0
- pydevd==2.5.0
- pyhocon==0.3.58
- PyMySQL==1.0.2
- pyparsing==2.4.7
- python-dateutil==2.8.2
- pytz==2021.1
- PyYAML==6.0.1
- regex==2022.10.31
- requests==2.23.0
- s3fs==2022.11.0
- s3transfer==0.6.0
- scikit-learn==0.24.2
- scipy==1.9.3
- setuptools==49.1.3
- six==1.16.0
- Spark==1.0
- statsmodels==0.13.5
- subprocess32==3.5.4
- sympy==1.8
- tbats==1.1.0
- threadpoolctl==3.1.0
- tqdm==4.64.1
- typing_extensions==4.4.0
- urllib3==1.25.11
- wheel==0.37.0
- wrapt==1.14.1
- yarl==1.8.2
- zipp==3.10.0

**Zipping libraries for inclusion**

Unless a library is contained in a single .py file, it should be packaged in a .zip archive. The package directory should be at the root of the archive, and must contain an __init__.py file for the package. Python will then be able to import the package in the normal way.

If your library only consists of a single Python module in one .py file, you do not need to place it in a .zip file.

**Loading Python libraries in a development endpoint**

If you are using different library sets for different ETL scripts, you can either set up a separate development endpoint for each set, or you can overwrite the library .zip file(s) that your development endpoint loads every time you switch scripts.

You can use the console to specify one or more library .zip files for a development endpoint when you create it. After assigning a name and an IAM role, choose **Script Libraries and job parameters (optional)** and enter the full Amazon S3 path to your library .zip file in the **Python library path** box. For example:

```
s3://bucket/prefix/site-packages.zip
```

If you want, you can specify multiple full paths to files, separating them with commas but no spaces, like this:
s3://bucket/prefix/lib_A.zip,s3://bucket_B/prefix/lib_X.zip

If you update these .zip files later, you can use the console to re-import them into your development endpoint. Navigate to the developer endpoint in question, check the box beside it, and choose **Update ETL libraries** from the **Action** menu.

In a similar way, you can specify library files using the AWS Glue APIs. When you create a development endpoint by calling **CreateDevEndpoint action (Python: create_dev_endpoint)**, you can specify one or more full paths to libraries in the **ExtraPythonLibsS3Path** parameter, in a call that looks this:

```python
dep = glue.create_dev_endpoint(
    EndpointName="testDevEndpoint",
    RoleArn="arn:aws:iam::123456789012",
    SecurityGroupIds="sg-7f5ad1ff",
    SubnetId="subnet-c12fdba4",
    PublicKey="ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQCtp04H/y...",
    NumberOfNodes=3,
    ExtraPythonLibsS3Path="s3://bucket/prefix/lib_A.zip,s3://bucket_B/prefix/lib_X.zip"
)
```

When you update a development endpoint, you can also update the libraries it loads using a **DevEndpointCustomLibraries** object and setting the **UpdateEtlLibraries** parameter to True when calling **UpdateDevEndpoint (update_dev_endpoint)**.

**Using Python libraries in a job or JobRun**

When you are creating a new Job on the console, you can specify one or more library .zip files by choosing **Script Libraries and job parameters (optional)** and entering the full Amazon S3 library path(s) in the same way you would when creating a development endpoint:

```python
s3://bucket/prefix/lib_A.zip,s3://bucket_B/prefix/lib_X.zip
```

If you are calling **CreateJob (create_job)**, you can specify one or more full paths to default libraries using the **--extra-py-files** default parameter, like this:

```python
job = glue.create_job(Name='sampleJob',
    Role='Glue_DefaultRole',
    Command={'Name': 'glueetl',
```

**ETL in PySpark**
'ScriptLocation': 's3://my_script_bucket/scripts/my_etl_script.py',

DefaultArguments={'--extra-py-files': 's3://bucket/prefix/lib_A.zip,s3://bucket_B/prefix/lib_X.zip'}

Then when you are starting a JobRun, you can override the default library setting with a different one:

```python
runId = glue.start_job_run(JobName='sampleJob',
                           Arguments={'--extra-py-files': 's3://bucket/prefix/lib_B.zip'})
```

**AWS Glue Python code samples**

- [Code example: Joining and relationalizing data](#)
- [Code example: Data preparation using ResolveChoice, Lambda, and ApplyMapping](#)

**Code example: Joining and relationalizing data**

This example uses a dataset that was downloaded from [http://everypolitician.org/](http://everypolitician.org/) to the sample-dataset bucket in Amazon Simple Storage Service (Amazon S3): s3://awsglue-datasets/examples/us-legislators/all. The dataset contains data in JSON format about United States legislators and the seats that they have held in the US House of Representatives and Senate, and has been modified slightly and made available in a public Amazon S3 bucket for purposes of this tutorial.

You can find the source code for this example in the `join_and_relationalize.py` file in the [AWS Glue samples repository](#) on the GitHub website.

Using this data, this tutorial shows you how to do the following:

- Use an AWS Glue crawler to classify objects that are stored in a public Amazon S3 bucket and save their schemas into the AWS Glue Data Catalog.
- Examine the table metadata and schemas that result from the crawl.
- Write a Python extract, transfer, and load (ETL) script that uses the metadata in the Data Catalog to do the following:
  - Join the data in the different source files together into a single data table (that is, denormalize the data).
• Filter the joined table into separate tables by type of legislator.
• Write out the resulting data to separate Apache Parquet files for later analysis.

The preferred way to debug Python or PySpark scripts while running on AWS is to use Notebooks on AWS Glue Studio.

Step 1: Crawl the data in the Amazon S3 bucket

1. Sign in to the AWS Management Console, and open the AWS Glue console at https://console.aws.amazon.com/glue/.

2. Following the steps in Working with crawlers on the AWS Glue console, create a new crawler that can crawl the s3://awsglue-datasets/examples/us-legislators/all dataset into a database named legislators in the AWS Glue Data Catalog. The example data is already in this public Amazon S3 bucket.

3. Run the new crawler, and then check the legislators database.

   The crawler creates the following metadata tables:

   • persons_json
   • memberships_json
   • organizations_json
   • events_json
   • areas_json
   • countries_r_json

   This is a semi-normalized collection of tables containing legislators and their histories.

Step 2: Add boilerplate script to the development endpoint notebook

Paste the following boilerplate script into the development endpoint notebook to import the AWS Glue libraries that you need, and set up a single GlueContext:

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
```
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

glueContext = GlueContext(SparkContext.getOrCreate())

Step 3: Examine the schemas from the data in the Data Catalog

Next, you can easily create examine a DynamicFrame from the AWS Glue Data Catalog, and examine the schemas of the data. For example, to see the schema of the persons_json table, add the following in your notebook:

```python
glueContext = GlueContext(SparkContext.getOrCreate())

persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators",
    table_name="persons_json")

print("Count: ", persons.count())
persons.printSchema()
```

Here's the output from the print calls:

```
Count:  1961
root
 |-- family_name: string
 |-- name: string
 |-- links: array
 |    |-- element: struct
 |    |    |-- note: string
 |    |    |-- url: string
 |-- gender: string
 |-- image: string
 |-- identifiers: array
 |    |-- element: struct
 |    |    |-- scheme: string
 |    |    |-- identifier: string
 |-- other_names: array
 |    |-- element: struct
 |    |    |-- note: string
 |    |    |-- name: string
 |    |    |-- lang: string
 |-- sort_name: string
```
Each person in the table is a member of some US congressional body.

To view the schema of the memberships_json table, type the following:

```python
memberships = glueContext.create_dynamic_frame.from_catalog(
    database="legislators",
    table_name="memberships_json")
print "Count: ", memberships.count()
memberships.printSchema()
```

The output is as follows:

```
Count:  10439
root
 |-- area_id: string
 |-- on_behalf_of_id: string
 |-- organization_id: string
 |-- role: string
 |-- person_id: string
 |-- legislative_period_id: string
 |-- start_date: string
 |-- end_date: string
```

The organizations are parties and the two chambers of Congress, the Senate and House of Representatives. To view the schema of the organizations_json table, type the following:

```python
orgs = glueContext.create_dynamic_frame.from_catalog(
```

ETL in PySpark
database="legislators",
table_name="organizations_json")
print "Count: ", orgs.count()
orgs.printSchema()

The output is as follows:

Count: 13
root
|-- classification: string
|-- links: array
|  |-- element: struct
|  |  |-- note: string
|  |  |-- url: string
|-- image: string
|-- identifiers: array
|  |-- element: struct
|  |  |-- scheme: string
|  |  |-- identifier: string
|-- other_names: array
|  |-- element: struct
|  |  |-- lang: string
|  |  |-- note: string
|  |  |-- name: string
|-- id: string
|-- name: string
|-- seats: int
|-- type: string

Step 4: Filter the data

Next, keep only the fields that you want, and rename id to org_id. The dataset is small enough that you can view the whole thing.

The toDF() converts a DynamicFrame to an Apache Spark DataFrame, so you can apply the transforms that already exist in Apache Spark SQL:

```python
orgs = orgs.drop_fields(['other_names', 'identifiers']).rename_field('id', 'org_id').rename_field('name', 'org_name')
```
The following shows the output:

<table>
<thead>
<tr>
<th>classification</th>
<th>org_id</th>
<th>org_name</th>
<th>links</th>
<th>seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>image</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>party</td>
<td>party/al</td>
<td>AL</td>
<td>null</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/democrat</td>
<td>Democrat</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/democrat-liberal</td>
<td>Democrat-Liberal</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>legislature</td>
<td>d56acebe-8fdc-47b</td>
<td>House of Representatives</td>
<td>null</td>
<td>435</td>
</tr>
<tr>
<td>party</td>
<td>party/independent</td>
<td>Independent</td>
<td>null</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/new_progressive</td>
<td>New Progressive</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/popular_democrat</td>
<td>Popular Democrat</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/republican</td>
<td>Republican</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/republican-conservative</td>
<td>Republican-Conser...</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/democrat</td>
<td>Democrat</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/independent</td>
<td>Independent</td>
<td>null</td>
<td>null</td>
</tr>
<tr>
<td>party</td>
<td>party/republican</td>
<td>Republican</td>
<td>[[website, http://...]]</td>
<td>null</td>
</tr>
<tr>
<td>legislature</td>
<td>8fa6c3d2-71dc-478</td>
<td>Senate</td>
<td>null</td>
<td>100</td>
</tr>
</tbody>
</table>

Type the following to view the organizations that appear in memberships:
Step 5: Put it all together

Now, use AWS Glue to join these relational tables and create one full history table of legislator memberships and their corresponding organizations.

1. First, join persons and memberships on id and person_id.
2. Next, join the result with orgs on org_id and organization_id.
3. Then, drop the redundant fields, person_id and org_id.

You can do all these operations in one (extended) line of code:

```python
l_history = Join.apply(orgs,
                        Join.apply(persons, memberships, 'id', 'person_id'),
                        'org_id', 'organization_id').drop_fields(['person_id',
                        'org_id'])
print "Count: ", l_history.count()
```

The output is as follows:

```
Count:  10439
root
 |-- role: string
 |-- seats: int
 |-- org_name: string
 |-- links: array
```
You now have the final table that you can use for analysis. You can write it out in a compact, efficient format for analytics—namely Parquet—that you can run SQL over in AWS Glue, Amazon Athena, or Amazon Redshift Spectrum.

The following call writes the table across multiple files to support fast parallel reads when doing analysis later:
To put all the history data into a single file, you must convert it to a data frame, repartition it, and write it out:

```python
glueContext.write_dynamic_frame.from_options(frame=l_history,  
    connection_type = "s3",  
    connection_options = {"path": "s3://glue-sample-target/output-dir/legislator_history"},  
    format = "parquet")
```

```python
s_history = l_history.toDF().repartition(1)  
s_history.write.parquet('s3://glue-sample-target/output-dir/legislator_single')
```

Or, if you want to separate it by the Senate and the House:

```python
l_history.toDF().write.parquet('s3://glue-sample-target/output-dir/legislator_part',  
    partitionBy=['org_name'])
```

**Step 6: Transform the data for relational databases**

AWS Glue makes it easy to write the data to relational databases like Amazon Redshift, even with semi-structured data. It offers a transform `relationalize`, which flattens DynamicFrames no matter how complex the objects in the frame might be.

Using the `l_history` DynamicFrame in this example, pass in the name of a root table (`hist_root`) and a temporary working path to `relationalize`. This returns a `DynamicFrameCollection`. You can then list the names of the DynamicFrames in that collection:

```python
dfc = l_history.relationalize("hist_root", "s3://glue-sample-target/temp-dir/")
dfc.keys()
```

The following is the output of the `keys` call:

```python
[u'hist_root', u'hist_root_contact_details', u'hist_root_links',
```
Relationalize broke the history table out into six new tables: a root table that contains a record for each object in the DynamicFrame, and auxiliary tables for the arrays. Array handling in relational databases is often suboptimal, especially as those arrays become large. Separating the arrays into different tables makes the queries go much faster.

Next, look at the separation by examining `contact_details`:

```python
l_history.select_fields('contact_details').printSchema()
dfc.select('hist_root_contact_details').toDF().where("id = 10 or id = 75").orderBy(['id','index']).show()
```

The following is the output of the `show` call:

```
root
|-- contact_details: array
  |-- element: struct
    |-- type: string
    |-- value: string
+-----+------------------------+-------------------------+
| id | index | contact_details.val.type| contact_details.val.value|
+-----+------------------------+-------------------------+
| 10 |   0 |                      fax|                         |
| 10 |   1 |                      phone|             202-225-1314|
| 10 |   2 |                   phone|                         |
| 10 |   3 |                      phone|             202-225-3772|
| 10 |   4 |                 twitter|                         |
| 10 |   5 |                        |          MikeRossUpdates|
| 75 |   0 |                      fax|                         |
| 75 |   1 |                      phone|             202-225-7856|
| 75 |   2 |                   phone|                         |
| 75 |   3 |                      phone|             202-225-2711|
| 75 |   4 |                 twitter|                         |
| 75 |   5 |                        |                SenCapito|
+-----+------------------------+-------------------------+
```

The `contact_details` field was an array of structs in the original DynamicFrame. Each element of those arrays is a separate row in the auxiliary table, indexed by `index`. The `id` here is a foreign key into the `hist_root` table with the key `contact_details`:
dfc.select('hist_root').toDF().where(
    "contact_details = 10 or contact_details = 75").select(
    ['id', 'given_name', 'family_name', 'contact_details']).show()

The following is the output:

<table>
<thead>
<tr>
<th>id</th>
<th>given_name</th>
<th>family_name</th>
<th>contact_details</th>
</tr>
</thead>
<tbody>
<tr>
<td>f4fc30ee-7b42-432</td>
<td>Mike</td>
<td>Ross</td>
<td>10</td>
</tr>
<tr>
<td>e3c60f34-7d1b-4c0</td>
<td>Shelley</td>
<td>Capito</td>
<td>75</td>
</tr>
</tbody>
</table>

Notice in these commands that toDF() and then a where expression are used to filter for the rows that you want to see.

So, joining the hist_root table with the auxiliary tables lets you do the following:

- Load data into databases without array support.
- Query each individual item in an array using SQL.

Safely store and access your Amazon Redshift credentials with a AWS Glue connection. For information about how to create your own connection, see [Connecting to data](#).

You are now ready to write your data to a connection by cycling through the DynamicFrames one at a time:

```python
for df_name in dfc.keys():
    m_df = dfc.select(df_name)
    print "Writing to table: ", df_name
    glueContext.write_dynamic_frame.from_jdbc_conf(frame = m_df, connection settings here)
```

Your connection settings will differ based on your type of relational database:

- For instructions on writing to Amazon Redshift consult [the section called “Redshift connections”](#).
• For other databases, consult [Connection types and options for ETL in AWS Glue for Spark](#).

**Conclusion**

Overall, AWS Glue is very flexible. It lets you accomplish, in a few lines of code, what normally would take days to write. You can find the entire source-to-target ETL scripts in the Python file `join_and_relationalize.py` in the [AWS Glue samples](https://github.com/aws-glue/aws-glue-samples) on GitHub.

**Code example: Data preparation using ResolveChoice, Lambda, and ApplyMapping**

The dataset that is used in this example consists of Medicare Provider payment data that was downloaded from two [Data.CMS.gov](https://data.cms.gov) data sets: "Inpatient Prospective Payment System Provider Summary for the Top 100 Diagnosis-Related Groups - FY2011" and "Inpatient Charge Data FY 2011". After downloading the data, we modified the dataset to introduce a couple of erroneous records at the end of the file. This modified file is located in a public Amazon S3 bucket at `s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv`.

You can find the source code for this example in the `data_cleaning_and_lambda.py` file in the [AWS Glue examples](https://github.com/aws-glue/aws-glue-samples) GitHub repository.

The preferred way to debug Python or PySpark scripts while running on AWS is to use [Notebooks on AWS Glue Studio](https://aws.amazon.com/glue).

**Step 1: Crawl the data in the Amazon S3 bucket**

2. Following the process described in [Working with crawlers on the AWS Glue console](https://docs.aws.amazon.com/glue/latest/dg/working-with-crawlers.html), create a new crawler that can crawl the `s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv` file, and can place the resulting metadata into a database named `payments` in the AWS Glue Data Catalog.
3. Run the new crawler, and then check the `payments` database. You should find that the crawler has created a metadata table named `medicare` in the database after reading the beginning of the file to determine its format and delimiter.

The schema of the new `medicare` table is as follows:

<table>
<thead>
<tr>
<th>Column name</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>Data type</td>
</tr>
<tr>
<td>Column 2</td>
<td>Data type</td>
</tr>
<tr>
<td>Column 3</td>
<td>Data type</td>
</tr>
</tbody>
</table>

[ETL in PySpark](#)
**Step 2: Add boilerplate script to the development endpoint notebook**

Paste the following boilerplate script into the development endpoint notebook to import the AWS Glue libraries that you need, and set up a single GlueContext:

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

glueContext = GlueContext(SparkContext.getOrCreate())
```

**Step 3: Compare different schema parsings**

Next, you can see if the schema that was recognized by an Apache Spark DataFrame is the same as the one that your AWS Glue crawler recorded. Run this code:

```python
medicare = spark.read.format("com.databricks.spark.csv").option("header", "true").option("inferSchema", "true").load('s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv')
medicare.printSchema()
```

Here's the output from the `printSchema` call:
Next, look at the schema that an AWS Glue DynamicFrame generates:

```python
c medicare_dynamicframe = glueContext.create_dynamic_frame.from_catalog(
    database = "payments",
    table_name = "medicare"
)
c medicare_dynamicframe.printSchema()
```

The output from `printSchema` is as follows:

```
root
  |-- drg definition: string
  |-- provider id: choice
  |    |-- long
  |    |-- string
  |-- provider name: string
  |-- provider street address: string
  |-- provider city: string
  |-- provider state: string
  |-- provider zip code: long
  |-- hospital referral region description: string
  |-- total discharges: long
  |-- average covered charges: string
  |-- average total payments: string
  |-- average medicare payments: string
```
The DynamicFrame generates a schema in which provider id could be either a long or a string type. The DataFrame schema lists Provider Id as being a string type, and the Data Catalog lists provider id as being a bigint type.

Which one is correct? There are two records at the end of the file (out of 160,000 records) with string values in that column. These are the erroneous records that were introduced to illustrate a problem.

To address this kind of problem, the AWS Glue DynamicFrame introduces the concept of a choice type. In this case, the DynamicFrame shows that both long and string values can appear in that column. The AWS Glue crawler missed the string values because it considered only a 2 MB prefix of the data. The Apache Spark DataFrame considered the whole dataset, but it was forced to assign the most general type to the column, namely string. In fact, Spark often resorts to the most general case when there are complex types or variations with which it is unfamiliar.

To query the provider id column, resolve the choice type first. You can use the resolveChoice transform method in your DynamicFrame to convert those string values to long values with a cast:long option:

```python
medicare_res = medicare_dynamicframe.resolveChoice(specs = [('provider id','cast:long')])
medicare_res.printSchema()
```

The printSchema output is now:

```
root
  |-- drg definition: string
  |-- provider id: long
  |-- provider name: string
  |-- provider street address: string
  |-- provider city: string
  |-- provider state: string
  |-- provider zip code: long
  |-- hospital referral region description: string
  |-- total discharges: long
  |-- average covered charges: string
  |-- average total payments: string
  |-- average medicare payments: string
```

Where the value was a string that could not be cast, AWS Glue inserted a null.
Another option is to convert the choice type to a `struct`, which keeps values of both types.

Next, look at the rows that were anomalous:

```python
medicare_res.toDF().where("'provider id' is NULL").show()
```

You see the following:

<table>
<thead>
<tr>
<th>drg definition</th>
<th>provider id</th>
<th>provider name</th>
<th>provider street address</th>
<th>provider city</th>
<th>provider state</th>
<th>provider zip code</th>
<th>hospital referral region description</th>
<th>total discharges</th>
<th>average covered charges</th>
<th>average total payments</th>
<th>average medicare payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>948 - SIGNS &amp; SYM...</td>
<td>null</td>
<td>INC</td>
<td>1050 DIVISION ST</td>
<td>MAUSTON</td>
<td>WI</td>
<td>53948</td>
<td>WI - Madison</td>
<td>12</td>
<td>$11961.41</td>
<td>$4619.00</td>
<td>$3775.33</td>
</tr>
<tr>
<td>948 - SIGNS &amp; SYM...</td>
<td>null</td>
<td>INC- ST JOSEPH</td>
<td>5000 W CHAMBERS ST</td>
<td>MILWAUKEE</td>
<td>WI</td>
<td>53210</td>
<td>WI - Milwaukee</td>
<td>14</td>
<td>$10514.28</td>
<td>$5562.50</td>
<td>$4522.78</td>
</tr>
</tbody>
</table>

Now remove the two malformed records, as follows:

```python
medicare_dataframe = medicare_res.toDF()
medicare_dataframe = medicare_dataframe.where("'provider id' is NOT NULL")
```

### Step 4: Map the data and use Apache Spark Lambda functions

AWS Glue does not yet directly support Lambda functions, also known as user-defined functions. But you can always convert a `DynamicFrame` to and from an Apache Spark `DataFrame` to take advantage of Spark functionality in addition to the special features of `DynamicFrames`.

Next, turn the payment information into numbers, so analytic engines like Amazon Redshift or Amazon Athena can do their number crunching faster:
from pyspark.sql.functions import udf
from pyspark.sql.types import StringType

chop_f = udf(lambda x: x[1:], StringType())

medicare_dataframe = medicare_dataframe.withColumn("ACC", chop_f(medicare_dataframe["average covered charges"])).withColumn("ATP", chop_f(medicare_dataframe["average total payments"])).withColumn("AMP", chop_f(medicare_dataframe["average medicare payments"]))

medicare_dataframe.select(["ACC", "ATP", "AMP"]).show()

The output from the show call is as follows:

+--------+-------+-------+
|   ACC  |   ATP  |   AMP  |
+--------+-------+-------+
|32963.07|5777.24|4763.73|
|15131.85|5787.57|4976.71|
|37560.37|5434.95|4453.79|
|13998.28|5417.56|4129.16|
|31633.27|5658.33|4851.44|
|16920.79|6653.80|5374.14|
|11977.13|5834.74|4761.41|
|35841.09|8031.12|5858.50|
|28523.39|6113.38|5228.40|
|75233.38|5541.05|4386.94|
|67327.92|5461.57|4493.57|
|39607.28|5356.28|4408.20|
|22862.23|5374.65|4186.02|
|31110.85|5366.23|4376.23|
|25411.33|5282.93|4383.73|
|9234.51|5676.55|4509.11|
|15895.85|5930.11|3972.85|
|19721.16|6192.54|5179.38|
|10710.88|4968.00|3898.88|
|51343.75|5996.00|4962.45|
+--------+-------+-------+

only showing top 20 rows
These are all still strings in the data. We can use the powerful apply_mapping transform method to drop, rename, cast, and nest the data so that other data programming languages and systems can easily access it:

```python
from awsglue.dynamicframe import DynamicFrame

medicare_tmp_dyf = DynamicFrame.fromDF(medicare_dataframe, glueContext, "nested")

medicare_nest_dyf = medicare_tmp_dyf.apply_mapping([('drg definition', 'string', 'drg'), ('provider id', 'long', 'provider.id', 'long'), ('provider name', 'string', 'provider.name', 'string'), ('provider city', 'string', 'provider.city', 'string'), ('provider state', 'string', 'provider.state', 'string'), ('provider zip code', 'long', 'provider.zip', 'long'), ('hospital referral region description', 'string', 'rr', 'string'), ('ACC', 'string', 'charges.covered', 'double'), ('ATP', 'string', 'charges.total_pay', 'double'), ('AMP', 'string', 'charges.medicare_pay', 'double')])

medicare_nest_dyf.printSchema()
```

The `printSchema` output is as follows:

```
root
 |-- drg: string
 |-- provider: struct
  |    |-- id: long
  |    |-- name: string
  |    |-- city: string
  |    |-- state: string
  |    |-- zip: long
  |-- rr: string
 |-- charges: struct
  |    |-- covered: double
  |    |-- total_pay: double
  |    |-- medicare_pay: double
```

Turning the data back into a Spark DataFrame, you can show what it looks like now:

```python
medicare_nest_dyf.toDF().show()
```

The output is as follows:
Step 5: Write the data to Apache Parquet

AWS Glue makes it easy to write the data in a format such as Apache Parquet that relational databases can effectively consume:

```python
    glueContext.write_dynamic_frame.from_options(
        frame = medicare_nest_dyf,
        connection_type = "s3",
        connection_options = {
            "path": "s3://glue-sample-target/output-dir/medicare_parquet"
        },
        format = "parquet"
    )
```

AWS Glue PySpark extensions reference

AWS Glue has created the following extensions to the PySpark Python dialect.

- **Accessing parameters using `getResolvedOptions`**
Accessing parameters using getResolvedOptions

The AWS Glue getResolvedOptions(args, options) utility function gives you access to the arguments that are passed to your script when you run a job. To use this function, start by importing it from the AWS Glue utils module, along with the sys module:

```python
import sys
from awsglue.utils import getResolvedOptions
```

getResolvedOptions(args, options)

- args – The list of arguments contained in sys.argv.
- options – A Python array of the argument names that you want to retrieve.

Example Retrieving arguments passed to a JobRun

Suppose that you created a JobRun in a script, perhaps within a Lambda function:

```python
response = client.start_job_run(
    JobName = 'my_test_Job',
    Arguments = {
        '--day_partition_key':   'partition_0',
        '--hour_partition_key':  'partition_1',
        '--day_partition_value':  day_partition_value,
        '--hour_partition_value': hour_partition_value }
)
```

To retrieve the arguments that are passed, you can use the getResolvedOptions function as follows:

```python
import sys
```
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv,
    ['JOB_NAME',
     'day_partition_key',
     'hour_partition_key',
     'day_partition_value',
     'hour_partition_value'])

print "The day-partition key is: ", args['day_partition_key']
print "and the day-partition value is: ", args['day_partition_value']

Note that each of the arguments are defined as beginning with two hyphens, then referenced in
the script without the hyphens. The arguments use only underscores, not hyphens. Your arguments
need to follow this convention to be resolved.

PySpark extension types

The types that are used by the AWS Glue PySpark extensions.

DataType

The base class for the other AWS Glue types.

__init__(properties={})

• properties – Properties of the data type (optional).

typeName(cls)

Returns the type of the AWS Glue type class (that is, the class name with "Type" removed from the
end).

• cls – An AWS Glue class instance derived from DataType.

jsonValue(  )

Returns a JSON object that contains the data type and properties of the class:
AtomicType and simple derivatives

Inherits from and extends the **DataType** class, and serves as the base class for all the AWS Glue atomic data types.

**fromJsonValue(cls, json_value)**

Initializes a class instance with values from a JSON object.

- **cls** – An AWS Glue type class instance to initialize.
- **json_value** – The JSON object to load key-value pairs from.

The following types are simple derivatives of the **AtomicType** class:

- **BinaryType** – Binary data.
- **BooleanType** – Boolean values.
- **ByteType** – A byte value.
- **DateType** – A datetime value.
- **DoubleType** – A floating-point double value.
- **IntegerType** – An integer value.
- **LongType** – A long integer value.
- **NullType** – A null value.
- **ShortType** – A short integer value.
- **StringType** – A text string.
- **TimestampType** – A timestamp value (typically in seconds from 1/1/1970).
- **UnknownType** – A value of unidentified type.

**DecimalType(AtomicType)**

Inherits from and extends the **AtomicType** class to represent a decimal number (a number expressed in decimal digits, as opposed to binary base-2 numbers).
__init__(precision=10, scale=2, properties={})

- precision – The number of digits in the decimal number (optional; the default is 10).
- scale – The number of digits to the right of the decimal point (optional; the default is 2).
- properties – The properties of the decimal number (optional).

EnumType(AtomicType)

Inherits from and extends the AtomicType class to represent an enumeration of valid options.

__init__(options)

- options – A list of the options being enumerated.

collection types

- ArrayType(DataType)
- ChoiceType(DataType)
- MapType(DataType)
- Field(Object)
- StructType(DataType)
- EntityType(DataType)

ArrayType(DataType)

__init__(elementType=UnknownType(), properties={})

- elementType – The type of elements in the array (optional; the default is UnknownType).
- properties – Properties of the array (optional).

ChoiceType(DataType)

__init__(choices=[], properties={})

- choices – A list of possible choices (optional).
- properties – Properties of these choices (optional).
add(new_choice)

Adds a new choice to the list of possible choices.

- new_choice – The choice to add to the list of possible choices.

merge(new_choices)

Merges a list of new choices with the existing list of choices.

- new_choices – A list of new choices to merge with existing choices.

MapType(DataType)

__init__(valueType=UnknownType, properties={})

- valueType – The type of values in the map (optional; the default is UnknownType).
- properties – Properties of the map (optional).

Field(Object)

Creates a field object out of an object that derives from DataTypes.

__init__(name, dataType, properties={})

- name – The name to be assigned to the field.
- dataType – The object to create a field from.
- properties – Properties of the field (optional).

StructType(DataType)

Defines a data structure (struct).

__init__(fields=[], properties={})

- fields – A list of the fields (of type Field) to include in the structure (optional).
- properties – Properties of the structure (optional).
add(field)

- field – An object of type Field to add to the structure.

hasField(field)

Returns True if this structure has a field of the same name, or False if not.

- field – A field name, or an object of type Field whose name is used.

ggetField(field)

- field – A field name or an object of type Field whose name is used. If the structure has a field of the same name, it is returned.

EntityType(DataType)

__init__(entity, base_type, properties)

This class is not yet implemented.

other types

- [DataSource(object)](DataSource)
- [DataSink(object)](DataSink)

DataSource(object)

__init__(j_source, sql_ctx, name)

- j_source – The data source.
- sql_ctx – The SQL context.
- name – The data-source name.

setFormat(format, **options)

- format – The format to set for the data source.
- options – A collection of options to set for the data source. For more information about format options, see the section called “Data format options”.

```
getFrame()
```

Returns a DynamicFrame for the data source.

```
DataSink(object)

__init__(j_sink, sql_ctx)
```

- j_sink – The sink to create.
- sql_ctx – The SQL context for the data sink.

```
setFormat(format, **options)
```

- format – The format to set for the data sink.
- options – A collection of options to set for the data sink. For more information about format options, see the section called “Data format options”.

```
setAccumulableSize(size)
```

- size – The accumulable size to set, in bytes.

```
writeFrame(dynamic_frame, info="")
```

- dynamic_frame – The DynamicFrame to write.
- info – Information about the DynamicFrame (optional).

```
write(dynamic_frame_or_dfc, info="")
```

Writes a DynamicFrame or a DynamicFrameCollection.

- dynamic_frame_or_dfc – Either a DynamicFrame object or a DynamicFrameCollection object to be written.
• info – Information about the DynamicFrame or DynamicFrames to be written (optional).

**DynamicFrame class**

One of the major abstractions in Apache Spark is the SparkSQL DataFrame, which is similar to the DataFrame construct found in R and Pandas. A DataFrame is similar to a table and supports functional-style (map/reduce/filter/etc.) operations and SQL operations (select, project, aggregate).

DataFrames are powerful and widely used, but they have limitations with respect to extract, transform, and load (ETL) operations. Most significantly, they require a schema to be specified before any data is loaded. SparkSQL addresses this by making two passes over the data—the first to infer the schema, and the second to load the data. However, this inference is limited and doesn’t address the realities of messy data. For example, the same field might be of a different type in different records. Apache Spark often gives up and reports the type as string using the original field text. This might not be correct, and you might want finer control over how schema discrepancies are resolved. And for large datasets, an additional pass over the source data might be prohibitively expensive.

To address these limitations, AWS Glue introduces the DynamicFrame. A DynamicFrame is similar to a DataFrame, except that each record is self-describing, so no schema is required initially. Instead, AWS Glue computes a schema on-the-fly when required, and explicitly encodes schema inconsistencies using a choice (or union) type. You can resolve these inconsistencies to make your datasets compatible with data stores that require a fixed schema.

Similarly, a DynamicRecord represents a logical record within a DynamicFrame. It is like a row in a Spark DataFrame, except that it is self-describing and can be used for data that does not conform to a fixed schema. When using AWS Glue with PySpark, you do not typically manipulate independent DynamicRecords. Rather, you will transform the dataset together through its DynamicFrame.

You can convert DynamicFrames to and from DataFrames after you resolve any schema inconsistencies.

**— construction —**

• `__init__`
• `fromDF`
- **toDF**

- **__init__**

  __init__(jdf, glue_ctx, name)

  - jdf – A reference to the data frame in the Java Virtual Machine (JVM).
  - glue_ctx – A GlueContext class object.
  - name – An optional name string, empty by default.

- **fromDF**

  fromDF(dataframe, glue_ctx, name)

  Converts a DataFrame to a DynamicFrame by converting DataFrame fields to DynamicRecord fields. Returns the new DynamicFrame.

  A DynamicRecord represents a logical record in a DynamicFrame. It is similar to a row in a Spark DataFrame, except that it is self-describing and can be used for data that does not conform to a fixed schema.

  This function expects columns with duplicated names in your DataFrame to have already been resolved.

  - dataframe – The Apache Spark SQL DataFrame to convert (required).
  - glue_ctx – The GlueContext class object that specifies the context for this transform (required).
  - name – The name of the resulting DynamicFrame (optional since AWS Glue 3.0).

- **toDF**

  toDF(options)

  Converts a DynamicFrame to an Apache Spark DataFrame by converting DynamicRecords into DataFrame fields. Returns the new DataFrame.

  A DynamicRecord represents a logical record in a DynamicFrame. It is similar to a row in a Spark DataFrame, except that it is self-describing and can be used for data that does not conform to a fixed schema.
• **options** – A list of options. Specify the target type if you choose the *Project* and *Cast* action type. Examples include the following.

```python
>>> toDF([ResolveOption("a.b.c", "KeepAsStruct")])
>>> toDF([ResolveOption("a.b.c", "Project", DoubleType())])
```

<table>
<thead>
<tr>
<th>— information —</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>count</strong></td>
</tr>
<tr>
<td>• <strong>schema</strong></td>
</tr>
<tr>
<td>• <strong>printSchema</strong></td>
</tr>
<tr>
<td>• <strong>show</strong></td>
</tr>
<tr>
<td>• <strong>repartition</strong></td>
</tr>
<tr>
<td>• <strong>coalesce</strong></td>
</tr>
</tbody>
</table>

**count**

`count()` – Returns the number of rows in the underlying DataFrame.

**schema**

`schematic()` – Returns the schema of this DynamicFrame, or if that is not available, the schema of the underlying DataFrame.

For more information about the DynamicFrame types that make up this schema, see the section called “Types”.

**printSchema**

`printSchema()` – Prints the schema of the underlying DataFrame.

**show**

`show(num_rows)` – Prints a specified number of rows from the underlying DataFrame.

**repartition**

`repartition(numPartitions)` – Returns a new DynamicFrame with numPartitions partitions.
coalesce

coalessce(numPartitions) – Returns a new DynamicFrame with numPartitions partitions.

--- transforms ---

- `apply_mapping`
- `drop_fields`
- `filter`
- `join`
- `map`
- `mergeDynamicFrame`
- `relationalize`
- `rename_field`
- `resolveChoice`
- `select_fields`
- `spigot`
- `split_fields`
- `split_rows`
- `unbox`
- `the section called “union”`
- `unnest`
- `unnest_ddb_json`
- `write`

apply_mapping

apply_mapping(mappings, transformation_ctx="", info="", stageThreshold=0, totalThreshold=0)

Applies a declarative mapping to a DynamicFrame and returns a new DynamicFrame with those mappings applied to the fields that you specify. Unspecified fields are omitted from the new DynamicFrame.
• mappings – A list of mapping tuples (required). Each consists of: (source column, source type, target column, target type).

If the source column has a dot "." in the name, you must place backticks "`" around it. For example, to map this.old.name (string) to thisNewName, you would use the following tuple:

```
("`this.old.name`", "string", "thisNewName", "string")
```

• transformation_ctx – A unique string that is used to identify state information (optional).

• info – A string to be associated with error reporting for this transformation (optional).

• stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

Example: Use apply_mapping to rename fields and change field types

The following code example shows how to use the apply_mapping method to rename selected fields and change field types.

```
# Example: Use apply_mapping to reshape source data into
# the desired column names and types as a new DynamicFrame

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
```

Note

To access the dataset that is used in this example, see [Code example: Joining and relationalizing data](#) and follow the instructions in [Step 1: Crawl the data in the Amazon S3 bucket](#).
# Create a DynamicFrame and view its schema
persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="persons_json"
)
print("Schema for the persons DynamicFrame:")
persons.printSchema()

# Select and rename fields, change field type
print("Schema for the persons_mapped DynamicFrame, created with apply_mapping:")
persons_mapped = persons.apply_mapping([  
    ("family_name", "String", "last_name", "String"),  
    ("name", "String", "first_name", "String"),  
    ("birth_date", "String", "date_of_birth", "Date"),  
])
persons_mapped.printSchema()

Output

Schema for the persons DynamicFrame:
root
|-- family_name: string
|-- name: string
|-- links: array
|  |-- element: struct
|  |  |-- note: string
|  |  |-- url: string
|-- gender: string
|-- image: string
|-- identifiers: array
|  |-- element: struct
|  |  |-- scheme: string
|  |  |-- identifier: string
|-- other_names: array
|  |-- element: struct
|  |  |-- lang: string
|  |  |-- note: string
|  |  |-- name: string
|-- sort_name: string
|-- images: array
| |-- element: struct
| | |-- url: string
|-- given_name: string
|-- birth_date: string
|-- id: string
|-- contact_details: array
| |-- element: struct
| | |-- type: string
| | |-- value: string
|-- death_date: string

Schema for the persons_mapped DynamicFrame, created with apply_mapping:
root
|-- last_name: string
|-- first_name: string
|-- date_of_birth: date

drop_fields

drop_fields(paths, transformation_ctx="", info="", stageThreshold=0, totalThreshold=0)

Calls the FlatMap class transform to remove fields from a DynamicFrame. Returns a new DynamicFrame with the specified fields dropped.

- paths – A list of strings. Each contains the full path to a field node that you want to drop. You can use dot notation to specify nested fields. For example, if field first is a child of field name in the tree, you specify "name.first" for the path.

  If a field node has a literal . in the name, you must enclose the name in backticks (``).

- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string to be associated with error reporting for this transformation (optional).
- stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
- totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
Example: Use drop_fields to remove fields from a DynamicFrame

This code example uses the drop_fields method to remove selected top-level and nested fields from a DynamicFrame.

Example dataset

The example uses the following dataset that is represented by the EXAMPLE-FRIENDS-DATA table in the code:

```json
{"name": "Sally", "age": 23, "location": {"state": "WY", "county": "Fremont"}, "friends": []}
{"name": "Varun", "age": 34, "location": {"state": "NE", "county": "Douglas"}, "friends": [{"name": "Arjun", "age": 3}]
{"name": "George", "age": 52, "location": {"state": "NY"}, "friends": [{"name": "Fred"}, {"name": "Amy", "age": 15}]
{"name": "Haruki", "age": 21, "location": {"state": "AK", "county": "Denali"}
{"name": "Sheila", "age": 63, "friends": [{"name": "Nancy", "age": 22}]
```

Example code

```python
# Example: Use drop_fields to remove top-level and nested fields from a DynamicFrame.
# Replace MY-EXAMPLE-DATABASE with your Glue Data Catalog database name.
# Replace EXAMPLE-FRIENDS-DATA with your table name.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Create a DynamicFrame from Glue Data Catalog
glue_source_database = "MY-EXAMPLE-DATABASE"
glue_source_table = "EXAMPLE-FRIENDS-DATA"

friends = glueContext.create_dynamic_frame.from_catalog(
    database=glue_source_database, table_name=glue_source_table
)
print("Schema for friends DynamicFrame before calling drop_fields:")
friends.printSchema()
```
# Remove location.county, remove friends.age, remove age
friends = friends.drop_fields(paths=['age', 'location.county', 'friends.age'])
print("Schema for friends DynamicFrame after removing age, county, and friend age:") friends.printSchema()

Output

Schema for friends DynamicFrame before calling drop_fields:
root
|-- name: string
|-- age: int
|-- location: struct
  |-- state: string
  |-- county: string
|-- friends: array
  |-- element: struct
  |  |-- name: string
  |  |-- age: int

Schema for friends DynamicFrame after removing age, county, and friend age:
root
|-- name: string
|-- location: struct
  |-- state: string
|-- friends: array
  |-- element: struct
  |  |-- name: string

filter

filter(f, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Returns a new DynamicFrame that contains all DynamicRecords within the input DynamicFrame that satisfy the specified predicate function f.

- f – The predicate function to apply to the DynamicFrame. The function must take a DynamicRecord as an argument and return True if the DynamicRecord meets the filter requirements, or False if not (required).
A DynamicRecord represents a logical record in a DynamicFrame. It's similar to a row in a Spark DataFrame, except that it is self-describing and can be used for data that doesn't conform to a fixed schema.

- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string to be associated with error reporting for this transformation (optional).
- stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
- totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

**Example: Use filter to get a filtered selection of fields**

This example uses the filter method to create a new DynamicFrame that includes a filtered selection of another DynamicFrame's fields.

Like the map method, filter takes a function as an argument that gets applied to each record in the original DynamicFrame. The function takes a record as an input and returns a Boolean value. If the return value is true, the record gets included in the resulting DynamicFrame. If it's false, the record is left out.

```
# Example: Use filter to create a new DynamicFrame
# with a filtered selection of records

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
```

**Note**

To access the dataset that is used in this example, see [Code example: Data preparation using ResolveChoice, Lambda, and ApplyMapping](#) and follow the instructions in **Step 1: Crawl the data in the Amazon S3 bucket.**
glueContext = GlueContext(sc)

# Create DynamicFrame from Glue Data Catalog
medicare = glueContext.create_dynamic_frame.from_options(
    "s3",
    {
        "paths": [
            "s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv"
        ],
    },
    "csv",
    {"withHeader": True},
)

# Create filtered DynamicFrame with custom lambda
# to filter records by Provider State and Provider City
sac_or_mon = medicare.filter(
    f=lambda x: x["Provider State"] in ["CA", "AL"]
    and x["Provider City"] in ["SACRAMENTO", "MONTGOMERY"]
)

# Compare record counts
print("Unfiltered record count: ", medicare.count())
print("Filtered record count: ", sac_or_mon.count())

Output

Unfiltered record count: 163065
Filtered record count: 564

join

join(paths1, paths2, frame2, transformation_ctx='", info='", stageThreshold=0, totalThreshold=0)

Performs an equality join with another DynamicFrame and returns the resulting DynamicFrame.

- paths1 – A list of the keys in this frame to join.
- paths2 – A list of the keys in the other frame to join.
- frame2 – The other DynamicFrame to join.
- transformation_ctx – A unique string that is used to identify state information (optional).
• info – A string to be associated with error reporting for this transformation (optional).

• stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

Example: Use join to combine DynamicFrames

This example uses the join method to perform a join on three DynamicFrames. AWS Glue performs the join based on the field keys that you provide. The resulting DynamicFrame contains rows from the two original frames where the specified keys match.

Note that the join transform keeps all fields intact. This means that the fields that you specify to match appear in the resulting DynamicFrame, even if they're redundant and contain the same keys. In this example, we use drop_fields to remove these redundant keys after the join.

To access the dataset that is used in this example, see Code example: Joining and relationalizing data and follow the instructions in Step 1: Crawl the data in the Amazon S3 bucket.

```python
# Example: Use join to combine data from three DynamicFrames
from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Load DynamicFrames from Glue Data Catalog
persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators",
    table_name="persons_json"
)
memberships = glueContext.create_dynamic_frame.from_catalog(
```
database="legislators", table_name="memberships_json"
)
orgs = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="organizations_json"
)
print("Schema for the persons DynamicFrame:")
persons.printSchema()
print("Schema for the memberships DynamicFrame:")
memberships.printSchema()
print("Schema for the orgs DynamicFrame:")
orgs.printSchema()

# Join persons and memberships by ID
persons_memberships = persons.join(
    paths1=["id"], paths2=["person_id"], frame2=memberships
)

# Rename and drop fields from orgs
# to prevent field name collisions with persons_memberships
orgs = (orgs.drop_fields(["other_names", "identifiers"])
    .rename_field("id", "org_id")
    .rename_field("name", "org_name")
)

# Create final join of all three DynamicFrames
legislators_combined = orgs.join(
    paths1=["org_id"], paths2=["organization_id"], frame2=persons_memberships
).drop_fields(["person_id", "org_id"])

# Inspect the schema for the joined data
print("Schema for the new legislators_combined DynamicFrame:")
legislators_combined.printSchema()

Output

Schema for the persons DynamicFrame:
root
    |-- family_name: string
    |-- name: string
    |-- links: array
    |    |-- element: struct
    |    |    |-- note: string
|    |    |-- url: string
|-- gender: string
|-- image: string
|-- identifiers: array
|    |-- element: struct
|    |    |-- scheme: string
|    |    |-- identifier: string
|-- other_names: array
|    |-- element: struct
|    |    |-- lang: string
|    |    |-- note: string
|    |    |-- name: string
|-- sort_name: string
|-- images: array
|    |-- element: struct
|    |    |-- url: string
|-- given_name: string
|-- birth_date: string
|-- id: string
|-- contact_details: array
|    |-- element: struct
|    |    |-- type: string
|    |    |-- value: string
|-- death_date: string

Schema for the memberships DynamicFrame:

root
|-- area_id: string
|-- on_behalf_of_id: string
|-- organization_id: string
|-- role: string
|-- person_id: string
|-- legislative_period_id: string
|-- start_date: string
|-- end_date: string

Schema for the orgs DynamicFrame:

root
|-- identifiers: array
|    |-- element: struct
|    |    |-- scheme: string
|    |    |-- identifier: string
|    |    |-- other_names: array
|    |    |-- element: struct
Schema for the new legislators_combined DynamicFrame:
root
|-- role: string
|-- seats: int
|-- org_name: string
|-- links: array
| |-- element: struct
| | |-- note: string
| | |-- url: string
|-- type: string
|-- sort_name: string
|-- area_id: string
|-- images: array
| |-- element: struct
| | |-- url: string
|-- on_behalf_of_id: string
|-- other_names: array
| |-- element: struct
| | |-- note: string
| | |-- name: string
| | |-- lang: string
|-- contact_details: array
| |-- element: struct
| | |-- type: string
| | |-- value: string
|-- name: string
|-- birth_date: string
|-- organization_id: string
|-- gender: string
|-- classification: string
map

map(f, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Returns a new DynamicFrame that results from applying the specified mapping function to all records in the original DynamicFrame.

- **f** – The mapping function to apply to all records in the DynamicFrame. The function must take a DynamicRecord as an argument and return a new DynamicRecord (required).

  A DynamicRecord represents a logical record in a DynamicFrame. It's similar to a row in an Apache Spark DataFrame, except that it is self-describing and can be used for data that doesn't conform to a fixed schema.

- **transformation_ctx** – A unique string that is used to identify state information (optional).

- **info** – A string that is associated with errors in the transformation (optional).

- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.

- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

**Example: Use map to apply a function to every record in a DynamicFrame**

This example shows how to use the map method to apply a function to every record of a DynamicFrame. Specifically, this example applies a function called MergeAddress to each record in order to merge several address fields into a single struct type.
## ETL in PySpark

```python
# Example: Use map to combine fields in all records
# of a DynamicFrame

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Create a DynamicFrame and view its schema
medicare = glueContext.create_dynamic_frame.from_options(
    "s3",
    {"paths": ["s3://awsglue-datasets/examples/medicare/Medicare_Hospital_Provider.csv"],
    "csv",
    "{"withHeader": True}})
print("Schema for medicare DynamicFrame:")
medicare.printSchema()

# Define a function to supply to the map transform
# that merges address fields into a single field
def MergeAddress(rec):
    rec["Address"] = {}
    rec["Address"]['Street'] = rec['Provider Street Address']
    rec["Address"]['City'] = rec['Provider City']
    rec["Address"]['State'] = rec['Provider State']
    rec["Address"]['Zip.Code'] = rec['Provider Zip Code']
    rec["Address"]["Array"] = [rec["Provider Street Address"], rec['Provider City'],
                                rec['Provider State'], rec['Provider Zip Code']]  
    del rec['Provider Street Address']
    del rec['Provider City']
    del rec['Provider State']
    del rec['Provider Zip Code']
    return rec
```
# Use map to apply MergeAddress to every record
mapped_medicare = medicare.map(f = MergeAddress)
print("Schema for mapped_medicare DynamicFrame:")
mapped_medicare.printSchema()

Output

Schema for medicare DynamicFrame:
root
|-- DRG Definition: string
|-- Provider Id: string
|-- Provider Name: string
|-- Provider Street Address: string
|-- Provider City: string
|-- Provider State: string
|-- Provider Zip Code: string
|-- Hospital Referral Region Description: string
|-- Total Discharges: string
|-- Average Covered Charges: string
|-- Average Total Payments: string
|-- Average Medicare Payments: string

Schema for mapped_medicare DynamicFrame:
root
|-- Average Total Payments: string
|-- Average Covered Charges: string
|-- DRG Definition: string
|-- Average Medicare Payments: string
|-- Hospital Referral Region Description: string
|-- Address: struct
|   |-- Zip.Code: string
|   |-- City: string
|   |-- Array: array
|   |   |-- element: string
|   |   |-- State: string
|   |   |-- Street: string
|   |-- Provider Id: string
|   |-- Total Discharges: string
|   |-- Provider Name: string
mergeDynamicFrame

mergeDynamicFrame(stage_dynamic_frame, primary_keys, transformation_ctx = "", options = {}, info = "", stageThreshold = 0, totalThreshold = 0)

Merges this DynamicFrame with a staging DynamicFrame based on the specified primary keys to identify records. Duplicate records (records with the same primary keys) are not deduplicated. If there is no matching record in the staging frame, all records (including duplicates) are retained from the source. If the staging frame has matching records, the records from the staging frame overwrite the records in the source in AWS Glue.

- stage_dynamic_frame – The staging DynamicFrame to merge.
- primary_keys – The list of primary key fields to match records from the source and staging dynamic frames.
- transformation_ctx – A unique string that is used to retrieve metadata about the current transformation (optional).
- options – A string of JSON name-value pairs that provide additional information for this transformation. This argument is not currently used.
- info – A String. Any string to be associated with errors in this transformation.
- stageThreshold – A Long. The number of errors in the given transformation for which the processing needs to error out.
- totalThreshold – A Long. The total number of errors up to and including this transformation for which the processing needs to error out.

This method returns a new DynamicFrame that is obtained by merging this DynamicFrame with the staging DynamicFrame.

The returned DynamicFrame contains record A in these cases:

- If A exists in both the source frame and the staging frame, then A in the staging frame is returned.
- If A is in the source table and A.primaryKeys is not in the stagingDynamicFrame, A is not updated in the staging table.

The source frame and staging frame don't need to have the same schema.
Example: Use mergeDynamicFrame to merge two DynamicFrames based on a primary key

The following code example shows how to use the mergeDynamicFrame method to merge a DynamicFrame with a "staging" DynamicFrame, based on the primary key id.

Example dataset

The example uses two DynamicFrames from a DynamicFrameCollection called split_rows_collection. The following is the list of keys in split_rows_collection.

```python
dict_keys(['high', 'low'])
```

Example code

```python
# Example: Use mergeDynamicFrame to merge DynamicFrames
# based on a set of specified primary keys

from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.transforms import SelectFromCollection

# Inspect the original DynamicFrames
frame_low = SelectFromCollection.apply(dfc=split_rows_collection, key="low")
print("Inspect the DynamicFrame that contains rows where ID < 10")
frame_low.toDF().show()

frame_high = SelectFromCollection.apply(dfc=split_rows_collection, key="high")
print("Inspect the DynamicFrame that contains rows where ID > 10")
frame_high.toDF().show()

# Merge the DynamicFrames based on the "id" primary key
merged_high_low = frame_high.mergeDynamicFrame(
    stage_dynamic_frame=frame_low, primary_keys=['id'])

# View the results where the ID is 1 or 20
print("Inspect the merged DynamicFrame that contains the combined rows")
merged_high_low.toDF().where("id = 1 or id= 20").orderBy("id").show()
```

Output

```
Inspect the DynamicFrame that contains rows where ID < 10
+---------+------------------------+-------------------------+
```

---
<table>
<thead>
<tr>
<th>id</th>
<th>index</th>
<th>contact_details.val.type</th>
<th>contact_details.val.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>fax</td>
<td>202-225-3307</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>phone</td>
<td>202-225-5731</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
</tbody>
</table>

only showing top 20 rows

Inspect the DataFrame that contains rows where ID > 10

<table>
<thead>
<tr>
<th>id</th>
<th>index</th>
<th>contact_details.val.type</th>
<th>contact_details.val.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
</tbody>
</table>
relationalize

relationalize(root_table_name, staging_path, options, 
transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Converts a DynamicFrame into a form that fits within a relational database. Relationalizing a 
DynamicFrame is especially useful when you want to move data from a NoSQL environment like 
DynamoDB into a relational database like MySQL.

The transform generates a list of frames by unnesting nested columns and pivoting array columns. 
You can join the pivoted array columns to the root table by using the join key that is generated 
during the unnest phase.

- root_table_name – The name for the root table.
- staging_path – The path where the method can store partitions of pivoted tables in CSV 
  format (optional). Pivoted tables are read back from this path.
- options – A dictionary of optional parameters.
- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string to be associated with error reporting for this transformation (optional).
• **stageThreshold** – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• **totalThreshold** – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

**Example: Use relationalize to flatten a nested schema in a DynamicFrame**

This code example uses the `relationalize` method to flatten a nested schema into a form that fits into a relational database.

**Example dataset**

The example uses a DynamicFrame called `legislators_combined` with the following schema. `legislators_combined` has multiple nested fields such as `links`, `images`, and `contact_details`, which will be flattened by the `relationalize` transform.

```python
root
|-- role: string
|-- seats: int
|-- org_name: string
|-- links: array
 | |-- element: struct
 |    |   |-- note: string
 |   |   |-- url: string
|-- type: string
|-- sort_name: string
|-- area_id: string
|-- images: array
 | |-- element: struct
 |    |   |-- url: string
|-- on_behalf_of_id: string
|-- other_names: array
 | |-- element: struct
 |    |   |-- note: string
 |   |   |-- name: string
 |   |   |-- lang: string
|-- contact_details: array
 | |-- element: struct
 |    |   |-- type: string
```
Example code

```python
# Example: Use relationalize to flatten
# a nested schema into a format that fits
# into a relational database.
# Replace DOC-EXAMPLE-S3-BUCKET/tmpDir with your own location.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Apply relationalize and inspect new tables
legislators_relationalized = legislators_combined.relationalize(
    "l_root", "s3://DOC-EXAMPLE-BUCKET/tmpDir"
)
legislators_relationalized.keys()

# Compare the schema of the contact_details
# nested field to the new relationalized table that
# represents it
legislators_combined.select_fields("contact_details").printSchema()
```
```scala
legislators_relationalized.select("l_root_contact_details").toDF().where(
  "id = 10 or id = 75"
).orderBy(['"id", "index"']).show()
```

Output

The following output lets you compare the schema of the nested field called `contact_details` to the table that the `relationalize` transform created. Notice that the table records link back to the main table using a foreign key called `id` and an `index` column that represents the positions of the array.

```python
dict_keys(['l_root', 'l_root_images', 'l_root_links', 'l_root_other_names', 'l_root_contact_details', 'l_root_identifiers'])
```

```json
root
  |-- contact_details: array
  |    |-- element: struct
  |    |    |-- type: string
  |    |    |-- value: string
```

```
+---+-----+------------------------+-------------------------+
| id|index|contact_details.val.type|contact_details.val.value|
+---+-----+------------------------+-------------------------+
| 10|    0|                     fax|             202-225-4160|
| 10|    1|                   phone|             202-225-3436|
| 75|    0|                     fax|             202-225-6791|
| 75|    1|                   phone|             202-225-2861|
| 75|    2|                 twitter|               RepSamFarr|
```

`rename_field`

```python
rename_field(oldName, newName, transformation_ctx='', info='',
stageThreshold=0, totalThreshold=0)
```

Renames a field in this DynamicFrame and returns a new DynamicFrame with the field renamed.

- **oldName** – The full path to the node you want to rename.

  If the old name has dots in it, RenameField doesn't work unless you place backticks around it (`\`). For example, to replace this.old.name with thisNewName, you would call rename_field as follows.
newDyF = oldDyF.rename_field("`this.old.name`", "thisNewName")

- **newName** – The new name, as a full path.
- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string to be associated with error reporting for this transformation (optional).
- **stageThreshold** – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
- **totalThreshold** – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

**Example: Use rename_field to rename fields in a DynamicFrame**

This code example uses the `rename_field` method to rename fields in a `DynamicFrame`. Notice that the example uses method chaining to rename multiple fields at the same time.

**Note**

To access the dataset that is used in this example, see [Code example: Joining and relationalizing data](#) and follow the instructions in [Step 1: Crawl the data in the Amazon S3 bucket](#).

**Example code**

```python
# Example: Use rename_field to rename fields
# in a DynamicFrame

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Inspect the original orgs schema
orgs = glueContext.create_dynamic_frame.from_catalog(
```

```python
database="legislators", table_name="organizations_json"
)
print("Original orgs schema: ")
orgs.printSchema()

# Rename fields and view the new schema
orgs = orgs.rename_field("id", "org_id").rename_field("name", "org_name")
print("New orgs schema with renamed fields: ")
orgs.printSchema()
```

**Output**

Original orgs schema:
```
root
|-- identifiers: array
| | |-- element: struct
| | | |-- scheme: string
| | | |-- identifier: string
|-- other_names: array
| | |-- element: struct
| | | |-- lang: string
| | | |-- note: string
| | | |-- name: string
|-- id: string
|-- classification: string
|-- name: string
|-- links: array
| | |-- element: struct
| | | |-- note: string
| | | |-- url: string
|-- image: string
|-- seats: int
|-- type: string
```

New orgs schema with renamed fields:
```
root
|-- identifiers: array
| | |-- element: struct
| | | |-- scheme: string
| | | |-- identifier: string
|-- other_names: array
| | |-- element: struct
| | | |-- lang: string
```
resolveChoice

```python
resolveChoice(specs = None, choice = "", database = None, table_name = None, transformation_ctx="", info="", stageThreshold=0, totalThreshold=0, catalog_id = None)
```

Resolves a choice type within this DynamicFrame and returns the new DynamicFrame.

- **specs** – A list of specific ambiguities to resolve, each in the form of a tuple: (field_path, action).

There are two ways to use `resolveChoice`. The first is to use the `specs` argument to specify a sequence of specific fields and how to resolve them. The other mode for `resolveChoice` is to use the `choice` argument to specify a single resolution for all ChoiceTypes.

Values for `specs` are specified as tuples made up of (field_path, action) pairs. The field_path value identifies a specific ambiguous element, and the action value identifies the corresponding resolution. The following are the possible actions:

- **cast**: `type` – Attempts to cast all values to the specified type. For example: `cast:int`.

- **make_cols** – Converts each distinct type to a column with the name `columnName_type`. It resolves a potential ambiguity by flattening the data. For example, if `columnA` could be an `int` or a `string`, the resolution would be to produce two columns named `columnA_int` and `columnA_string` in the resulting DynamicFrame.

- **make_struct** – Resolves a potential ambiguity by using a struct to represent the data. For example, if data in a column could be an `int` or a `string`, the `make_struct` action produces
a column of structures in the resulting DataFrame. Each structure contains both an int and a string.

- **project:** type – Resolves a potential ambiguity by projecting all the data to one of the possible data types. For example, if data in a column could be an int or a string, using a `project:string` action produces a column in the resulting DataFrame where all the int values have been converted to strings.

If the field path identifies an array, place empty square brackets after the name of the array to avoid ambiguity. For example, suppose you are working with data structured as follows:

```python
"myList": [
    { "price": 100.00 },
    { "price": "$100.00" }
]
```

You can select the numeric rather than the string version of the price by setting the field_path to "myList[].price", and setting the action to "cast:double".

### Note

You can only use one of the specs and choice parameters. If the specs parameter is not None, then the choice parameter must be an empty string. Conversely, if the choice is not an empty string, then the specs parameter must be None.

- **choice** – Specifies a single resolution for all ChoiceTypes. You can use this in cases where the complete list of ChoiceTypes is unknown before runtime. In addition to the actions listed previously for specs, this argument also supports the following action:
  - **match_catalog** – Attempts to cast each ChoiceType to the corresponding type in the specified Data Catalog table.

- **database** – The Data Catalog database to use with the match_catalog action.
- **table_name** – The Data Catalog table to use with the match_catalog action.
- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string to be associated with error reporting for this transformation (optional).
- **stageThreshold** – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
• totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• catalog_id – The catalog ID of the Data Catalog being accessed (the account ID of the Data Catalog). When set to None (default value), it uses the catalog ID of the calling account.

Example: Use resolveChoice to handle a column that contains multiple types

This code example uses the resolveChoice method to specify how to handle a DynamicFrame column that contains values of multiple types. The example demonstrates two common ways to handle a column with different types:

• Cast the column to a single data type.
• Retain all types in separate columns.

Example dataset

Note

To access the dataset that is used in this example, see Code example: Data preparation using ResolveChoice, Lambda, and ApplyMapping and follow the instructions in Step 1: Crawl the data in the Amazon S3 bucket.

The example uses a DynamicFrame called medicare with the following schema:

```
root
 |-- drg definition: string
 |-- provider id: choice
  |  |-- long
  |  |-- string
 |-- provider name: string
 |-- provider street address: string
 |-- provider city: string
 |-- provider state: string
 |-- provider zip code: long
 |-- hospital referral region description: string
 |-- total discharges: long
 |-- average covered charges: string
```
Example code

```python
# Example: Use resolveChoice to handle
# a column that contains multiple types

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Load the input data and inspect the "provider id" column
medicare = glueContext.create_dynamic_frame.from_catalog(
    database="payments", table_name="medicare_hospital_provider_csv"
)
print("Inspect the provider id column:")
medicare.toDF().select("provider id").show()

# Cast provider id to type long
medicare_resolved_long = medicare.resolveChoice(specs=[("provider id", "cast:long")])
print("Schema after casting provider id to type long:")
medicare_resolved_long.printSchema()
medicare_resolved_long.toDF().select("provider id").show()

# Create separate columns
# for each provider id type
medicare_resolved_cols = medicare.resolveChoice(choice="make_cols")
print("Schema after creating separate columns for each type:")
medicare_resolved_cols.printSchema()
medicare_resolved_cols.toDF().select("provider id_long", "provider id_string").show()
```

Output

Inspect the 'provider id' column:

```
+-----------+
| provider id|
+-----------+
| [10001,]  |
| [10005,]  |
```
<table>
<thead>
<tr>
<th>provider id</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
</tr>
<tr>
<td>10005</td>
</tr>
<tr>
<td>10006</td>
</tr>
<tr>
<td>10010</td>
</tr>
<tr>
<td>10011</td>
</tr>
</tbody>
</table>

---

Schema after casting 'provider id' to type long:

```
root
|-- drg definition: string
|-- provider id: long
|-- provider name: string
|-- provider street address: string
|-- provider city: string
|-- provider state: string
|-- provider zip code: long
|-- hospital referral region description: string
|-- total discharges: long
|-- average covered charges: string
|-- average total payments: string
|-- average medicare payments: string
```
Schema after creating separate columns for each type:

root
|-- drg definition: string
|-- provider id_string: string
|-- provider id_long: long
|-- provider name: string
|-- provider street address: string
|-- provider city: string
|-- provider state: string
|-- provider zip code: long
|-- hospital referral region description: string
|-- total discharges: long
|-- average covered charges: string
|-- average total payments: string
|-- average medicare payments: string

only showing top 20 rows

| provider id_long | provider id_string |
|----------------+------------------|
|           10001|              null|
|           10005|              null|
|           10006|              null|
|           10011|              null|
|           10016|              null|
|           10023|              null|
|           10029|              null|
select_fields

select_fields(paths, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Returns a new DynamicFrame that contains the selected fields.

- paths – A list of strings. Each string is a path to a top-level node that you want to select.
- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string to be associated with error reporting for this transformation (optional).
- stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
- totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

Example: Use select_fields to create a new DynamicFrame with chosen fields

The following code example shows how to use the select_fields method to create a new DynamicFrame with a chosen list of fields from an existing DynamicFrame.
# Example: Use select_fields to select specific fields from a DynamicFrame

```python
from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Create a DynamicFrame and view its schema
persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="persons_json"
)
print("Schema for the persons DynamicFrame:")
persons.printSchema()

# Create a new DynamicFrame with chosen fields
names = persons.select_fields(paths=['family_name', 'given_name'])
print("Schema for the names DynamicFrame, created with select_fields:")
names.printSchema()
names.toDF().show()
```

**Output**

```
Schema for the persons DynamicFrame:
root
 |-- family_name: string
 |-- name: string
 |-- links: array
  |-- element: struct
  |    |-- note: string
  |    |-- url: string
 |-- gender: string
 |-- image: string
 |-- identifiers: array
```
Schema for the names DynamicFrame:

```
root
|-- family_name: string
|-- given_name: string
```

<table>
<thead>
<tr>
<th>family_name</th>
<th>given_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collins</td>
<td>Michael</td>
</tr>
<tr>
<td>Huizenga</td>
<td>Bill</td>
</tr>
<tr>
<td>Clawson</td>
<td>Curtis</td>
</tr>
<tr>
<td>Solomon</td>
<td>Gerald</td>
</tr>
<tr>
<td>Rigell</td>
<td>Edward</td>
</tr>
<tr>
<td>Crapo</td>
<td>Michael</td>
</tr>
<tr>
<td>Hutto</td>
<td>Earl</td>
</tr>
<tr>
<td>Ertel</td>
<td>Allen</td>
</tr>
<tr>
<td>Minish</td>
<td>Joseph</td>
</tr>
<tr>
<td>Andrews</td>
<td>Robert</td>
</tr>
<tr>
<td>Walden</td>
<td>Greg</td>
</tr>
<tr>
<td>Kazen</td>
<td>Abraham</td>
</tr>
<tr>
<td>Turner</td>
<td>Michael</td>
</tr>
<tr>
<td>Kolbe</td>
<td>James</td>
</tr>
<tr>
<td>Lowenthal</td>
<td>Alan</td>
</tr>
</tbody>
</table>
spigot

`spigot(path, options={})`

Writes sample records to a specified destination to help you verify the transformations performed by your job.

- **path** – The path of the destination to write to (required).
- **options** – Key-value pairs that specify options (optional). The "topk" option specifies that the first k records should be written. The "prob" option specifies the probability (as a decimal) of choosing any given record. You can use it in selecting records to write.
- **transformation_ctx** – A unique string that is used to identify state information (optional).

**Example: Use spigot to write sample fields from a DynamicFrame to Amazon S3**

This code example uses the `spigot` method to write sample records to an Amazon S3 bucket after applying the `select_fields` transform.

**Example dataset**

Note

To access the dataset that is used in this example, see [Code example: Joining and relationalizing data](#) and follow the instructions in Step 1: Crawl the data in the Amazon S3 bucket.

The example uses a DynamicFrame called `persons` with the following schema:

```
root
 |-- family_name: string
```
Example code

# Example: Use spigot to write sample records
to a destination during a transformation
# from pyspark.context import SparkContext.
# Replace DOC-EXAMPLE-BUCKET with your own location.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
# Load table data into a DynamicFrame
persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="persons_json"
)

# Perform the select_fields on the DynamicFrame
persons = persons.select_fields(paths=['family_name', 'given_name', 'birth_date'])

# Use spigot to write a sample of the transformed data
# (the first 10 records)
spigot_output = persons.spigot(
    path="s3://DOC-EXAMPLE-BUCKET", options={'topk': 10}
)

Output

The following is an example of the data that spigot writes to Amazon S3. Because the example code specified options={'topk': 10}, the sample data contains the first 10 records.

```json
"family_name":"Collins","given_name":"Michael","birth_date":"1944-10-15"}
{"family_name":"Huizenga","given_name":"Bill","birth_date":"1969-01-31"}
{"family_name":"Clawson","given_name":"Curtis","birth_date":"1959-09-28"}
{"family_name":"Solomon","given_name":"Gerald","birth_date":"1930-08-14"}
{"family_name":"Rigell","given_name":"Edward","birth_date":"1960-05-28"}
{"family_name":"Crapo","given_name":"Michael","birth_date":"1951-05-20"}
{"family_name":"Hutto","given_name":"Earl","birth_date":"1926-05-12"}
{"family_name":"Ertel","given_name":"Allen","birth_date":"1937-11-07"}
{"family_name":"Minish","given_name":"Joseph","birth_date":"1916-09-01"}
{"family_name":"Andrews","given_name":"Robert","birth_date":"1957-08-04"}
```

split_fields

split_fields(paths, name1, name2, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Returns a new DynamicFrameCollection that contains two DynamicFrames. The first DynamicFrame contains all the nodes that have been split off, and the second contains the nodes that remain.

- paths – A list of strings, each of which is a full path to a node that you want to split into a new DynamicFrame.
- name1 – A name string for the DynamicFrame that is split off.
- name2 – A name string for the DynamicFrame that remains after the specified nodes have been split off.
- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string to be associated with error reporting for this transformation (optional).
- stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
- totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

**Example: Use split_fields to split selected fields into a separate DynamicFrame**

This code example uses the `split_fields` method to split a list of specified fields into a separate DynamicFrame.

**Example dataset**

The example uses a DynamicFrame called `l_root_contact_details` that is from a collection named `legislators_relationalized`.

`l_root_contact_details` has the following schema and entries.

```
root
|-- id: long
|-- index: int
|-- contact_details.val.type: string
|-- contact_details.val.value: string

+--------+------------------------+-------------------------+
| id | index | contact_details.val.type | contact_details.val.value |
+--------+------------------------+-------------------------+
| 1 | 0 | phone | 202-225-5265 |
| 1 | 1 | twitter | kathyhochul |
| 2 | 0 | phone | 202-225-3252 |
| 2 | 1 | twitter | repjackyrosen |
| 3 | 0 | fax | 202-225-1314 |
```
Example code

```python
# Example: Use split_fields to split selected
# fields into a separate DynamicFrame

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Load the input DynamicFrame and inspect its schema
frame_to_split = legislators_relationalized.select("l_root_contact_details")
print("Inspect the input DynamicFrame schema:")
frame_to_split.printSchema()

# Split id and index fields into a separate DynamicFrame
split_fields_collection = frame_to_split.split_fields(["id", "index"], "left", "right")

# Inspect the resulting DynamicFrames
print("Inspect the schemas of the DynamicFrames created with split_fields:")
split_fields_collection.select("left").printSchema()
split_fields_collection.select("right").printSchema()
```

Output

```
Inspect the input DynamicFrame's schema:
root
 |-- id: long
 |-- index: int
 |-- contact_details.val.type: string
 |-- contact_details.val.value: string

Inspect the schemas of the DynamicFrames created with split_fields:
root
 |-- id: long
 |-- index: int
```

ETL in PySpark
split_rows

split_rows(comparison_dict, name1, name2, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)

Splits one or more rows in a DynamicFrame off into a new DynamicFrame.

The method returns a new DataFrameCollection that contains two DataFrames. The first DataFrame contains all the rows that have been split off, and the second contains the rows that remain.

• comparison_dict – A dictionary where the key is a path to a column, and the value is another dictionary for mapping comparators to values that the column values are compared to. For example, {"age": {">": 10, "<": 20}} splits off all rows whose value in the age column is greater than 10 and less than 20.
• name1 – A name string for the DataFrame that is split off.
• name2 – A name string for the DataFrame that remains after the specified nodes have been split off.
• transformation_ctx – A unique string that is used to identify state information (optional).
• info – A string to be associated with error reporting for this transformation (optional).
• stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
• totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

Example: Use split_rows to split rows in a DataFrame

This code example uses the split_rows method to split rows in a DataFrame based on the id field value.

Example dataset
The example uses a DynamicFrame called `l_root_contact_details` that is selected from a collection named `legislators_relationalized`.

`l_root_contact_details` has the following schema and entries.

```
root
|-- id: long
|-- index: int
|-- contact_details.val.type: string
|-- contact_details.val.value: string

+-----+------------------------+-------------------------+
| id | index | contact_details.val.type | contact_details.val.value |
+-----+------------------------+-------------------------+
|  1 |    0 | phone                   | 202-225-5265            |
|  1 |    1 | twitter                 | kathyhochul             |
|  2 |    0 | phone                   | 202-225-3252            |
|  2 |    1 | twitter                 | repjackyrosen           |
|  3 |    0 | fax                     | 202-225-1314            |
|  3 |    1 | phone                   | 202-225-3772            |
|  3 |    2 | twitter                 | MikeRossUpdates         |
|  4 |    0 | fax                     | 202-225-1314            |
|  4 |    1 | phone                   | 202-225-3772            |
|  4 |    2 | twitter                 | MikeRoss Updates        |
|  5 |    0 | fax                     | 202-225-1314            |
|  5 |    1 | phone                   | 202-225-3772            |
|  5 |    2 | twitter                 | MikeRossUpdates         |
|  6 |    0 | fax                     | 202-225-1314            |
|  6 |    1 | phone                   | 202-225-3772            |
|  6 |    2 | twitter                 | MikeRossUpdates         |
|  7 |    0 | fax                     | 202-225-1314            |
|  7 |    1 | phone                   | 202-225-3772            |
|  7 |    2 | twitter                 | MikeRossUpdates         |
|  8 |    0 | fax                     | 202-225-1314            |
+-----+------------------------+-------------------------+
```

**Example code**

```python
# Example: Use split_rows to split up
# rows in a DynamicFrame based on value

from pyspark.context import SparkContext
from awsglue.context import GlueContext
```
# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Retrieve the DynamicFrame to split
frame_to_split = legislators_relationalized.select("l_root_contact_details")

# Split up rows by ID
split_rows_collection = frame_to_split.split_rows({"id": {">": 10}}, "high", "low")

# Inspect the resulting DynamicFrames
print("Inspect the DynamicFrame that contains IDs < 10")
split_rows_collection.select("low").toDF().show()
print("Inspect the DynamicFrame that contains IDs > 10")
split_rows_collection.select("high").toDF().show()
AWS Glue

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+---+-----+------------------------+-------------------------+
only showing top 20 rows
Inspect the DynamicFrame that contains IDs > 10
+---+-----+------------------------+-------------------------+
| id|index|contact_details.val.type|contact_details.val.value|
+---+-----+------------------------+-------------------------+
| 11|
0|
phone|
202-225-5476|
| 11|
1|
twitter|
RepDavidYoung|
| 12|
0|
phone|
202-225-4035|
| 12|
1|
twitter|
RepStephMurphy|
| 13|
0|
fax|
202-226-0774|
| 13|
1|
phone|
202-225-6335|
| 14|
0|
fax|
202-226-0774|
| 14|
1|
phone|
202-225-6335|
| 15|
0|
fax|
202-226-0774|
| 15|
1|
phone|
202-225-6335|
| 16|
0|
fax|
202-226-0774|
| 16|
1|
phone|
202-225-6335|
| 17|
0|
fax|
202-226-0774|
| 17|
1|
phone|
202-225-6335|
| 18|
0|
fax|
202-226-0774|
| 18|
1|
phone|
202-225-6335|
| 19|
0|
fax|
202-226-0774|
| 19|
1|
phone|
202-225-6335|
| 20|
0|
fax|
202-226-0774|
| 20|
1|
phone|
202-225-6335|
+---+-----+------------------------+-------------------------+
only showing top 20 rows

unbox
unbox(path, format, transformation_ctx="", info="", stageThreshold=0,
totalThreshold=0, **options)
Unboxes (reformats) a string ﬁeld in a DynamicFrame and returns a new DynamicFrame that
contains the unboxed DynamicRecords.
A DynamicRecord represents a logical record in a DynamicFrame. It's similar to a row in an
Apache Spark DataFrame, except that it is self-describing and can be used for data that doesn't
conform to a ﬁxed schema.
ETL in PySpark

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• path – A full path to the string node you want to unbox.

• format – A format specification (optional). You use this for an Amazon S3 or AWS Glue connection that supports multiple formats. For the formats that are supported, see Data format options for inputs and outputs in AWS Glue for Spark.

• transformation_ctx – A unique string that is used to identify state information (optional).

• info – A string to be associated with error reporting for this transformation (optional).

• stageThreshold – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• totalThreshold – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

• options – One or more of the following:
  • separator – A string that contains the separator character.
  • escaper – A string that contains the escape character.
  • skipFirst – A Boolean value that indicates whether to skip the first instance.
  • withSchema – A string containing a JSON representation of the node's schema. The format of a schema's JSON representation is defined by the output of StructType.json().
  • withHeader – A Boolean value that indicates whether a header is included.

Example: Use unbox to unbox a string field into a struct

This code example uses the unbox method to unbox, or reformat, a string field in a DynamicFrame into a field of type struct.

Example dataset

The example uses a DynamicFrame called mapped_with_string with the following schema and entries.

Notice the field named AddressString. This is the field that the example unboxes into a struct.

```
root
 |-- Average Total Payments: string
 |-- AddressString: string
 |-- Average Covered Charges: string
```
Example code

# Example: Use unbox to unbox a string field
# into a struct in a DynamicFrame
from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

unboxed = mapped_with_string.unbox("AddressString", "json")
unboxed.printSchema()
unboxed.toDF().show()

Output

root
|-- Average Total Payments: string
| |-- AddressString: struct
|   |-- Street: string
|   |-- City: string
|   |-- State: string
|   |-- Zip.Code: string
|   |-- Array: array
|   |   |-- element: string
||-- Average Covered Charges: string
|-- DRG Definition: string
|-- Average Medicare Payments: string
|-- Hospital Referral Region Description: string
|-- Address: struct
|   |-- Zip.Code: string
|   |-- City: string
|   |-- Array: array
|   |   |-- element: string
|   |-- State: string
|   |-- Street: string
|-- Provider Id: string
|-- Total Discharges: string
|-- Provider Name: string

+---------------------+----------------------+-------------------------+--------------------+
|Average Total Payments| AddressString |Average Covered Charges| DRG Definition |
|Average Medicare Payments| Hospital Referral Region Description |
|Address|Provider Id|Total Discharges|Provider Name |

ETL in PySpark
| $5777.24| [1108 ROSS CLARK ...| $32963.07| [3601, DOthan] |
| EXTRACRANIA...| $4763.73| AL - Dothan|
| DOTHAN, [ ... | 10001| 91| SOUTHEAST ALABAMA... |
| $5787.57| [2505 U S HIGHWAY...| $15131.85| [36039 - |
| EXTRACRANIA...| $4976.71| AL - Birmingham|
| BOAZ, [25 ...| 10005| 14| MARSHALL MEDICAL ... |
| $5434.95| [205 MARENGO STRE...| $37560.37| [36039 - |
| EXTRACRANIA...| $4453.79| AL - Birmingham|
| FLORENCE,... | 10006| 24| ELIZA COFFEE MEMO... |
| $5417.56| [50 MEDICAL PARK ...| $13998.28| [36039 - |
| EXTRACRANIA...| $4129.16| AL - Birmingham|
| BIRMINGHA... | 10011| 25| ST VINCENT'S EAST |
| $5658.33| [1000 FIRST STREE...| $31633.27| [36007, |
| EXTRACRANIA...| $4851.44| AL - Birmingham|
| ALABASTER... | 10016| 18| SHELBY BAPTIST ME... |
| $6653.80| [2105 EAST SOUTH ...| $16920.79| [36007, |
| EXTRACRANIA...| $5374.14| AL - Montgomery|
| MONTGOMER... | 10023| 67| BAPTIST MEDICAL C... |
| $534.74| [2000 PEPPERELL P...| $11977.13| [36007, |
| EXTRACRANIA...| $4761.41| AL - Birmingham|
| OPELIA, ... | 100029| 51| EAST ALABAMA MEDI... |
| $8031.12| [619 SOUTH 19TH S...| $35841.09| [36007, |
| EXTRACRANIA...| $5858.50| AL - Birmingham|
| BIRMINGHA... | 10033| 32| UNIVERSITY OF ALA... |
| $6113.38| [101 SIVLEY RD, H...| $28523.39| [36007, |
| EXTRACRANIA...| $5228.40| AL - Huntsville|
| HUNTSVILL... | 10039| 135| HUNTSVILLE HOSPITAL |
| $5541.05| [1007 GOODYEAR AV...| $75233.38| [36007, |
| EXTRACRANIA...| $4386.94| AL - Birmingham|
| GADSDEN, ... | 10040| 34| GADSDEN REGIONAL ... |
| $5461.57| [600 SOUTH THIRD ...| $67327.92| [36007, |
| EXTRACRANIA...| $4408.57| AL - Birmingham|
| GADSDEN, ... | 10046| 14| RIVERVIEW REGIONA... |
| $5365.28| [4370 WEST MAIN S...| $39607.28| [36007, |
| EXTRACRANIA...| $4408.20| AL - Dothan|
| DOthan, [ ...| 10055| 45| FLOWERS HOSPITAL |
| $5374.65| [810 ST VINCENT'S...| $22862.23| [36007, |
| EXTRACRANIA...| $4186.02| AL - Birmingham|
| BIRMINGHA... | 10056| 43| ST VINCENT'S BIRM... |
| EXTRACRANIA... | $5366.23 | [400 EAST 10TH ST... | $31110.85 | 039 - AL - Birmingham| [36207, ANNISTON,... | 10078 | 21| NORTHEAST ALABAMA... |
| EXTRACRANIA... | $5282.93 | [1613 NORTH MCKEN... | $25411.33 | 039 - AL - Mobile| [36535, FOLEY, [1... | 10083 | 15| SOUTH BALDWIN REG... |
| EXTRACRANIA... | $5676.55 | [1201 7TH STREET ... | $9234.51 | 039 - AL - Huntsville| [35609, DECatur, ... | 10085 | 27| DECatur GENERAL H... |
| EXTRACRANIA... | $5930.11 | [6801 AIRPORT BOU... | $15895.85 | 039 - AL - Mobile| [36680, MOBILE, [... | 10090 | 27| PROVIDENCE HOSPITAL |
| EXTRACRANIA... | $6192.54 | [809 UNIVERSITY B... | $19721.16 | 039 - AL - Tuscaloosa| [35401, TUSCALOOS... | 10092 | 31| D C H REGIONAL ME... |
| EXTRACRANIA... | $4968.00 | [750 MORPHY AVENU... | $10710.88 | 039 - AL - Mobile| [36532, FAIRHOPE,... | 10100 | 18| THOMAS HOSPITAL |
| EXTRACRANIA... | $5996.00 | [701 PRINCETON AV... | $51343.75 | 039 - AL - Birmingham| [35211, BIRMINGHA... | 10103 | 33| BAPTIST MEDICAL C... |

union

union(frame1, frame2, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold = 0)

Union two DynamicFrames. Returns DynamicFrame containing all records from both input DynamicFrames. This transform may return different results from the union of two DataFrames with equivalent data. If you need the Spark DataFrame union behavior, consider using toDF.

- frame1 – First DynamicFrame to union.
- frame2 – Second DynamicFrame to union.
- transformation_ctx – (optional) A unique string that is used to identify stats / state information
- info – (optional) Any string to be associated with errors in the transformation
• `stageThreshold` – (optional) Max number of errors in the transformation until processing will error out
• `totalThreshold` – (optional) Max number of errors total until processing will error out.

`unnest`

`unnest(transformation_ctx='', info='', stageThreshold=0, totalThreshold=0)`

Unnests nested objects in a DynamicFrame, which makes them top-level objects, and returns a new unnested DynamicFrame.

• `transformation_ctx` – A unique string that is used to identify state information (optional).
• `info` – A string to be associated with error reporting for this transformation (optional).
• `stageThreshold` – The number of errors encountered during this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.
• `totalThreshold` – The number of errors encountered up to and including this transformation at which the process should error out (optional). The default is zero, which indicates that the process should not error out.

**Example: Use unnest to turn nested fields into top-level fields**

This code example uses the `unnest` method to flatten all of the nested fields in a DynamicFrame into top-level fields.

**Example dataset**

The example uses a DynamicFrame called `mapped_medicare` with the following schema. Notice that the `Address` field is the only field that contains nested data.

```
root
|-- Average Total Payments: string
|-- Average Covered Charges: string
|-- DRG Definition: string
|-- Average Medicare Payments: string
|-- Hospital Referral Region Description: string
|-- Address: struct
  |-- Zip.Code: string
  |-- City: string
```
Example code

```python
# Example: Use unnest to unnest nested objects in a DynamicFrame
from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Unnest all nested fields
unnested = mapped_medicare.unnest()
unnested.printSchema()
```

Output

```
root
|-- Average Total Payments: string
|-- Average Covered Charges: string
|-- DRG Definition: string
|-- Average Medicare Payments: string
|-- Hospital Referral Region Description: string
|-- Address.Zip.Code: string
|-- Address.City: string
|-- Address.Array: array
 | |-- element: string
|-- Address.State: string
|-- Address.Street: string
|-- Provider Id: string
|-- Total Discharges: string
|-- Provider Name: string
```
unnest_ddb_json

Unnests nested columns in a DynamicFrame that are specifically in the DynamoDB JSON structure, and returns a new unnested DynamicFrame. Columns that are of an array of struct types will not be unnested. Note that this is a specific type of unnesting transform that behaves differently from the regular unnest transform and requires the data to already be in the DynamoDB JSON structure. For more information, see DynamoDB JSON.

**unnest_ddb_json(transformation_ctx="", info="", stageThreshold=0, totalThreshold=0)**

- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string to be associated with error reporting for this transformation (optional).
- **stageThreshold** – The number of errors encountered during this transformation at which the process should error out (optional: zero by default, indicating that the process should not error out).
- **totalThreshold** – The number of errors encountered up to and including this transformation at which the process should error out (optional: zero by default, indicating that the process should not error out).

For example, the schema of a reading an export with the DynamoDB JSON structure might look like the following:

```
root
 |-- Item: struct
  |   |-- ColA: struct
  |   |   |-- S: string
  |   |-- ColB: struct
  |   |   |-- S: string
  |   |-- ColC: struct
  |   |   |-- N: string
  |   |-- ColD: struct
  |   |   |-- L: array
  |   |   |   |-- element: null

The unnest_ddb_json() transform would convert this to:
```

```
root
 |-- ColA: string
```
The following code example shows how to use the AWS Glue DynamoDB export connector, invoke a DynamoDB JSON unnest, and print the number of partitions:

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

# Get resolved options
args = getResolvedOptions(sys.argv, ["JOB_NAME"])

# Initialize GlueContext
glue_context= GlueContext(SparkContext.getOrCreate())

# Create a Glue job
job = Job(glue_context)
job.init(args["JOB_NAME"], args)

# Create a DynamoDB dynamic frame
dynamicFrame = glue_context.create_dynamic_frame.from_options(
    connection_type="dynamodb",
    connection_options={
        "dynamodb.export": "ddb",
        "dynamodb.tableArn": "<test_source>",
        "dynamodb.s3.bucket": "<bucket name>",
        "dynamodb.s3.prefix": "<bucket prefix>",
        "dynamodb.s3.bucketOwner": "<account_id>",
    }
)

# Unnest the dynamic frame
unnested = dynamicFrame.unnest_ddb_json()

# Print the number of partitions
print(unnested.getNumPartitions())

# Commit the job
job.commit()
```

**write**

```
write(connection_type, connection_options, format, format_options, accumulator_size)
```

Gets a `DataSink(object)` of the specified connection type from the `GlueContext class` of this DynamicFrame, and uses it to format and write the contents of this DynamicFrame. Returns the new DynamicFrame formatted and written as specified.
connection_type – The connection type to use. Valid values include s3, mysql, postgresql, redshift, sqlserver, and oracle.

connection_options – The connection option to use (optional). For a connection_type of s3, an Amazon S3 path is defined.

```python
connection_options = {"path": "s3://aws-glue-target/temp"}
```

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.

⚠️ Warning

Storing passwords in your script is not recommended. Consider using boto3 to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.

```python
connection_options = {
    "url": "jdbc-url/database", 
    "user": "username", 
    "password": passwordVariable,"dbtable": "table-name", 
    "redshiftTmpDir": "s3-tempdir-path"
}
```

format – A format specification (optional). This is used for an Amazon Simple Storage Service (Amazon S3) or an AWS Glue connection that supports multiple formats. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

format_options – Format options for the specified format. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

accumulator_size – The accumulable size to use, in bytes (optional).

--- errors ---

- `assertErrorThreshold`
- `errorsAsDynamicFrame`
- `errorsCount`
- `stageErrorsCount`
assertErrorThreshold

assertErrorThreshold() – An assert for errors in the transformations that created this DynamicFrame. Returns an Exception from the underlying DataFrame.

errorsAsDynamicFrame

errorsAsDynamicFrame() – Returns a DynamicFrame that has error records nested inside.

Example: Use errorsAsDynamicFrame to view error records

The following code example shows how to use the errorsAsDynamicFrame method to view an error record for a DynamicFrame.

Example dataset

The example uses the following dataset that you can upload to Amazon S3 as JSON. Notice that the second record is malformed. Malformed data typically breaks file parsing when you use SparkSQL. However, DynamicFrame recognizes malformation issues and turns malformed lines into error records that you can handle individually.

```
{"id": 1, "name": "george", "surname": "washington", "height": 178}
{"id": 2, "name": "benjamin", "surname": "franklin",
{"id": 3, "name": "alexander", "surname": "hamilton", "height": 171}
{"id": 4, "name": "john", "surname": "jay", "height": 190}
```

Example code

```
# Example: Use errorsAsDynamicFrame to view error records.
# Replace s3://DOC-EXAMPLE-S3-BUCKET/error_data.json with your location.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Create errors DynamicFrame, view schema
effects = glueContext.create_dynamic_frame.from_options(
    "s3", {"paths": ["s3://DOC-EXAMPLE-S3-BUCKET/error_data.json"]}, "json"
)
print("Schema of errors DynamicFrame:")
errors.printSchema()

# Show that errors only contains valid entries from the dataset
print("errors contains only valid records from the input dataset (2 of 4 records)")
errors.toDF().show()

# View errors
print("Errors count:", str(errors.errorsCount()))
print("Errors:")
errors.errorsAsDynamicFrame().toDF().show()

# View error fields and error data
error_record = errors.errorsAsDynamicFrame().toDF().head()

error_fields = error_record["error"]
print("Error fields: ")
print(error_fields.asDict().keys())

print("\nError record data:")
for key in error_fields.asDict().keys():
    print("\n", key, ": ", str(error_fields[key]))

Output

Schema of errors DynamicFrame:
root
|-- id: int
|-- name: string
|-- surname: string
|-- height: int

errors contains only valid records from the input dataset (2 of 4 records)
+--------+---------+----------+------+
<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>surname</th>
<th>height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>george</td>
<td>washington</td>
<td>178</td>
</tr>
<tr>
<td>4</td>
<td>john</td>
<td>jay</td>
<td>190</td>
</tr>
</tbody>
</table>
+--------+---------+----------+------+

Errors count: 1
Errors:
+----------+

Error fields:
dict_keys(['callsite', 'msg', 'stackTrace', 'input', 'bytesread', 'source', 'dynamicRecord'])

Error record data:
callsite : Row(site='File "/tmp/2060612586885849088", line 549, in <module>
sys.exit(main())
File "/tmp/2060612586885849088", line 523, in main
response = handler(content)
File "/tmp/2060612586885849088", line 197, in execute_request
result = node.execute()
File "/tmp/2060612586885849088", line 103, in execute
exec(code, global_dict)
File "/<stdin>", line 10, in <module>
File "/opt/amazon/lib/python3.6/site-packages/awsglue/dynamicframe.py", line 625, in from_options
format_options, transformation_ctx, push_down_predicate, **kwargs
File "/opt/amazon/lib/python3.6/site-packages/awsglue/context.py", line 233, in create_dynamic_frame_from_options
source.setFormat(format, **format_options)

msg : error in jackson reader

stackTrace : com.fasterxml.jackson.core.JsonParseException: Unexpected character ('{' (code 123)): was expecting either valid name character (for unquoted name) or double-quote (for quoted) to start field name
at [Source: com.amazonaws.services.glue.readers.BufferedStream@73492578; line: 3, column: 2]
at com.fasterxml.jackson.core.JsonParser._constructError(JsonParser.java:1581)
at com.fasterxml.jackson.core.base.ParserMinimalBase._reportError(ParserMinimalBase.java:533)
at com.fasterxml.jackson.core.base.ParserMinimalBase._reportUnexpectedChar(ParserMinimalBase.java:462)
at com.fasterxml.jackson.core.json.UTF8StreamJsonParser._handleOddName(UTF8StreamJsonParser.java:2012)
at com.fasterxml.jackson.core.json.UTF8StreamJsonParser._parseName(UTF8StreamJsonParser.java:1650)
at com.fasterxml.jackson.core.json.UTF8StreamJsonParser.nextToken(UTF8StreamJsonParser.java:740)
at com.amazonaws.services.glue.readers.JacksonReader$$anonfun$hasNextGoodToken$1.apply(JacksonReader.scala:57)
at com.amazonaws.services.glue.readers.JacksonReader$$anonfun$hasNextGoodToken$1.apply(JacksonReader.scala:57)
ETL in PySpark
input:

  bytesread: 252

source:

dynamicRecord: Row(id=2, name='benjamin', surname='franklin')

errorsCount

errorsCount() – Returns the total number of errors in a DynamicFrame.

stageErrorsCount

stageErrorsCount – Returns the number of errors that occurred in the process of generating this DynamicFrame.

DynamicFrameCollection class

A DynamicFrameCollection is a dictionary of DynamicFrame class objects, in which the keys are the names of the DynamicFrames and the values are the DynamicFrame objects.

__init__

__init__(dynamic_frames, glue_ctx)

  • dynamic_frames – A dictionary of DynamicFrame class objects.
  • glue_ctx – A GlueContext class object.

Keys

keys() – Returns a list of the keys in this collection, which generally consists of the names of the corresponding DynamicFrame values.
Values

values(key) – Returns a list of the DynamicFrame values in this collection.

Select

select(key)

Returns the DynamicFrame that corresponds to the specified key (which is generally the name of the DynamicFrame).

- key – A key in the DynamicFrameCollection, which usually represents the name of a DynamicFrame.

Map

map(callable, transformation_ctx="")

Uses a passed-in function to create and return a new DynamicFrameCollection based on the DynamicFrames in this collection.

- callable – A function that takes a DynamicFrame and the specified transformation context as parameters and returns a DynamicFrame.
- transformation_ctx – A transformation context to be used by the callable (optional).

Flatmap

flatmap(f, transformation_ctx="")

Uses a passed-in function to create and return a new DynamicFrameCollection based on the DynamicFrames in this collection.

- f – A function that takes a DynamicFrame as a parameter and returns a DynamicFrame or DynamicFrameCollection.
- transformation_ctx – A transformation context to be used by the function (optional).

DynamicFrameWriter class
methods

- __init__
- from_options
- from_catalog
- from_jdbc_conf

__init__

__init__(glue_context)

- glue_context – The GlueContext class to use.

from_options

from_options(frame, connection_type, connection_options={}, format=None, format_options={}, transformation_ctx="")

Writes a DynamicFrame using the specified connection and format.

- frame – The DynamicFrame to write.
- connection_type – The connection type. Valid values include s3, mysql, postgresql, redshift, sqlserver, and oracle.
- connection_options – Connection options, such as path and database table (optional). For a connection_type of s3, an Amazon S3 path is defined.

  connection_options = {"path": "s3://aws-glue-target/temp"}

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.

⚠️ Warning

Storing passwords in your script is not recommended. Consider using boto3 to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.
connection_options = {
    "url": "jdbc-url/database",
    "user": "username",
    "password": passwordVariable,
    "dbtable": "table-name",
    "redshiftTmpDir": "s3-tempdir-path"
}

The `dbtable` property is the name of the JDBC table. For JDBC data stores that support schemas within a database, specify `schema.table-name`. If a schema is not provided, then the default "public" schema is used.

For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).

- **format** – A format specification (optional). This is used for an Amazon Simple Storage Service (Amazon S3) or an AWS Glue connection that supports multiple formats. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

- **format_options** – Format options for the specified format. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

- **transformation_ctx** – A transformation context to use (optional).

**from_catalog**

```python
from_catalog(frame, name_space, table_name, redshift_tmp_dir='',
transformation_ctx='')
```

Writes a DynamicFrame using the specified catalog database and table name.

- **frame** – The DynamicFrame to write.
- **name_space** – The database to use.
- **table_name** – The table_name to use.
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – A transformation context to use (optional).
- **additional_options** – Additional options provided to AWS Glue.

To write to Lake Formation governed tables, you can use these additional options:

- **transactionId** – (String) The transaction ID at which to do the write to the Governed table. This transaction can not be already committed or aborted, or the write will fail.
• **callDeleteObjectsOnCancel** – (Boolean, optional) If set to `true` (default), AWS Glue automatically calls the `DeleteObjectsOnCancel` API after the object is written to Amazon S3. For more information, see `DeleteObjectsOnCancel` in the AWS Lake Formation Developer Guide.

**Example:** Writing to a governed table in Lake Formation

```python
txId = glueContext.start_transaction(read_only=False)
glueContext.write_dynamic_frame.from_catalog(
    frame=dyf,
    database = db,
    table_name = tbl,
    transformation_ctx = "datasource0",
    additional_options={"transactionId":txId})
...
glueContext.commit_transaction(txId)
```

**from_jdbc_conf**

```python
from_jdbc_conf(frame, catalog_connection, connection_options={},
redshift_tmp_dir = "", transformation_ctx="")
```

Writes a `DynamicFrame` using the specified JDBC connection information.

- **frame** – The `DynamicFrame` to write.
- **catalog_connection** – A catalog connection to use.
- **connection_options** – Connection options, such as path and database table (optional).
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – A transformation context to use (optional).

**Example for write_dynamic_frame**

This example writes the output locally using a `connection_type` of S3 with a POSIX path argument in `connection_options`, which allows writing to local storage.

```python
glueContext.write_dynamic_frame.from_options(
    frame = dyf_splitFields,
    connection_options = {'path': '/home/glue/GlueLocalOutput/'),
```

ETL in PySpark
connection_type = 's3',
format = 'json')

DynamicFrameReader class

— methods —

• __init__
• from_rdd
• from_options
• from_catalog

__init__

__init__(glue_context)

• glue_context – The GlueContext class to use.

from_rdd

from_rdd(data, name, schema=None, sampleRatio=None)

Reads a DynamicFrame from a Resilient Distributed Dataset (RDD).

• data – The dataset to read from.
• name – The name to read from.
• schema – The schema to read (optional).
• sampleRatio – The sample ratio (optional).

from_options

from_options(connection_type, connection_options={}, format=None,
format_options={}, transformation_ctx="")

Reads a DynamicFrame using the specified connection and format.

• connection_type – The connection type. Valid values include s3, mysql, postgresql, redshift, sqlserver, oracle, and dynamodb.
connection_options – Connection options, such as path and database table (optional). For a connection_type of s3, Amazon S3 paths are defined in an array.

connection_options = {
  "paths": ["s3://mybucket/object_a", "s3://mybucket/object_b"]
}

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.

⚠️ Warning

Storing passwords in your script is not recommended. Consider using boto3 to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.

connection_options = {
  "url": "jdbc-url/database",
  "user": "username",
  "password": passwordVariable,
  "dbtable": "table-name",
  "redshiftTmpDir": "s3-tempdir-path"
}

For a JDBC connection that performs parallel reads, you can set the hashfield option. For example:

connection_options = {
  "url": "jdbc-url/database",
  "user": "username",
  "password": passwordVariable,
  "dbtable": "table-name",
  "redshiftTmpDir": "s3-tempdir-path",
  "hashfield": "month"
}

For more information, see Reading from JDBC tables in parallel.

format – A format specification (optional). This is used for an Amazon Simple Storage Service (Amazon S3) or an AWS Glue connection that supports multiple formats. See Data format options for inputs and outputs in AWS Glue for Spark for the formats that are supported.

format_options – Format options for the specified format. See Data format options for inputs and outputs in AWS Glue for Spark for the formats that are supported.

transformation_ctx – The transformation context to use (optional).

push_down_predicate – Filters partitions without having to list and read all the files in your dataset. For more information, see Pre-Filtering Using Pushdown Predicates.
from_catalog

from_catalog(database, table_name, redshift_tmp_dir="", transformation_ctx="", push_down_predicate="", additional_options={})

Reads a DynamicFrame using the specified catalog namespace and table name.

- `database` – The database to read from.
- `table_name` – The name of the table to read from.
- `redshift_tmp_dir` – An Amazon Redshift temporary directory to use (optional if not reading data from Redshift).
- `transformation_ctx` – The transformation context to use (optional).
- `push_down_predicate` – Filters partitions without having to list and read all the files in your dataset. For more information, see Pre-filtering using pushdown predicates.
- `additional_options` – Additional options provided to AWS Glue.
  - To use a JDBC connection that performs parallel reads, you can set the `hashfield`, `hashexpression`, or `hashpartitions` options. For example:
    ```python
    additional_options = {"hashfield": "month"}
    ```
    For more information, see Reading from JDBC tables in parallel.
  - To pass a catalog expression to filter based on the index columns, you can see the `catalogPartitionPredicate` option.
    `catalogPartitionPredicate` — You can pass a catalog expression to filter based on the index columns. This pushes down the filtering to the server side. For more information, see AWS Glue Partition Indexes. Note that `push_down_predicate` and `catalogPartitionPredicate` use different syntaxes. The former one uses Spark SQL standard syntax and the later one uses JSQL parser.
    For more information, see Managing partitions for ETL output in AWS Glue.
  - To read from Lake Formation governed tables, you can use these additional options:
    - `transactionId` – (String) The transaction ID at which to read the Governed table contents. If this transaction is not committed, the read will be treated as part of that transaction and will see its writes. If this transaction is committed, its writes will be visible in this read.
If this transaction has aborted, an error will be returned. Cannot be specified along with asOfTime.

**Note**

Either `transactionId` or `asOfTime` must set to access the governed table.

- `asOfTime` – (TimeStamp: `yyyy-[m]-[d]-hh:mm:ss`) The time as of when to read the table contents. Cannot be specified along with `transactionId`.

- `query` – (Optional) A PartiQL query statement used as an input to the Lake Formation planner service. If not set, the default setting is to select all data from the table. For more details about PartiQL, see [PartiQL Support in Row Filter Expressions](#) in the *AWS Lake Formation Developer Guide*.

**Example** Example: Using a PartiQL query statement when reading from a governed table in Lake Formation

```python
txId = glueContext.start_transaction(read_only=False)
datasource0 = glueContext.create_dynamic_frame.from_catalog(
    database = db,
    table_name = tbl,
    transformation_ctx = "datasource0",
    additional_options={
        "transactionId":txId,
        "query" : "SELECT * from tblName WHERE partitionKey=value;"
    })
...
glueContext.commit_transaction(txId)
```

**GlueContext class**

Wraps the Apache Spark `SparkContext` object, and thereby provides mechanisms for interacting with the Apache Spark platform.

```python
__init__

__init__(sparkContext)
```

- `sparkContext` – The Apache Spark context to use.
Creating

- __init__
- getSource
  - create_dynamic_frame_from_rdd
  - create_dynamic_frame_from_catalog
  - create_dynamic_frame_from_options
  - create_sample_dynamic_frame_from_catalog
  - create_sample_dynamic_frame_from_options
  - add_ingestion_time_columns
  - create_data_frame_from_catalog
  - create_data_frame_from_options
  - forEachBatch

getSource

getSource(connection_type, transformation_ctx = "", **options)

Creates a DataSource object that can be used to read DynamicFrames from external sources.

- connection_type – The connection type to use, such as Amazon Simple Storage Service (Amazon S3), Amazon Redshift, and JDBC. Valid values include s3, mysql, postgresql, redshift, sqlserver, oracle, and dynamodb.
- transformation_ctx – The transformation context to use (optional).
- options – A collection of optional name-value pairs. For more information, see Connection types and options for ETL in AWS Glue for Spark.

The following is an example of using getSource.

```python
>>> data_source = context.getSource("file", paths=["/in/path"])
>>> data_source.setFormat("json")
>>> myFrame = data_source.getFrame()
```
create_dynamic_frame_from_rdd

create_dynamic_frame_from_rdd(data, name, schema=None, sample_ratio=None, transformation_ctx="")

Returns a DynamicFrame that is created from an Apache Spark Resilient Distributed Dataset (RDD).

- data – The data source to use.
- name – The name of the data to use.
- schema – The schema to use (optional).
- sample_ratio – The sample ratio to use (optional).
- transformation_ctx – The transformation context to use (optional).

create_dynamic_frame_from_catalog

create_dynamic_frame_from_catalog(database, table_name, redshift_tmp_dir, transformation_ctx = "", push_down_predicate= ", additional_options = {}, catalog_id = None)

Returns a DynamicFrame that is created using a Data Catalog database and table name. When using this method, you provide format_options through table properties on the specified AWS Glue Data Catalog table and other options through the additional_options argument.

- Database – The database to read from.
- table_name – The name of the table to read from.
- redshift_tmp_dir – An Amazon Redshift temporary directory to use (optional).
- transformation_ctx – The transformation context to use (optional).
- push_down_predicate – Filters partitions without having to list and read all the files in your dataset. For more information, see Pre-filtering using pushdown predicates.
- additional_options – A collection of optional name-value pairs. The possible options include those listed in Connection types and options for ETL in AWS Glue for Spark except for endpointUrl, streamName, bootstrap.servers, security.protocol, topicName, classification, and delimiter. Another supported option is catalogPartitionPredicate:
catalogPartitionPredicate — You can pass a catalog expression to filter based on the index columns. This pushes down the filtering to the server side. For more information, see AWS Glue Partition Indexes. Note that push_down_predicate and catalogPartitionPredicate use different syntaxes. The former one uses Spark SQL standard syntax and the later one uses JSQL parser.

• catalog_id — The catalog ID (account ID) of the Data Catalog being accessed. When None, the default account ID of the caller is used.

create_dynamic_frame_from_options

create_dynamic_frame_from_options(connection_type, connection_options=\{}, format=\None, format_options=\{}, transformation_ctx = "")

Returns a DynamicFrame created with the specified connection and format.

• connection_type – The connection type, such as Amazon S3, Amazon Redshift, and JDBC. Valid values include s3, mysql, postgresql, redshift, sqlserver, oracle, and dynamodb.

• connection_options – Connection options, such as paths and database table (optional). For a connection_type of s3, a list of Amazon S3 paths is defined.

```python
connection_options = {"paths": ["s3://aws-glue-target/temp"]}
```

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.

⚠️ Warning

Storing passwords in your script is not recommended. Consider using boto3 to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.

```python
connection_options = {"url": "jdbc-url/database", "user": "username", "password": passwordVariable,"dbtable": "table-name", "redshiftTmpDir": "s3-tempdir-path"}
```
The dbtable property is the name of the JDBC table. For JDBC data stores that support schemas within a database, specify schema.table-name. If a schema is not provided, then the default "public" schema is used.

For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).

- **format** – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

- **format_options** – Format options for the specified format. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.

- **transformation_ctx** – The transformation context to use (optional).

- **push_down_predicate** – Filters partitions without having to list and read all the files in your dataset. For more information, see [Pre-Filtering Using Pushdown Predicates](#).

---

**create_sample_dynamic_frame_from_catalog**

```python
create_sample_dynamic_frame_from_catalog(database, table_name, num, redshift_tmp_dir, transformation_ctx = '', push_down_predicate= '', additional_options = {}, sample_options = {}, catalog_id = None)
```

Returns a sample DynamicFrame that is created using a Data Catalog database and table name. The DynamicFrame only contains first num records from a datasource.

- **database** – The database to read from.
- **table_name** – The name of the table to read from.
- **num** – The maximum number of records in the returned sample dynamic frame.
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – The transformation context to use (optional).
- **push_down Predicate** – Filters partitions without having to list and read all the files in your dataset. For more information, see [Pre-filtering using pushdown predicates](#).
- **additional_options** – A collection of optional name-value pairs. The possible options include those listed in [Connection types and options for ETL in AWS Glue for Spark](#) except for endpointUrl, streamName, bootstrap.servers, security.protocol, topicName, classification, and delimiter.
• sample_options – Parameters to control sampling behavior (optional). Current available parameters for Amazon S3 sources:
  • maxSamplePartitions – The maximum number of partitions the sampling will read. Default value is 10
  • maxSampleFilesPerPartition – The maximum number of files the sampling will read in one partition. Default value is 10.

  These parameters help to reduce the time consumed by file listing. For example, suppose the dataset has 1000 partitions, and each partition has 10 files. If you set maxSamplePartitions = 10, and maxSampleFilesPerPartition = 10, instead of listing all 10,000 files, the sampling will only list and read the first 10 partitions with the first 10 files in each: 10*10 = 100 files in total.

• catalog_id – The catalog ID of the Data Catalog being accessed (the account ID of the Data Catalog). Set to None by default. None defaults to the catalog ID of the calling account in the service.

create_sample_dynamic_frame_from_options

create_sample_dynamic_frame_from_options(\text{connection\_type}, \text{connection\_options}=[], \text{num}, \text{sample\_options}=[], \text{format}\text{=}None, \text{format\_options}=[], \text{transformation\_ctx} = ")"

Returns a sample DynamicFrame created with the specified connection and format. The DynamicFrame only contains first num records from a datasource.

• connection\_type – The connection type, such as Amazon S3, Amazon Redshift, and JDBC. Valid values include s3, mysql, postgresql, redshift, sqlserver, oracle, and dynamodb.
• connection\_options – Connection options, such as paths and database table (optional). For more information, see \url{Connection types and options for ETL in AWS Glue for Spark}.
• num – The maximum number of records in the returned sample dynamic frame.
• sample\_options – Parameters to control sampling behavior (optional). Current available parameters for Amazon S3 sources:
  • maxSamplePartitions – The maximum number of partitions the sampling will read. Default value is 10
  • maxSampleFilesPerPartition – The maximum number of files the sampling will read in one partition. Default value is 10.
These parameters help to reduce the time consumed by file listing. For example, suppose the dataset has 1000 partitions, and each partition has 10 files. If you set `maxSamplePartitions = 10`, and `maxSampleFilesPerPartition = 10`, instead of listing all 10,000 files, the sampling will only list and read the first 10 partitions with the first 10 files in each: $10 \times 10 = 100$ files in total.

- **format** – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. See Data format options for inputs and outputs in AWS Glue for Spark for the formats that are supported.

- **format_options** – Format options for the specified format. See Data format options for inputs and outputs in AWS Glue for Spark for the formats that are supported.

- **transformation_ctx** – The transformation context to use (optional).

- **push_down_predicate** – Filters partitions without having to list and read all the files in your dataset. For more information, see Pre-filtering using pushdown predicates.

### add_ingestion_time_columns

#### add_ingestion_time_columns(dataFrame, timeGranularity = '')

Appends ingestion time columns like `ingest_year`, `ingest_month`, `ingest_day`, `ingest_hour`, `ingest_minute` to the input DataFrame. This function is automatically generated in the script generated by the AWS Glue when you specify a Data Catalog table with Amazon S3 as the target. This function automatically updates the partition with ingestion time columns on the output table. This allows the output data to be automatically partitioned on ingestion time without requiring explicit ingestion time columns in the input data.

- **dataFrame** – The DataFrame to append the ingestion time columns to.

- **timeGranularity** – The granularity of the time columns. Valid values are "day", "hour" and "minute". For example, if "hour" is passed in to the function, the original DataFrame will have "ingest_year", "ingest_month", "ingest_day", and "ingest_hour" time columns appended.

Returns the data frame after appending the time granularity columns.

Example:
```python
dynamic_frame = DynamicFrame.fromDF(glueContext.add_ingestion_time_columns(dataFrame, "hour"))
```

### create_data_frame_from_catalog

```python
create_data_frame_from_catalog(database, table_name, transformation_ctx = "", additional_options = {})
```

Returns a DataFrame that is created using information from a Data Catalog table.

- **database** – The Data Catalog database to read from.
- **table_name** – The name of the Data Catalog table to read from.
- **transformation_ctx** – The transformation context to use (optional).
- **additional_options** – A collection of optional name-value pairs. The possible options include those listed in `Connection types and options for ETL in AWS Glue for Spark` for streaming sources, such as `startingPosition`, `maxFetchTimeInMs`, and `startingOffsets`.
- **useSparkDataSource** – When set to true, forces AWS Glue to use the native Spark Data Source API to read the table. The Spark Data Source API supports the following formats: AVRO, binary, CSV, JSON, ORC, Parquet, and text. In a Data Catalog table, you specify the format using the `classification` property. To learn more about the Spark Data Source API, see the official [Apache Spark documentation](https://spark.apache.org/docs/).

Using `create_data_frame_from_catalog` with `useSparkDataSource` has the following benefits:

- Directly returns a DataFrame and provides an alternative to `create_dynamic_frame.from_catalog().toDF()`.
- Supports AWS Lake Formation table-level permission control for native formats.
- Supports reading data lake formats without AWS Lake Formation table-level permission control. For more information, see [Using data lake frameworks with AWS Glue ETL jobs](https://docs.aws.amazon.com/glue/latest/dg/etl-data-lake-frameworks.html).

When you enable `useSparkDataSource`, you can also add any of the [Spark Data Source options](https://spark.apache.org/docs/) in `additional_options` as needed. AWS Glue passes these options directly to the Spark reader.

- **useCatalogSchema** – When set to true, AWS Glue applies the Data Catalog schema to the resulting DataFrame. Otherwise, the reader infers the schema from the data. When you enable `useCatalogSchema`, you must also set `useSparkDataSource` to true.
Limitations

Consider the following limitations when you use the `useSparkDataSource` option:

- When you use `useSparkDataSource`, AWS Glue creates a new DataFrame in a separate Spark session that is different from the original Spark session.

- Spark DataFrame partition filtering doesn't work with the following AWS Glue features.
  - **Job bookmarks**
  - **Excluding Amazon S3 storage classes**
  - **Catalog partition predicates**

To use partition filtering with these features, you can use the AWS Glue pushdown predicate. For more information, see [Pre-filtering using pushdown predicates](#). Filtering on non-partitioned columns is not affected.

The following example script demonstrates the incorrect way to perform partition filtering with the `excludeStorageClasses` option.

```python
// Incorrect partition filtering using Spark filter with excludeStorageClasses
read_df = glueContext.create_data_frame.from_catalog(
    database=database_name,
    table_name=table_name,
    additional_options = {
        "useSparkDataSource": True,
        "excludeStorageClasses" : ["GLACIER", "DEEP_ARCHIVE"]
    }
)
//  Suppose year and month are partition keys.
//  Filtering on year and month won't work, the filtered_df will still
//  contain data with other year/month values.
filtered_df = read_df.filter("year == '2017 and month == '04' and 'state == 'CA'"
)
```

The following example script demonstrates the correct way to use a pushdown predicate in order to perform partition filtering with the `excludeStorageClasses` option.

```python
// Correct partition filtering using the AWS Glue pushdown predicate
// with excludeStorageClasses
read_df = glueContext.create_data_frame.from_catalog(
    database=database_name,
    table_name=table_name,
    additional_options = {
        "useSparkDataSource": True,
        "excludeStorageClasses" : ["GLACIER", "DEEP_ARCHIVE"]
    }
)
//  Correct way to use pushdown predicate
filtered_df = read_df.filter("year == '2017 and month == '04' and 'state == 'CA'"
)
// Use AWS Glue pushdown predicate to perform partition filtering
push_down_predicate = "(year=='2017' and month=='04')"
additional_options = {
    "useSparkDataSource": True,
    "excludeStorageClasses" : ["GLACIER", "DEEP_ARCHIVE"]
}

// Use Spark filter only on non-partitioned columns
filtered_df = read_df.filter("state == 'CA'"

Example: Creating a CSV table using the Spark data source reader

// Read a CSV table with '\t' as separator
read_df = glueContext.create_data_frame.from_catalog(
    database=<database_name>,
    table_name=<table_name>,
    additional_options = {"useSparkDataSource": True,  "sep": '\t'}
)

create_data_frame_from_options

create_data_frame_from_options(connection_type, connection_options={}, format=None, format_options={}, transformation_ctx = "")

This API is now deprecated. Instead use the getSource() API. Returns a DataFrame created with the specified connection and format. Use this function only with AWS Glue streaming sources.

- connection_type – The streaming connection type. Valid values include kinesis and kafka.
- connection_options – Connection options, which are different for Kinesis and Kafka. You can find the list of all connection options for each streaming data source at Connection types and options for ETL in AWS Glue for Spark. Note the following differences in streaming connection options:
  - Kinesis streaming sources require streamARN, startingPosition, inferSchema, and classification.
  - Kafka streaming sources require connectionName, topicName, startingOffsets, inferSchema, and classification.
• **format** – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. For information about the supported formats, see [Data format options for inputs and outputs in AWS Glue for Spark](#).

• **format_options** – Format options for the specified format. For information about the supported format options, see [Data format options for inputs and outputs in AWS Glue for Spark](#).

• **transformation_ctx** – The transformation context to use (optional).

**Example for Amazon Kinesis streaming source:**

```python
kinesis_options =
      "startingPosition": "TRIM_HORIZON",
      "inferSchema": "true",
      "classification": "json"
    }
data_frame_datasource0 =
    glueContext.create_data_frame.from_options(connection_type="kinesis",
                                             connection_options=kinesis_options)
```

**Example for Kafka streaming source:**

```python
kafka_options =
    { "connectionName": "ConfluentKafka",
      "topicName": "kafka-auth-topic",
      "startingOffsets": "earliest",
      "inferSchema": "true",
      "classification": "json"
    }
data_frame_datasource0 =
    glueContext.create_data_frame.from_options(connection_type="kafka",
                                             connection_options=kafka_options)
```

**forEachBatch**

```python
forEachBatch(frame, batch_function, options)
```

Applies the `batch_function` passed in to every micro batch that is read from the Streaming source.
• frame – The DataFrame containing the current micro batch.

• batch_function – A function that will be applied for every micro batch.

• options – A collection of key-value pairs that holds information about how to process micro batches. The following options are required:
  
  • windowSize – The amount of time to spend processing each batch.
  
  • checkpointLocation – The location where checkpoints are stored for the streaming ETL job.
  
  • batchMaxRetries – The maximum number of times to retry the batch if it fails. The default value is 3. This option is only configurable for Glue version 2.0 and above.

Example:

```python
glueContext.forEachBatch(
    frame = data_frame_datasource0,
    batch_function = processBatch,
    options = {
        "windowSize": "100 seconds",
        "checkpointLocation": "s3://kafka-auth-dataplane/confluent-test/output/checkpoint/
    }
)

def processBatch(data_frame, batchId):
    if (data_frame.count() > 0):
        datasource0 = DynamicFrame.fromDF(
            glueContext.add_ingestion_time_columns(data_frame, "hour"),
            glueContext, "from_data_frame"
        )
        additionalOptions_datasink1 = {"enableUpdateCatalog": True}
        additionalOptions_datasink1["partitionKeys"] = ["ingest_yr", "ingest_mo",
            "ingest_day"]
        datasink1 = glueContext.write_dynamic_frame.from_catalog(
            frame = datasource0,
            database = "tempdb",
            table_name = "kafka-auth-table-output",
            transformation_ctx = "datasink1",
            additional_options = additionalOptions_datasink1
        )
```
### Working with datasets in Amazon S3

- **purge_table**
- **purge_s3_path**
- **transition_table**
- **transition_s3_path**

**purge_table**

```python
purge_table(catalog_id=None, database='', table_name='', options={}, transformation_ctx='')
```

Deletes files from Amazon S3 for the specified catalog's database and table. If all files in a partition are deleted, that partition is also deleted from the catalog.

If you want to be able to recover deleted objects, you can turn on [object versioning](https://docs.aws.amazon.com/AmazonS3/latest/userguide/enable-versioning.html) on the Amazon S3 bucket. When an object is deleted from a bucket that doesn't have object versioning enabled, the object can't be recovered. For more information about how to recover deleted objects in a version-enabled bucket, see [How can I retrieve an Amazon S3 object that was deleted?](https://aws.amazon.com/s3/support/knowledge-center/how-can-i-retrieve-an-amazon-s3-object-that-was-deleted/) in the AWS Support Knowledge Center.

- **catalog_id** – The catalog ID of the Data Catalog being accessed (the account ID of the Data Catalog). Set to None by default. None defaults to the catalog ID of the calling account in the service.
- **database** – The database to use.
- **table_name** – The name of the table to use.
- **options** – Options to filter files to be deleted and for manifest file generation.
  - **retentionPeriod** – Specifies a period in number of hours to retain files. Files newer than the retention period are retained. Set to 168 hours (7 days) by default.
  - **partitionPredicate** – Partitions satisfying this predicate are deleted. Files within the retention period in these partitions are not deleted. Set to "" – empty by default.
  - **excludeStorageClasses** – Files with storage class in the excludeStorageClasses set are not deleted. The default is Set() – an empty set.
  - **manifestFilePath** – An optional path for manifest file generation. All files that were successfully purged are recorded in Success.csv, and those that failed in Failed.csv
• **transformation_ctx** – The transformation context to use (optional). Used in the manifest file path.

**Example**

```python
glueContext.purge_table("database", "table", {"partitionPredicate": "(month=='march')", "retentionPeriod": 1, "excludeStorageClasses": ["STANDARD_IA"], "manifestFilePath": "s3://bucketmanifest/")
```

**purge_s3_path**

```python
glueContext.purge_s3_path("s3://bucket/path/", {})
```

**Example**

```python
glueContext.purge_s3_path("s3://bucket/path/", {"retentionPeriod": 1, "excludeStorageClasses": ["STANDARD_IA"], "manifestFilePath": "s3://bucketmanifest/"})
```
transition_table
transition_table(database, table_name, transition_to, options={},
transformation_ctx='', catalog_id=None)

Transitions the storage class of the files stored on Amazon S3 for the specified catalog's database and table.

You can transition between any two storage classes. For the GLACIER and DEEP_ARCHIVE storage classes, you can transition to these classes. However, you would use an S3 RESTORE to transition from GLACIER and DEEP_ARCHIVE storage classes.

If you're running AWS Glue ETL jobs that read files or partitions from Amazon S3, you can exclude some Amazon S3 storage class types. For more information, see Excluding Amazon S3 Storage Classes.

- database – The database to use.
- table_name – The name of the table to use.
- transition_to – The Amazon S3 storage class to transition to.
- options – Options to filter files to be deleted and for manifest file generation.
  - retentionPeriod – Specifies a period in number of hours to retain files. Files newer than the retention period are retained. Set to 168 hours (7 days) by default.
  - partitionPredicate – Partitions satisfying this predicate are transitioned. Files within the retention period in these partitions are not transitioned. Set to "" – empty by default.
  - excludeStorageClasses – Files with storage class in the excludeStorageClasses set are not transitioned. The default is Set() – an empty set.
  - manifestFilePath – An optional path for manifest file generation. All files that were successfully transitioned are recorded in Success.csv, and those that failed in Failed.csv
  - accountId – The Amazon Web Services account ID to run the transition transform. Mandatory for this transform.
  - roleArn – The AWS role to run the transition transform. Mandatory for this transform.
  - transformation_ctx – The transformation context to use (optional). Used in the manifest file path.
  - catalog_id – The catalog ID of the Data Catalog being accessed (the account ID of the Data Catalog). Set to None by default. None defaults to the catalog ID of the calling account in the service.
Example

```python
glueContext.transition_table("database", "table", "STANDARD_IA", {"retentionPeriod": 1, "excludeStorageClasses": ["STANDARD_IA"], "manifestFilePath": "s3://bucketmanifest/", "accountId": "12345678901", "roleArn": "arn:aws:iam::123456789012:user/example-username"})
```

**transition_s3_path**

```python
transition_s3_path(s3_path, transition_to, options={}, transformation_ctx="")
```

Transitions the storage class of the files in the specified Amazon S3 path recursively.

You can transition between any two storage classes. For the GLACIER and DEEP_ARCHIVE storage classes, you can transition to these classes. However, you would use an S3 RESTORE to transition from GLACIER and DEEP_ARCHIVE storage classes.

If you're running AWS Glue ETL jobs that read files or partitions from Amazon S3, you can exclude some Amazon S3 storage class types. For more information, see [Excluding Amazon S3 Storage Classes](#).

- **s3_path** – The path in Amazon S3 of the files to be transitioned in the format s3://<bucket>/<prefix/>
- **transition_to** – The [Amazon S3 storage class](#) to transition to.
- **options** – Options to filter files to be deleted and for manifest file generation.
  - **retentionPeriod** – Specifies a period in number of hours to retain files. Files newer than the retention period are retained. Set to 168 hours (7 days) by default.
  - **partitionPredicate** – Partitions satisfying this predicate are transitioned. Files within the retention period in these partitions are not transitioned. Set to "" – empty by default.
  - **excludeStorageClasses** – Files with storage class in the excludeStorageClasses set are not transitioned. The default is Set() – an empty set.
  - **manifestFilePath** – An optional path for manifest file generation. All files that were successfully transitioned are recorded in Success.csv, and those that failed in Failed.csv
  - **accountId** – The Amazon Web Services account ID to run the transition transform. Mandatory for this transform.
  - **roleArn** – The AWS role to run the transition transform. Mandatory for this transform.
• transformation_ctx – The transformation context to use (optional). Used in the manifest file path.

Example

glueContext.transition_s3_path("s3://bucket/prefix/", "STANDARD_IA",
{"retentionPeriod": 1, "excludeStorageClasses": ["STANDARD_IA"],
"manifestFilePath": "s3://bucketmanifest/", "accountId": "12345678901", "roleArn":
"arn:aws:iam::123456789012:user/example-username")

Extracting

• extract_jdbc_conf

extract_jdbc_conf

eextract_jdbc_conf(connection_name, catalog_id = None)

Returns a dict with keys with the configuration properties from the AWS Glue connection object in the Data Catalog.

• user – The database user name.
• password – The database password.
• vendor – Specifies a vendor (mysql, postgresql, oracle, sqlserver, etc.).
• enforceSSL – A boolean string indicating if a secure connection is required.
• customJDBCCert – Use a specific client certificate from the Amazon S3 path indicated.
• skipCustomJDBCCertValidation – A boolean string indicating if the customJDBCCert must be validated by a CA.
• customJDBCCertString – Additional information about the custom certificate, specific for the driver type.
• url – (Deprecated) JDBC URL with only protocol, server and port.
• fullUrl – JDBC URL as entered when the connection was created (Available in AWS Glue version 3.0 or later).

Example retrieving JDBC configurations:
jdbc_conf = glueContext.extract_jdbc_conf(connection_name="your_glue_connection_name")
print(jdbc_conf)

```python
>>> {'enforceSSL': 'false', 'skipCustomJDBCCertValidation': 'false', 'url':
    'customJDBCCertString': '', 'user': 'admin', 'customJDBCCert': '', 'password': '1234',
    'vendor': 'mysql'}
```
cancel_transaction

cancel_transaction(transaction_id)

Attempts to cancel the specified transaction. Returns a TransactionCommittedException exception if the transaction was previously committed. Internally calls the Lake Formation CancelTransaction API.

- transaction_id – (String) The transaction to cancel.

Writing

- getSink
- write_dynamic_frame_from_options
- write_from_options
- write_dynamic_frame_from_catalog
- write_data_frame_from_catalog
- write_dynamic_frame_from_jdbc_conf
- write_from_jdbc_conf

getSink

gSink(connection_type, format = None, transformation_ctx = "", **options)

Gets a DataSink object that can be used to write DynamicFrames to external sources. Check the SparkSQL format first to be sure to get the expected sink.

- connection_type – The connection type to use, such as Amazon S3, Amazon Redshift, and JDBC. Valid values include s3, mysql, postgresql, redshift, sqlserver, and oracle.
- format – The SparkSQL format to use (optional).
- transformation_ctx – The transformation context to use (optional).
- options – A collection of name-value pairs used to specify the connection options. Some of the possible values are:
  - user and password: For authorization
  - url: The endpoint for the data store
  - dbtable: The name of the target table
- **bulkSize**: Degree of parallelism for insert operations

The options that you can specify depends on the connection type. See [Connection types and options for ETL in AWS Glue for Spark](#) for additional values and examples.

Example:

```python
>>> data_sink = context.getSink("s3")
>>> data_sink.setFormat("json"),
>>> data_sink.writeFrame(myFrame)
```

**write_dynamic_frame_from_options**

```python
write_dynamic_frame_from_options(frame, connection_type, connection_options={}, format=None, format_options={}, transformation_ctx = "")
```

Writes and returns a `DynamicFrame` using the specified connection and format.

- **frame** – The `DynamicFrame` to write.
- **connection_type** – The connection type, such as Amazon S3, Amazon Redshift, and JDBC. Valid values include `s3`, `mysql`, `postgresql`, `redshift`, `sqlserver`, and `oracle`.
- **connection_options** – Connection options, such as path and database table (optional). For a `connection_type` of `s3`, an Amazon S3 path is defined.

```python
connection_options = {"path": "s3://aws-glue-target/temp"}
```

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.

⚠️ **Warning**

Storing passwords in your script is not recommended. Consider using `boto3` to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.
connection_options = {
    "url": "jdbc-url/database",
    "user": "username",
    "password": "passwordVariable",
    "dbtable": "table-name",
    "redshiftTmpDir": "s3-tempdir-path"
}

The `dbtable` property is the name of the JDBC table. For JDBC data stores that support schemas within a database, specify `schema.table-name`. If a schema is not provided, then the default "public" schema is used.

For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).

- **format** – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.
- **format_options** – Format options for the specified format. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.
- **transformation_ctx** – A transformation context to use (optional).

**write_from_options**

```python
write_from_options(frame_or_dfc, connection_type, connection_options={}, format={}, format_options={}, transformation_ctx = "")
```

Writes and returns a DynamicFrame or DynamicFrameCollection that is created with the specified connection and format information.

- **frame_or_dfc** – The DynamicFrame or DynamicFrameCollection to write.
- **connection_type** – The connection type, such as Amazon S3, Amazon Redshift, and JDBC. Valid values include s3, mysql, postgresql, redshift, sqlserver, and oracle.
- **connection_options** – Connection options, such as path and database table (optional). For a connection_type of s3, an Amazon S3 path is defined.

```python
connection_options = {
    "path": "s3://aws-glue-target/temp"
}
```

For JDBC connections, several properties must be defined. Note that the database name must be part of the URL. It can optionally be included in the connection options.
Warning

Storing passwords in your script is not recommended. Consider using boto3 to retrieve them from AWS Secrets Manager or the AWS Glue Data Catalog.

```python
connection_options = {"url": "jdbc-url/database", "user": "username", "password": passwordVariable,"dbtable": "table-name", "redshiftTmpDir": "s3-tempdir-path"}
```

The `dbtable` property is the name of the JDBC table. For JDBC data stores that support schemas within a database, specify `schema.table-name`. If a schema is not provided, then the default "public" schema is used.

For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).

- **format** – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.
- **format_options** – Format options for the specified format. See [Data format options for inputs and outputs in AWS Glue for Spark](#) for the formats that are supported.
- **transformation_ctx** – A transformation context to use (optional).

### write_dynamic_frame_from_catalog

```python
write_dynamic_frame_from_catalog(frame, database, table_name, redshift_tmp_dir, transformation_ctx = "", additional_options = {}, catalog_id = None)
```

Writes and returns a DynamicFrame using information from a Data Catalog database and table.

- **frame** – The DynamicFrame to write.
- **database** – The Data Catalog database that contains the table.
- **table_name** – The name of the Data Catalog table associated with the target.
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – The transformation context to use (optional).
• additional_options – A collection of optional name-value pairs.
• catalog_id — The catalog ID (account ID) of the Data Catalog being accessed. When None, the
default account ID of the caller is used.

**write_data_frame_from_catalog**

```python
write_data_frame_from_catalog(frame, database, table_name,
redshift_tmp_dir, transformation_ctx = "", additional_options = {},
catalog_id = None)
```

Writes and returns a DataFrame using information from a Data Catalog database and table.
This method supports writing to data lake formats (Hudi, Iceberg, and Delta Lake). For more
information, see [Using data lake frameworks with AWS Glue ETL jobs](#).

• frame – The DataFrame to write.
• Database – The Data Catalog database that contains the table.
• table_name – The name of the Data Catalog table that is associated with the target.
• redshift_tmp_dir – An Amazon Redshift temporary directory to use (optional).
• transformation_ctx – The transformation context to use (optional).
• additional_options – A collection of optional name-value pairs.
  • useSparkDataSink – When set to true, forces AWS Glue to use the native Spark Data Sink
    API to write to the table. When you enable this option, you can add any Spark Data Source
    options to additional_options as needed. AWS Glue passes these options directly to the
    Spark writer.
• catalog_id – The catalog ID (account ID) of the Data Catalog being accessed. When you don't
  specify a value, the default account ID of the caller is used.

**Limitations**

Consider the following limitations when you use the useSparkDataSink option:

• The **enableUpdateCatalog** option isn't supported when you use the useSparkDataSink
  option.

**Example: Writing to a Hudi table using the Spark Data Source writer**
hudi_options = {
    'useSparkDataSink': True,
    'hoodie.table.name': '<table_name>',
    'hoodie.datasource.write.storage.type': 'COPY_ON_WRITE',
    'hoodie.datasource.write.recordkey.field': 'product_id',
    'hoodie.datasource.write.table.name': '<table_name>',
    'hoodie.datasource.write.operation': 'upsert',
    'hoodie.datasource.write.precombine.field': 'updated_at',
    'hoodie.datasource.write.hive_style_partitioning': 'true',
    'hoodie.upsert.shuffle.parallelism': 2,
    'hoodie.insert.shuffle.parallelism': 2,
    'hoodie.datasource.hive_sync.enable': 'true',
    'hoodie.datasource.hive_sync.database': '<database_name>',
    'hoodie.datasource.hive_sync.table': '<table_name>',
    'hoodie.datasource.hive_sync.use_jdbc': 'false',
    'hoodie.datasource.hive_sync.mode': 'hms'}

glueContext.write_data_frame.from_catalog(
    frame = <df_product_inserts>,
    database = <database_name>,
    table_name = <table_name>,
    additional_options = hudi_options
)

write_dynamic_frame_from_jdbc_conf

write_dynamic_frame_from_jdbc_conf(frame, catalog_connection, connection_options={}, redshift_tmp_dir = '', transformation_ctx = '', catalog_id = None)

Writes and returns a DynamicFrame using the specified JDBC connection information.

- **frame** – The DynamicFrame to write.
- **catalog_connection** – A catalog connection to use.
- **connection_options** – Connection options, such as path and database table (optional). For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – A transformation context to use (optional).
- **catalog_id** – The catalog ID (account ID) of the Data Catalog being accessed. When None, the default account ID of the caller is used.
write_from_jdbc_conf

```python
write_from_jdbc_conf(frame_or_dfc, catalog_connection,
connection_options={}, redshift_tmp_dir = '',
transformation_ctx = '',
catalog_id = None)
```

Writes and returns a DynamicFrame or DynamicFrameCollection using the specified JDBC connection information.

- **frame_or_dfc** – The DynamicFrame or DynamicFrameCollection to write.
- **catalog_connection** – A catalog connection to use.
- **connection_options** – Connection options, such as path and database table (optional). For more information, see [Connection types and options for ETL in AWS Glue for Spark](#).
- **redshift_tmp_dir** – An Amazon Redshift temporary directory to use (optional).
- **transformation_ctx** – A transformation context to use (optional).
- **catalog_id** — The catalog ID (account ID) of the Data Catalog being accessed. When None, the default account ID of the caller is used.

## AWS Glue PySpark transforms reference

AWS Glue provides the following built-in transforms that you can use in PySpark ETL operations. Your data passes from transform to transform in a data structure called a `DynamicFrame`, which is an extension to an Apache Spark SQL DataFrame. The DynamicFrame contains your data, and you reference its schema to process your data.

Most of these transforms also exist as methods of the DynamicFrame class. For more information, see [DynamicFrame transforms](#).

- [GlueTransform base class](#)
- [ApplyMapping class](#)
- [DropFields class](#)
- [DropNullFields class](#)
- [ErrorsAsDynamicFrame class](#)
- [EvaluateDataQuality class](#)
- [FillMissingValues class](#)
• **Filter class**
• **FindIncrementalMatches class**
• **FindMatches class**
• **FlatMap class**
• **Join class**
• **Map class**
• **MapToCollection class**
• **mergeDynamicFrame**
• **Relationalize class**
• **RenameField class**
• **ResolveChoice class**
• **SelectFields class**
• **SelectFromCollection class**
• **Spigot class**
• **SplitFields class**
• **SplitRows class**
• **Unbox class**
• **UnnestFrame class**

**GlueTransform base class**

The base class that all the `awsglue.transforms` classes inherit from.

The classes all define a `__call__` method. They either override the `GlueTransform` class methods listed in the following sections, or they are called using the class name by default.

**Methods**

• `apply(cls, *args, **kwargs)`
• `name(cls)`
• `describeArgs(cls)`
• `describeReturn(cls)`
• `describeTransform(cls)`
• **describeErrors(cls)**

• **describe(cls)**

**apply(cls, *args, **kwargs)**

Applies the transform by calling the transform class, and returns the result.

• cls – The self class object.

**name(cls)**

Returns the name of the derived transform class.

• cls – The self class object.

**describeArgs(cls)**

• cls – The self class object.

Returns a list of dictionaries, each corresponding to a named argument, in the following format:

```json
[
  {
    "name": "(name of argument)",
    "type": "(type of argument)",
    "description": "(description of argument)",
    "optional": "(Boolean, True if the argument is optional)",
    "defaultValue": "(Default value string, or None)(String; the default value, or None)"
  },
  ...,
]
```

 Raises a `NotImplementedError` exception when called in a derived transform where it is not implemented.

**describeReturn(cls)**

• cls – The self class object.
Returns a dictionary with information about the return type, in the following format:

```python
{
    "type": "(return type)",
    "description": "(description of output)"
}
```

Raises a `NotImplementedError` exception when called in a derived transform where it is not implemented.

**describeTransform(cls)**

Returns a string describing the transform.

- `cls` – The `self` class object.

Raises a `NotImplementedError` exception when called in a derived transform where it is not implemented.

**describeErrors(cls)**

- `cls` – The `self` class object.

Returns a list of dictionaries, each describing a possible exception thrown by this transform, in the following format:

```python
[
    {
        "type": "(type of error)",
        "description": "(description of error)"
    },
    ...
]
```

**describe(cls)**

- `cls` – The `self` class object.

Returns an object with the following format:
ApplyMapping class

Applies a mapping in a DynamicFrame.

Example

We recommend that you use the `DynamicFrame.apply_mapping()` method to apply a mapping in a DynamicFrame. To view a code example, see **Example: Use apply_mapping to rename fields and change field types**.

Methods

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
- `Describe`

`__call__(frame, mappings, transformation_ctx = '', info = '', stageThreshold = 0, totalThreshold = 0)`

Applies a declarative mapping to a specified DynamicFrame.

- `frame` – The DynamicFrame to apply the mapping to (required).
- `mappings` – A list of mapping tuples (required). Each consists of: (source column, source type, target column, target type).
If the source column has a dot "." in the name, you must place back-ticks "\`\`" around it. For example, to map `this.old.name` (string) to `thisNewName`, you would use the following tuple:

```
("\`this.old.name\`", "string", "thisNewName", "string")
```

- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string that is associated with errors in the transformation (optional).
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

Returns only the fields of the `DynamicFrame` that are specified in the "mapping" tuples.

```python
apply(cls, *args, **kwargs)
```

Inherited from `GlueTransform apply`.

```python
name(cls)
```

Inherited from `GlueTransform name`.

```python
describeArgs(cls)
```

Inherited from `GlueTransform describeArgs`.

```python
describeReturn(cls)
```

Inherited from `GlueTransform describeReturn`.

```python
describeTransform(cls)
```

Inherited from `GlueTransform describeTransform`.

```python
describeErrors(cls)
```

Inherited from `GlueTransform describeErrors`.

```python
describe(cls)
```

Inherited from `GlueTransform describe`. 

- **ETL in PySpark**
DropFields class

Drops fields within a DynamicFrame.

Example

We recommend that you use the `DynamicFrame.drop_fields()` method to drop fields from a DynamicFrame. To view a code example, see Example: Use drop_fields to remove fields from a DynamicFrame.

Methods

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
- `Describe`

`__call__(frame, paths, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold = 0)`

Drops nodes within a DynamicFrame.

- `frame` – The DynamicFrame to drop the nodes in (required).
- `paths` – A list of full paths to the nodes to drop (required).
- `transformation_ctx` – A unique string that is used to identify state information (optional).
- `info` – A string associated with errors in the transformation (optional).
- `stageThreshold` – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- `totalThreshold` – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

Returns a new DynamicFrame without the specified fields.
apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.

describeTransform(cls)

Inherited from GlueTransform describeTransform.

describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

**DropNullFields class**

Drops all null fields in a DynamicFrame whose type is NullType. These are fields with missing or null values in every record in the DynamicFrame dataset.

**Example**

This example uses DropNullFields to create a new DynamicFrame where fields of type NullType have been dropped. In order to demonstrate DropNullFields, we add a new column named empty_column with type null to the already-loaded persons dataset.

![Note](note_icon.png)

To access the dataset that is used in this example, see [Code example: Joining and relationalizing data](#) and follow the instructions in [Step 1: Crawl the data in the Amazon S3 bucket](#).
# Example: Use DropNullFields to create a new DynamicFrame without NullType fields

from pyspark.context import SparkContext
from awsglue.context import GlueContext
from pyspark.sql.functions import lit
from pyspark.sql.types import NullType
from awsglue.dynamicframe import DynamicFrame
from awsglue.transforms import DropNullFields

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Create DynamicFrame
persons = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="persons_json"
)
print("Schema for the persons DynamicFrame:"
)
persons.printSchema()

# Add new column "empty_column" with NullType
persons_with_nulls = persons.toDF().withColumn("empty_column",
    lit(None).cast(NullType()))
persons_with_nulls_dyf = DynamicFrame.fromDF(persons_with_nulls, glueContext,
    "persons_with_nulls")
print("Schema for the persons_with_nulls_dyf DynamicFrame:"
)
persons_with_nulls_dyf.printSchema()

# Remove the NullType field
persons_no_nulls = DropNullFields.apply(persons_with_nulls_dyf)
print("Schema for the persons_no_nulls DynamicFrame:"
)
persons_no_nulls.printSchema()

Output

Schema for the persons DynamicFrame:
root
 |-- family_name: string
 |-- name: string
 |-- links: array
 |    |-- element: struct
 |    |    |-- note: string
 |    |    |-- url: string
|-- gender: string
|-- image: string
|-- identifiers: array
|   |-- element: struct
|     |-- scheme: string
|     |-- identifier: string
|-- other_names: array
|   |-- element: struct
|     |-- lang: string
|     |-- note: string
|     |-- name: string
|-- sort_name: string
|-- images: array
|   |-- element: struct
|     |-- url: string
|-- given_name: string
|-- birth_date: string
|-- id: string
|-- contact_details: array
|   |-- element: struct
|     |-- type: string
|     |-- value: string
|-- death_date: string

Schema for the persons_with_nulls_dyf DynamicFrame:
root
|-- family_name: string
|-- name: string
|-- links: array
|   |-- element: struct
|     |-- note: string
|     |-- url: string
|-- gender: string
|-- image: string
|-- identifiers: array
|   |-- element: struct
|     |-- scheme: string
|     |-- identifier: string
|-- other_names: array
|   |-- element: struct
|     |-- lang: string
|     |-- note: string
|     |-- name: string
|-- sort_name: string
null_fields ['empty_column']

Schema for the persons_no_nulls DynamicFrame:

root
 |-- family_name: string
 |-- name: string
 |-- links: array
  |-- element: struct
   |-- note: string
   |-- url: string
 |-- gender: string
 |-- image: string
 |-- identifiers: array
  |-- element: struct
   |-- scheme: string
   |-- identifier: string
 |-- other_names: array
  |-- element: struct
   |-- lang: string
   |-- note: string
   |-- name: string
 |-- sort_name: string
 |-- images: array
  |-- element: struct
   |-- url: string
 |-- given_name: string
 |-- birth_date: string
 |-- id: string
 |-- contact_details: array
  |-- element: struct
   |-- type: string
   |-- value: string
 |-- death_date: string
|-- empty_column: null
Methods

- `_call_`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
- `Describe`

__call__(frame, transformation_ctx = '', info = '', stageThreshold = 0, totalThreshold = 0)

Drops all null fields in a `DynamicFrame` whose type is `NullType`. These are fields with missing or null values in every record in the `DynamicFrame` dataset.

- `frame` – The `DynamicFrame` to drop null fields in (required).
- `transformation_ctx` – A unique string that is used to identify state information (optional).
- `info` – A string associated with errors in the transformation (optional).
- `stageThreshold` – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- `totalThreshold` – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

Returns a new `DynamicFrame` with no null fields.

`apply(cls, *args, **kwargs)`

- `cls` – `cls`

`name(cls)`

- `cls` – `cls`
describeArgs(cls)

- cls – cls

describeReturn(cls)

- cls – cls

describeTransform(cls)

- cls – cls

describeErrors(cls)

- cls – cls

describe(cls)

- cls – cls

ErrorsAsDynamicFrame class

Returns a DynamicFrame that contains nested records for errors that occurred while the source DynamicFrame was created.

Example

We recommend that you use the `DynamicFrame.errorsAsDynamicFrame()` method to retrieve and view error records. To view a code example, see Example: Use errorsAsDynamicFrame to view error records.

Methods

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
__call__(frame)

Returns a DynamicFrame that contains nested error records that relate to the source DynamicFrame.

- frame – The source DynamicFrame (required).

apply(cls, *args, **kwargs)

- cls – cls

name(cls)

- cls – cls

describeArgs(cls)

- cls – cls

describeReturn(cls)

- cls – cls

describeTransform(cls)

- cls – cls

describeErrors(cls)

- cls – cls
describe(cls)

- cls - cls

EvaluateDataQuality class

Evaluates a data quality ruleset against a DynamicFrame and returns a new DynamicFrame with results of the evaluation.

Example

The following example code demonstrates how to evaluate data quality for a DynamicFrame and then view the data quality results.

```python
from awsglue.transforms import *
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsgluedq.transforms import EvaluateDataQuality

# Create Glue context
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Define DynamicFrame
legislatorsAreas = glueContext.create_dynamic_frame.from_catalog(
    database="legislators", table_name="areas_json")

# Create data quality ruleset
ruleset = """Rules = [ColumnExists "id", IsComplete "id"]""

# Evaluate data quality
dqResults = EvaluateDataQuality.apply(
    frame=legislatorsAreas,
    ruleset=ruleset,
    publishing_options={
        "dataQualityEvaluationContext": "legislatorsAreas",
        "enableDataQualityCloudWatchMetrics": True,
        "enableDataQualityResultsPublishing": True,
        "resultsS3Prefix": "DOC-EXAMPLE-BUCKET1",
    },
)
```
# Inspect data quality results

dqResults.printSchema()
dqResults.toDF().show()

## Output

```
root
|-- Rule: string
|-- Outcome: string
|-- FailureReason: string
|-- EvaluatedMetrics: map
  |   |-- keyType: string
  |   |-- valueType: double

+-----------------------+-------+-------------+---------------------------------------+
|Rule                   |Outcome|FailureReason|EvaluatedMetrics                       |
+-----------------------+-------+-------------+---------------------------------------+
|ColumnExists "id"      |Passed |null         |{}                                     |
|IsComplete "id"        |Passed |null         |{Column.first_name.Completeness -> 1.0}|
+-----------------------+-------+-------------+---------------------------------------+
```

## Methods

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
- `describe`

```python
__call__(frame, ruleset, publishing_options = {})
```

- `frame` – The DynamicFrame that you want evaluate the data quality of.
- `ruleset` – A Data Quality Definition Language (DQDL) ruleset in string format. To learn more about DQDL, see the Data Quality Definition Language (DQDL) reference guide.
• publishing_options – A dictionary that specifies the following options for publishing evaluation results and metrics:
  • dataQualityEvaluationContext – A string that specifies the namespace under which AWS Glue should publish Amazon CloudWatch metrics and the data quality results. The aggregated metrics appear in CloudWatch, while the full results appear in the AWS Glue Studio interface.
    • Required: No
    • Default value: default_context
  • enableDataQualityCloudWatchMetrics – Specifies whether the results of the data quality evaluation should be published to CloudWatch. You specify a namespace for the metrics using the dataQualityEvaluationContext option.
    • Required: No
    • Default value: False
  • enableDataQualityResultsPublishing – Specifies whether the data quality results should be visible on the Data Quality tab in the AWS Glue Studio interface.
    • Required: No
    • Default value: True
  • resultsS3Prefix – Specifies the Amazon S3 location where AWS Glue can write the data quality evaluation results.
    • Required: No
    • Default value: "" (empty string)

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.
describeTransform(cls)

Inherited from GlueTransform describeTransform.

describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

**FillMissingValues class**

The FillMissingValues class locates null values and empty strings in a specified DynamicFrame and uses machine learning methods, such as linear regression and random forest, to predict the missing values. The ETL job uses the values in the input dataset to train the machine learning model, which then predicts what the missing values should be.

**Tip**

If you use incremental data sets, then each incremental set is used as the training data for the machine learning model, so the results might not be as accurate.

To import:

```python
from awsglueml.transforms import FillMissingValues
```

**Methods**

- **Apply**

```
apply(frame, missing_values_column, output_column ="", transformation_ctx ="", info ="", stageThreshold = 0, totalThreshold = 0)
```

Fills a dynamic frame's missing values in a specified column and returns a new frame with estimates in a new column. For rows without missing values, the specified column's value is duplicated to the new column.

- **frame** – The DynamicFrame in which to fill missing values. Required.
• missing_values_column – The column containing missing values (null values and empty strings). Required.

• output_column – The name of the new column that will contain estimated values for all rows whose value was missing. Optional; the default is the name of missing_values_column suffixed by "_filled".

• transformation_ctx – A unique string that is used to identify state information (optional).

• info – A string associated with errors in the transformation (optional).

• stageThreshold – The maximum number of errors that can occur in the transformation before it errors out (optional; the default is zero).

• totalThreshold – The maximum number of errors that can occur overall before processing errors out (optional; the default is zero).

Returns a new DynamicFrame with one additional column that contains estimations for rows with missing values and the present value for other rows.

**Filter class**

Builds a new DynamicFrame that contains records from the input DynamicFrame that satisfy a specified predicate function.

**Example**

We recommend that you use the `DynamicFrame.filter()` method to filter records in a DynamicFrame. To view a code example, see Example: Use filter to get a filtered selection of fields.

**Methods**

• `__call__`
• `apply`
• `name`
• `describeArgs`
• `describeReturn`
• `describeTransform`
• `describeErrors`
• `describe`
__call__(frame, f, transformation_ctx='', info='', stageThreshold=0, totalThreshold=0))

Returns a new DynamicFrame that is built by selecting records from the input DynamicFrame that satisfy a specified predicate function.

- frame – The source DynamicFrame to apply the specified filter function to (required).
- f – The predicate function to apply to each DynamicRecord in the DynamicFrame. The function must take a DynamicRecord as its argument and return True if the DynamicRecord meets the filter requirements, or False if it doesn't (required).

A DynamicRecord represents a logical record in a DynamicFrame. It's similar to a row in a Spark DataFrame, except that it is self-describing and can be used for data that doesn't conform to a fixed schema.

- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string that is associated with errors in the transformation (optional).
- stageThreshold – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- totalThreshold – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.

describeTransform(cls)

Inherited from GlueTransform describeTransform.
describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

FindIncrementalMatches class

Identifies matching records in the existing and incremental DynamicFrame and creates a new DynamicFrame with a unique identifier assigned to each group of matching records.

To import:

```python
from awsglueml.transforms import FindIncrementalMatches
```

Methods

- **Apply**

```python
apply(existingFrame, incrementalFrame, transformId, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold = 0, enforcedMatches = none, computeMatchConfidenceScores = 0)
```

Identifies matching records in the input DynamicFrame and creates a new DynamicFrame with a unique identifier assigned to each group of matching records.

- **existingFrame** – The existing and pre-matched DynamicFrame to apply the FindIncrementalMatches transform. Required.
- **incrementalFrame** – The incremental DynamicFrame to apply the FindIncrementalMatches transform to match against the existingFrame. Required.
- **transformId** – The unique ID associated with the FindIncrementalMatches transform to apply on records in the DynamicFrames. Required.
- **transformation_ctx** – A unique string that is used to identify stats/state information. Optional.
- **info** – A string to be associated with errors in the transformation. Optional.
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out. Optional. The default is zero.
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• totalThreshold – The maximum number of errors that can occur overall before processing
errors out. Optional. The default is zero.
• enforcedMatches – The DynamicFrame used to enforce matches. Optional. The default is
None.
• computeMatchConfidenceScores – A Boolean value indicating whether to compute a
conﬁdence score for each group of matching records. Optional. The default is false.
Returns a new DynamicFrame with a unique identiﬁer assigned to each group of matching records.
FindMatches class
Identiﬁes matching records in the input DynamicFrame and creates a new DynamicFrame with a
unique identiﬁer assigned to each group of matching records.
To import:
from awsglueml.transforms import FindMatches

Methods
• Apply
apply(frame, transformId, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold
= 0, enforcedMatches = none, computeMatchConﬁdenceScores = 0)
Identiﬁes matching records in the input DynamicFrame and creates a new DynamicFrame with a
unique identiﬁer assigned to each group of matching records.
• frame – The DynamicFrame to apply the FindMatches transform. Required.
• transformId – The unique ID associated with the FindMatches transform to apply on records in
the DynamicFrame. Required.
• transformation_ctx – A unique string that is used to identify stats/state information.
Optional.
• info – A string to be associated with errors in the transformation. Optional.
• stageThreshold – The maximum number of errors that can occur in the transformation before
it errors out. Optional. The default is zero.
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- `totalThreshold` – The maximum number of errors that can occur overall before processing errors out. Optional. The default is zero.

- `enforcedMatches` – The `DynamicFrame` used to enforce matches. Optional. The default is `None`.

- `computeMatchConfidenceScores` – A Boolean value indicating whether to compute a confidence score for each group of matching records. Optional. The default is `false`.

Returns a new `DynamicFrame` with a unique identifier assigned to each group of matching records.

**FlatMap class**

Applies a transform to each `DynamicFrame` in a collection. Results are not flattened into a single `DynamicFrame`, but preserved as a collection.

**Examples for FlatMap**

The following example snippet demonstrates how to use the `ResolveChoice` transform on a collection of dynamic frames when applied to a `FlatMap`. The data used for input is in the JSON located at the placeholder Amazon S3 address `s3://bucket/path-for-data/sample.json` and contains the following data.

**Example JSON data**

```json
[{
    "firstname": "Arnav",
    "lastname": "Desai",
    "address": {
        "street": "6 Anyroad Avenue",
        "city": "London",
        "state": "England",
        "country": "UK"
    },
    "phone": 17235550101,
    "affiliations": [
        "General Anonymous Example Products",
        "Example Independent Research",
        "Government Department of Examples"
    ]
},
{
    "firstname": "Mary",
```
Example Apply ResolveChoice to a DynamicFrameCollection and show output.

#Read DynamicFrame

datasource = glueContext.create_dynamic_frame_from_options("s3", connection_options = {
"paths": ["s3://bucket/path/to/file/mysamplejson.json"], format="json"
})
datasource.printSchema()
datasource.show()

## Split to create a DynamicFrameCollection

split_frame = datasource.split_fields(["firstname","lastname","address"], "personal_info","business_info")
split_frame.keys()
print("---")
## Use FlatMap to run ResolveChoice

```python
kw args = {"choice": "cast:string"}
flat = FlatMap.apply(split_frame, ResolveChoice, frame_name="frame",
  transformation_ctx='tcx', **kwargs)
flat.keys()
```

## Select one of the DynamicFrames

```python
personal_info = flat.select("personal_info")
personal_info.printSchema()
personal_info.show()
print("--")
```

```python
business_info = flat.select("business_info")
business_info.printSchema()
business_info.show()
```

---

### Important

When calling `FlatMap.apply`, the `frame_name` parameter **must** be "frame". No other value is currently accepted.

---

**Example output**

```
root
|-- firstname: string
|-- lastname: string
|-- address: struct
  |-- street: string
  |-- city: string
  |-- state: string
  |-- country: string
|-- phone: long
|-- affiliations: array
  |-- element: string
  ```

```json
{"firstname": "Mary",
 "lastname": "Major",
 "address": {
   "street": "7821 Spot Place",
   "city": "Centerville",
```
"state": "OK",
"country": "US"
},
"phone": 19185550023,
"affiliations": [
   "Example Dot Com",
   "Example Independent Research",
   "Example.io"
]
}

{
   "firstname": "Paulo",
   "lastname": "Santos",
   "address": {
      "street": "123 Maple Street",
      "city": "London",
      "state": "Ontario",
      "country": "CA"
   },
   "phone": 12175550181,
   "affiliations": [
      "General Anonymous Example Products",
      "Example Dot Com"
   ]
}

---

root
|-- firstname: string
|-- lastname: string
|-- address: struct
   |-- street: string
   |-- city: string
   |-- state: string
   |-- country: string

{
   "firstname": "Mary",
   "lastname": "Major",
   "address": {
      "street": "7821 Spot Place",
      "city": "Centerville",
      "state": "OK",
      "country": "US"
Methods

- __call__
- Apply
- Name
- describeArgs
__call__ (dfc, BaseTransform, frame_name, transformation_ctx = "", **base_kwargs)

Applies a transform to each DynamicFrame in a collection and flattens the results.

- dfc – The DynamicFrameCollection over which to flatmap (required).
- BaseTransform – A transform derived from GlueTransform to apply to each member of the collection (required).
- frame_name – The argument name to pass the elements of the collection to (required).
- transformation_ctx – A unique string that is used to identify state information (optional).
- base_kwargs – Arguments to pass to the base transform (required).

Returns a new DynamicFrameCollection created by applying the transform to each DynamicFrame in the source DynamicFrameCollection.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.

describeTransform(cls)

Inherited from GlueTransform describeTransform.
describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

Join class

Performs an equality join on two DynamicFrames.

Example

We recommend that you use the DynamicFrame.join() method to join DynamicFrames. To view a code example, see Example: Use join to combine DynamicFrames.

Methods

- __call__
- apply
- name
- describeArgs
- describeReturn
- describeTransform
- describeErrors
- Describe

__call__(frame1, frame2, keys1, keys2, transformation_ctx = "")

Performs an equality join on two DynamicFrames.

- frame1 – The first DynamicFrame to join (required).
- frame2 – The second DynamicFrame to join (required).
- keys1 – The keys to join on for the first frame (required).
- keys2 – The keys to join on for the second frame (required).
- transformation_ctx – A unique string that is used to identify state information (optional).
Returns a new DynamicFrame that is created by joining the two DynamicFrames.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.

describeTransform(cls)

Inherited from GlueTransform describeTransform.

describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

Map class

Builds a new DynamicFrame by applying a function to all records in the input DynamicFrame.

Example

We recommend that you use the DynamicFrame.map() method to apply a function to all records in a DynamicFrame. To view a code example, see Example: Use map to apply a function to every record in a DynamicFrame.

Methods

- __call__
- apply
- name
__call__(frame, f, transformation_ctx="", info="", stageThreshold=0, totalThreshold=0)

Returns a new DynamicFrame that results from applying the specified function to all DynamicRecords in the original DynamicFrame.

- **frame** – The original DynamicFrame to apply the mapping function to (required).
- **f** – The function to apply to all DynamicRecords in the DynamicFrame. The function must take a DynamicRecord as an argument and return a new DynamicRecord that is produced by the mapping (required).

A DynamicRecord represents a logical record in a DynamicFrame. It's similar to a row in an Apache Spark DataFrame, except that it is self-describing and can be used for data that doesn't conform to a fixed schema.

- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string associated with errors in the transformation (optional).
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

Returns a new DynamicFrame that results from applying the specified function to all DynamicRecords in the original DynamicFrame.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.
**describeArgs(cls)**
Inherited from GlueTransform **describeArgs**.

**describeReturn(cls)**
Inherited from GlueTransform **describeReturn**.

**describeTransform(cls)**
Inherited from GlueTransform **describeTransform**.

**describeErrors(cls)**
Inherited from GlueTransform **describeErrors**.

**describe(cls)**
Inherited from GlueTransform **describe**.

**MapToCollection class**
Applies a transform to each DynamicFrame in the specified DynamicFrameCollection.

**Methods**
- __call__
- Apply
- Name
- describeArgs
- describeReturn
- describeTransform
- describeErrors
- Describe

**__call__(dfc, BaseTransform, frame_name, transformation_ctx = "", **base_kwargs)**
Applies a transform function to each DynamicFrame in the specified DynamicFrameCollection.

- dfc – The DynamicFrameCollection over which to apply the transform function (required).
- callable – A callable transform function to apply to each member of the collection (required).
transformation_ctx – A unique string that is used to identify state information (optional).

Returns a new DynamicFrameCollection created by applying the transform to each DynamicFrame in the source DynamicFrameCollection.

```python
apply(cls, *args, **kwargs)
```

Inherited from GlueTransform `apply`

```python
name(cls)
```

Inherited from GlueTransform `name`

```python
describeArgs(cls)
```

Inherited from GlueTransform `describeArgs`

```python
describeReturn(cls)
```

Inherited from GlueTransform `describeReturn`

```python
describeTransform(cls)
```

Inherited from GlueTransform `describeTransform`

```python
describeErrors(cls)
```

Inherited from GlueTransform `describeErrors`

```python
describe(cls)
```

Inherited from GlueTransform `describe`

**Relationalize class**

Flattens a nested schema in a DynamicFrame and pivots out array columns from the flattened frame.

**Example**

We recommend that you use the `DynamicFrame.relationalize()` method to relationalize a DynamicFrame. To view a code example, see [Example: Use relationalize to flatten a nested schema in a DynamicFrame](#).
Methods

- __call__
- apply
- name
- describeArgs
- describeReturn
- describeTransform
- describeErrors
- describe

__call__(frame, staging_path=None, name='roottable', options=None, transformation_ctx = '', info = '', stageThreshold = 0, totalThreshold = 0)

Relationalizes a DynamicFrame and produces a list of frames that are generated by unnesting nested columns and pivoting array columns. You can join a pivoted array column to the root table by using the join key that is generated in the unnest phase.

- frame – The DynamicFrame to relationalize (required).
- staging_path – The path where the method can store partitions of pivoted tables in CSV format (optional). Pivoted tables are read back from this path.
- name – The name of the root table (optional).
- options – A dictionary of optional parameters. Currently unused.
- transformation_ctx – A unique string that is used to identify state information (optional).
- info – A string associated with errors in the transformation (optional).
- stageThreshold – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- totalThreshold – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.
name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.

describeTransform(cls)

Inherited from GlueTransform describeTransform.

describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

**RenameField class**

Renames a node within a DynamicFrame.

**Example**

We recommend that you use the `DynamicFrame.rename_field()` method to rename a field in a DynamicFrame. To view a code example, see [Example: Use rename_field to rename fields in a DynamicFrame](#).

**Methods**

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
• **describe**

```python
__call__(frame, old_name, new_name, transformation_ctx = '', info = '', stageThreshold = 0, totalThreshold = 0)
```

Renames a node within a DynamicFrame.

- **frame** – The DynamicFrame in which to rename a node (required).
- **old_name** – The full path to the node to rename (required).

If the old name has dots in it, RenameField will not work unless you place backticks around it (```). For example, to replace `this.old.name` with `thisNewName`, you would call RenameField as follows:

```python
newDyF = RenameField(oldDyF, "\`this.old.name\`", "thisNewName")
```

- **new_name** – The new name, including full path (required).
- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string associated with errors in the transformation (optional).
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

**apply(cls, *args, **kwargs)**

Inherited from GlueTransform `apply`.

**name(cls)**

Inherited from GlueTransform `name`.

**describeArgs(cls)**

Inherited from GlueTransform `describeArgs`.

**describeReturn(cls)**

Inherited from GlueTransform `describeReturn`.
describeTransform(cls)

Inherited from GlueTransform describeTransform.

describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

ResolveChoice class

Resolves a choice type within a DynamicFrame.

Example

We recommend that you use the DynamicFrame.resolveChoice() method to handle fields that contain multiple types in a DynamicFrame. To view a code example, see Example: Use resolveChoice to handle a column that contains multiple types.

Methods

- __call__
- apply
- name
- describeArgs
- describeReturn
- describeTransform
- describeErrors
- describe

__call__(frame, specs = none, choice = "", transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold = 0)

Provides information for resolving ambiguous types within a DynamicFrame. It returns the resulting DynamicFrame.
• frame – The DynamicFrame in which to resolve the choice type (required).

• specs – A list of specific ambiguities to resolve, each in the form of a tuple: (path, action). The path value identifies a specific ambiguous element, and the action value identifies the corresponding resolution.

You can only use one of the spec and choice parameters. If the spec parameter is not None, then the choice parameter must be an empty string. Conversely, if the choice is not an empty string, then the spec parameter must be None. If neither parameter is provided, AWS Glue tries to parse the schema and use it to resolve ambiguities.

You can specify one of the following resolution strategies in the action portion of a specs tuple:

• cast – Allows you to specify a type to cast to (for example, cast:int).

• make_cols – Resolves a potential ambiguity by flattening the data. For example, if columnA could be an int or a string, the resolution is to produce two columns named columnA_int and columnA_string in the resulting DynamicFrame.

• make_struct – Resolves a potential ambiguity by using a struct to represent the data. For example, if data in a column could be an int or a string, using the make_struct action produces a column of structures in the resulting DynamicFrame with each containing both an int and a string.

• project – Resolves a potential ambiguity by retaining only values of a specified type in the resulting DynamicFrame. For example, if data in a ChoiceType column could be an int or a string, specifying a project:string action drops values from the resulting DynamicFrame that are not type string.

If the path identifies an array, place empty square brackets after the name of the array to avoid ambiguity. For example, suppose you are working with data structured as follows:

```
"myList": [ 
    { "price": 100.00 },
    { "price": "$100.00" }
  ]
```

You can select the numeric rather than the string version of the price by setting the path to "myList[].price", and setting the action to "cast:double".

• choice – The default resolution action if the specs parameter is None. If the specs parameter is not None, then this must not be set to anything but an empty string.
In addition to the specs actions previously described, this argument also supports the following action:

- **MATCH_CATALOG** – Attempts to cast each ChoiceType to the corresponding type in the specified Data Catalog table.

- **database** – The AWS Glue Data Catalog database to use with the MATCH_CATALOG choice (required for MATCH_CATALOG).

- **table_name** – The AWS Glue Data Catalog table name to use with the MATCH_CATALOG action (required for MATCH_CATALOG).

- **transformation_ctx** – A unique string that is used to identify state information (optional).

- **info** – A string associated with errors in the transformation (optional).

- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.

- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

**apply(cls, *args, **kwargs)**

Inherited from GlueTransform `apply`.

**name(cls)**

Inherited from GlueTransform `name`.

**describeArgs(cls)**

Inherited from GlueTransform `describeArgs`.

**describeReturn(cls)**

Inherited from GlueTransform `describeReturn`.

**describeTransform(cls)**

Inherited from GlueTransform `describeTransform`.

**describeErrors(cls)**

Inherited from GlueTransform `describeErrors`. 
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describe(cls)
Inherited from GlueTransform describe.
SelectFields class
The SelectFields class creates a new DynamicFrame from an existing DynamicFrame, and
keeps only the ﬁelds that you specify. SelectFields provides similar functionality to a SQL
SELECT statement.
Example
We recommend that you use the DynamicFrame.select_fields() method to select ﬁelds
from a DynamicFrame. To view a code example, see Example: Use select_ﬁelds to create a new
DynamicFrame with chosen ﬁelds.
Methods
• __call__
• apply
• name
• describeArgs
• describeReturn
• describeTransform
• describeErrors
• Describe
__call__(frame, paths, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold =
0)
Gets ﬁelds (nodes) in a DynamicFrame.
• frame – The DynamicFrame to select ﬁelds in (required).
• paths – A list of full paths to the ﬁelds to select (required).
• transformation_ctx – A unique string that is used to identify state information (optional).
• info – A string that is associated with errors in the transformation (optional).
• stageThreshold – The maximum number of errors that can occur in the transformation before
it errors out (optional). The default is zero.
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• `totalThreshold` – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

Returns a new `DynamicFrame` that contains only the specified fields.

```python
apply(cls, *args, **kwargs)
```

Inherited from `GlueTransform apply`.

```python
name(cls)
```

Inherited from `GlueTransform name`.

```python
describeArgs(cls)
```

Inherited from `GlueTransform describeArgs`.

```python
describeReturn(cls)
```

Inherited from `GlueTransform describeReturn`.

```python
describeTransform(cls)
```

Inherited from `GlueTransform describeTransform`.

```python
describeErrors(cls)
```

Inherited from `GlueTransform describeErrors`.

```python
describe(cls)
```

Inherited from `GlueTransform describe`.

**SelectFromClass**

Selects one `DynamicFrame` in a `DynamicFrameCollection`.

**Example**

This example uses `SelectFromClass` to select a `DynamicFrame` from a `DynamicFrameCollection`.

**Example dataset**
The example selects two DynamicFrames from a DynamicFrameCollection called split_rows_collection. The following is the list of keys in split_rows_collection:

```python
dict_keys(["high", 'low'])
```

**Example code**

```python
# Example: Use SelectFromCollection to select DynamicFrames from a DynamicFrameCollection

from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.transforms import SelectFromCollection

# Create GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

# Select frames and inspect entries
frame_low = SelectFromCollection.apply(dfc=split_rows_collection, key="low")
frame_low.toDF().show()

frame_high = SelectFromCollection.apply(dfc=split_rows_collection, key="high")
frame_high.toDF().show()
```

**Output**

```
+---+-----+------------------------+-------------------------+
| id|index|contact_details.val.type|contact_details.val.value|
|----+-----+------------------------+-------------------------|
|  1|    0|                     fax|             202-225-3307|
|  1|    1|                   phone|             202-225-5731|
|  2|    0|                     fax|             202-225-3307|
|  2|    1|                   phone|             202-225-5731|
|  3|    0|                     fax|             202-225-3307|
|  3|    1|                   phone|             202-225-5731|
|  4|    0|                     fax|             202-225-3307|
|  4|    1|                   phone|             202-225-5731|
|  5|    0|                     fax|             202-225-3307|
|  5|    1|                   phone|             202-225-5731|
|  6|    0|                     fax|             202-225-3307|
|  6|    1|                   phone|             202-225-5731|
```
<table>
<thead>
<tr>
<th>id</th>
<th>index</th>
<th>contact_details.val.type</th>
<th>contact_details.val.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>twitter</td>
<td>RepTrentFranks</td>
</tr>
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<td>phone</td>
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<td>0</td>
<td>fax</td>
<td>202-225-6328</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>phone</td>
<td>202-225-4576</td>
</tr>
</tbody>
</table>

Methods

- `__call__`
- `apply`
- `name`
• **describeArgs**
• **describeReturn**
• **describeTransform**
• **describeErrors**
• **describe**

```python
__call__(dfc, key, transformation_ctx = "")
```

Gets one DynamicFrame from a DynamicFrameCollection.

- dfc – The DynamicFrameCollection that the DynamicFrame should be selected from (required).
- key – The key of the DynamicFrame to select (required).
- transformation_ctx – A unique string that is used to identify state information (optional).

```python
apply(cls, *args, **kwargs)
```

Inherited from GlueTransform `apply`.

```python
name(cls)
```

Inherited from GlueTransform `name`.

```python
describeArgs(cls)
```

Inherited from GlueTransform `describeArgs`.

```python
describeReturn(cls)
```

Inherited from GlueTransform `describeReturn`.

```python
describeTransform(cls)
```

Inherited from GlueTransform `describeTransform`.

```python
describeErrors(cls)
```

Inherited from GlueTransform `describeErrors`.  

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describe(cls)

Inherited from GlueTransform describe.

Spigot class

Writes sample records to a specified destination to help you verify the transformations performed by your AWS Glue job.

Example

We recommend that you use the DynamicFrame.spigot() method to write a subset of records from a DynamicFrame to a specified destination. To view a code example, see Example: Use spigot to write sample fields from a DynamicFrame to Amazon S3.

Methods

• __call__
• apply
• name
• describeArgs
• describeReturn
• describeTransform
• describeErrors
• describe

__call__(frame, path, options, transformation_ctx = "")

Writes sample records to a specified destination during a transformation.

• frame – The DynamicFrame to spigot (required).
• path – The path of the destination to write to (required).
• options – JSON key-value pairs that specify options (optional). The "topk" option specifies that the first k records should be written. The "prob" option specifies the probability (as a decimal) of picking any given record. You use this in selecting records to write.
• transformation_ctx – A unique string that is used to identify state information (optional).
apply(cls, *args, **kwargs)

Inherited from GlueTransform apply

name(cls)

Inherited from GlueTransform name

describeArgs(cls)

Inherited from GlueTransform describeArgs

describeReturn(cls)

Inherited from GlueTransform describeReturn

describeTransform(cls)

Inherited from GlueTransform describeTransform

describeErrors(cls)

Inherited from GlueTransform describeErrors

describe(cls)

Inherited from GlueTransform describe

SplitFields class

Splits a DynamicFrame into two new ones, by specified fields.

Example

We recommend that you use the DynamicFrame.split_fields() method to split fields in a DynamicFrame. To view a code example, see Example: Use split_fields to split selected fields into a separate DynamicFrame.

Methods

• __call__
• apply
name

describeArgs

describeReturn

describeTransform

describeErrors

describe

__call__(frame, paths, name1 = none, name2 = none, transformation_ctx = "", info = "", stageThreshold = 0, totalThreshold = 0)

Splits one or more fields in a DynamicFrame off into a new DynamicFrame, and creates another new DynamicFrame that contains the fields that remain.

• frame – The source DynamicFrame to split into two new ones (required).
• paths – A list of full paths to the fields to be split (required).
• name1 – The name to assign to the DynamicFrame that will contain the fields to be split off (optional). If no name is supplied, the name of the source frame is used with "1" appended.
• name2 – The name to assign to the DynamicFrame that will contain the fields that remain after the specified fields are split off (optional). If no name is provided, the name of the source frame is used with "2" appended.
• transformation_ctx – A unique string that is used to identify state information (optional).
• info – A string associated with errors in the transformation (optional).
• stageThreshold – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
• totalThreshold – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.
**describeArgs(cls)**

Inherited from GlueTransform `describeArgs`.

**describeReturn(cls)**

Inherited from GlueTransform `describeReturn`.

**describeTransform(cls)**

Inherited from GlueTransform `describeTransform`.

**describeErrors(cls)**

Inherited from GlueTransform `describeErrors`.

**describe(cls)**

Inherited from GlueTransform `describe`.

**SplitRows class**

Creates a DynamicFrameCollection that contains two DynamicFrames. One DynamicFrame contains only the specified rows to be split, and the other contains all remaining rows.

**Example**

We recommend that you use the `DynamicFrame.split_rows()` method to split rows in a DynamicFrame. To view a code example, see [Example: Use split_rows to split rows in a DynamicFrame](#).

**Methods**

- `__call__`
- `apply`
- `name`
- `describeArgs`
- `describeReturn`
- `describeTransform`
- `describeErrors`
__call__(frame, comparison_dict, name1="frame1", name2="frame2", transformation_ctx = ",
info = none, stageThreshold = 0, totalThreshold = 0)

Splits one or more rows in a DynamicFrame off into a new DynamicFrame.

- **frame** – The source DynamicFrame to split into two new ones (required).
- **comparison_dict** – A dictionary where the key is the full path to a column, and the value is another dictionary for mapping comparators to values that the column values are compared to. For example, {"age": {">": 10, "<": 20}} splits rows where the value of "age" is between 10 and 20, exclusive, from rows where "age" is outside that range (required).
- **name1** – The name to assign to the DynamicFrame that will contain the rows to be split off (optional).
- **name2** – The name to assign to the DynamicFrame that will contain the rows that remain after the specified rows are split off (optional).
- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string associated with errors in the transformation (optional).
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

apply(cls, *args, **kwargs)

Inherited from GlueTransform apply.

name(cls)

Inherited from GlueTransform name.

describeArgs(cls)

Inherited from GlueTransform describeArgs.

describeReturn(cls)

Inherited from GlueTransform describeReturn.
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describeTransform(cls)
Inherited from GlueTransform describeTransform.
describeErrors(cls)
Inherited from GlueTransform describeErrors.
describe(cls)
Inherited from GlueTransform describe.
Unbox class
Unboxes (reformats) a string ﬁeld in a DynamicFrame.
Example
We recommend that you use the DynamicFrame.unbox() method to unbox a ﬁeld in a
DynamicFrame. To view a code example, see Example: Use unbox to unbox a string ﬁeld into a
struct.
Methods
• __call__
• apply
• name
• describeArgs
• describeReturn
• describeTransform
• describeErrors
• describe
__call__(frame, path, format, transformation_ctx = "", info="", stageThreshold=0,
totalThreshold=0, **options)
Unboxes a string ﬁeld in a DynamicFrame.
• frame – The DynamicFrame in which to unbox a ﬁeld. (required).
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- **path** – The full path to the StringNode to unbox (required).
- **format** – A format specification (optional). This is used for an Amazon S3 or AWS Glue connection that supports multiple formats. For the formats that are supported, see [Data format options for inputs and outputs in AWS Glue for Spark](https://docs.aws.amazon.com/glue/latest/dg/dataformat-options-inputs-outputs.html).
- **transformation_ctx** – A unique string that is used to identify state information (optional).
- **info** – A string associated with errors in the transformation (optional).
- **stageThreshold** – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- **totalThreshold** – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.
- **separator** – A separator token (optional).
- **escaper** – An escape token (optional).
- **skipFirst** – True if the first line of data should be skipped, or False if it should not be skipped (optional).
- **withSchema** – A string that contains a schema for the data to be unboxed (optional). This should always be created using `StructType.json`.
- **withHeader** – True if the data being unpacked includes a header, or False if not (optional).

**apply(cls, *args, **kwargs)**

Inherited from `GlueTransform apply`.

**name(cls)**

Inherited from `GlueTransform name`.

**describeArgs(cls)**

Inherited from `GlueTransform describeArgs`.

**describeReturn(cls)**

Inherited from `GlueTransform describeReturn`.

**describeTransform(cls)**

Inherited from `GlueTransform describeTransform`.

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describeErrors(cls)

Inherited from GlueTransform describeErrors.

describe(cls)

Inherited from GlueTransform describe.

UnnestFrame class

Unnests a DynamicFrame, flattens nested objects to top-level elements, and generates join keys for array objects.

Example

We recommend that you use the DynamicFrame.unnest() method to flatten nested structures in a DynamicFrame. To view a code example, see Example: Use unnest to turn nested fields into top-level fields.

Methods

• __call__
• apply
• name
• describeArgs
• describeReturn
• describeTransform
• describeErrors
• describe

__call__(frame, transformation_ctx = "", info="", stageThreshold=0, totalThreshold=0)

Unnests a DynamicFrame, flattens nested objects to top-level elements, and generates join keys for array objects.

• frame – The DynamicFrame to unnest (required).
• transformation_ctx – A unique string that is used to identify state information (optional).
• info – A string associated with errors in the transformation (optional).
- `stageThreshold` – The maximum number of errors that can occur in the transformation before it errors out (optional). The default is zero.
- `totalThreshold` – The maximum number of errors that can occur overall before processing errors out (optional). The default is zero.

```python
apply(cls, *args, **kwargs)
```

Inherited from `GlueTransform apply`.

```python
name(cls)
```

Inherited from `GlueTransform name`.

```python
describeArgs(cls)
```

Inherited from `GlueTransform describeArgs`.

```python
describeReturn(cls)
```

Inherited from `GlueTransform describeReturn`.

```python
describeTransform(cls)
```

Inherited from `GlueTransform describeTransform`.

```python
describeErrors(cls)
```

Inherited from `GlueTransform describeErrors`.

```python
describe(cls)
```

Inherited from `GlueTransform describe`.

## Programming AWS Glue ETL scripts in Scala

You can find Scala code examples and utilities for AWS Glue in the [AWS Glue samples repository](https://github.com/aws-glue/aws-glue-samples) on the GitHub website.

AWS Glue supports an extension of the PySpark Scala dialect for scripting extract, transform, and load (ETL) jobs. The following sections describe how to use the AWS Glue Scala library and the AWS Glue API in ETL scripts, and provide reference documentation for the library.
Contents

- Using Scala to program AWS Glue ETL scripts
  - Testing a Scala ETL program in a Jupyter notebook on a development endpoint
  - Testing a Scala ETL program in a Scala REPL
- Scala script example - streaming ETL
- APIs in the AWS Glue Scala library
  - com.amazonaws.services.glue
  - com.amazonaws.services.glue.ml
  - com.amazonaws.services.glue.dq
  - com.amazonaws.services.glue.types
  - com.amazonaws.services.glue.util
- AWS Glue Scala ChoiceOption APIs
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  - ChoiceOption object
    - Def apply
  - Case class ChoiceOptionWithResolver
  - Case class MatchCatalogSchemaChoiceOption
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  - Def pyWriteDynamicFrame
  - Def writeDataFrame
  - Def pyWriteDataFrame
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  - Def supportsFormat
  - Def setFormat
  - Def withFormat
  - Def setAccumulableSize
  - Def getOutputErrorRecordsAccumulable
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- DataSink object
• Def recordMetrics

AWS Glue Scala DataSource trait

AWS Glue Scala DynamicFrame APIs

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  • Def assertErrorThreshold
  • Def count
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  • Def dropFields
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  • Def getNumPartitions
  • Def getSchemelfComputed
  • Def isSchemaComputed
  • Def javaToPython
  • Def join
  • Def map
  • Def mergeDynamicFrames
  • Def printSchema
  • Def recomputeSchema
  • Def relationalize
  • Def renameField
  • Def repartition
  • Def resolveChoice
  • Def schema
  • Def selectField
  • Def selectFields
• Def show
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• Def stageErrorsCount
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  • Def inlineErrors
  • Def newFrameWithErrors

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  • Def dropField
  • Def setError
  • Def isError
  • Def getError
  • Def clearError
  • Def write
  • Def readFields
  • Def clone
  • Def schema
- Def getRoot
- Def toJson
- Def getFieldNode
- Def getField
- Def hashCode
- Def equals
- DynamicRecord object
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- AWS Glue Scala GlueContext APIs
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  - def createDataFrameFromOptions
  - forEachBatch
  - def getCatalogSink
  - def getCatalogSource
  - def getJDBCSink
  - def getSink
  - def getSinkWithFormat
  - def getSource
  - def getSourceWithFormat
  - def getSparkSession
  - def startTransaction
  - def commitTransaction
  - def cancelTransaction
  - def this
  - def this
  - def this
  - def this

- MappingSpec
  - MappingSpec case class
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- Def apply
- Def apply

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**AWS Glue Scala BooleanNode APIs**
- BooleanNode case class
  - BooleanNode val fields
  - BooleanNode def methods

**AWS Glue Scala ByteNode APIs**
- ByteNode case class
  - ByteNode val fields
  - ByteNode def methods

**AWS Glue Scala DateNode APIs**
- DateNode case class
  - DateNode val fields
  - DateNode def methods

**AWS Glue Scala DecimalNode APIs**
- **DecimalNode case class**
  - **DecimalNode val fields**
  - **DecimalNode def methods**

- **AWS Glue Scala DoubleNode APIs**
  - **DoubleNode case class**
    - **DoubleNode val fields**
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- **AWS Glue Scala DynamicNode APIs**
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• AWS Glue Scala ShortNode APIs
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• AWS Glue Scala StringNode APIs
  • StringNode case class
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Using Scala to program AWS Glue ETL scripts

You can automatically generate a Scala extract, transform, and load (ETL) program using the AWS Glue console, and modify it as needed before assigning it to a job. Or, you can write your own program from scratch. For more information, see Adding jobs in AWS Glue. AWS Glue then compiles your Scala program on the server before running the associated job.

To ensure that your program compiles without errors and runs as expected, it's important that you load it on a development endpoint in a REPL (Read-Eval-Print Loop) or a Jupyter Notebook and test it there before running it in a job. Because the compile process occurs on the server, you will not have good visibility into any problems that happen there.

Testing a Scala ETL program in a Jupyter notebook on a development endpoint

To test a Scala program on an AWS Glue development endpoint, set up the development endpoint as described in Adding a development endpoint.

Next, connect it to a Jupyter Notebook that is either running locally on your machine or remotely on an Amazon EC2 notebook server. To install a local version of a Jupyter Notebook, follow the instructions in Tutorial: Jupyter notebook in JupyterLab.

The only difference between running Scala code and running PySpark code on your Notebook is that you should start each paragraph on the Notebook with the following:

```
%spark
```
This prevents the Notebook server from defaulting to the PySpark flavor of the Spark interpreter.

**Testing a Scala ETL program in a Scala REPL**

You can test a Scala program on a development endpoint using the AWS GlueScala REPL. Follow the instructions in [Tutorial: Use a SageMaker notebook](#), except at the end of the SSH-to-REPL command, replace `-t gluepyspark` with `-t glue-spark-shell`. This invokes the AWS Glue Scala REPL.

To close the REPL when you are finished, type `sys.exit`.

**Scala script example - streaming ETL**

**Example**

The following example script connects to Amazon Kinesis Data Streams, uses a schema from the Data Catalog to parse a data stream, joins the stream to a static dataset on Amazon S3, and outputs the joined results to Amazon S3 in parquet format.

```scala
// This script connects to an Amazon Kinesis stream, uses a schema from the data
// catalog to parse the stream,
// joins the stream to a static dataset on Amazon S3, and outputs the joined results to
// Amazon S3 in parquet format.
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import java.util.Calendar
import org.apache.spark.SparkContext
import org.apache.spark.sql.Dataset
import org.apache.spark.sql.Row
import org.apache.spark.sql.SaveMode
import org.apache.spark.sql.functions.from_json
import org.apache.spark.sql.streaming.Trigger
import scala.collection.JavaConverters._
object streamJoiner {
  def main(sysArgs: Array[String]) {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val sparkSession: SparkSession = glueContext.getSparkSession
    import sparkSession.implicits._
    // @params: [JOB_NAME]
```
val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

val staticData = sparkSession.read
    .format("csv")
    .option("header", "true")
    .load("s3://awsexamplebucket-streaming-demo2/inputs/productsStatic.csv") // load() returns a DataFrame

val datasource0 = sparkSession.readStream
    .format("kinesis")
    .option("streamName", "stream-join-demo")
    .option("endpointUrl", "https://kinesis.us-east-1.amazonaws.com")
    .option("startingPosition", "TRIM_HORIZON")
    .load // load() returns a DataFrame

val selectfields1 = datasource0.select(from_json($"data").cast("string"),
    glueContext.getCatalogSchemaAsSparkSchema("stream-demos", "stream-join-demo2") as "data").select("data.*")

val datasink2 = selectfields1.writeStream.foreachBatch {
    (dataFrame: Dataset[Row],
     batchId: Long) => {
        val joined = dataFrame.join(staticData, "product_id")
        val year: Int = Calendar.getInstance().get(Calendar.YEAR)
        val month :Int = Calendar.getInstance().get(Calendar.MONTH) + 1
        val day: Int = Calendar.getInstance().get(Calendar.DATE)
        val hour: Int = Calendar.getInstance().get(Calendar.HOUR_OF_DAY)

        if (dataFrame.count() > 0) {
            joined.write
                .mode(SaveMode.Append)
                .format("parquet")
                .option("quote", " ")
                .save("s3://awsexamplebucket-streaming-demo2/output/" + "+" +
                    "/year(" + "/month(" + "/day(" + "}")
        }
    }
}

.trigger(Trigger.ProcessingTime("100 seconds"))
    .option("checkpointLocation", "s3://awsexamplebucket-streaming-demo2/
        checkpoint/"
APIs in the AWS Glue Scala library

AWS Glue supports an extension of the PySpark Scala dialect for scripting extract, transform, and load (ETL) jobs. The following sections describe the APIs in the AWS Glue Scala library.

**com.amazonaws.services.glue**

The `com.amazonaws.services.glue` package in the AWS Glue Scala library contains the following APIs:

- `ChoiceOption`
- `DataSink`
- `DataSource trait`
- `DynamicFrame`
- `DynamicRecord`
- `GlueContext`
- `MappingSpec`
- `ResolveSpec`

**com.amazonaws.services.glue.ml**

The `com.amazonaws.services.glue.ml` package in the AWS Glue Scala library contains the following APIs:

- `FillMissingValues`
- `FindIncrementalMatches`
- `FindMatches`

**com.amazonaws.services.glue.dq**

The `com.amazonaws.services.glue.dq` package in the AWS Glue Scala library contains the following APIs:
• **EvaluateDataQuality**

**com.amazonaws.services.glue.types**

The **com.amazonaws.services.glue.types** package in the AWS Glue Scala library contains the following APIs:

• **ArrayNode**
• **BinaryNode**
• **BooleanNode**
• **ByteNode**
• **DateNode**
• **DecimalNode**
• **DoubleNode**
• **DynamicNode**
• **FloatNode**
• **IntegerNode**
• **LongNode**
• **MapLikeNode**
• **MapNode**
• **NullNode**
• **ObjectNode**
• **ScalarNode**
• **ShortNode**
• **StringNode**
• **TimestampNode**

**com.amazonaws.services.glue.util**

The **com.amazonaws.services.glue.util** package in the AWS Glue Scala library contains the following APIs:

• **GlueArgParser**
AWS Glue Scala ChoiceOption APIs

Topics

- **ChoiceOption trait**
- **ChoiceOption object**
- **Case class ChoiceOptionWithResolver**
- **Case class MatchCatalogSchemaChoiceOption**

Package: com.amazonaws.services.glue

ChoiceOption trait

```
trait ChoiceOption extends Serializable
```

ChoiceOption object

```
object ChoiceOption
```

A general strategy to resolve choice applicable to all ChoiceType nodes in a DynamicFrame.

- `val CAST`
- `val MAKE_COLS`
- `val MAKE_STRUCT`
- `val MATCH_CATALOG`
- `val PROJECT`

Def apply

```
def apply(choice: String): ChoiceOption
```
Case class `ChoiceOptionWithResolver`:

```scala
case class ChoiceOptionWithResolver(name: String, choiceResolver: ChoiceResolver) extends ChoiceOption {}
```

Case class `MatchCatalogSchemaChoiceOption`:

```scala
case class MatchCatalogSchemaChoiceOption() extends ChoiceOption {}
```

Abstract `DataSink` class:

**Topics**

- `Def writeDynamicFrame`
- `Def pyWriteDynamicFrame`
- `Def writeDataFrame`
- `Def pyWriteDataFrame`
- `Def setCatalogInfo`
- `Def supportsFormat`
- `Def setFormat`
- `Def withFormat`
- `Def setAccumulableSize`
- `Def getOutputErrorRecordsAccumulable`
- `Def errorsAsDynamicFrame`
- `DataSink object`

**Package:** `com.amazonaws.services.glue`

```scala
abstract class DataSink
```

The writer analog to a `DataSource`. `DataSink` encapsulates a destination and a format that a `DynamicFrame` can be written to.
Def writeDynamicFrame

```scala
def writeDynamicFrame( frame : DynamicFrame, 
callSite : CallSite = CallSite("Not provided", ") ) : DynamicFrame```

Def pyWriteDynamicFrame

```scala
def pyWriteDynamicFrame( frame : DynamicFrame, 
site : String = "Not provided", 
info : String = "" )
```

Def writeDataFrame

```scala
def writeDataFrame(frame: DataFrame, 
glueContext: GlueContext, 
callSite: CallSite = CallSite("Not provided", ") : DataFrame```

Def pyWriteDataFrame

```scala
def pyWriteDataFrame(frame: DataFrame, 
glueContext: GlueContext, 
site: String = "Not provided", 
info: String = "" ) : DataFrame```

Def setCatalogInfo

```scala
def setCatalogInfo(catalogDatabase: String, 
catalogTableName : String, 
catalogId : String = "")
```

Def supportsFormat

```scala
def supportsFormat( format : String ) : Boolean```
Def `setFormat`

```scala
def setFormat( format : String,
                options : JsonOptions
            ) : Unit
```

Def `withFormat`

```scala
def withFormat( format : String,
                options : JsonOptions = JsonOptions.empty
            ) : DataSink
```

Def `setAccumulableSize`

```scala
def setAccumulableSize( size : Int ) : Unit
```

Def `getErrorRecordsAccumulable`

```scala
def getErrorRecordsAccumulable : Accumulable[List[OutputError], OutputError]
```

Def `errorsAsDynamicFrame`

```scala
def errorsAsDynamicFrame : DynamicFrame
```

DataSink object

```scala
object DataSink
```

Def `recordMetrics`

```scala
def recordMetrics( frame : DynamicFrame,
                    ctxt : String
                ) : DynamicFrame
```
AWS Glue Scala DataSource trait

Package: com.amazonaws.services.glue

A high-level interface for producing a DynamicFrame.

```scala
trait DataSource {
  def getDynamicFrame : DynamicFrame

  def getDynamicFrame( minPartitions : Int,
                        targetPartitions : Int
                      ) : DynamicFrame
  def getDataFrame : DataFrame

  /** @param num: the number of records for sampling.
     * @param options: optional parameters to control sampling behavior. Current available parameter for Amazon S3 sources in options:
     *  1. maxSamplePartitions: the maximum number of partitions the sampling will read.
     *  2. maxSampleFilesPerPartition: the maximum number of files the sampling will read in one partition.
     */
  def getSampleDynamicFrame(num:Int, options: JsonOptions = JsonOptions.empty): DynamicFrame

  def glueContext : GlueContext

  def setFormat( format : String,
                 options : String
               ) : Unit

  def setFormat( format : String,
                 options : JsonOptions
               ) : Unit

  def supportsFormat( format : String ) : Boolean

  def withFormat( format : String,
                  options : JsonOptions = JsonOptions.empty
               ) : DataSource
}
```
AWS Glue Scala DynamicFrame APIs

Package: com.amazonaws.services.glue

Contents

- AWS Glue Scala DynamicFrame class
  - Val errorsCount
  - Def applyMapping
  - Def assertErrorThreshold
  - Def count
  - Def dropField
  - Def dropFields
  - Def dropNulls
  - Def errorsAsDynamicFrame
  - Def filter
  - Def getName
  - Def getNumPartitions
  - Def getSchemaIfComputed
  - Def isSchemaComputed
  - Def javaToPython
  - Def join
  - Def map
  - Def mergeDynamicFrames
  - Def printSchema
  - Def recomputeSchema
  - Def relationalize
  - Def renameField
  - Def repartition
  - Def resolveChoice
  - Def schema
  - Def selectField
  - Def selectFields
- Def show
- Def spigot
- Def splitFields
- Def splitRows
- Def stageErrorsCount
- Def toDF
- Def unbox
- Def unnest
- Def unnestDDBJson
- Def withFrameSchema
- Def withName
- Def withTransformationContext

The DynamicFrame object

- Def apply
- Def emptyDynamicFrame
- Def fromPythonRDD
- Def ignoreErrors
- Def inlineErrors
- Def newFrameWithErrors

AWS Glue Scala DynamicFrame class

**Package:** com.amazonaws.services.glue

class DynamicFrame extends Serializable with Logging {
    val glueContext : GlueContext,
    _records : RDD[DynamicRecord],
    val name : String = s'",
    val transformationContext : String = DynamicFrame.UNDEFINED,
    callSite : CallSite = CallSite("Not provided", ""),
    stageThreshold : Long = 0,
    totalThreshold : Long = 0,
    prevErrors : => Long = 0,
    errorExpr : => Unit = {} )
A DynamicFrame is a distributed collection of self-describing DynamicRecord objects.

DynamicFrames are designed to provide a flexible data model for ETL (extract, transform, and load) operations. They don't require a schema to create, and you can use them to read and transform data that contains messy or inconsistent values and types. A schema can be computed on demand for those operations that need one.

DynamicFrames provide a range of transformations for data cleaning and ETL. They also support conversion to and from SparkSQL DataFrames to integrate with existing code and the many analytics operations that DataFrames provide.

The following parameters are shared across many of the AWS Glue transformations that construct DynamicFrames:

- **transformationContext** — The identifier for this DynamicFrame. The transformationContext is used as a key for job bookmark state that is persisted across runs.
- **callSite** — Provides context information for error reporting. These values are automatically set when calling from Python.
- **stageThreshold** — The maximum number of error records that are allowed from the computation of this DynamicFrame before throwing an exception, excluding records that are present in the previous DynamicFrame.
- **totalThreshold** — The maximum number of total error records before an exception is thrown, including those from previous frames.

```scala
val errorsCount
```

The number of error records in this DynamicFrame. This includes errors from previous operations.

```scala
def applyMapping( mappings : Seq[Product4[String, String, String, String]],
    caseSensitive : Boolean = true,
    transformationContext : String = "",
    callSite : CallSite = CallSite("Not provided", ""),
    stageThreshold : Long = 0,
    totalThreshold : Long = 0
) : DynamicFrame
```
- **mappings** — A sequence of mappings to construct a new DynamicFrame.
- **caseSensitive** — Whether to treat source columns as case sensitive. Setting this to false might help when integrating with case-insensitive stores like the AWS Glue Data Catalog.

Selects, projects, and casts columns based on a sequence of mappings.

Each mapping is made up of a source column and type and a target column and type. Mappings can be specified as either a four-tuple (source_path, source_type, target_path, target_type) or a `MappingSpec` object containing the same information.

In addition to using mappings for simple projections and casting, you can use them to nest or unnest fields by separating components of the path with '.' (period).

For example, suppose that you have a DynamicFrame with the following schema.

```
{{{
root
|-- name: string
|-- age: int
|-- address: struct
  |  |-- state: string
  |  |-- zip: int
}}}
```

You can make the following call to unnest the state and zip fields.

```
{{{
  df.applyMapping(
    Seq(("name", "string", "name", "string"),
       ("age", "int", "age", "int"),
       ("address.state", "string", "state", "string"),
       ("address.zip", "int", "zip", "int")))
}}}
```

The resulting schema is as follows.

```
{{{
  root
  |-- name: string
  |-- age: int
  |-- state: string
}}}
```
You can also use `applyMapping` to re-nest columns. For example, the following inverts the previous transformation and creates a struct named `address` in the target.

```scala
{{{
  df.applyMapping(
    Seq(("name", "string", "name", "string"),
         ("age", "int", "age", "int"),
         ("state", "string", "address.state", "string"),
         ("zip", "int", "address.zip", "int")))
}}}
```

Field names that contain the period (period) characters can be quoted by using backticks (`

**Note**

Currently, you can't use the `applyMapping` method to map columns that are nested under arrays.

---

**Def assertErrorThreshold**

```scala
def assertErrorThreshold : Unit
```

An action that forces computation and verifies that the number of error records falls below `stageThreshold` and `totalThreshold`. Throws an exception if either condition fails.

**Def count**

```scala
lazy def count
```

Returns the number of elements in this DynamicFrame.

**Def dropField**

```scala
def dropField( path : String,
               transformationContext : String = ",
```
callSite : CallSite = CallSite("Not provided", ""),
stageThreshold : Long = 0,
totalThreshold : Long = 0
) : DynamicFrame

Returns a new DynamicFrame with the specified column removed.

**Def dropFields**

def dropFields( fieldNames : Seq[String],  // The column names to drop.
transformationContext : String = "",
callSite : CallSite = CallSite("Not provided", ""),
stageThreshold : Long = 0,
totalThreshold : Long = 0
) : DynamicFrame

Returns a new DynamicFrame with the specified columns removed.

You can use this method to delete nested columns, including those inside of arrays, but not to drop specific array elements.

**Def dropNulls**

def dropNulls( transformationContext : String = "",
callSite : CallSite = CallSite("Not provided", ""),
stageThreshold : Long = 0,
totalThreshold : Long = 0 )

Returns a new DynamicFrame with all null columns removed.

**Note**

This only removes columns of type NullType. Individual null values in other columns are not removed or modified.

**Def errorsAsDynamicFrame**

def errorsAsDynamicFrame

Returns a new DynamicFrame containing the error records from this DynamicFrame.
Def filter

```scala
def filter( f : DynamicRecord => Boolean, 
    errorMsg : String = "", 
    transformationContext : String = "", 
    callSite : CallSite = CallSite("Not provided"), 
    stageThreshold : Long = 0, 
    totalThreshold : Long = 0 
) : DynamicFrame
```

Constructs a new DynamicFrame containing only those records for which the function 'f' returns true. The filter function 'f' should not mutate the input record.

Def getName

```scala
def getName : String
```

Returns the name of this DynamicFrame.

Def getNumPartitions

```scala
def getNumPartitions
```

Returns the number of partitions in this DynamicFrame.

Def getSchemaIfComputed

```scala
def getSchemaIfComputed : Option[Schema]
```

Returns the schema if it has already been computed. Does not scan the data if the schema has not already been computed.

Def isSchemaComputed

```scala
def isSchemaComputed : Boolean
```

Returns true if the schema has been computed for this DynamicFrame, or false if not. If this method returns false, then calling the schema method requires another pass over the records in this DynamicFrame.
Def javaToPython

```scala
def javaToPython : JavaRDD[Array[Byte]]
```

Def join

```scala
def join( keys1 : Seq[String],
          keys2 : Seq[String],
          frame2 : DynamicFrame,
          transformationContext : String = 
            
          callSite : CallSite = CallSite("Not provided", 
            
          stageThreshold : Long = 0,
          totalThreshold : Long = 0
        ) : DynamicFrame
```

- keys1 — The columns in this DynamicFrame to use for the join.
- keys2 — The columns in frame2 to use for the join. Must be the same length as keys1.
- frame2 — The DynamicFrame to join against.

Returns the result of performing an equijoin with frame2 using the specified keys.

Def map

```scala
def map( f : DynamicRecord => DynamicRecord,
          errorMsg : String = 
            
          transformationContext : String = 
            
          callSite : CallSite = CallSite("Not provided", 
            
          stageThreshold : Long = 0,
          totalThreshold : Long = 0
        ) : DynamicFrame
```

Returns a new DynamicFrame constructed by applying the specified function 'f' to each record in this DynamicFrame.

This method copies each record before applying the specified function, so it is safe to mutate the records. If the mapping function throws an exception on a given record, that record is marked as an error, and the stack trace is saved as a column in the error record.
Def mergeDynamicFrames

def mergeDynamicFrames( stageDynamicFrame: DynamicFrame, primaryKeys: Seq[String],
transformationContext: String = "",
options: JsonOptions = JsonOptions.empty, callSite: CallSite =
CallSite("Not provided"),
stageThreshold: Long = 0, totalThreshold: Long = 0):
  DynamicFrame

- stageDynamicFrame — The staging DynamicFrame to merge.
- primaryKeys — The list of primary key fields to match records from the source and staging DynamicFrames.
- transformationContext — A unique string that is used to retrieve metadata about the current transformation (optional).
- options — A string of JSON name-value pairs that provide additional information for this transformation.
- callSite — Used to provide context information for error reporting.
- stageThreshold — A Long. The number of errors in the given transformation for which the processing needs to error out.
- totalThreshold — A Long. The total number of errors up to and including in this transformation for which the processing needs to error out.

Merges this DynamicFrame with a staging DynamicFrame based on the specified primary keys to identify records. Duplicate records (records with the same primary keys) are not de-duplicated. If there is no matching record in the staging frame, all records (including duplicates) are retained from the source. If the staging frame has matching records, the records from the staging frame overwrite the records in the source in AWS Glue.

The returned DynamicFrame contains record A in the following cases:

1. If A exists in both the source frame and the staging frame, then A in the staging frame is returned.
2. If A is in the source table and A.primaryKeys is not in the stagingDynamicFrame (that means A is not updated in the staging table).

The source frame and staging frame do not need to have the same schema.
Example

```scala
val mergedFrame: DynamicFrame = srcFrame.mergeDynamicFrames(stageFrame, Seq("id1", "id2"))
```

**Def printSchema**

```scala
def printSchema : Unit
```

Prints the schema of this DynamicFrame to stdout in a human-readable format.

**Def recomputeSchema**

```scala
def recomputeSchema : Schema
```

Forces a schema recomputation. This requires a scan over the data, but it might "tighten" the schema if there are some fields in the current schema that are not present in the data.

Returns the recomputed schema.

**Def relationalize**

```scala
def relationalize( rootTableName : String,
    stagingPath : String,
    options : JsonOptions = JsonOptions.empty,
    transformationContext : String = ",
    callSite : CallSite = CallSite("Not provided"),
    stageThreshold : Long = 0,
    totalThreshold : Long = 0
  ) : Seq[DynamicFrame]
```

- rootTableName — The name to use for the base DynamicFrame in the output. DynamicFrames that are created by pivoting arrays start with this as a prefix.
- stagingPath — The Amazon Simple Storage Service (Amazon S3) path for writing intermediate data.
- options — Relationalize options and configuration. Currently unused.

Flattens all nested structures and pivots arrays into separate tables.
You can use this operation to prepare deeply nested data for ingestion into a relational database. Nested structs are flattened in the same manner as the Unnest transform. Additionally, arrays are pivoted into separate tables with each array element becoming a row. For example, suppose that you have a DynamicFrame with the following data.

```
"name": "Nancy", "age": 47, "friends": ["Fred", "Lakshmi"]
"name": "Stephanie", "age": 28, "friends": ["Yao", "Phil", "Alvin"]
"name": "Nathan", "age": 54, "friends": ["Nicolai", "Karen"]
```

Run the following code.

```
{{
  df.relationalize("people", "s3:/my_bucket/my_path", JsonOptions.empty)
}}
```

This produces two tables. The first table is named "people" and contains the following.

```
{{
  "name": "Nancy", "age": 47, "friends": 1
  "name": "Stephanie", "age": 28, "friends": 2
  "name": "Nathan", "age": 54, "friends": 3
}}
```

Here, the friends array has been replaced with an auto-generated join key. A separate table named people.friends is created with the following content.

```
{{
  "id": 1, "index": 0, "val": "Fred"
  "id": 1, "index": 1, "val": "Lakshmi"
  "id": 2, "index": 0, "val": "Yao"
  "id": 2, "index": 1, "val": "Phil"
  "id": 2, "index": 2, "val": "Alvin"
  "id": 3, "index": 0, "val": "Nicolai"
  "id": 3, "index": 1, "val": "Karen"
}}
```

In this table, 'id' is a join key that identifies which record the array element came from, 'index' refers to the position in the original array, and 'val' is the actual array entry.

The relationalize method returns the sequence of DynamicFrames created by applying this process recursively to all arrays.
Note

The AWS Glue library automatically generates join keys for new tables. To ensure that join keys are unique across job runs, you must enable job bookmarks.

def renameField

```scala
def renameField( oldName : String,
                newName : String,
                transformationContext : String = "",
                callSite : CallSite = CallSite("Not provided", ""),
                stageThreshold : Long = 0,
                totalThreshold : Long = 0
            ) : DynamicFrame
```

- `oldName` — The original name of the column.
- `newName` — The new name of the column.

Returns a new DynamicFrame with the specified field renamed.

You can use this method to rename nested fields. For example, the following code would rename `state` to `state_code` inside the address struct.

```scala
{{{
    df.renameField("address.state", "address.state_code")
}}}
```

Def repartition

```scala
def repartition( numPartitions : Int,
                transformationContext : String = "",
                callSite : CallSite = CallSite("Not provided", ""),
                stageThreshold : Long = 0,
                totalThreshold : Long = 0
            ) : DynamicFrame
```

Returns a new DynamicFrame with `numPartitions` partitions.
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Def resolveChoice
def resolveChoice( specs : Seq[Product2[String, String]] = Seq.empty[ResolveSpec],
choiceOption : Option[ChoiceOption] = None,
database : Option[String] = None,
tableName : Option[String] = None,
transformationContext : String = "",
callSite : CallSite = CallSite("Not provided", ""),
stageThreshold : Long = 0,
totalThreshold : Long = 0
) : DynamicFrame

• choiceOption — An action to apply to all ChoiceType columns not listed in the specs
sequence.
• database — The Data Catalog database to use with the match_catalog action.
• tableName — The Data Catalog table to use with the match_catalog action.
Returns a new DynamicFrame by replacing one or more ChoiceTypes with a more speciﬁc type.
There are two ways to use resolveChoice. The ﬁrst is to specify a sequence of speciﬁc columns
and how to resolve them. These are speciﬁed as tuples made up of (column, action) pairs.
The following are the possible actions:
• cast:type — Attempts to cast all values to the speciﬁed type.
• make_cols — Converts each distinct type to a column with the name columnName_type.
• make_struct — Converts a column to a struct with keys for each distinct type.
• project:type — Retains only values of the speciﬁed type.
The other mode for resolveChoice is to specify a single resolution for all ChoiceTypes. You can
use this in cases where the complete list of ChoiceTypes is unknown before execution. In addition
to the actions listed preceding, this mode also supports the following action:
• match_catalog — Attempts to cast each ChoiceType to the corresponding type in the
speciﬁed catalog table.
Examples:
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Resolve the `user.id` column by casting to an int, and make the `address` field retain only structs.

```scala
{{{
    df.resolveChoice(specs = Seq(("user.id", "cast:int"), ("address", "project:struct")))
}}}
```

Resolve all ChoiceTypes by converting each choice to a separate column.

```scala
{{{
    df.resolveChoice(choiceOption = Some(ChoiceOption("make_cols")))
}}}
```

Resolve all ChoiceTypes by casting to the types in the specified catalog table.

```scala
{{{
    df.resolveChoice(choiceOption = Some(ChoiceOption("match_catalog")),
                      database = Some("my_database"),
                      tableName = Some("my_table"))
}}}
```

**Def schema**

```scala
def schema : Schema
```

Returns the schema of this `DynamicFrame`.

The returned schema is guaranteed to contain every field that is present in a record in this `DynamicFrame`. But in a small number of cases, it might also contain additional fields. You can use the `Unnest` method to "tighten" the schema based on the records in this `DynamicFrame`.

**Def selectField**

```scala
def selectField( fieldName : String,
                 transformationContext : String = ",",
                 callSite : CallSite = CallSite("Not provided", ","),
                 stageThreshold : Long = 0,
                 totalThreshold : Long = 0
                 ) : DynamicFrame
```

Returns a single field as a `DynamicFrame`. 
Def selectFields

```scala
def selectFields(  
  paths : Seq[String],  
  transformationContext : String = "",  
  callSite : CallSite = CallSite("Not provided", ""),  
  stageThreshold : Long = 0,  
  totalThreshold : Long = 0  
): DynamicFrame
```

- **paths** — The sequence of column names to select.

Returns a new DynamicFrame containing the specified columns.

**Note**

You can only use the selectFields method to select top-level columns. You can use the applyMapping method to select nested columns.

Def show

```scala
def show(  
  numRows : Int = 20  
): Unit
```

- **numRows** — The number of rows to print.

Prints rows from this DynamicFrame in JSON format.

Def spigot

```scala
def spigot(  
  path : String,  
  options : JsonOptions = new JsonOptions("[]"),  
  transformationContext : String = "",  
  callSite : CallSite = CallSite("Not provided"),  
  stageThreshold : Long = 0,  
  totalThreshold : Long = 0  
): DynamicFrame
```

Passthrough transformation that returns the same records but writes out a subset of records as a side effect.
• **path** — The path in Amazon S3 to write output to, in the form `s3://bucket//path`.

• **options** — An optional JsonOptions map describing the sampling behavior.

Returns a DynamicFrame that contains the same records as this one.

By default, writes 100 arbitrary records to the location specified by `path`. You can customize this behavior by using the `options` map. Valid keys include the following:

• **topk** — Specifies the total number of records written out. The default is 100.

• **prob** — Specifies the probability (as a decimal) that an individual record is included. Default is 1.

For example, the following call would sample the dataset by selecting each record with a 20 percent probability and stopping after 200 records have been written.

```{{{
  df.spigot("s3://my_bucket/my_path", JsonOptions(Map("topk" -> 200, "prob" -> 0.2)))
}}}
```

**Def splitFields**

```scala
def splitFields(  
  paths : Seq[String],
  transformationContext : String = ",",
  callSite : CallSite = CallSite("Not provided", ","),
  stageThreshold : Long = 0,
  totalThreshold : Long = 0
) : Seq[DynamicFrame]
```

• **paths** — The paths to include in the first DynamicFrame.

Returns a sequence of two DynamicFrames. The first DynamicFrame contains the specified paths, and the second contains all other columns.

**Example**

This example takes a DynamicFrame created from the `persons` table in the `legislators` database in the AWS Glue Data Catalog and splits the DynamicFrame into two, with the
specified fields going into the first DynamicFrame and the remaining fields going into a second DynamicFrame. The example then chooses the first DynamicFrame from the result.

```scala
val InputFrame = glueContext.getCatalogSource(database="legislators",
  tableName="persons",
  transformationContext="InputFrame").getDynamicFrame()

val SplitField_collection = InputFrame.splitFields(paths=Seq("family_name", "name",
  "links.note",
  "links.url", "gender", "image", "identifiers.scheme", "identifiers.identifier",
  "other_names.lang",
  "other_names.note", "other_names.name"), transformationContext="SplitField_collection")

val ResultFrame = SplitField_collection(0)
```

Def splitRows

```scala
def splitRows(  
  paths : Seq[String],
  values : Seq[Any],
  operators : Seq[String],
  transformationContext : String,
  callSite : CallSite,
  stageThreshold : Long,
  totalThreshold : Long
) : Seq[DynamicFrame]
```

Splits rows based on predicates that compare columns to constants.

- **paths** — The columns to use for comparison.
- **values** — The constant values to use for comparison.
- **operators** — The operators to use for comparison.

Returns a sequence of two DynamicFrames. The first contains rows for which the predicate is true and the second contains those for which it is false.

Predicates are specified using three sequences: 'paths' contains the (possibly nested) column names, 'values' contains the constant values to compare to, and 'operators' contains the operators to use for comparison. All three sequences must be the same length: The nth operator is used to compare the nth column with the nth value.
Each operator must be one of "!="", ",=", "<=", ",<", ",>="", or ",>".

As an example, the following call would split a DynamicFrame so that the first output frame would contain records of people over 65 from the United States, and the second would contain all other records.

```scala
{{
  df.splitRows(Seq("age", "address.country"), Seq(65, "USA"), Seq("&gt;="", ",="))
}}
```

### Def stageErrorsCount

```scala
def stageErrorsCount
```

Returns the number of error records created while computing this DynamicFrame. This excludes errors from previous operations that were passed into this DynamicFrame as input.

### Def toDF

```scala
def toDF( specs : Seq[ResolveSpec] = Seq.empty[ResolveSpec] ) : DataFrame
```

Converts this DynamicFrame to an Apache Spark SQL DataFrame with the same schema and records.

#### Note

Because DataFrames don't support ChoiceTypes, this method automatically converts ChoiceType columns into StructTypes. For more information and options for resolving choice, see [resolveChoice](#).

### Def unbox

```scala
def unbox( path : String,
          format : String,
          optionString : String = "{}",
          transformationContext : String = "",
          callSite : CallSite = CallSite("Not provided"),
          stageThreshold : Long = 0,
          )
```
- path — The column to parse. Must be a string or binary.
- format — The format to use for parsing.
- optionString — Options to pass to the format, such as the CSV separator.

Parses an embedded string or binary column according to the specified format.Parsed columns are nested under a struct with the original column name.

For example, suppose that you have a CSV file with an embedded JSON column.

```
name, age, address
Sally, 36, {"state": "NE", "city": "Omaha"}
```

After an initial parse, you would get a DynamicFrame with the following schema.

```
{{{
    root
    |-- name: string
    |-- age: int
    |-- address: string
}}}
```

You can call `unbox` on the address column to parse the specific components.

```
{{{
    df.unbox("address", "json")
}}}
```

This gives us a DynamicFrame with the following schema.

```
{{{
    root
    |-- name: string
    |-- age: int
    |-- address: struct
    |    |-- state: string
}}}
```
Def unnest

```scala
def unnest( transformationContext : String = "", 
           callSite : CallSite = CallSite("Not Provided"), 
           stageThreshold : Long = 0, 
           totalThreshold : Long = 0 ) : DynamicFrame
```

Returns a new DynamicFrame with all nested structures flattened. Names are constructed using the '.' (period) character.

For example, suppose that you have a DynamicFrame with the following schema.

```json
{{{
  root
  |-- name: string
  |-- age: int
  |-- address: struct
     |-- state: string
     |-- city: string
}}}
```

The following call unnests the address struct.

```scala
{{{
  df.unnest()
}}}
```

The resulting schema is as follows.

```json
{{{
  root
  |-- name: string
  |-- age: int
  |-- address.state: string
  |-- address.city: string
}}}
```
This method also unnests nested structs inside of arrays. But for historical reasons, the names of such fields are prepended with the name of the enclosing array and ".val".

**Def unnestDDBJson**

```scala
unnestDDBJson(transformationContext : String = "", callSite : CallSite = CallSite("Not Provided"), stageThreshold : Long = 0, totalThreshold : Long = 0): DynamicFrame
```

Unnests nested columns in a `DynamicFrame` that are specifically in the DynamoDB JSON structure, and returns a new unnested `DynamicFrame`. Columns that are of an array of struct types will not be unnested. Note that this is a specific type of unnesting transform that behaves differently from the regular `unnest` transform and requires the data to already be in the DynamoDB JSON structure. For more information, see [DynamoDB JSON](#).

For example, the schema of a reading an export with the DynamoDB JSON structure might look like the following:

```
root
|-- Item: struct
 |-- ColA: struct
  |  |-- S: string
  |-- ColB: struct
  |  |-- S: string
  |-- ColC: struct
  |  |-- N: string
  |-- ColD: struct
  |  |-- L: array
  |     `-- element: null
```

The `unnestDDBJson()` transform would convert this to:

```
root
|-- ColA: string
|-- ColB: string
|-- ColC: string
|-- ColD: array
  `-- element: null
The following code example shows how to use the AWS Glue DynamoDB export connector, invoke a DynamoDB JSON unnest, and print the number of partitions:

```scala
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamoDbDataSink
import org.apache.spark.SparkContext
import scala.collection.JavaConverters_

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val glueContext = new GlueContext(SparkContext.getOrCreate())
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    val dynamicFrame = glueContext.getSourceWithFormat(
      connectionType = "dynamodb",
      options = JsonOptions(Map(
        "dynamodb.export" -> "ddb",
        "dynamodb.tableArn" -> "<test_source>",
        "dynamodb.s3.bucket" -> "<bucket name>",
        "dynamodb.s3.prefix" -> "<bucket prefix>",
        "dynamodb.s3.bucketOwner" -> "<account_id of bucket>",
      ))
    ).getDynamicFrame()

    val unnested = dynamicFrame.unnestDDBJson()
    print(unnested.getNumPartitions())

    Job.commit()
  }
}
```

**Def withFrameSchema**

```scala
def withFrameSchema( getSchema : () => Schema ) : DynamicFrame
```
- **getSchema** — A function that returns the schema to use. Specified as a zero-parameter function to defer potentially expensive computation.

Sets the schema of this `DynamicFrame` to the specified value. This is primarily used internally to avoid costly schema recomputation. The passed-in schema must contain all columns present in the data.

**Def withName**

``` scala
def withName( name : String ) : DynamicFrame
```

- **name** — The new name to use.

Returns a copy of this `DynamicFrame` with a new name.

**Def withTransformationContext**

``` scala
def withTransformationContext( ctx : String ) : DynamicFrame
```

Returns a copy of this `DynamicFrame` with the specified transformation context.

**The DynamicFrame object**

**Package: com.amazonaws.services.glue**

``` scala
object DynamicFrame
```

**Def apply**

``` scala
def apply( df : DataFrame,
            glueContext : GlueContext
        ) : DynamicFrame
```

**Def emptyDynamicFrame**

``` scala
def emptyDynamicFrame( glueContext : GlueContext ) : DynamicFrame
```
**Def fromPythonRDD**

```scala
def fromPythonRDD( rdd : JavaRDD[Array[Byte]],
    glueContext : GlueContext
  ) : DynamicFrame
```

**Def ignoreErrors**

```scala
def ignoreErrors( fn : DynamicRecord => DynamicRecord ) : DynamicRecord
```

**Def inlineErrors**

```scala
def inlineErrors( msg : String,
    callSite : CallSite
  ) : (DynamicRecord => DynamicRecord)
```

**Def newFrameWithErrors**

```scala
def newFrameWithErrors( prevFrame : DynamicFrame,
    rdd : RDD[DynamicRecord],
    name : String = "",
    transformationContext : String = "",
    callSite : CallSite,
    stageThreshold : Long,
    totalThreshold : Long
  ) : DynamicFrame
```

---

**AWS Glue Scala DynamicRecord class**

**Topics**

- [Def addField](#)
- [Def dropField](#)
- [Def setError](#)
- [Def isError](#)
Def getError
Def clearError
Def write
Def readFields
Def clone
Def schema
Def getRoot
Def toJson
Def getFieldNode
Def getField
Def hashCode
Def equals

DynamicRecord object
RecordTraverser trait

Package: com.amazonaws.services.glue

```scala
class DynamicRecord extends Serializable with Writable with Cloneable
```

A DynamicRecord is a self-describing data structure that represents a row of data in the dataset that is being processed. It is self-describing in the sense that you can get the schema of the row that is represented by the DynamicRecord by inspecting the record itself. A DynamicRecord is similar to a Row in Apache Spark.

**Def addField**

```scala
def addField( path : String,
              dynamicNode : DynamicNode
        ) : Unit
```

Adds a DynamicNode to the specified path.

- path — The path for the field to be added.
- dynamicNode — The DynamicNode to be added at the specified path.
**Def dropField**

```scala
def dropField(path: String, underRename: Boolean = false): Option[DynamicNode]
```

Drops a `DynamicNode` from the specified path and returns the dropped node if there is not an array in the specified path.

- **path** — The path to the field to drop.
- **underRename** — True if `dropField` is called as part of a rename transform, or false otherwise (false by default).

Returns a `scala.Option Option (DynamicNode)`.

**Def setError**

```scala
def setError( error : Error )
```

Sets this record as an error record, as specified by the `error` parameter.

Returns a `DynamicRecord`.

**Def isError**

```scala
def isError
```

Checks whether this record is an error record.

**Def getError**

```scala
def getError
```

Gets the `Error` if the record is an error record. Returns `scala.Some Some (Error)` if this record is an error record, or otherwise `scala.None`.

**Def clearError**

```scala
def clearError
```
Set the Error to scala.None.None.

**Def write**

```scala
override def write( out : DataOutput ) : Unit
```

**Def readFields**

```scala
override def readFields( in : DataInput ) : Unit
```

**Def clone**

```scala
override def clone : DynamicRecord
```

Clones this record to a new DynamicRecord and returns it.

**Def schema**

```scala
def schema
```

Gets the Schema by inspecting the record.

**Def getRoot**

```scala
def getRoot : ObjectNode
```

Gets the root ObjectNode for the record.

**Def toJson**

```scala
def toJson : String
```

Gets the JSON string for the record.

**Def getFieldNode**

```scala
def getFieldNode( path : String ) : Option[DynamicNode]
```
Gets the field's value at the specified path as an option of DynamicNode.

Returns scala.Some(Some(DynamicNode)) if the field exists, or otherwise scala.None.None.

**Def getField**

```scala
def getField( path : String ) : Option[Any]
```

Gets the field's value at the specified path as an option of DynamicNode.

Returns scala.Some(Some(value)).

**Def hashCode**

```scala
override def hashCode : Int
```

**Def equals**

```scala
override def equals( other : Any )
```

**DynamicRecord object**

```scala
object DynamicRecord
```

**Def apply**

```scala
def apply( row : Row,
            schema : SparkStructType )
```

Apply method to convert an Apache Spark SQL Row to a DynamicRecord.

- **row** — A Spark SQL Row.
- **schema** — The Schema of that row.

Returns a DynamicRecord.
RecordTraverser trait

```scala
trait RecordTraverser {
    def nullValue(): Unit
    def byteValue(value: Byte): Unit
    def binaryValue(value: Array[Byte]): Unit
    def booleanValue(value: Boolean): Unit
    def shortValue(value: Short): Unit
    def intValue(value: Int): Unit
    def longValue(value: Long): Unit
    def floatValue(value: Float): Unit
    def doubleValue(value: Double): Unit
    def decimalValue(value: BigDecimal): Unit
    def stringValue(value: String): Unit
    def dateValue(value: Date): Unit
    def timestampValue(value: Timestamp): Unit
    def objectStart(length: Int): Unit
    def objectKey(key: String): Unit
    def objectEnd(): Unit
    def mapStart(length: Int): Unit
    def mapKey(key: String): Unit
    def mapEnd(): Unit
    def arrayStart(length: Int): Unit
    def arrayEnd(): Unit
}
```

AWS Glue Scala GlueContext APIs

**Package: com.amazonaws.services.glue**

```scala
class GlueContext extends SQLContext(sc) {
    @transient val sc : SparkContext,
    val defaultSourcePartitioner : PartitioningStrategy )
```

GlueContext is the entry point for reading and writing a [DynamicFrame](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-programming-ref-dynamicframe.html) from and to Amazon Simple Storage Service (Amazon S3), the AWS Glue Data Catalog, JDBC, and so on. This class provides utility functions to create [DataSource trait](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-programming-ref-sourcetransformtrait.html) and [DataSink](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-programming-ref-sourcetransformtrait.html) objects that can in turn be used to read and write DynamicFrames.

You can also use GlueContext to set a target number of partitions (default 20) in the DynamicFrame if the number of partitions created from the source is less than a minimum threshold for partitions (default 10).
def addIngestionTimeColumns

    def addIngestionTimeColumns(
        df : DataFrame,
        timeGranularity : String = "") : DataFrame

Appends ingestion time columns like ingest_year, ingest_month, ingest_day, ingest_hour, ingest_minute to the input DataFrame. This function is automatically generated in the script generated by the AWS Glue when you specify a Data Catalog table with Amazon S3 as the target. This function automatically updates the partition with ingestion time columns on the output table. This allows the output data to be automatically partitioned on ingestion time without requiring explicit ingestion time columns in the input data.

- **dataFrame** – The DataFrame to append the ingestion time columns to.

- **timeGranularity** – The granularity of the time columns. Valid values are "day", "hour" and "minute". For example, if "hour" is passed in to the function, the original DataFrame will have "ingest_year", "ingest_month", "ingest_day", and "ingest_hour" time columns appended.

Returns the data frame after appending the time granularity columns.

Example:

    glueContext.addIngestionTimeColumns(dataFrame, "hour")

def createDataFrameFromOptions

    def createDataFrameFromOptions( connectionType : String,
                                    connectionOptions : JsonOptions,
                                    transformationContext : String = "",
                                    format : String = null,
                                    formatOptions : JsonOptions = JsonOptions.empty
                          ) : DataSource

Returns a DataFrame created with the specified connection and format. Use this function only with AWS Glue streaming sources.

- **connectionType** – The streaming connection type. Valid values include kinesis and kafka.
• connectionOptions – Connection options, which are different for Kinesis and Kafka. You can find the list of all connection options for each streaming data source at [Connection types and options for ETL in AWS Glue for Spark](#). Note the following differences in streaming connection options:

  • Kinesis streaming sources require streamARN, startingPosition, inferSchema, and classification.
  • Kafka streaming sources require connectionName, topicName, startingOffsets, inferSchema, and classification.

• transformationContext – The transformation context to use (optional).

• format – A format specification (optional). This is used for an Amazon S3 or an AWS Glue connection that supports multiple formats. For information about the supported formats, see [Data format options for inputs and outputs in AWS Glue for Spark](#)

• formatOptions – Format options for the specified format. For information about the supported format options, see [Data format options](#).

Example for Amazon Kinesis streaming source:

```scala
val data_frame_datasource0 =
glueContext.createDataFrameFromOptions(transformationContext = "datasource0",
    connectionType = "kinesis",
    connectionOptions = JsonOptions("{"streamName": "example_stream", "startingPosition": "TRIM_HORIZON", "inferSchema": "true", "classification": "json"}""))
```

Example for Kafka streaming source:

```scala
val data_frame_datasource0 =
glueContext.createDataFrameFromOptions(transformationContext = "datasource0",
    connectionType = "kafka",
    connectionOptions = JsonOptions("{"connectionName": "example_connection",
    "topicName": "example_topic", "startingPosition": "earliest", "inferSchema": "false",
    "classification": "json", "schema": "\"column1\ STRING, \column2\ STRING\""}""))
```

**forEachBatch**

**forEachBatch(frame, batch_function, options)**

Applies the batch_function passed in to every micro batch that is read from the Streaming source.
• frame – The DataFrame containing the current micro batch.
• batch_function – A function that will be applied for every micro batch.
• options – A collection of key-value pairs that holds information about how to process micro batches. The following options are required:
  • windowSize – The amount of time to spend processing each batch.
  • checkpointLocation – The location where checkpoints are stored for the streaming ETL job.
  • batchMaxRetries – The maximum number of times to retry the batch if it fails. The default value is 3. This option is only configurable for Glue version 2.0 and above.

Example:

```scala
glueContext.forEachBatch(data_frame_datasource0, (dataFrame: Dataset[Row], batchId: Long) =>
{
  if (dataFrame.count() > 0)
  {
    val datasource0 = DynamicFrame(glueContext.addIngestionTimeColumns(dataFrame, "hour"), glueContext)
    // @type: DataSink
    // @args: [database = "tempdb", table_name = "fromoptionsoutput",
    //  stream_batch_time = "100 seconds",
    //  stream_checkpoint_location = "s3://from-options-testing-eu-central-1/fromOptionsOutput/checkpoint/",
    //  transformation_ctx = "datasink1"
    //  @return: datasink1
    //  @inputs: [frame = datasource0]
    val options_datasink1 = JsonOptions(
      Map("partitionKeys" -> Seq("ingest_year", "ingest_month","ingest_day",
      "ingest_hour"),
      "enableUpdateCatalog" -> true))
    val datasink1 = glueContext.getCatalogSink(
      database = "tempdb",
      tableName = "fromoptionsoutput",
      redshiftTmpDir = ",
      transformationContext = "datasink1",
      additionalOptions = options_datasink1).writeDynamicFrame(datasource0)
  }
  }, JsonOptions(""{""windowSize" : "100 seconds",
  "checkpointLocation" : "s3://from-options-testing-eu-central-1/fromOptionsOutput/checkpoint/"}"")
```
def getCatalogSink

```scala
def getCatalogSink( database : String,
                     tableName : String,
                     redshiftTmpDir : String = "",
                     transformationContext : String = ""
                     additionalOptions: JsonOptions = JsonOptions.empty,
                     catalogId: String = null
                     ) : DataSink
```

Creates a [DataSink](#) that writes to a location specified in a table that is defined in the Data Catalog.

- **database** — The database name in the Data Catalog.
- **tableName** — The table name in the Data Catalog.
- **redshiftTmpDir** — The temporary staging directory to be used with certain data sinks. Set to empty by default.
- **transformationContext** — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.
- **additionalOptions** — Additional options provided to AWS Glue.
- **catalogId** — The catalog ID (account ID) of the Data Catalog being accessed. When null, the default account ID of the caller is used.

Returns the DataSink.

def getCatalogSource

```scala
def getCatalogSource( database : String,
                      tableName : String,
                      redshiftTmpDir : String = "",
                      transformationContext : String = ""
                      pushDownPredicate : String = ""
                      additionalOptions: JsonOptions = JsonOptions.empty,
                      catalogId: String = null
                      ) : DataSource
```

Creates a [DataSource trait](#) that reads data from a table definition in the Data Catalog.

- **database** — The database name in the Data Catalog.
- **tableName** — The table name in the Data Catalog.
- **redshiftTmpDir** — The temporary staging directory to be used with certain data sinks. Set to empty by default.

- **transformationContext** — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.

- **pushDownPredicate** — Filters partitions without having to list and read all the files in your dataset. For more information, see Pre-filtering using pushdown predicates.

- **additionalOptions** — A collection of optional name-value pairs. The possible options include those listed in Connection types and options for ETL in AWS Glue for Spark except for endpointUrl, streamName, bootstrap.servers, security.protocol, topicName, classification, and delimiter. Another supported option is catalogPartitionPredicate:

  catalogPartitionPredicate — You can pass a catalog expression to filter based on the index columns. This pushes down the filtering to the server side. For more information, see AWS Glue Partition Indexes. Note that push_down_predicate and catalogPartitionPredicate use different syntaxes. The former one uses Spark SQL standard syntax and the later one uses JSQL parser.

- **catalogId** — The catalog ID (account ID) of the Data Catalog being accessed. When null, the default account ID of the caller is used.

Returns the DataSource.

**Example for streaming source**

```scala
val data_frame_datasource0 = glueContext.getCatalogSource(
  database = "tempdb",
  tableName = "test-stream-input",
  redshiftTmpDir = ",",
  transformationContext = "datasource0",
  additionalOptions = JsonOptions("{
      "startingPosition": "TRIM_HORIZON", "inferSchema": "false""
    }"
  ).getDataFrame()
```

**def getJDBCSink**

```scala
def getJDBCSink( catalogConnection : String,
  options : JsonOptions,
  redshiftTmpDir : String = ",",
```
transformationContext : String = "",
catalogId: String = null
): DataSink

Creates a DataSink that writes to a JDBC database that is specified in a Connection object in the Data Catalog. The Connection object has information to connect to a JDBC sink, including the URL, user name, password, VPC, subnet, and security groups.

- **catalogConnection** — The name of the connection in the Data Catalog that contains the JDBC URL to write to.

- **options** — A string of JSON name-value pairs that provide additional information that is required to write to a JDBC data store. This includes:
  - **dbtable** (required) — The name of the JDBC table. For JDBC data stores that support schemas within a database, specify schema.table-name. If a schema is not provided, then the default "public" schema is used. The following example shows an options parameter that points to a schema named test and a table named test_table in database test_db.

  ```
  options = JsonOptions(""{"dbtable": "test.test_table", "database": "test_db"}""")
  ```

  - **database** (required) — The name of the JDBC database.

  - Any additional options passed directly to the SparkSQL JDBC writer. For more information, see Redshift data source for Spark.

  - **redshiftTmpDir** — A temporary staging directory to be used with certain data sinks. Set to empty by default.

  - **transformationContext** — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.

  - **catalogId** — The catalog ID (account ID) of the Data Catalog being accessed. When null, the default account ID of the caller is used.

**Example code:**

```scala
getJDBCSink(catalogConnection = "my-connection-name", options =
  JsonOptions(""{"dbtable": "my-jdbc-table", "database": "my-jdbc-db"}""),
  redshiftTmpDir = "", transformationContext = "datasink4")
```

Returns the DataSink.
def getSink

def getSink( connectionType : String,
             connectionOptions : JsonOptions,
             transformationContext : String = ""
         ) : DataSink

Creates a `DataSink` that writes data to a destination like Amazon Simple Storage Service (Amazon S3), JDBC, or the AWS Glue Data Catalog.

- `connectionType` — The type of the connection. See [the section called “Connection parameters”](#).
- `connectionOptions` — A string of JSON name-value pairs that provide additional information to establish the connection with the data sink. See [the section called “Connection parameters”](#).
- `transformationContext` — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.

Returns the `DataSink`.

def getSinkWithFormat

def getSinkWithFormat( connectionType : String,
                        options : JsonOptions,
                        transformationContext : String = "",
                        format : String = null,
                        formatOptions : JsonOptions = JsonOptions.empty
                  ) : DataSink

Creates a `DataSink` that writes data to a destination like Amazon S3, JDBC, or the Data Catalog, and also sets the format for the data to be written out to the destination.

- `connectionType` — The type of the connection. See [the section called “Connection parameters”](#).
- `options` — A string of JSON name-value pairs that provide additional information to establish a connection with the data sink. See [the section called “Connection parameters”](#).
- `transformationContext` — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.
- `format` — The format of the data to be written out to the destination.
• **formatOptions** — A string of JSON name-value pairs that provide additional options for formatting data at the destination. See Data format options.

Returns the DataSink.

**def getSource**

```python
def getSource( connectionType : String,  
            connectionOptions : JsonOptions,  
            transformationContext : String = ""  
            pushDownPredicate  
            ) : DataSource
```

Creates a **DataSource trait** that reads data from a source like Amazon S3, JDBC, or the AWS Glue Data Catalog. Also supports Kafka and Kinesis streaming data sources.

• **connectionType** — The type of the data source. See the section called “Connection parameters”.

• **connectionOptions** — A string of JSON name-value pairs that provide additional information for establishing a connection with the data source. For more information, see the section called “Connection parameters”.

A Kinesis streaming source requires the following connection options: streamARN, startingPosition, inferSchema, and classification.

A Kafka streaming source requires the following connection options: connectionName, topicName, startingOffsets, inferSchema, and classification.

• **transformationContext** — The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.

• **pushDownPredicate** — Predicate on partition columns.

Returns the DataSource.

**Example for Amazon Kinesis streaming source:**

```scala
val kinesisOptions = jsonOptions()  
data_frame_datasource0 = glueContext.getSource("kinesis",  
            kinesisOptions).get DataFrame()
```
private def jsonOptions(): JsonOptions = {
    new JsonOptions(
        s""""{"streamARN": "arn:aws:kinesis:eu-central-1:123456789012:stream/toOptionsStream",
            |"startingPosition": "TRIM_HORIZON",
            |"inferSchema": "true",
            |"classification": "json"}"""".stripMargin)
}

Example for Kafka streaming source:

val kafkaOptions = jsonOptions()
val data_frame_datasource0 = glueContext.getSource("kafka",
    kafkaOptions).getDataFrame()

private def jsonOptions(): JsonOptions = {
    new JsonOptions(
        s""""{"connectionName": "ConfluentKafka",
            |"topicName": "kafka-auth-topic",
            |"startingOffsets": "earliest",
            |"inferSchemas": "true",
            |"classification": "json"}"""".stripMargin)
}

def getSourceWithFormat

def getSourceWithFormat( connectionType : String,
    options : JsonOptions,
    transformationContext : String = ",
    format : String = null,
    formatOptions : JsonOptions = JsonOptions.empty
) : DataSource

Creates a DataSource trait that reads data from a source like Amazon S3, JDBC, or the AWS Glue Data Catalog, and also sets the format of data stored in the source.

• connectionType – The type of the data source. See the section called “Connection parameters”.
• options – A string of JSON name-value pairs that provide additional information for establishing a connection with the data source. See the section called “Connection parameters”.


- **transformationContext** – The transformation context that is associated with the sink to be used by job bookmarks. Set to empty by default.

- **format** – The format of the data that is stored at the source. When the `connectionType` is "s3", you can also specify format. Can be one of “avro”, “csv”, “grokLog”, “ion”, “json”, “xml”, “parquet”, or “orc”.

- **formatOptions** – A string of JSON name-value pairs that provide additional options for parsing data at the source. See [Data format options](#).

Returns the DataSource.

**Examples**

Create a DynamicFrame from a data source that is a comma-separated values (CSV) file on Amazon S3:

```scala
val datasource0 = glueContext.getSourceWithFormat(
  connectionType="s3",
  options =JsonOptions(s""""{"paths": [ "s3://csv/nycflights.csv"]}""""),
  transformationContext = "datasource0",
  format = "csv",
  formatOptions=JsonOptions(s""""{"withHeader":true,"separator": ","}"""")
).getDynamicFrame()
```

Create a DynamicFrame from a data source that is a PostgreSQL using a JDBC connection:

```scala
val datasource0 = glueContext.getSourceWithFormat(
  connectionType="postgresql",
  options =JsonOptions(s""""{"url":"jdbc:postgresql://databasePostgres-1.rds.amazonaws.com:5432/testdb","dbtable": "public.company","redshiftTmpDir":null,"user":"username","password":"password123"}""""),
  transformationContext = "datasource0").getDynamicFrame()
```

Create a DynamicFrame from a data source that is a MySQL using a JDBC connection:

```scala
val datasource0 = glueContext.getSourceWithFormat(
```
connectionType="mysql",
options =JsonOptions(s""""{
 "url":"jdbc:mysql://databaseMysql-1.rds.amazonaws.com:3306/testdb",
 "dbtable": "athenatest_nycflights13_csv",
 "redshiftTmpDir": "",
 "user": "username",
 "password": "password123"
 }""""),
transformationContext = "datasource0").getDynamicFrame()

def getSparkSession

def getSparkSession : SparkSession

Gets the SparkSession object associated with this GlueContext. Use this SparkSession object to register tables and UDFs for use with DataFrame created from DynamicFrames.

Returns the SparkSession.

def startTransaction

def startTransaction(readOnly: Boolean):String

Start a new transaction. Internally calls the Lake Formation startTransaction API.

• readOnly – (Boolean) Indicates whether this transaction should be read only or read and write. Writes made using a read-only transaction ID will be rejected. Read-only transactions do not need to be committed.

Returns the transaction ID.

def commitTransaction

def commitTransaction(transactionId: String, waitForCommit: Boolean): Boolean

Attempts to commit the specified transaction. commitTransaction may return before the transaction has finished committing. Internally calls the Lake Formation commitTransaction API.

• transactionId – (String) The transaction to commit.
• `waitForCommit` – (Boolean) Determines whether the `commitTransaction` returns immediately. The default value is true. If false, `commitTransaction` polls and waits until the transaction is committed. The amount of wait time is restricted to 1 minute using exponential backoff with a maximum of 6 retry attempts.

Returns a Boolean to indicate whether the commit is done or not.

```scala
def cancelTransaction
```

```scala
def cancelTransaction(transactionId: String): Unit
```

Attempts to cancel the specified transaction. Internally calls the Lake Formation [CancelTransaction API](#).

• `transactionId` – (String) The transaction to cancel.

Returns a `TransactionCommittedException` exception if the transaction was previously committed.

```scala
def this
```

```scala
def this( sc : SparkContext, 
  minPartitions : Int, 
  targetPartitions : Int )
```

Creates a `GlueContext` object using the specified `SparkContext`, minimum partitions, and target partitions.

• `sc` — The `SparkContext`.
• `minPartitions` — The minimum number of partitions.
• `targetPartitions` — The target number of partitions.

Returns the `GlueContext`.

```scala
def this
```

```scala
def this( sc : SparkContext )
```
Creates a `GlueContext` object with the provided `SparkContext`. Sets the minimum partitions to 10 and target partitions to 20.

- `sc` — The `SparkContext`.

Returns the `GlueContext`.

```scala
def this( sparkContext : JavaSparkContext )
```

Creates a `GlueContext` object with the provided `JavaSparkContext`. Sets the minimum partitions to 10 and target partitions to 20.

- `sparkContext` — The `JavaSparkContext`.

Returns the `GlueContext`.

**MappingSpec**

**Package: com.amazonaws.services.glue**

**MappingSpec case class**

```scala
case class MappingSpec( sourcePath: SchemaPath,
  sourceType: DataType,
  targetPath: SchemaPath,
  targetType: DataType ) extends Product4[String, String, String, String] {
  override def _1: String = sourcePath.toString
  override def _2: String = ExtendedTypeName.fromDataType(sourceType)
  override def _3: String = targetPath.toString
  override def _4: String = ExtendedTypeName.fromDataType(targetType)
}
```

- `sourcePath` — The `SchemaPath` of the source field.
- `sourceType` — The `DataType` of the source field.
- `targetPath` — The `SchemaPath` of the target field.
- `targetType` — The `DataType` of the target field.
A MappingSpec specifies a mapping from a source path and a source data type to a target path and a target data type. The value at the source path in the source frame appears in the target frame at the target path. The source data type is cast to the target data type.

It extends from Product4 so that you can handle any Product4 in your applyMapping interface.

**MappingSpec object**

```scala
object MappingSpec
```

The MappingSpec object has the following members:

**Val orderingByTarget**

```scala
val orderingByTarget: Ordering[MappingSpec]
```

**Def apply**

```scala
def apply( sourcePath : String,
            sourceType : DataType,
            targetPath : String,
            targetType : DataType
          ) : MappingSpec
```

Creates a MappingSpec.

- **sourcePath** — A string representation of the source path.
- **sourceType** — The source DataType.
- **targetPath** — A string representation of the target path.
- **targetType** — The target DataType.

Returns a MappingSpec.

**Def apply**

```scala
def apply( sourcePath : String,
            sourceTypeString : String,
            targetTypeString : String,
            # This line is incomplete and seems to be a placeholder.
```
Create a MappingSpec.

- **sourcePath** — A string representation of the source path.
- **sourceType** — A string representation of the source data type.
- **targetPath** — A string representation of the target path.
- **targetType** — A string representation of the target data type.

Returns a MappingSpec.

**Def apply**

```scala
def apply( product : Product4[String, String, String, String] ) : MappingSpec
```

Create a MappingSpec.

- **product** — The Product4 of the source path, source data type, target path, and target data type.

Returns a MappingSpec.

---

**AWS Glue Scala ResolveSpec APIs**

**Topics**

- [ResolveSpec object](#)
- [ResolveSpec case class](#)

**Package:** com.amazonaws.services.glue

**ResolveSpec object**

**ResolveSpec**

```scala
object ResolveSpec
```
**Def**

```scala
def apply( path : String,
            action : String
      ) : ResolveSpec
```

Creates a ResolveSpec.

- **path** — A string representation of the choice field that needs to be resolved.
- **action** — A resolution action. The action can be one of the following: Project, KeepAsStruct, or Cast.

Returns the ResolveSpec.

**Def**

```scala
def apply( product : Product2[String, String] ) : ResolveSpec
```

Creates a ResolveSpec.

- **product** — Product2 of: source path, resolution action.

Returns the ResolveSpec.

**ResolveSpec case class**

```scala
case class ResolveSpec extends Product2[String, String]  (
    path : SchemaPath,
    action : String
)
```

Creates a ResolveSpec.

- **path** — The SchemaPath of the choice field that needs to be resolved.
- **action** — A resolution action. The action can be one of the following: Project, KeepAsStruct, or Cast.
ResolveSpec def methods

```scala
def _1 : String

def _2 : String
```

AWS Glue Scala ArrayNode APIs

Package: com.amazonaws.services.glue.types

ArrayNode case class

ArrayNode

case class ArrayNode extends DynamicNode (  
  value : ArrayBuffer[DynamicNode]  )

ArrayNode def methods

```scala
def add( node : DynamicNode )

def clone

def equals( other : Any )

def get( index : Int ) : Option[DynamicNode]

def getValue

def hashCode : Int

def isEmpty : Boolean

def nodeType

def remove( index : Int )
```
def this

def toIterator : Iterator[DynamicNode]

def toJson : String

def update( index : Int,
        node : DynamicNode )

AWS Glue Scala BinaryNode APIs

Package: com.amazonaws.services.glue.types

BinaryNode case class

BinaryNode

case class BinaryNode extends ScalarNode(value, TypeCode.BINARY) (
    value : Array[Byte] )

BinaryNode val fields

• ordering

BinaryNode def methods

def clone

def equals( other : Any )

def hashCode : Int

AWS Glue Scala BooleanNode APIs

Package: com.amazonaws.services.glue.types

BooleanNode case class

BooleanNode

ETL in Scala
case class BooleanNode extends ScalarNode(value, TypeCode.BOOLEAN) {
  value : Boolean
}

BooleanNode val fields

• ordering

BooleanNode def methods

def equals( other : Any )

AWS Glue Scala ByteNode APIs

Package: com.amazonaws.services.glue.types

ByteNode case class

ByteNode

case class ByteNode extends ScalarNode(value, TypeCode.BYTE) {
  value : Byte
}

ByteNode val fields

• ordering

ByteNode def methods

def equals( other : Any )

AWS Glue Scala DateNode APIs

Package: com.amazonaws.services.glue.types

DateNode case class

DateNode

case class DateNode extends ScalarNode(value, TypeCode.DATE) {
  value : Date
}
DateNode val fields

- ordering

DateNode def methods

def equals( other : Any )

def this( value : Int )

AWS Glue Scala DecimalNode APIs

Package: com.amazonaws.services.glue.types

DecimalNode case class

DecimalNode

case class DecimalNode extends ScalarNode(value, TypeCode.DECIMAL) {
    value : BigDecimal
}

DecimalNode val fields

- ordering

DecimalNode def methods

def equals( other : Any )

def this( value : Decimal )

AWS Glue Scala DoubleNode APIs

Package: com.amazonaws.services.glue.types

DoubleNode case class

DoubleNode

case class DoubleNode extends ScalarNode(value, TypeCode.DOUBLE) {
DoubleNode val fields

- ordering

DoubleNode def methods

```scala
def equals( other : Any )
```

AWS Glue Scala DynamicNode APIs

Topics

- DynamicNode class
- DynamicNode object

Package: com.amazonaws.services.glue.types

DynamicNode class

DynamicNode

```scala
class DynamicNode extends Serializable with Cloneable
```

DynamicNode def methods

```scala
def getValue : Any
```

Get plain value and bind to the current record:

```scala
def nodeType : TypeCode
```

```scala
def toJson : String
```

Method for debug:

```scala
def toRow( schema : Schema,
             options : Map[String, ResolveOption]
```
DynamicNode object

DynamicNode

object DynamicNode

DynamicNode def methods

def quote( field : String,
useQuotes : Boolean
) : String

def quote( node : DynamicNode,
useQuotes : Boolean
) : String

EvaluateDataQuality class

AWS Glue Data Quality is in preview release for AWS Glue and is subject to change.

Package: com.amazonaws.services.glue.dq

object EvaluateDataQuality

Def apply

def apply(frame: DynamicFrame,
ruleset: String,
publishingOptions: JsonOptions = JsonOptions.empty): DynamicFrame

Evaluates a data quality ruleset against a DynamicFrame, and returns a new DynamicFrame with results of the evaluation. To learn more about AWS Glue Data Quality, see AWS Glue Data Quality.

frame – The DynamicFrame that you want to evaluate the data quality of.
• ruleset – A Data Quality Definition Language (DQDL) ruleset in string format. To learn more about DQDL, see the Data Quality Definition Language (DQDL) reference guide.

• publishingOptions – A dictionary that specifies the following options for publishing evaluation results and metrics:
  • dataQualityEvaluationContext – A string that specifies the namespace under which AWS Glue should publish Amazon CloudWatch metrics and the data quality results. The aggregated metrics appear in CloudWatch, while the full results appear in the AWS Glue Studio interface.
    • Required: No
    • Default value: default_context
  • enableDataQualityCloudWatchMetrics – Specifies whether the results of the data quality evaluation should be published to CloudWatch. You specify a namespace for the metrics using the dataQualityEvaluationContext option.
    • Required: No
    • Default value: False
  • enableDataQualityResultsPublishing – Specifies whether the data quality results should be visible on the Data Quality tab in the AWS Glue Studio interface.
    • Required: No
    • Default value: True
  • resultsS3Prefix – Specifies the Amazon S3 location where AWS Glue can write the data quality evaluation results.
    • Required: No
    • Default value: "" (empty string)

Example

The following example code demonstrates how to evaluate data quality for a DynamicFrame before performing a SelectFields transform. The script verifies that all data quality rules pass before it attempts the transform.

```java
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
```
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._
import com.amazonaws.services.glue.dq.EvaluateDataQuality

object GlueApp {
  def main(sysArgs: Array[String]) {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    // @params: [JOB_NAME]
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    // Create DynamicFrame with data
    val Legislators_Area = glueContext.getCatalogSource(database="legislators",
    tableName="areas_json", transformationContext="S3bucket_node1").getDynamicFrame()

    // Define data quality ruleset
    val DQ_Ruleset = ""
    Rules = [ColumnExists "id"]
    ""

    // Evaluate data quality
    val DQ_Results = EvaluateDataQuality.apply(frame=Legislators_Area,
    ruleset=DQ_Ruleset, publishingOptions=JsonOptions("""{"dataQualityEvaluationContext":
    "Legislators_Area", "enableDataQualityMetrics": "true",
    "enableDataQualityResultsPublishing": "true"}""
    ))
    assert(DQ_Results.filter(_.getField("Outcome").contains("Failed")).count == 0,
    "Failing DQ rules for Legislators_Area caused the job to fail.")

    // Script generated for node Select Fields
    val SelectFields_Results = Legislators_Area.selectFields(paths=Seq("id", "name"),
    transformationContext="Legislators_Area")

    Job.commit()
  }
}

AWS Glue Scala FloatNode APIs

Package: com.amazonaws.services.glue.types

FloatNode case class

FloatNode
case class FloatNode extends ScalarNode(value, TypeCode.FLOAT) {
  value : Float
}

FloatNode val fields

- ordering

FloatNode def methods

  def equals( other : Any )

FillMissingValues class

Package: com.amazonaws.services.glue.ml

object FillMissingValues

Def apply

  def apply(frame: DynamicFrame,
            missingValuesColumn: String,
            outputColumn: String = "",
            transformationContext: String = "",
            callSite: CallSite = CallSite("Not provided", ","),
            stageThreshold: Long = 0,
            totalThreshold: Long = 0): DynamicFrame

Fills a dynamic frame's missing values in a specified column and returns a new frame with estimates in a new column. For rows without missing values, the specified column's value is duplicated to the new column.

- frame — The DynamicFrame in which to fill missing values. Required.
- missingValuesColumn — The column containing missing values (null values and empty strings). Required.
- outputColumn — The name of the new column that will contain estimated values for all rows whose value was missing. Optional; the default is the value of missingValuesColumn suffixed by "_filled".
• **transformationContext** — A unique string that is used to identify state information (optional).

• **callSite** — Used to provide context information for error reporting. (optional).

• **stageThreshold** — The maximum number of errors that can occur in the transformation before it errors out (optional; the default is zero).

• **totalThreshold** — The maximum number of errors that can occur overall before processing errors out (optional; the default is zero).

Returns a new dynamic frame with one additional column that contains estimations for rows with missing values and the present value for other rows.

**FindMatches class**

**Package: com.amazonaws.services.glue.ml**

```scala
object FindMatches

Def apply

def apply(frame: DynamicFrame,
          transformId: String,
          transformationContext: String = "",
          callSite: CallSite = CallSite("Not provided", ""),
          stageThreshold: Long = 0,
          totalThreshold: Long = 0,
          enforcedMatches: DynamicFrame = null): DynamicFrame,
          computeMatchConfidenceScores: Boolean
```

Find matches in an input frame and return a new frame with a new column containing a unique ID per match group.

• **frame** — The DynamicFrame in which to find matches. Required.

• **transformId** — A unique ID associated with the FindMatches transform to apply on the input frame. Required.

• **transformationContext** — Identifier for this DynamicFrame. The transformationContext is used as a key for the job bookmark state that is persisted across runs. Optional.
• callSite — Used to provide context information for error reporting. These values are automatically set when calling from Python. Optional.

• stageThreshold — The maximum number of error records allowed from the computation of this DynamicFrame before throwing an exception, excluding records present in the previous DynamicFrame. Optional. The default is zero.

• totalThreshold — The maximum number of total errors records before an exception is thrown, including those from previous frames. Optional. The default is zero.

• enforcedMatches — The frame for enforced matches. Optional. The default is null.

• computeMatchConfidenceScores — A Boolean value indicating whether to compute a confidence score for each group of matching records. Optional. The default is false.

Returns a new dynamic frame with a unique identifier assigned to each group of matching records.

FindIncrementalMatches class

Package: com.amazonaws.services.glue.ml

object FindIncrementalMatches

Def apply

apply(existingFrame: DynamicFrame,
    incrementalFrame: DynamicFrame,
    transformId: String,
    transformationContext: String = "",
    callSite: CallSite = CallSite("Not provided", ""),
    stageThreshold: Long = 0,
    totalThreshold: Long = 0,
    enforcedMatches: DynamicFrame = null): DynamicFrame,
    computeMatchConfidenceScores: Boolean

Find matches across the existing and incremental frames and return a new frame with a column containing a unique ID per match group.

• existingFrame — An existing frame which has been assigned a matching ID for each group. Required.

• incrementalFrame — An incremental frame used to find matches against the existing frame. Required.
• transformId — A unique ID associated with the FindIncrementalMatches transform to apply on the input frames. Required.

• transformationContext — Identifier for this DataFrame. The transformationContext is used as a key for the job bookmark state that is persisted across runs. Optional.

• callSite — Used to provide context information for error reporting. These values are automatically set when calling from Python. Optional.

• stageThreshold — The maximum number of error records allowed from the computation of this DataFrame before throwing an exception, excluding records present in the previous DataFrame. Optional. The default is zero.

• totalThreshold — The maximum number of total error records before an exception is thrown, including those from previous frames. Optional. The default is zero.

• enforcedMatches — The frame for enforced matches. Optional. The default is null.

• computeMatchConfidenceScores — A Boolean value indicating whether to compute a confidence score for each group of matching records. Optional. The default is false.

Returns a new dynamic frame with a unique identifier assigned to each group of matching records.

AWS Glue Scala IntegerNode APIs

Package: com.amazonaws.services.glue.types

IntegerNode case class

IntegerNode

```
case class IntegerNode extends ScalarNode(value, TypeCode.INT) {
  value : Int
}
```

IntegerNode val fields

• ordering

IntegerNode def methods

```
def equals( other : Any )
```
AWS Glue Scala LongNode APIs

Package: com.amazonaws.services.glue.types

LongNode case class

LongNode

case class LongNode extends ScalarNode(value, TypeCode.LONG) (  
  value : Long )

LongNode val fields

• ordering

LongNode def methods

def equals( other : Any )

AWS Glue Scala MapLikeNode APIs

Package: com.amazonaws.services.glue.types

MapLikeNode class

MapLikeNode

class MapLikeNode extends DynamicNode (  
  value : mutable.Map[String, DynamicNode] )

MapLikeNode def methods

def clear : Unit

def get( name : String ) : Option[DynamicNode]

def getValue

def has( name : String ) : Boolean
def isEmpty : Boolean

def put( name : String,
         node : DynamicNode
     ) : Option[DynamicNode]

def remove( name : String ) : Option[DynamicNode]

def toIterator : Iterator[(String, DynamicNode)]

def toJson : String

def toJson( useQuotes : Boolean ) : String

Example: Given this JSON:

{
"foo": "bar"
}

If useQuotes == true, toJson yields {"foo": "bar"}. If useQuotes == false, toJson yields {foo: bar} @return.

AWS Glue Scala MapNode APIs

Package: com.amazonaws.services.glue.types

MapNode case class

MapNode

case class MapNode extends MapLikeNode(value)  (
    value : mutable.Map[String, DynamicNode]  )

MapNode def methods

def clone

def equals( other : Any )
def hashCode : Int

def nodeType

def this

AWS Glue Scala `NullNode` APIs

Topics

- `NullNode class`
- `NullNode case object`

Package: com.amazonaws.services.glue.types

NullNode class

NullNode

class NullNode

NullNode case object

NullNode

case object NullNode extends NullNode

AWS Glue Scala `ObjectNode` APIs

Topics

- `ObjectNode object`
- `ObjectNode case class`

Package: com.amazonaws.services.glue.types

ObjectNode object

ObjectNode
object ObjectNode

ObjectNode def methods

def apply( frameKeys : Set[String],
  v1 : mutable.Map[String, DynamicNode],
  v2 : mutable.Map[String, DynamicNode],
  resolveWith : String
  ) : ObjectNode

ObjectNode case class

ObjectNode
case class ObjectNode extends MapLikeNode(value) (
  val value : mutable.Map[String, DynamicNode] )

ObjectNode def methods

def clone

def equals( other : Any )

def hashCode : Int

def nodeType

def this

AWS Glue Scala ScalarNode APIs

Topics
- ScalarNode class
- ScalarNode object

Package: com.amazonaws.services.glue.types
ScalarNode class

ScalarNode

class ScalarNode extends DynamicNode {
    value : Any,
    scalarType : TypeCode
}

ScalarNode def methods

def compare( other : Any,
             operator : String
) : Boolean

def getValue

def hashCode : Int

def nodeType

def toJson

ScalarNode object

ScalarNode

object ScalarNode

ScalarNode def methods

def apply( v : Any ) : DynamicNode

def compare( tv : Ordered[T],
             other : T,
             operator : String
) : Boolean
def compareAny( v : Any, 
               y : Any, 
               o : String )

def withEscapedSpecialCharacters( jsonToEscape : String ) : String

AWS Glue Scala ShortNode APIs

Package: com.amazonaws.services.glue.types

ShortNode case class

ShortNode

case class ShortNode extends ScalarNode(value, TypeCode.SHORT) ( 
    value : Short 
)

ShortNode val fields

• ordering

ShortNode def methods

def equals( other : Any )

AWS Glue Scala StringNode APIs

Package: com.amazonaws.services.glue.types

StringNode case class

StringNode

case class StringNode extends ScalarNode(value, TypeCode.STRING) ( 
    value : String 
)

StringNode val fields

• ordering
StringNode def methods

```scala
def equals( other : Any )

def this( value : UTF8String )
```

AWS Glue Scala TimestampNode APIs

**Package:** com.amazonaws.services.glue.types

**TimestampNode case class**

```scala
case class TimestampNode extends ScalarNode(value, TypeCode.TIMESTAMP) (
  value : Timestamp
)
```

**TimestampNode val fields**

- ordering

**TimestampNode def methods**

```scala
def equals( other : Any )

def this( value : Long )
```

AWS Glue Scala GlueArgParser APIs

**Package:** com.amazonaws.services.glue.util

**GlueArgParser object**

```scala
object GlueArgParser
```

This is strictly consistent with the Python version of `utils.getResolvedOptions` in the AWSGlueDataplanePython package.
GlueArgParser def methods

```scala
def getResolvedOptions( args : Array[String],
    options : Array[String]
  ) : Map[String, String]
```

```scala
def initParser( userOptionsSet : mutable.Set[String] ) : ArgumentParser
```

Example Retrieving arguments passed to a job

To retrieve job arguments, you can use the `getResolvedOptions` method. Consider the following example, which retrieves a job argument named `aws_region`.

```scala
val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME","aws_region").toArray)
Job.init(args("JOB_NAME"), glueContext, args.asJava)
val region = args("aws_region")
println(region)
```

AWS Glue Scala job APIs

Package: com.amazonaws.services.glue.util

Job object

Job

```scala
object Job
```

Job def methods

```scala
def commit
```

```scala
def init( jobName : String,
    glueContext : GlueContext,
    args : java.util.Map[String, String] = Map[String, String]().asJava
  ) : this.type
```

```scala
def init( jobName : String,
```

ETL in Scala
Features and optimizations for programming AWS Glue for Spark ETL scripts

The following sections describe techniques and values that apply generally to AWS Glue for Spark ETL (extract, transform, and load) programming in any language.

Topics

- Connection types and options for ETL in AWS Glue for Spark
- Data format options for inputs and outputs in AWS Glue for Spark
- AWS Glue Data Catalog support for Spark SQL jobs
- Using job bookmarks
- Optimizing reads with pushdown in AWS Glue ETL
- Using Sensitive Data Detection outside AWS Glue Studio
- AWS Glue Visual Job API

Connection types and options for ETL in AWS Glue for Spark

In AWS Glue for Spark, various PySpark and Scala methods and transforms specify the connection type using a connectionType parameter. They specify connection options using a connectionOptions or options parameter.

The connectionType parameter can take the values shown in the following table. The associated connectionOptions (or options) parameter values for each type are documented in the following sections. Except where otherwise noted, the parameters apply when the connection is used as a source or sink.
For sample code that demonstrates setting and using connection options, see the homepage for each connection type.

<table>
<thead>
<tr>
<th>connectionType</th>
<th>Connects to</th>
</tr>
</thead>
<tbody>
<tr>
<td>dynamodb</td>
<td>Amazon DynamoDB database</td>
</tr>
<tr>
<td>kinesis</td>
<td>Amazon Kinesis Data Streams</td>
</tr>
<tr>
<td>s3</td>
<td>Amazon S3</td>
</tr>
<tr>
<td>documentdb</td>
<td>Amazon DocumentDB (with MongoDB compatibility) database</td>
</tr>
<tr>
<td>opensearch</td>
<td>Amazon OpenSearch Service.</td>
</tr>
<tr>
<td>redshift</td>
<td>Amazon Redshift database</td>
</tr>
<tr>
<td>kafka</td>
<td>Kafka or Amazon Managed Streaming for Apache Kafka</td>
</tr>
<tr>
<td>azurecosmos</td>
<td>Azure Cosmos for NoSQL.</td>
</tr>
<tr>
<td>azuresql</td>
<td>Azure SQL.</td>
</tr>
<tr>
<td>bigquery</td>
<td>Google BigQuery.</td>
</tr>
<tr>
<td>mongodb</td>
<td>MongoDB database, including MongoDB Atlas.</td>
</tr>
<tr>
<td>sqlserver</td>
<td>Microsoft SQL Server database (see JDBC connections)</td>
</tr>
<tr>
<td>mysql</td>
<td>MySQL database (see JDBC connections)</td>
</tr>
<tr>
<td>oracle</td>
<td>Oracle database (see JDBC connections)</td>
</tr>
<tr>
<td>postgresql</td>
<td>PostgreSQL database (see JDBC connections)</td>
</tr>
<tr>
<td>saphana</td>
<td>SAP HANA.</td>
</tr>
<tr>
<td>snowflake</td>
<td>Snowflake data lake</td>
</tr>
<tr>
<td>teradata</td>
<td>Teradata Vantage.</td>
</tr>
<tr>
<td>vertica</td>
<td>Vertica.</td>
</tr>
</tbody>
</table>
### connectionType

<table>
<thead>
<tr>
<th>connectionType</th>
<th>Connects to</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>custom.*</code></td>
<td>Spark, Athena, or JDBC data stores (see Custom and AWS Marketplace connectionType values)</td>
</tr>
<tr>
<td><code>marketplace.*</code></td>
<td>Spark, Athena, or JDBC data stores (see Custom and AWS Marketplace connectionType values)</td>
</tr>
</tbody>
</table>

### DynamoDB connections

You can use AWS Glue for Spark to read from and write to tables in DynamoDB in AWS Glue. You connect to DynamoDB using IAM permissions attached to your AWS Glue job. AWS Glue supports writing data into another AWS account's DynamoDB table. For more information, see [the section called “Cross-account cross-Region access to DynamoDB tables”](#).

In addition to the AWS Glue DynamoDB ETL connector, you can read from DynamoDB using the DynamoDB export connector, that invokes a DynamoDB ExportTableToPointInTime request and stores it in an Amazon S3 location you supply, in the format of [DynamoDB JSON](#). AWS Glue then creates a DynamicFrame object by reading the data from the Amazon S3 export location.

The DynamoDB writer is available in AWS Glue version 1.0 or later versions. The AWS Glue DynamoDB export connector is available in AWS Glue version 2.0 or later versions.

For more information about DynamoDB, consult [Amazon DynamoDB](#) documentation.

---

**Note**

The DynamoDB ETL reader does not support filters or pushdown predicates.

### Configuring DynamoDB connections

To connect to DynamoDB from AWS Glue, grant the IAM role associated with your AWS Glue job permission to interact with DynamoDB. For more information about permissions necessary to read or write from DynamoDB, consult [Actions, resources, and condition keys for DynamoDB](#) in the IAM documentation.

In the following situations, you may need additional configuration:
• When using the DynamoDB export connector, you will need to configure IAM so your job can request DynamoDB table exports. Additionally, you will need to identify an Amazon S3 bucket for the export and provide appropriate permissions in IAM for DynamoDB to write to it, and for your AWS Glue job to read from it. For more information, consult Request a table export in DynamoDB.

• If your AWS Glue job has specific Amazon VPC connectivity requirements, use the NETWORK AWS Glue connection type to provide network options. Since access to DynamoDB is authorized by IAM, there is no need for a AWS Glue DynamoDB connection type.

Reading from and writing to DynamoDB

The following code examples show how to read from (via the ETL connector) and write to DynamoDB tables. They demonstrate reading from one table and writing to another table.

Python

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ["JOB_NAME"])
glue_context = GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args["JOB_NAME"], args)

dyf = glue_context.create_dynamic_frame.from_options(
    connection_type="dynamodb",
    connection_options={"dynamodb.input.tableName": test_source,
                       "dynamodb.throughput.read.percent": "1.0",
                       "dynamodb.splits": "100"
                      }
)

print(dyf.getNumPartitions())

glue_context.write_dynamic_frame_from_options(
    frame=dyf,
    connection_type="dynamodb",
    connection_options={"dynamodb.output.tableName": test_sink,
                        "dynamodb.throughput.write.percent": "1.0"}
)
```
Scala

```scala
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamoDbDataSink
import org.apache.spark.SparkContext
import scala.collection.JavaConverters

object GlueApp {

  def main(sysArgs: Array[String]): Unit = {
    val glueContext = new GlueContext(SparkContext.getOrCreate())
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    val dynamicFrame = glueContext.getSourceWithFormat(
      connectionType = "dynamodb",
      options = JsonOptions(Map(
        "dynamodb.input.tableName" -> test_source,
        "dynamodb.throughput.read.percent" -> "1.0",
        "dynamodb.splits" -> "100"
      ))
    ).getDynamicFrame()

    print(dynamicFrame.getNumPartitions())

    val dynamoDbSink: DynamoDbDataSink = glueContext.getSinkWithFormat(
      connectionType = "dynamodb",
      options = JsonOptions(Map(
        "dynamodb.output.tableName" -> test_sink,
        "dynamodb.throughput.write.percent" -> "1.0"
      ))
    ).asInstanceOf[DynamoDbDataSink]

    dynamoDbSink.writeDynamicFrame(dynamicFrame)
  }

```
Using the DynamoDB export connector

The export connector performs better than the ETL connector when the DynamoDB table size is larger than 80 GB. In addition, given that the export request is conducted outside from the Spark processes in an AWS Glue job, you can enable auto scaling of AWS Glue jobs to save DPU usage during the export request. With the export connector, you also do not need to configure the number of splits for Spark executor parallelism or DynamoDB throughput read percentage.

Note

DynamoDB has specific requirements to invoke the ExportTableToPointInTime requests. For more information, see Requesting a table export in DynamoDB. For example, Point-in-Time-Restore (PITR) needs to be enabled on the table to use this connector.

The DynamoDB connector also supports AWS KMS encryption for DynamoDB exports to Amazon S3. Supplying your security configuration in the AWS Glue job configuration enables AWS KMS encryption for a DynamoDB export. The KMS key must be in the same Region as the Amazon S3 bucket.

Note that additional charges for DynamoDB export and Amazon S3 storage costs apply. Exported data in Amazon S3 persists after a job run finishes so you can reuse it without additional DynamoDB exports. A requirement for using this connector is that point-in-time recovery (PITR) is enabled for the table.

The DynamoDB ETL connector or export connector do not support filters or pushdown predicates to be applied at the DynamoDB source.

The following code examples show how to read from (via the export connector) and print the number of partitions.

Python

```python
import sys
from pyspark.context import SparkContext`
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ["JOB_NAME"])
glue_context = GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args["JOB_NAME"], args)

dyf = glue_context.create_dynamic_frame.from_options(
    connection_type="dynamodb",
    connection_options={
        "dynamodb.export": "ddb",
        "dynamodb.tableArn": test_source,
        "dynamodb.s3.bucket": bucket_name,
        "dynamodb.s3.prefix": bucket_prefix,
        "dynamodb.s3.bucketOwner": account_id_of_bucket,
    }
)
print(dyf.getNumPartitions())

job.commit()

Scala

import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamoDbDataSink
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._

object GlueApp {

    def main(sysArgs: Array[String]): Unit = {
        val glueContext = new GlueContext(SparkContext.getOrCreate())
        val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
        Job.init(args("JOB_NAME"), glueContext, args.asJava)

        val dynamicFrame = glueContext.getSourceWithFormat(
            connectionType = "dynamodb",}
These examples show how to do the read from (via the export connector) and print the number of partitions from an AWS Glue Data Catalog table that has a dynamodb classification:

**Python**

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ["JOB_NAME"])
glue_context= GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args["JOB_NAME"], args)

dynamicFrame = glue_context.create_dynamic_frame.from_catalog(
    database=database,
    table_name=table_name,
    additional_options={
        "dynamodb.export": "ddb",
        "dynamodb.s3.bucket": s3_bucket,
        "dynamodb.s3.prefix": s3_bucket_prefix
    }
)
print(dynamicFrame.getNumPartitions())
```
Scala

```scala
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamoDbDataSink
import org.apache.spark.SparkContext
import scala.collection.JavaConverters

object GlueApp {

  def main(sysArgs: Array[String]): Unit = {
    val glueContext = new GlueContext(SparkContext.getOrCreate())
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    val dynamicFrame = glueContext.getCatalogSource(
        database = catalog_database,
        tableName = catalog_table_name,
        additionalOptions = JsonOptions(Map(
            "dynamodb.export" -> "ddb",
            "dynamodb.s3.bucket" -> s3_bucket,
            "dynamodb.s3.prefix" -> s3_bucket_prefix
        ))
    ).getDynamicFrame()
    print(dynamicFrame.getNumPartitions())
  }
}
```

**Simplifying usage of DynamoDB export JSON**

The DynamoDB exports with the AWS Glue DynamoDB export connector results in JSON files of specific nested structures. For more information, see [Data objects](#). AWS Glue supplies a `DynamicFrame` transformation, which can unnest such structures into an easier-to-use form for downstream applications.

The transform can be invoked in one of two ways. You can set the connection option "dynamodb.simplifyDDBJson" with the value "true" when calling a method to read from
DynamoDB. You can also call the transform as a method independently available in the AWS Glue library.

Consider the following schema generated by a DynamoDB export:

```
root
|-- Item: struct
 | |-- parentMap: struct
 | | |-- M: struct
 | | | |-- childMap: struct
 | | | | |-- M: struct
 | | | | | |-- appName: struct
 | | | | | | |-- S: string
 | | | | | | |-- packageName: struct
 | | | | | | | |-- S: string
 | | | | | | | |-- updatedAt: string
 | | | | | | | | |-- N: string
 | | |-- strings: struct
 | | | |-- SS: array
 | | | | |-- element: string
 | | |-- numbers: struct
 | | | |-- NS: array
 | | | | |-- element: string
 | | |-- binaries: struct
 | | | |-- BS: array
 | | | | |-- element: string
 | |-- isDDBJson: struct
 | | |-- BOOL: boolean
 | |-- nullValue: struct
 | | |-- NULL: boolean
```

The `simplifyDDBJson` transform will simplify this to:

```
root
|-- parentMap: struct
 | |-- childMap: struct
 | | |-- appName: string
 | | |-- packageName: string
 | | |-- updatedAt: string
 | |-- strings: array
 | | |-- element: string
 | -- numbers: array
 | | |-- element: string
```
Configuring parallelism in DynamoDB operations

To improve performance, you can tune certain parameters available for the DynamoDB connector. Your goal when tuning parallelism parameters is to maximize the use of the provisioned AWS Glue workers. Then, if you need more performance, we recommend you to scale out your job by increasing the number of DPUs.

You can alter the parallelism in a DynamoDB read operation using the dynamodb.splits parameter when using the ETL connector. When reading with the export connector, you do not need to configure the number of splits for Spark executor parallelism. You can alter the parallelism in a DynamoDB write operation with dynamodb.output.numParallelTasks.

Reading with the DynamoDB ETL connector

We recommend you to calculate dynamodb.splits based on the maximum number of workers set in your job configuration and the following numSlots calculation. If autoscaling, the actual number of workers available may change under that cap. For more information about setting the maximum number of workers, see Number of workers (NumberOfWorkers) in the section called “Adding jobs”.

- numExecutors = NumberOfWorkers - 1

  For context, one executor is reserved for the Spark driver; other executors are used to process data.

- numSlotsPerExecutor =

  AWS Glue 3.0 and later versions
    - 4 if WorkerType is G.1X

Features and optimizations
• 8 if WorkerType is G.2X
• 16 if WorkerType is G.4X
• 32 if WorkerType is G.8X

AWS Glue 2.0 and legacy versions
• 8 if WorkerType is G.1X
• 16 if WorkerType is G.2X

numSlots = numSlotsPerExecutor * numExecutors

We recommend you set dynamodb.splits to the number of slots available, numSlots.

Writing to DynamoDB

The dynamodb.output.numParallelTasks parameter is used to determine WCU per Spark task, using the following calculation:

\[
\text{permittedWcuPerTask} = \left( \frac{\text{TableWCU} \times \text{dynamodb\.throughput\.write\.percent}}{\text{dynamodb\.output\.numParallelTasks}} \right)
\]

The DynamoDB writer will function best if configuration accurately represents the number of Spark tasks writing to DynamoDB. In some cases, you may need to override the default calculation to improve write performance. If you do not specify this parameter, the permitted WCU per Spark task will be automatically calculated by the following formula:

• numPartitions = dynamicframe.getNumPartitions()
• numSlots (as defined previously in this section)
• numParallelTasks = min(numPartitions, numSlots)

Example 1. DPU=10, WorkerType=Standard. Input DynamicFrame has 100 RDD partitions.
• numPartitions = 100
• numExecutors = (10 - 1) * 2 - 1 = 17
• numSlots = 4 * 17 = 68
• numParallelTasks = min(100, 68) = 68

Example 2. DPU=10, WorkerType=Standard. Input DynamicFrame has 20 RDD partitions.
• numPartitions = 20
• numExecutors = (10 - 1) * 2 - 1 = 17
• numSlots = 4 * 17 = 68
• numParallelTasks = min(20, 68) = 20

**Note**

Jobs on legacy AWS Glue versions and those using Standard workers require different methods to calculate the number of slots. If you need to performance tune these jobs, we recommend you transition to supported AWS Glue versions.

**DynamoDB connection option reference**

Designates a connection to Amazon DynamoDB.

Connection options differ for a source connection and a sink connection.

"connectionType": "dynamodb" with the ETL connector as source

Use the following connection options with "connectionType": "dynamodb" as a source, when using the AWS Glue DynamoDB ETL connector:

- "dynamodb.input.tableName": (Required) The DynamoDB table to read from.
- "dynamodb.throughput.read.percent": (Optional) The percentage of read capacity units (RCU) to use. The default is set to "0.5". Acceptable values are from "0.1" to "1.5", inclusive.
- "0.5" represents the default read rate, meaning that AWS Glue will attempt to consume half of the read capacity of the table. If you increase the value above "0.5", AWS Glue increases the request rate; decreasing the value below "0.5" decreases the read request rate. (The actual read rate will vary, depending on factors such as whether there is a uniform key distribution in the DynamoDB table.)
- When the DynamoDB table is in on-demand mode, AWS Glue handles the read capacity of the table as 40000. For exporting a large table, we recommend switching your DynamoDB table to on-demand mode.
- "dynamodb.splits": (Optional) Defines how many splits we partition this DynamoDB table into while reading. The default is set to "1". Acceptable values are from "1" to "1,000,000", inclusive.
1 represents there is no parallelism. We highly recommend that you specify a larger value for better performance by using the below formula. For more information on appropriately setting a value, see the section called “DynamoDB parallelism”.

- "dynamodb.sts.roleArn": (Optional) The IAM role ARN to be assumed for cross-account access. This parameter is available in AWS Glue 1.0 or later.
- "dynamodb.sts.roleSessionName": (Optional) STS session name. The default is set to "glue-dynamodb-read-sts-session". This parameter is available in AWS Glue 1.0 or later.

"connectionType": "dynamodb" with the AWS Glue DynamoDB export connector as source

Use the following connection options with "connectionType": "dynamodb" as a source, when using the AWS Glue DynamoDB export connector, which is available only for AWS Glue version 2.0 onwards:

- "dynamodb.export": (Required) A string value:
  - If set to ddb enables the AWS Glue DynamoDB export connector where a new ExportTableToPointInTimeRequest will be invoked during the AWS Glue job. A new export will be generated with the location passed from dynamodb.s3.bucket and dynamodb.s3.prefix.
  - If set to s3 enables the AWS Glue DynamoDB export connector but skips the creation of a new DynamoDB export and instead uses the dynamodb.s3.bucket and dynamodb.s3.prefix as the Amazon S3 location of a past export of that table.
- "dynamodb.tableArn": (Required) The DynamoDB table to read from.
- "dynamodb.unnestDDBJson": (Optional) Default: false. Valid values: boolean. If set to true, performs an unnest transformation of the DynamoDB JSON structure that is present in exports. It is an error to set "dynamodb.unnestDDBJson" and "dynamodb.simplifyDDBJson" to true at the same time. In AWS Glue 3.0 and later versions, we recommend you use "dynamodb.simplifyDDBJson" for better behavior when simplifying DynamoDB Map types. For more information, see the section called “Simplifying usage of DynamoDB export JSON”.
- "dynamodb.simplifyDDBJson": (Optional) Default: false. Valid values: boolean. If set to true, performs a transformation to simplify the schema of the DynamoDB JSON structure that is present in exports. This has the same purpose as the "dynamodb.unnestDDBJson" option but provides better support for DynamoDB Map types or even nested Map types in your DynamoDB table. This option is available in AWS Glue 3.0 and later versions. It is an error to set
"dynamodb.unnestDDBJson" and "dynamodb.simplifyDDBJson" to true at the same time. For more information, see the section called “Simplifying usage of DynamoDB export JSON”.

- "dynamodb.s3.bucket": (Optional) Indicates the Amazon S3 bucket location in which the DynamoDB ExportTableToPointInTime process is to be conducted. The file format for the export is DynamoDB JSON.
- "dynamodb.s3.prefix": (Optional) Indicates the Amazon S3 prefix location inside the Amazon S3 bucket in which the DynamoDB ExportTableToPointInTime loads are to be stored. If neither dynamodb.s3.prefix nor dynamodb.s3.bucket are specified, these values will default to the Temporary Directory location specified in the AWS Glue job configuration. For more information, see Special Parameters Used by AWS Glue.
- "dynamodb.s3.bucketOwner": Indicates the bucket owner needed for cross-account Amazon S3 access.
- "dynamodb.sts.roleArn": (Optional) The IAM role ARN to be assumed for cross-account access and/or cross-Region access for the DynamoDB table. Note: The same IAM role ARN will be used to access the Amazon S3 location specified for the ExportTableToPointInTime request.
- "dynamodb.sts.roleSessionName": (Optional) STS session name. The default is set to "glue-dynamodb-read-sts-session".
- "dynamodb.exportTime": (Optional) Valid values: strings representing ISO-8601 instants. A point-in-time at which the export should be made.
- "dynamodb.sts.region": (Required if making a cross-region call using a regional endpoint) The region hosting the DynamoDB table you want to read.

"connectionType": "dynamodb" with the ETL connector as sink

Use the following connection options with "connectionType": "dynamodb" as a sink:

- "dynamodb.output.tableName": (Required) The DynamoDB table to write to.
- "dynamodb.throughput.write.percent": (Optional) The percentage of write capacity units (WCU) to use. The default is set to "0.5". Acceptable values are from "0.1" to "1.5", inclusive.
  - 0.5 represents the default write rate, meaning that AWS Glue will attempt to consume half of the write capacity of the table. If you increase the value above 0.5, AWS Glue increases the request rate; decreasing the value below 0.5 decreases the write request rate. (The actual write rate will vary, depending on factors such as whether there is a uniform key distribution in the DynamoDB table).
• When the DynamoDB table is in on-demand mode, AWS Glue handles the write capacity of the table as 40000. For importing a large table, we recommend switching your DynamoDB table to on-demand mode.

• "dynamodb.output.numParallelTasks": (Optional) Defines how many parallel tasks write into DynamoDB at the same time. Used to calculate permissive WCU per Spark task. In most cases, AWS Glue will calculate a reasonable default for this value. For more information, see the section called “DynamoDB parallelism”.

• "dynamodb.output.retry": (Optional) Defines how many retries we perform when there is a ProvisionedThroughputExceededException from DynamoDB. The default is set to "10".

• "dynamodb.sts.roleArn": (Optional) The IAM role ARN to be assumed for cross-account access.

• "dynamodb.sts.roleSessionName": (Optional) STS session name. The default is set to "glue-dynamodb-write-sts-session".

Cross-account cross-Region access to DynamoDB tables

AWS Glue ETL jobs support both cross-region and cross-account access to DynamoDB tables. AWS Glue ETL jobs support both reading data from another AWS Account's DynamoDB table, and writing data into another AWS Account's DynamoDB table. AWS Glue also supports both reading from a DynamoDB table in another region, and writing into a DynamoDB table in another region. This section gives instructions on setting up the access, and provides an example script.

The procedures in this section reference an IAM tutorial for creating an IAM role and granting access to the role. The tutorial also discusses assuming a role, but here you will instead use a job script to assume the role in AWS Glue. This tutorial also contains information about general cross-account practices. For more information, see Tutorial: Delegate Access Across AWS Accounts Using IAM Roles in the IAM User Guide.

Create a role

Follow step 1 in the tutorial to create an IAM role in account A. When defining the permissions of the role, you can choose to attach existing policies such as AmazonDynamoDBReadOnlyAccess, or AmazonDynamoDBFullAccess to allow the role to read/write DynamoDB. The following example shows creating a role named DynamoDBCrossAccessRole, with the permission policy AmazonDynamoDBFullAccess.
Grant access to the role

Follow step 2 in the tutorial in the IAM User Guide to allow account B to switch to the newly-created role. The following example creates a new policy with the following statement:

```json
{
    "Version": "2012-10-17",
    "Statement": {
        "Effect": "Allow",
        "Action": "sts:AssumeRole",
        "Resource": "<DynamoDBCrossAccessRole's ARN>"
    }
}
```

Then, you can attach this policy to the group/role/user you would like to use to access DynamoDB.

Assume the role in the AWS Glue job script

Now, you can log in to account B and create an AWS Glue job. To create a job, refer to the instructions at Adding jobs in AWS Glue.

In the job script you need to use the `dynamodb.sts.roleArn` parameter to assume the DynamoDBCrossAccessRole role. Assuming this role allows you to get the temporary credentials, which need to be used to access DynamoDB in account B. Review these example scripts.

For a cross-account read across regions (ETL connector):

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ["JOB_NAME"])

glue_context= GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args["JOB_NAME"], args)

dyf = glue_context.create_dynamic_frame_from_options(
    connection_type="dynamodb",
    connection_options={
        "dynamodb.region": "us-east-1",
        "dynamodb.input.tableName": "test_source",
    }
)
```
For a cross-account read across regions (ELT connector):

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ['JOB_NAME'])
glue_context= GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args['JOB_NAME'], args)

dyf = glue_context.create_dynamic_frame_from_options(
    connection_type="dynamodb",
    connection_options={
        "dynamodb.export": "ddb",
        "dynamodb.tableArn": "<test_source ARN>",
        "dynamodb.sts.roleArn": "<DynamoDBCrossAccessRole's ARN>"
    }
)
dyf.show()
job.commit()
```

For a read and cross-account write across regions:

```python
import sys
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job
from awsglue.utils import getResolvedOptions

args = getResolvedOptions(sys.argv, ['JOB_NAME'])
glue_context= GlueContext(SparkContext.getOrCreate())
job = Job(glue_context)
job.init(args['JOB_NAME'], args)
```
dyf = glue_context.create_dynamic_frame_from_options(
    connection_type="dynamodb",
    connection_options={
        "dynamodb.region": "us-east-1",
        "dynamodb.input.tableName": "test_source"
    }
)

dyf.show()

job.commit()

---

Kinesis connections

You can read and write to Amazon Kinesis data streams using information stored in a Data Catalog table, or by providing information to directly access the data stream. You can read information from Kinesis into a Spark DataFrame, then convert it to a AWS Glue DynamicFrame. You can write DynamicFrames to Kinesis in a JSON format. If you directly access the data stream, use these options to provide the information about how to access the data stream.

If you use `getCatalogSource` or `create_data_frame_from_catalog` to consume records from a Kinesis streaming source, the job has the Data Catalog database and table name information, and can use that to obtain some basic parameters for reading from the Kinesis streaming source. If you use `getSource`, `getSourceWithFormat`, `createDataFrameFromOptions` or `create_data_frame_from_options`, you must specify these basic parameters using the connection options described here.

You can specify the connection options for Kinesis using the following arguments for the specified methods in the GlueContext class.

- Scala
  - `connectionOptions`: Use with `getSource`, `createDataFrameFromOptions`, `getSink`
• additionalOptions: Use with getCatalogSource, getCatalogSink
• options: Use with getSourceWithFormat, getSinkWithFormat

Python
• connection_options: Use with create_data_frame_from_options, write_dynamic_frame_from_options
• additional_options: Use with create_data_frame_from_catalog, write_dynamic_frame_from_catalog
• options: Use with getSource, getSink

For notes and restrictions about Streaming ETL jobs, consult the section called “Streaming ETL notes and restrictions”.

Configure Kinesis

To connect to a Kinesis data stream in an AWS Glue Spark job, you will need some prerequisites:

• If reading, the AWS Glue job must have Read access level IAM permissions to the Kinesis data stream.
• If writing, the AWS Glue job must have Write access level IAM permissions to the Kinesis data stream.

In certain cases, you will need to configure additional prerequisites:

• If your AWS Glue job is configured with Additional network connections (typically to connect to other datasets) and one of those connections provides Amazon VPC Network options, this will direct your job to communicate over Amazon VPC. In this case you will also need to configure your Kinesis data stream to communicate over Amazon VPC. You can do this by creating an interface VPC endpoint between your Amazon VPC and Kinesis data stream. For more information, see Using Kinesis Data Streams with Interface VPC Endpoints.

• When specifying Amazon Kinesis Data Streams in another account, you must setup the roles and policies to allow cross-account access. For more information, see Example: Read From a Kinesis Stream in a Different Account.

For more information about Streaming ETL job prerequisites, consult the section called “Streaming ETL jobs”.

Features and optimizations
Example: Reading from Kinesis streams

Used in conjunction with the section called “forEachBatch”.

Example for Amazon Kinesis streaming source:

```python
kinesis_options =
      "startingPosition": "TRIM_HORIZON",
      "inferSchema": "true",
      "classification": "json"
    }
data_frame_datasource0 =
    glueContext.create_data_frame.from_options(connection_type="kinesis",
                                                connection_options=kinesis_options)
```

Example: Writing to Kinesis streams

Used in conjunction with the section called “forEachBatch”. Your DynamicFrame will be written to the stream in a JSON format. If the job cannot write after several retries, it will fail. By default, each DynamicFrame record will be sent to the Kinesis stream individually. You can configure this behavior using aggregationEnabled and associated parameters.

Example writing to Amazon Kinesis from a streaming job:

Python

```python
glueContext.write_dynamic_frame.from_options(  
    frame=frameToWrite
    connection_type="kinesis",
    connection_options={  
        "partitionKey": "part1",
        "streamARN": "arn:aws:kinesis:us-east-1:111122223333:stream/streamName",
    }
)
```

Scala

```scala
glueContext.getSinkWithFormat(  
    connectionType="kinesis",
    options=JsonOptions("""
        "streamARN": "arn:aws:kinesis:us-east-1:111122223333:stream/streamName",
    
```
Kinesis connection option reference

Designates connection options for Amazon Kinesis Data Streams.

Use the following connection options for Kinesis streaming data sources:

- **"streamARN"** (Required) Used for Read/Write. The ARN of the Kinesis data stream.
- **"classification"** (Required for read) Used for Read. The file format used by the data in the record. Required unless provided through the Data Catalog.
- **"streamName"** – (Optional) Used for Read. The name of a Kinesis data stream to read from. Used with endpointUrl.
- **"endpointUrl"** – (Optional) Used for Read. Default: "https://kinesis.us-east-1.amazonaws.com". The AWS endpoint of the Kinesis stream. You do not need to change this unless you are connecting to a special region.
- **"partitionKey"** – (Optional) Used for Write. The Kinesis partition key used when producing records.
- **"delimiter"** (Optional) Used for Read. The value separator used when classification is CSV. Default is ",,.
- **"startingPosition"**: (Optional) Used for Read. The starting position in the Kinesis data stream to read data from. The possible values are "latest", "trim_horizon", "earliest", or a Timestamp string in UTC format in the pattern yyyy-mm-ddTHH:MM:SSZ (where Z represents a UTC timezone offset with a +/-). For example "2023-04-04T08:00:00-04:00". The default value is "latest". Note: the Timestamp string in UTC Format for "startingPosition" is supported only for AWS Glue version 4.0 or later.
- **"failOnDataLoss"**: (Optional) Fail the job if any active shard is missing or expired. The default value is "false".
- **"awsSTSRoleARN"**: (Optional) Used for Read/Write. The Amazon Resource Name (ARN) of the role to assume using AWS Security Token Service (AWS STS). This role must have permissions for describe or read record operations for the Kinesis data stream. You must use this parameter when accessing a data stream in a different account. Used in conjunction with "awsSTSSessionName".
• "awsSTSSessionName": (Optional) Used for Read/Write. An identifier for the session assuming
the role using AWS STS. You must use this parameter when accessing a data stream in a different
account. Used in conjunction with "awsSTSRoleARN".

• "awsSTSEndpoint": (Optional) The AWS STS endpoint to use when connecting to Kinesis with
an assumed role. This allows using the regional AWS STS endpoint in a VPC, which is not possible
with the default global endpoint.

• "maxFetchTimeInMs": (Optional) Used for Read. The maximum time spent in the job executor
to fetch a record from the Kinesis data stream per shard, specified in milliseconds (ms). The
default value is 1000.

• "maxFetchRecordsPerShard": (Optional) Used for Read. The maximum number of records to
fetch per shard in the Kinesis data stream. The default value is 100000.

• "maxRecordPerRead": (Optional) Used for Read. The maximum number of records to fetch
from the Kinesis data stream in each getRecords operation. The default value is 10000.

• "addIdleTimeBetweenReads": (Optional) Used for Read. Adds a time delay between
two consecutive getRecords operations. The default value is "False". This option is only
configurable for Glue version 2.0 and above.

• "idleTimeBetweenReadsInMs": (Optional) Used for Read. The minimum time delay between
two consecutive getRecords operations, specified in ms. The default value is 1000. This option
is only configurable for Glue version 2.0 and above.

• "describeShardInterval": (Optional) Used for Read. The minimum time interval between
two ListShards API calls for your script to consider resharding. For more information, see
Strategies for Resharding in Amazon Kinesis Data Streams Developer Guide. The default value is
1s.

• "numRetries": (Optional) Used for Read. The maximum number of retries for Kinesis Data
Streams API requests. The default value is 3.

• "retryIntervalMs": (Optional) Used for Read. The cool-off time period (specified in ms)
before retrying the Kinesis Data Streams API call. The default value is 1000.

• "maxRetryIntervalMs": (Optional) Used for Read. The maximum cool-off time period
(specified in ms) between two retries of a Kinesis Data Streams API call. The default value is
10000.

• "avoidEmptyBatches": (Optional) Used for Read. Avoids creating an empty microbatch job by
checking for unread data in the Kinesis data stream before the batch is started. The default value
is "False".
• "schema": (Required when inferSchema set to false) Used for Read. The schema to use to process the payload. If classification is avro the provided schema must be in the Avro schema format. If the classification is not avro the provided schema must be in the DDL schema format.

The following are schema examples.

Example in DDL schema format

`column1` INT, `column2` STRING , `column3` FLOAT

Example in Avro schema format

```json
{
   "type":"array",
   "items":
   {
      "type":"record",
      "name":"test",
      "fields":
      [
      {
         "name":"_id",
         "type":"string"
      },
      {
         "name":"index",
         "type":
         [
            "int",
            "string",
            "float"
         ]
      }
      ]
   }
}
```

• "inferSchema": (Optional) Used for Read. The default value is 'false'. If set to 'true', the schema will be detected at runtime from the payload within foreachbatch.

• "avroSchema": (Deprecated) Used for Read. Parameter used to specify a schema of Avro data when Avro format is used. This parameter is now deprecated. Use the schema parameter.
- "addRecordTimestamp": (Optional) Used for Read. When this option is set to 'true', the data output will contain an additional column named "__src_timestamp" that indicates the time when the corresponding record received by the stream. The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

- "emitConsumerLagMetrics": (Optional) Used for Read. When the option is set to 'true', for each batch, it will emit the metrics for the duration between the oldest record received by the stream and the time it arrives in AWS Glue to CloudWatch. The metric's name is "glue.driver.streaming.maxConsumerLagInMs". The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

- "fanoutConsumerARN": (Optional) Used for Read. The ARN of a Kinesis stream consumer for the stream specified in streamARN. Used to enable enhanced fan-out mode for your Kinesis connection. For more information on consuming a Kinesis stream with enhanced fan-out, see the section called “Using enhanced fan-out in Kinesis streaming jobs”.

- "recordMaxBufferedTime" – (Optional) Used for Write. Default: 1000 (ms). Maximum time a record is buffered while waiting to be written.

- "aggregationEnabled" – (Optional) Used for Write. Default: true. Specifies if records should be aggregated before sending them to Kinesis.

- "aggregationMaxSize" – (Optional) Used for Write. Default: 51200 (bytes). If a record is larger than this limit, it will bypass the aggregator. Note Kinesis enforces a limit of 50KB on record size. If you set this beyond 50KB, oversize records will be rejected by Kinesis.

- "aggregationMaxCount" – (Optional) Used for Write. Default: 4294967295. Maximum number of items to pack into an aggregated record.

- "producerRateLimit" – (Optional) Used for Write. Default: 150 (%). Limits per-shard throughput sent from a single producer (such as your job), as a percentage of the backend limit.

- "collectionMaxCount" – (Optional) Used for Write. Default: 500. Maximum number of items to pack into an PutRecords request.

- "collectionMaxSize" – (Optional) Used for Write. Default: 5242880 (bytes). Maximum amount of data to send with a PutRecords request.

**Using enhanced fan-out in Kinesis streaming jobs**

An enhanced fan-out consumer is able to receive records from a Kinesis stream with dedicated throughput that can be greater than typical consumers. This is done by optimizing the transfer protocol used to provide data to a Kinesis consumer, such as your job. For more information about Kinesis Enhanced Fan-Out, see the Kinesis documentation.
In enhanced fan-out mode, the maxRecordPerRead and idleTimeBetweenReadsInMs connection options no longer apply, as those parameters are not configurable when using enhanced fan-out. The configuration options for retries perform as described.

Use the following procedures to enable and disable enhanced fan-out for your streaming job. You should register a stream consumer for each job that will consume data from your stream.

**To enable enhanced fan-out consumption on your job:**

1. Register a stream consumer for your job using the Kinesis API. Follow the instructions to register a consumer with enhanced fan-out using the Kinesis Data Streams API in the Kinesis documentation. You will only need to follow the first step - calling `RegisterStreamConsumer`. Your request should return an ARN, `consumerARN`.
2. Set the connection option `fanoutConsumerARN` to `consumerARN` in your connection method arguments.
3. Restart your job.

**To disable enhanced fan-out consumption on your job:**

1. Remove the `fanoutConsumerARN` connection option from your method call.
2. Restart your job.
3. Follow the instructions to deregister a consumer in the Kinesis documentation. These instructions apply to the console, but can also be achieved through the Kinesis API. For more information about stream consumer deregistration through the Kinesis API, consult `DeregisterStreamConsumer` in the Kinesis documentation.

**Amazon S3 connections**

You can use AWS Glue for Spark to read and write files in Amazon S3. AWS Glue for Spark supports many common data formats stored in Amazon S3 out of the box, including CSV, Avro, JSON, Orc and Parquet. For more information about supported data formats, see the section called “Data format options”. Each data format may support a different set of AWS Glue features. Consult the page for your data format for the specifics of feature support. Additionally, you can read and write versioned files stored in the Hudi, Iceberg and Delta Lake data lake frameworks. For more information about data lake frameworks, see the section called “Data lake frameworks”.
With AWS Glue you can partition your Amazon S3 objects into a folder structure while writing, then retrieve it by partition to improve performance using simple configuration. You can also set configuration to group small files together when transforming your data to improve performance. You can read and write bzip2 and gzip archives in Amazon S3.

Topics

- Configuring S3 connections
- Amazon S3 connection option reference
- Deprecated connection syntaxes for data formats
- Excluding Amazon S3 storage classes
- Managing partitions for ETL output in AWS Glue
- Reading input files in larger groups
- Amazon VPC endpoints for Amazon S3

Configuring S3 connections

To connect to Amazon S3 in a AWS Glue with Spark job, you will need some prerequisites:

- The AWS Glue job must have IAM permissions for relevant Amazon S3 buckets.

In certain cases, you will need to configure additional prerequisites:

- When configuring cross-account access, appropriate access controls on the Amazon S3 bucket.
- For security reasons, you may choose to route your Amazon S3 requests through an Amazon VPC. This approach can introduce bandwidth and availability challenges. For more information, see the section called “Amazon VPC endpoints for Amazon S3”.

Amazon S3 connection option reference

Designates a connection to Amazon S3.

Since Amazon S3 manages files rather than tables, in addition to specifying the connection properties provided in this document, you will need to specify additional configuration about your file type. You specify this information through data format options. For more information about format options, see the section called “Data format options”. You can also specify this information by integrating with the AWS Glue Data Catalog.
For an example of the distinction between connection options and format options, consider how the section called “create_dynamic_frame_from_options” method takes connection_type, connection_options, format and format_options. This section specifically discusses parameters provided to connection_options.

Use the following connection options with "connectionType": "s3":

- "paths": (Required) A list of the Amazon S3 paths to read from.
- "exclusions": (Optional) A string containing a JSON list of Unix-style glob patterns to exclude. For example, "["**.pdf"]" excludes all PDF files. For more information about the glob syntax that AWS Glue supports, see Include and Exclude Patterns.
- "compressionType": or "compression": (Optional) Specifies how the data is compressed. Use "compressionType" for Amazon S3 sources and "compression" for Amazon S3 targets. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip2"). Additional compression formats may be supported for specific formats. For the specifics of feature support, consult the data format page.
- "groupFiles": (Optional) Grouping files is turned on by default when the input contains more than 50,000 files. To turn on grouping with fewer than 50,000 files, set this parameter to "inPartition". To disable grouping when there are more than 50,000 files, set this parameter to "none".
- "groupName": (Optional) The target group size in bytes. The default is computed based on the input data size and the size of your cluster. When there are fewer than 50,000 input files, "groupFiles" must be set to "inPartition" for this to take effect.
- "recurse": (Optional) If set to true, recursively reads files in all subdirectories under the specified paths.
- "maxBand": (Optional, advanced) This option controls the duration in milliseconds after which the s3 listing is likely to be consistent. Files with modification timestamps falling within the last maxBand milliseconds are tracked specially when using JobBookmarks to account for Amazon S3 eventual consistency. Most users don’t need to set this option. The default is 900000 milliseconds, or 15 minutes.
- "maxFilesInBand": (Optional, advanced) This option specifies the maximum number of files to save from the last maxBand seconds. If this number is exceeded, extra files are skipped and only processed in the next job run. Most users don’t need to set this option.
• "isFailFast": (Optional) This option determines if an AWS Glue ETL job throws reader parsing exceptions. If set to true, jobs fail fast if four retries of the Spark task fail to parse the data correctly.

• "catalogPartitionPredicate": (Optional) Used for Read. The contents of a SQL WHERE clause. Used when reading from Data Catalog tables with a very large quantity of partitions. Retrieves matching partitions from Data Catalog indices. Used with push_down_predicate, an option on the the section called “create_dynamic_frame_from_catalog” method (and other similar methods). For more information, see the section called “Catalog partition predicates”.

• "partitionKeys": (Optional) Used for Write. An array of column label strings. AWS Glue will partition your data as specified by this configuration. For more information, see the section called “Writing partitions”.

• "excludeStorageClasses": (Optional) Used for Read. An array of strings specifying Amazon S3 storage classes. AWS Glue will exclude Amazon S3 objects based on this configuration. For more information, see the section called “Excluding Amazon S3 storage classes”.

Deprecated connection syntaxes for data formats

Certain data formats can be accessed using a specific connection type syntax. This syntax is deprecated. We recommend you specify your formats using the s3 connection type and the format options provided in the section called “Data format options” instead.

"connectionType": "Orc"

Designates a connection to files stored in Amazon S3 in the Apache Hive Optimized Row Columnar (ORC) file format.

Use the following connection options with "connectionType": "orc":

• paths: (Required) A list of the Amazon S3 paths to read from.

• (Other option name/value pairs): Any additional options, including formatting options, are passed directly to the SparkSQL DataSource.

"connectionType": "parquet"

Designates a connection to files stored in Amazon S3 in the Apache Parquet file format.

Use the following connection options with "connectionType": "parquet":


paths: (Required) A list of the Amazon S3 paths to read from.

(Other option name/value pairs): Any additional options, including formatting options, are passed directly to the SparkSQL DataSource.

Excluding Amazon S3 storage classes

If you're running AWS Glue ETL jobs that read files or partitions from Amazon Simple Storage Service (Amazon S3), you can exclude some Amazon S3 storage class types.

The following storage classes are available in Amazon S3:

- STANDARD — For general-purpose storage of frequently accessed data.
- INTELLIGENT_TIERING — For data with unknown or changing access patterns.
- STANDARD_IA and ONEZONE_IA — For long-lived, but less frequently accessed data.
- GLACIER, DEEP_ARCHIVE, and REDUCED_REDUNDANCY — For long-term archive and digital preservation.

For more information, see Amazon S3 Storage Classes in the Amazon S3 Developer Guide.

The examples in this section show how to exclude the GLACIER and DEEP_ARCHIVE storage classes. These classes allow you to list files, but they won't let you read the files unless they are restored. (For more information, see Restoring Archived Objects in the Amazon S3 Developer Guide.)

By using storage class exclusions, you can ensure that your AWS Glue jobs will work on tables that have partitions across these storage class tiers. Without exclusions, jobs that read data from these tiers fail with the following error: AmazonS3Exception: The operation is not valid for the object's storage class.

There are different ways that you can filter Amazon S3 storage classes in AWS Glue.

Topics

- Excluding Amazon S3 storage classes when creating a Dynamic Frame
- Excluding Amazon S3 storage classes on a Data Catalog table

Excluding Amazon S3 storage classes when creating a Dynamic Frame

To exclude Amazon S3 storage classes while creating a dynamic frame, use excludeStorageClasses in additionalOptions. AWS Glue automatically uses its own
Amazon S3 Lister implementation to list and exclude files corresponding to the specified storage classes.

The following Python and Scala examples show how to exclude the GLACIER and DEEP_ARCHIVE storage classes when creating a dynamic frame.

Python example:

```python
glueContext.create_dynamic_frame.from_catalog(
    database = "my_database",
    tableName = "my_table_name",
    redshift_tmp_dir = "",
    transformation_ctx = "my_transformation_context",
    additional_options = {
        "excludeStorageClasses" : ["GLACIER", "DEEP_ARCHIVE"]
    }
)
```

Scala example:

```scala
val * *df = glueContext.getCatalogSource(
    nameSpace, tableName, "", "my_transformation_context",
    additionalOptions = JsonOptions(
        Map("excludeStorageClasses" -> List("GLACIER", "DEEP_ARCHIVE"))
    )
).getDynamicFrame()
```

Excluding Amazon S3 storage classes on a Data Catalog table

You can specify storage class exclusions to be used by an AWS Glue ETL job as a table parameter in the AWS Glue Data Catalog. You can include this parameter in the CreateTable operation using the AWS Command Line Interface (AWS CLI) or programmatically using the API. For more information, see Table Structure and CreateTable.

You can also specify excluded storage classes on the AWS Glue console.

**To exclude Amazon S3 storage classes (console)**

2. In the navigation pane on the left, choose Tables.
3. Choose the table name in the list, and then choose **Edit table**.

4. In **Table properties**, add `excludeStorageClasses` as a key and `\"GLACIER\", \"DEEP_ARCHIVE\"` as a value.

5. Choose **Apply**.

**Managing partitions for ETL output in AWS Glue**

Partitioning is an important technique for organizing datasets so they can be queried efficiently. It organizes data in a hierarchical directory structure based on the distinct values of one or more columns.

For example, you might decide to partition your application logs in Amazon Simple Storage Service (Amazon S3) by date, broken down by year, month, and day. Files that correspond to a single day's worth of data are then placed under a prefix such as `s3://my_bucket/logs/year=2018/month=01/day=23/`. Systems like Amazon Athena, Amazon Redshift Spectrum, and now AWS Glue can use these partitions to filter data by partition value without having to read all the underlying data from Amazon S3.

Crawlers not only infer file types and schemas, they also automatically identify the partition structure of your dataset when they populate the AWS Glue Data Catalog. The resulting partition columns are available for querying in AWS Glue ETL jobs or query engines like Amazon Athena.

After you crawl a table, you can view the partitions that the crawler created. In the AWS Glue console, choose **Tables** in the left navigation pane. Choose the table created by the crawler, and then choose **View Partitions**.

For Apache Hive-style partitioned paths in `key=val` style, crawlers automatically populate the column name using the key name. Otherwise, it uses default names like `partition_0`, `partition_1`, and so on. You can change the default names on the console. To do so, navigate to the table. Check if indexes exist under the **Indexes** tab. If that's the case, you need to delete them to proceed (you can recreate them using the new column names afterwards). Then, choose **Edit Schema**, and modify the names of the partition columns there.

In your ETL scripts, you can then filter on the partition columns. Because the partition information is stored in the Data Catalog, use the `from_catalog` API calls to include the partition columns in the DynamicFrame. For example, use `create_dynamic_frame.from_catalog` instead of `create_dynamic_frame.from_options`.
Pre-filtering using pushdown predicates

In many cases, you can use a pushdown predicate to filter on partitions without having to list and read all the files in your dataset. Instead of reading the entire dataset and then filtering in a DynamicFrame, you can apply the filter directly on the partition metadata in the Data Catalog. Then you only list and read what you actually need into a DynamicFrame.

For example, in Python, you could write the following.

```python
glue_context.create_dynamic_frame.from_catalog(
    database = "my_S3_data_set",
    table_name = "catalog_data_table",
    push_down Predicate = my_partition Predicate)
```

This creates a DynamicFrame that loads only the partitions in the Data Catalog that satisfy the predicate expression. Depending on how small a subset of your data you are loading, this can save a great deal of processing time.

The predicate expression can be any Boolean expression supported by Spark SQL. Anything you could put in a WHERE clause in a Spark SQL query will work. For example, the predicate expression `pushDownPredicate = "(year=='2017' and month=='04')"` loads only the partitions in the Data Catalog that have both `year` equal to 2017 and `month` equal to 04. For more information, see the Apache Spark SQL documentation, and in particular, the Scala SQL functions reference.

Server-side filtering using catalog partition predicates

The `push_down Predicate` option is applied after listing all the partitions from the catalog and before listing files from Amazon S3 for those partitions. If you have a lot of partitions for a table, catalog partition listing can still incur additional time overhead. To address this overhead, you can use server-side partition pruning with the `catalogPartitionPredicate` option that uses partition indexes in the AWS Glue Data Catalog. This makes partition filtering much faster when you have millions of partitions in one table. You can use both `push_down Predicate` and `catalogPartitionPredicate` in `additional_options` together if your `catalogPartitionPredicate` requires predicate syntax that is not yet supported with the catalog partition indexes.

Python:

```python
dynamic_frame = glueContext.create_dynamic_frame.from_catalog(
```
database=dbname,
table_name=tablename,
transformation_ctx="datasource0",
push_down_predicate="day>=10 and customer_id like '10%'",
additional_options={"catalogPartitionPredicate":"year='2021' and month='06'"}
)

Scala:

```scala
val dynamicFrame = glueContext.getCatalogSource(
    database = dbname,
    tableName = tablename,
    transformationContext = "datasource0",
    pushDownPredicate="day>=10 and customer_id like '10%'",
    additionalOptions = JsonOptions("""{
        "catalogPartitionPredicate": "year='2021' and month='06'"
    }""
    ).getDynamicFrame()
```

Note
---

The `push_down_predicate` and `catalogPartitionPredicate` use different syntaxes. The former one uses Spark SQL standard syntax and the later one uses JSQL parser.

Writing partitions
---

By default, a DynamicFrame is not partitioned when it is written. All of the output files are written at the top level of the specified output path. Until recently, the only way to write a DynamicFrame into partitions was to convert it to a Spark SQL DataFrame before writing.

However, DynamicFrames now support native partitioning using a sequence of keys, using the `partitionKeys` option when you create a sink. For example, the following Python code writes out a dataset to Amazon S3 in the Parquet format, into directories partitioned by the type field. From there, you can process these partitions using other systems, such as Amazon Athena.

```python
glue_context.write_dynamic_frame.from_options(
    frame = projectedEvents,
    connection_type = "s3",
    connection_options = {
        "path": "$outpath", "partitionKeys": ["type"],
        format = "parquet"
)
Reading input files in larger groups

You can set properties of your tables to enable an AWS Glue ETL job to group files when they are read from an Amazon S3 data store. These properties enable each ETL task to read a group of input files into a single in-memory partition, this is especially useful when there is a large number of small files in your Amazon S3 data store. When you set certain properties, you instruct AWS Glue to group files within an Amazon S3 data partition and set the size of the groups to be read. You can also set these options when reading from an Amazon S3 data store with the create_dynamic_frame.from_options method.

To enable grouping files for a table, you set key-value pairs in the parameters field of your table structure. Use JSON notation to set a value for the parameter field of your table. For more information about editing the properties of a table, see Viewing and editing table details.

You can use this method to enable grouping for tables in the Data Catalog with Amazon S3 data stores.

groupFiles

Set groupFiles to inPartition to enable the grouping of files within an Amazon S3 data partition. AWS Glue automatically enables grouping if there are more than 50,000 input files, as in the following example.

```json
'groupFiles': 'inPartition'
```

groupSize

Set groupSize to the target size of groups in bytes. The groupSize property is optional, if not provided, AWS Glue calculates a size to use all the CPU cores in the cluster while still reducing the overall number of ETL tasks and in-memory partitions.

For example, the following sets the group size to 1 MB.

```json
'groupSize': '1048576'
```

Note that the groupsize should be set with the result of a calculation. For example 1024 * 1024 = 1048576.
**recurse**

Set `recurse` to `True` to recursively read files in all subdirectories when specifying paths as an array of paths. You do not need to set `recurse` if paths is an array of object keys in Amazon S3, or if the input format is parquet/orc, as in the following example.

```
'recurse':True
```

If you are reading from Amazon S3 directly using the `create_dynamic_frame.from_options` method, add these connection options. For example, the following attempts to group files into 1 MB groups.

```
df = glueContext.create_dynamic_frame.from_options("s3", {'paths': ['s3://s3path/'], 'recurse':True, 'groupFiles': 'inPartition', 'groupSize': '1048576'}, format="json")
```

**Note**

`groupFiles` is supported for DynamicFrames created from the following data formats: csv, ion, grokLog, json, and xml. This option is not supported for avro, parquet, and orc.

**Amazon VPC endpoints for Amazon S3**

For security reasons, many AWS customers run their applications within an Amazon Virtual Private Cloud environment (Amazon VPC). With Amazon VPC, you can launch Amazon EC2 instances into a virtual private cloud, which is logically isolated from other networks—including the public internet. With an Amazon VPC, you have control over its IP address range, subnets, routing tables, network gateways, and security settings.

**Note**

If you created your AWS account after 2013-12-04, you already have a default VPC in each AWS Region. You can immediately start using your default VPC without any additional configuration.

For more information, see [Your Default VPC and Subnets](#) in the Amazon VPC User Guide.
Many customers have legitimate privacy and security concerns about sending and receiving data across the public internet. Customers can address these concerns by using a virtual private network (VPN) to route all Amazon S3 network traffic through their own corporate network infrastructure. However, this approach can introduce bandwidth and availability challenges.

VPC endpoints for Amazon S3 can alleviate these challenges. A VPC endpoint for Amazon S3 enables AWS Glue to use private IP addresses to access Amazon S3 with no exposure to the public internet. AWS Glue does not require public IP addresses, and you don't need an internet gateway, a NAT device, or a virtual private gateway in your VPC. You use endpoint policies to control access to Amazon S3. Traffic between your VPC and the AWS service does not leave the Amazon network.

When you create a VPC endpoint for Amazon S3, any requests to an Amazon S3 endpoint within the Region (for example, s3.us-west-2.amazonaws.com) are routed to a private Amazon S3 endpoint within the Amazon network. You don’t need to modify your applications running on Amazon EC2 instances in your VPC—the endpoint name remains the same, but the route to Amazon S3 stays entirely within the Amazon network, and does not access the public internet.

For more information about VPC endpoints, see VPC Endpoints in the Amazon VPC User Guide.

The following diagram shows how AWS Glue can use a VPC endpoint to access Amazon S3.
To set up access for Amazon S3

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

2. In the left navigation pane, choose **Endpoints**.

3. Choose **Create Endpoint**, and follow the steps to create an Amazon S3 VPC endpoint of type **Gateway**.

Amazon DocumentDB connections

You can use AWS Glue for Spark to read from and write to tables in Amazon DocumentDB. You can connect to Amazon DocumentDB using credentials stored in AWS Secrets Manager through a AWS Glue connection.
For more information about Amazon DocumentDB, consult the Amazon DocumentDB documentation.

**Note**

Amazon DocumentDB elastic clusters are not currently supported when using the AWS Glue connector. For more information about elastic clusters, see Using Amazon DocumentDB elastic clusters.

## Reading and writing to Amazon DocumentDB collections

**Note**

When you create an ETL job that connects to Amazon DocumentDB, for the Connections job property, you must designate a connection object that specifies the virtual private cloud (VPC) in which Amazon DocumentDB is running. For the connection object, the connection type must be JDBC, and the JDBC URL must be mongo://<DocumentDB_host>:27017.

**Note**

These code samples were developed for AWS Glue 3.0. To migrate to AWS Glue 4.0, consult the section called “MongoDB”. The uri parameter has changed.

**Note**

When using Amazon DocumentDB, retryWrites must be set to false in certain situations, such as when the document written specifies _id. For more information, consult Functional Differences with MongoDB in the Amazon DocumentDB documentation.

The following Python script demonstrates using connection types and connection options for reading and writing to Amazon DocumentDB.

```python
import sys
```
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext, SparkConf
from awsglue.context import GlueContext
from awsglue.job import Job
import time

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

job = Job(glueContext)
job.init(args['JOB_NAME'], args)

output_path = "s3://some_bucket/output/" + str(time.time()) + "/

documentdb_uri = "mongodb://<mongo-instanced-ip-address>:27017"
documentdb_write_uri = "mongodb://<mongo-instanced-ip-address>:27017"

read_docdb_options = {
  "uri": documentdb_uri,
  "database": "test",
  "collection": "coll",
  "username": "username",
  "password": "1234567890",
  "ssl": "true",
  "ssl.domain_match": "false",
  "partitioner": "MongoSamplePartitioner",
  "partitionerOptions.partitionSizeMB": "10",
  "partitionerOptions.partitionKey": "_id"
}

write_documentdb_options = {
  "retryWrites": "false",
  "uri": documentdb_write_uri,
  "database": "test",
  "collection": "coll",
  "username": "username",
  "password": "pwd"
}

# Get DynamicFrame from DocumentDB
The following Scala script demonstrates using connection types and connection options for reading and writing to Amazon DocumentDB.

```scala
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamicFrame
import org.apache.spark.SparkContext
import scala.collection.JavaConverters_

object GlueApp {
  val DOC_URI: String = "mongodb://<mongo-instanced-ip-address>:27017"
  val DOC_WRITE_URI: String = "mongodb://<mongo-instanced-ip-address>:27017"
  lazy val documentDBJsonOption = jsonOptions(DOC_URI)
  lazy val writeDocumentDBJsonOption = jsonOptions(DOC_WRITE_URI)
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    // Get DynamicFrame from DocumentDB
    val resultFrame2: DynamicFrame = glueContext.getSource("documentdb",
    documentDBJsonOption).getDynamicFrame()

    // Write DynamicFrame to DocumentDB
    glueContext.getSink("documentdb", writeJsonOption).writeDynamicFrame(resultFrame2)
  }
}
```
Amazon DocumentDB connection option reference

Designates a connection to Amazon DocumentDB (with MongoDB compatibility).

Connection options differ for a source connection and a sink connection.

"connectionType": "Documentdb" as source

Use the following connection options with "connectionType": "documentdb" as a source:

- "uri": (Required) The Amazon DocumentDB host to read from, formatted as mongodb://<host>:<port>.
- "database": (Required) The Amazon DocumentDB database to read from.
- "collection": (Required) The Amazon DocumentDB collection to read from.
- "username": (Required) The Amazon DocumentDB user name.
- "password": (Required) The Amazon DocumentDB password.
- "ssl": (Required if using SSL) If your connection uses SSL, then you must include this option with the value "true".
- "ssl.domain_match": (Required if using SSL) If your connection uses SSL, then you must include this option with the value "false".
• "batchSize": (Optional): The number of documents to return per batch, used within the cursor of internal batches.

• "partitioner": (Optional): The class name of the partitioner for reading input data from Amazon DocumentDB. The connector provides the following partitioners:
  • MongoDefaultPartitioner (default) (Not supported in AWS Glue 4.0)
  • MongoSamplePartitioner (Not supported in AWS Glue 4.0)
  • MongoShardedPartitioner
  • MongoSplitVectorPartitioner
  • MongoPaginateByCountPartitioner
  • MongoPaginateBySizePartitioner (Not supported in AWS Glue 4.0)

• "partitionerOptions": (Optional): Options for the designated partitioner. The following options are supported for each partitioner:
  • MongoSamplePartitioner: partitionKey, partitionSizeMB, samplesPerPartition
  • MongoShardedPartitioner: shardkey
  • MongoSplitVectorPartitioner: partitionKey, partitionSizeMB
  • MongoPaginateByCountPartitioner: partitionKey, numberOfPartitions
  • MongoPaginateBySizePartitioner: partitionKey, partitionSizeMB

For more information about these options, see Partitioner Configuration in the MongoDB documentation.

"connectionType": "Documentdb" as sink

Use the following connection options with "connectionType": "documentdb" as a sink:

• "uri": (Required) The Amazon DocumentDB host to write to, formatted as mongodb://<host>;<port>.

• "database": (Required) The Amazon DocumentDB database to write to.

• "collection": (Required) The Amazon DocumentDB collection to write to.

• "username": (Required) The Amazon DocumentDB user name.

• "password": (Required) The Amazon DocumentDB password.

• "extendedBsonTypes": (Optional) If true, allows extended BSON types when writing data to Amazon DocumentDB. The default is true.
• "replaceDocument": (Optional) If true, replaces the whole document when saving datasets that contain an _id field. If false, only fields in the document that match the fields in the dataset are updated. The default is true.

• "maxBatchSize": (Optional): The maximum batch size for bulk operations when saving data. The default is 512.

• "retryWrites": (Optional): Automatically retry certain write operations a single time if AWS Glue encounters a network error.

OpenSearch Service connections

You can use AWS Glue for Spark to read from and write to tables in OpenSearch Service in AWS Glue 4.0 and later versions. You can define what to read from OpenSearch Service with an OpenSearch query. You connect to OpenSearch Service using HTTP basic authentication credentials stored in AWS Secrets Manager through a AWS Glue connection. This feature is not compatible with OpenSearch Service serverless.

For more information about Amazon OpenSearch Service, see the Amazon OpenSearch Service documentation.

Configuring OpenSearch Service connections

To connect to OpenSearch Service from AWS Glue, you will need to create and store your OpenSearch Service credentials in a AWS Secrets Manager secret, then associate that secret with a OpenSearch Service AWS Glue connection.

Prerequisites:

• Identify the domain endpoint, aosEndpoint and port, aosPort you would like to read from, or create the resource by following instructions in the Amazon OpenSearch Service documentation. For more information on creating a domain, see Creating and managing Amazon OpenSearch Service domains in the Amazon OpenSearch Service documentation.

An Amazon OpenSearch Service domain endpoint will have the following default form, https://search-domainName-unstructuredIdContent.region.es.amazonaws.com. For more information on identifying your domain endpoint, see Creating and managing Amazon OpenSearch Service domains in the Amazon OpenSearch Service documentation.

Identify or generate HTTP basic authentication credentials, aosUser and aosPassword for your domain.
To configure a connection to OpenSearch Service:

1. In AWS Secrets Manager, create a secret using your OpenSearch Service credentials. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.

   • When selecting Key/value pairs, create a pair for the key opensearch.net.http.auth.user with the value aosUser.

   • When selecting Key/value pairs, create a pair for the key opensearch.net.http.auth.user with the value aosPassword.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for future use in AWS Glue.

   • When selecting a Connection type, select OpenSearch Service.

   • When selecting a Domain endpoint, provide aosEndpoint.

   • When selecting a port, provide aosPort.

   • When selecting an AWS Secret, provide secretName.

After creating a AWS Glue OpenSearch Service connection, you will need to perform the following steps before running your AWS Glue job:

• Grant the IAM role associated with your AWS Glue job permission to read secretName.

• In your AWS Glue job configuration, provide connectionName as an Additional network connection.

Reading from OpenSearch Service indexes

Prerequisites:

• A OpenSearch Service index you would like to read from, aosIndex.

• A AWS Glue OpenSearch Service connection configured to provide auth and network location information. To acquire this, complete the steps in the previous procedure, To configure a connection to OpenSearch Service. You will need the name of the AWS Glue connection, connectionName.
This example reads an index from Amazon OpenSearch Service. You will need to provide the pushdown parameter.

For example:

```python
opensearch_read = glueContext.create_dynamic_frame.from_options(
    connection_type="opensearch",
    connection_options={
        "connectionName": "connectionName",
        "opensearch.resource": "aosIndex",
        "pushdown": "true",
    }
)
```

You can also provide a query string to filter the results returned in your DynamicFrame. You will need to configure `opensearch.query`.

`opensearch.query` can take a URL query parameter string `queryString` or a query DSL JSON object `queryObject`. For more information about the query DSL, see [Query DSL](#) in the OpenSearch documentation. To provide a URL query parameter string, prepend `?q=` to your query, as you would in a fully qualified URL. To provide a query DSL object, string escape the JSON object before providing it.

For example:

```python
queryObject = "{ "query": { "multi_match": { "query": "Sample", "fields": [ "sample" ] } } }"
queryString = "?q=queryString"

opensearch_read_query = glueContext.create_dynamic_frame.from_options(
    connection_type="opensearch",
    connection_options={
        "connectionName": "connectionName",
        "opensearch.resource": "aosIndex",
        "opensearch.query": queryString,
        "pushdown": "true",
    }
)
```

For more information about how to build a query outside of its specific syntax, see [Query string syntax](#) in the OpenSearch documentation.
When reading from OpenSearch collections that contain array type data, you must specify which fields are array type in your method call using the `opensearch.read.field.as.array.include` parameter.

For example, when reading the following document, you will encounter the `genre` and `actor` array fields:

```json
{
    "_index": "movies",
    "_id": "2",
    "_version": 1,
    "_seq_no": 0,
    "_primary_term": 1,
    "found": true,
    "_source": {
        "director": "Frankenheimer, John",
        "genre": [
            "Drama",
            "Mystery",
            "Thriller",
            "Crime"
        ],
        "year": 1962,
        "actor": [
            "Lansbury, Angela",
            "Sinatra, Frank",
            "Leigh, Janet",
            "Harvey, Laurence",
            "Silva, Henry",
            "Frees, Paul",
            "Gregory, James",
            "Bissell, Whit",
            "McGiver, John",
            "Parrish, Leslie",
            "Edwards, James",
            "Flowers, Bess",
            "Dhiegh, Khigh",
            "Payne, Julie",
            "Kleeb, Helen",
            "Gray, Joe",
            "Nalder, Reggie",
            "Stevens, Bert",
            "Masters, Michael"
        ]
    }
}
```
In this case, you would include those field names in your method call. For example:

"opensearch.read.field.as.array.include": "genre,actor"

If your array field is nested inside of your document structure, refer to it using dot notation: "genre,actor,foo.bar.baz". This would specify an array baz included in your source document through the embedded document foo containing the embedded document bar.

**Writing to OpenSearch Service tables**

This example writes information from an existing DynamicFrame, `dynamicFrame` to OpenSearch Service. If the index already has information, AWS Glue will append data from your DynamicFrame. You will need to provide the `pushdown` parameter.

**Prerequisites:**

- A OpenSearch Service table you would like to write to. You will need identification information for the table. Let's call this `tableName`.
- A AWS Glue OpenSearch Service connection configured to provide auth and network location information. To acquire this, complete the steps in the previous procedure, *To configure a connection to OpenSearch Service*. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="opensearch",
    connection_options={
        "connectionName": "connectionName",
        "opensearch.resource": "aosIndex",
    },
)
```
OpenSearch Service connection option reference

- **connectionName** — Required. Used for Read/Write. The name of a AWS Glue OpenSearch Service connection configured to provide auth and network location information to your connection method.

- **opensearch.resource** — Required. Used for Read/Write. Valid Values: OpenSearch index names. The name of the index your connection method will interact with.

- **opensearch.query** — Used for Read. Valid Values: String escaped JSON or, when this string begins with `?`, the search part of a URL. An OpenSearch query that filters what should be retrieved when reading. For more information on using this parameter, consult the previous section the section called “Read from OpenSearch Service”.

- **pushdown** — Required if. Used for Read. Valid Values: boolean. Instructs Spark to pass read queries down to OpenSearch so the database only returns relevant documents.

- **opensearch.read.field.as.array.include** — Required if reading array type data. Used for Read. Valid Values: comma separated lists of field names. Specifies fields to read as arrays from OpenSearch documents. For more information on using this parameter, consult the previous section the section called “Read from OpenSearch Service”.

Redshift connections

You can use AWS Glue for Spark to read from and write to tables in Amazon Redshift databases. When connecting to Amazon Redshift databases, AWS Glue moves data through Amazon S3 to achieve maximum throughput, using the Amazon Redshift SQL COPY and UNLOAD commands. In AWS Glue 4.0 and later, you can use the Amazon Redshift integration for Apache Spark to read and write with optimizations and features specific to Amazon Redshift beyond those available when connecting through previous versions.

Learn about how AWS Glue is making it easier than ever for Amazon Redshift users to migrate to AWS Glue for serverless data integration and ETL.

Configuring Redshift connections

To use Amazon Redshift clusters in AWS Glue, you will need some prerequisites:

- An Amazon S3 directory to use for temporary storage when reading from and writing to the database.
- An Amazon VPC enabling communication between your Amazon Redshift cluster, your AWS Glue job and your Amazon S3 directory.
• Appropriate IAM permissions on the AWS Glue job and Amazon Redshift cluster.

Configuring IAM roles

Set up the role for the Amazon Redshift cluster

Your Amazon Redshift cluster needs to be able to read and write to Amazon S3 in order to integrate with AWS Glue jobs. To allow this, you can associate IAM roles with the Amazon Redshift cluster you want to connect to. Your role should have a policy allowing read from and write to your Amazon S3 temporary directory. Your role should have a trust relationship allowing the redshift.amazonaws.com service to AssumeRole.

To associate an IAM role with Amazon Redshift

1. Prerequisites: An Amazon S3 bucket or directory used for the temporary storage of files.
2. Identify which Amazon S3 permissions your Amazon Redshift cluster will need. When moving data to and from an Amazon Redshift cluster, AWS Glue jobs issue COPY and UNLOAD statements against Amazon Redshift. If your job modifies a table in Amazon Redshift, AWS Glue will also issue CREATE LIBRARY statements. For information on specific Amazon S3 permissions required for Amazon Redshift to execute these statements, refer to the Amazon Redshift documentation: Amazon Redshift: Permissions to access other AWS Resources.
3. In the IAM console, create an IAM policy with the necessary permissions. For more information about creating a policy Creating IAM policies.
4. In the IAM console, create a role and trust relationship allowing Amazon Redshift to assume the role. Follow the instructions in the IAM documentation To create a role for an AWS service (console)

   • When asked to choose an AWS service use case, choose "Redshift - Customizable".
   • When asked to attach a policy, choose the policy you previously defined.

Note

For more information about configuring roles for Amazon Redshift, see Authorizing Amazon Redshift to access other AWS services on your behalf in the Amazon Redshift documentation.
5. In the Amazon Redshift console, associate the role with your Amazon Redshift cluster. Follow the instructions in the Amazon Redshift documentation.

Select the highlighted option in the Amazon Redshift console to configure this setting:

![Amazon Redshift console screenshot]

**Note**

By default, AWS Glue jobs pass Amazon Redshift temporary credentials that are created using the role that you specified to run the job. We do not recommend using these credentials. For security purposes, these credentials expire after 1 hour.

**Set up the role for the AWS Glue job**

The AWS Glue job needs a role to access the Amazon S3 bucket. You do not need IAM permissions for the Amazon Redshift cluster, your access is controlled by connectivity in Amazon VPC and your database credentials.
**Set up Amazon VPC**

### To set up access for Amazon Redshift data stores

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. In the left navigation pane, choose **Clusters**.

3. Choose the cluster name that you want to access from AWS Glue.

4. In the **Cluster Properties** section, choose a security group in **VPC security groups** to allow AWS Glue to use. Record the name of the security group that you chose for future reference. Choosing the security group opens the Amazon EC2 console **Security Groups** list.

5. Choose the security group to modify and navigate to the **Inbound** tab.

6. Add a self-referencing rule to allow AWS Glue components to communicate. Specifically, add or confirm that there is a rule of **Type** All TCP, **Protocol** is TCP, **Port Range** includes all ports, and whose **Source** is the same security group name as the **Group ID**.

   The inbound rule looks similar to the following:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>database-security-group</td>
</tr>
</tbody>
</table>

   For example:

   ![Inbound Rules](image)

7. Add a rule for outbound traffic also. Either open outbound traffic to all ports, for example:
Or create a self-referencing rule where Type All, Protocol is TCP, Port Range includes all ports, and whose Destination is the same security group name as the Group ID. If using an Amazon S3 VPC endpoint, also add an HTTPS rule for Amazon S3 access. The `s3-prefix-list-id` is required in the security group rule to allow traffic from the VPC to the Amazon S3 VPC endpoint.

For example:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>security-group</td>
</tr>
<tr>
<td>HTTPS</td>
<td>TCP</td>
<td>443</td>
<td>s3-prefix-list-id</td>
</tr>
</tbody>
</table>

Set up AWS Glue

You will need to create an AWS Glue Data Catalog connection that provides Amazon VPC connection information.

To configure Amazon Redshift Amazon VPC connectivity to AWS Glue in the console

1. Create a Data Catalog connection by following the steps in: the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select **Amazon Redshift**.
   - When selecting a **Redshift cluster**, select your cluster by name.
   - Provide default connection information for a Amazon Redshift user on your cluster.
   - Your Amazon VPC settings will be automatically configured.
© Note
You will need to manually provide PhysicalConnectionRequirements for your Amazon VPC when creating an Amazon Redshift connection through the AWS SDK.

2. In your AWS Glue job configuration, provide connectionName as an Additional network connection.

Example: Reading from Amazon Redshift tables

You can read from Amazon Redshift clusters and Amazon Redshift serverless environments.

Prerequisites: An Amazon Redshift table you would like to read from. Follow the steps in the previous section the section called “Configure Redshift” after which you should have the Amazon S3 URI for a temporary directory, temp-s3-dir and an IAM role, rs-role-name, (in account role-account-id).

Using the Data Catalog

Additional Prerequisites: A Data Catalog Database and Table for the Amazon Redshift table you would like to read from. For more information about Data Catalog, see Data Catalog and crawlers. After creating a entry for your Amazon Redshift table you will identify your connection with a redshift-dc-database-name and redshift-table-name.

Configuration: In your function options you will identify your Data Catalog Table with the database and table_name parameters. You will identify your Amazon S3 temporary directory with redshift_tmp_dir. You will also provide rs-role-name using the aws_iam_role key in the additional_options parameter.

```python
glueContext.create_dynamic_frame.from_catalog(
    database = "redshift-dc-database-name",
    table_name = "redshift-table-name",
    redshift_tmp_dir = args["temp-s3-dir"],
    additional_options = {
        "aws_iam_role": "arn:aws:iam::role-account-id:role/rs-role-name"}
)```
Connecting directly

**Additional Prerequisites:** You will need the name of your Amazon Redshift table (*redshift-table-name*). You will need the JDBC connection information for the Amazon Redshift cluster storing that table. You will supply your connection information with *host*, *port*, *redshift-database-name*, *username* and *password*.

You can retrieve your connection information from the Amazon Redshift console when working with Amazon Redshift clusters. When using Amazon Redshift serverless, consult [Connecting to Amazon Redshift Serverless](#) in the Amazon Redshift documentation.

**Configuration:** In your function options you will identify your connection parameters with *url*, *dbtable*, *user* and *password*. You will identify your Amazon S3 temporary directory with *redshift_tmp_dir*. You can specify your IAM role using *aws_iam_role* when you use `from_options`. The syntax is similar to connecting through the Data Catalog, but you put the parameters in the `connection_options` map.

It is bad practice to hardcode passwords into AWS Glue scripts. Consider storing your passwords in AWS Secrets Manager and retrieving them in your script with SDK for Python (Boto3).

```python
my_conn_options = {
    "url": "jdbc:redshift://host:port/redshift-database-name",
    "dbtable": "redshift-table-name",
    "user": "username",
    "password": "password",
    "redshiftTmpDir": args["temp-s3-dir"],
    "aws_iam_role": "arn:aws:iam::account id:role/rs-role-name"
}

df = glueContext.create_dynamic_frame.from_options("redshift", my_conn_options)
```

**Example: Writing to Amazon Redshift tables**

You can write to Amazon Redshift clusters and Amazon Redshift serverless environments.

**Prerequisites:** An Amazon Redshift cluster and follow the steps in the previous section [the section called “Configure Redshift”](#) after which you should have the Amazon S3 URI for a temporary
directory, \textit{temp-s3-dir} and an IAM role, \textit{rs-role-name}, (in account \textit{role-account-id}). You will also need a DynamicFrame whose contents you would like to write to the database.

Using the Data Catalog

\textbf{Additional Prerequisites} A Data Catalog Database for the Amazon Redshift cluster and table you would like to write to. For more information about Data Catalog, see \textit{Data Catalog and crawlers}. You will identify your connection with \textit{redshift-dc-database-name} and the target table with \textit{redshift-table-name}.

\textbf{Configuration:} In your function options you will identify your Data Catalog Database with the database parameter, then provide table with table_name. You will identify your Amazon S3 temporary directory with \textit{redshift_tmp_dir}. You will also provide \textit{rs-role-name} using the \textit{aws_iam_role} key in the additional_options parameter.

\begin{verbatim}
  glueContext.write_dynamic_frame.from_catalog(
    frame = input dynamic frame,
    database = "redshift-dc-database-name",
    table_name = "redshift-table-name",
    redshift_tmp_dir = args["temp-s3-dir"],
    additional_options = {"aws_iam_role": "arn:aws:iam::account-id:role/rs-role-name"})
\end{verbatim}

Connecting through a AWS Glue connection

You can connect to Amazon Redshift directly using the \texttt{write_dynamic_frame.from_options} method. However, rather than insert your connection details directly into your script, you can reference connection details stored in a Data Catalog connection with the \texttt{from_jdbc_conf} method. You can do this without crawling or creating Data Catalog tables for your database. For more information about Data Catalog connections, see \textit{Connecting to data}.

\textbf{Additional Prerequisites:} A Data Catalog connection for your database, a Amazon Redshift table you would like to read from

\textbf{Configuration:} you will identify your Data Catalog connection with \textit{dc-connection-name}. You will identify your Amazon Redshift database and table with \textit{redshift-table-name} and \textit{redshift-database-name}. You will provide your Data Catalog connection information with
catalog_connection and your Amazon Redshift information with dbtable and database. The syntax is similar to connecting through the Data Catalog, but you put the parameters in the connection_options map.

```python
my_conn_options = {
    "dbtable": "redshift-table-name",
    "database": "redshift-database-name",
    "aws_iam_role": "arn:aws:iam::role-account-id:role/rs-role-name"
}

glueContext.write_dynamic_frame.from_jdbc_conf(
    frame = input dynamic frame,
    catalog_connection = "dc-connection-name",
    connection_options = my_conn_options,
    redshift_tmp_dir = args["temp-s3-dir"]
)
```

**Amazon Redshift connection option reference**

The basic connection options used for all AWS Glue JDBC connections to set up information like url, user and password are consistent across all JDBC types. For more information about standard JDBC parameters, see the section called "JDBC connection parameters".

The Amazon Redshift connection type takes some additional connection options:

- "redshiftTmpDir": (Required) The Amazon S3 path where temporary data can be staged when copying out of the database.
- "aws_iam_role": (Optional) ARN for an IAM role. The AWS Glue job will pass this role to the Amazon Redshift cluster to grant the cluster permissions needed to complete instructions from the job.

**Additional connection options available in AWS Glue 4.0+**

You can also pass options for the new Amazon Redshift connector through AWS Glue connection options. For a complete list of supported connector options, see the Spark SQL parameters section in Amazon Redshift integration for Apache Spark.

For your convenience, we reiterate certain new options here:
<table>
<thead>
<tr>
<th>Name</th>
<th>Required</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>autopushdown</td>
<td>No</td>
<td>TRUE</td>
<td>Applies predicate and query pushdown by capturing and analyzing the Spark logical plans for SQL operations. The operations are translated into a SQL query, and then run in Amazon Redshift to improve performance.</td>
</tr>
<tr>
<td>autopushdown.s3_result_cache</td>
<td>No</td>
<td>FALSE</td>
<td>Caches the SQL query to unload data for Amazon S3 path mapping in memory so that the same query doesn't need to run again in the same Spark session. Only supported when autopushdown is enabled.</td>
</tr>
<tr>
<td>unload_s3_format</td>
<td>No</td>
<td>PARQUET</td>
<td>PARQUET - Unloads the query results in Parquet format. TEXT - Unloads the query results in pipe-delimited text format.</td>
</tr>
</tbody>
</table>
### Required Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Required</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sse_kms_key</td>
<td>No</td>
<td>N/A</td>
<td>The AWS SSE-KMS key to use for encryption during UNLOAD operations instead of the default encryption for AWS.</td>
</tr>
<tr>
<td>extracopyoptions</td>
<td>No</td>
<td>N/A</td>
<td>A list of extra options to append to the Amazon Redshift COPY command when loading data, such as TRUNCATECOLUMNS or MAXERROR n (for other options see <a href="#">COPY: Optional parameters</a>). Note that because these options are appended to the end of the COPY command, only options that make sense at the end of the command can be used. That should cover most possible use cases.</td>
</tr>
<tr>
<td>Name</td>
<td>Required</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>csvnullstring (experimental)</td>
<td>No</td>
<td>NULL</td>
<td>The String value to write for nulls when using the CSV tempformat. This should be a value that doesn't appear in your actual data.</td>
</tr>
</tbody>
</table>

These new parameters can be used in the following ways.

**New options for performance improvement**

The new connector introduces some new performance improvement options:

- autopushdown: Enabled by default.
- autopushdown.s3_result_cache: Disabled by default.
- unload_s3_format: PARQUET by default.

For information about using these options, see [Amazon Redshift integration for Apache Spark](#). We recommend that you don’t turn on autopushdown.s3_result_cache when you have mixed read and write operations because the cached results might contain stale information. The option unload_s3_format is set to PARQUET by default for the UNLOAD command, to improve performance and reduce storage cost. To use the UNLOAD command default behavior, reset the option to TEXT.

**New encryption option for reading**

By default, the data in the temporary folder that AWS Glue uses when it reads data from the Amazon Redshift table is encrypted using SSE-S3 encryption. To use customer managed keys from AWS Key Management Service (AWS KMS) to encrypt your data, you can set up "sse_kms_key" # kmsKey) where kmsKey is the key ID from AWS KMS, instead of the legacy setting option ("extraunloadoptions" # s"ENCRYPTED KMS_KEY_ID '$kmsKey'"), in AWS Glue version 3.0.

```python
datasource0 = glueContext.create_dynamic_frame.from_catalog(
```
database = "database-name",
table_name = "table-name",
redshift_tmp_dir = args["TempDir"],
additional_options = {"sse_kms_key":"<KMS_KEY_ID>"},
transformation_ctx = "datasource0"
)

Support IAM-based JDBC URL

The new connector supports an IAM-based JDBC URL so you don't need to pass in a user/password or secret. With an IAM-based JDBC URL, the connector uses the job runtime role to access to the Amazon Redshift data source.

Step 1: Attach the following minimal required policy to your AWS Glue job runtime role.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "VisualEditor0",
         "Effect": "Allow",
         "Action": "redshift:GetClusterCredentials",
         "Resource": [
            "arn:aws:redshift:<region>:<account>:dbgroup:<cluster name>/*",
            "arn:aws:redshift:*:<account>:dbuser:*/*",
            "arn:aws:redshift:<region>:<account>:dbname:<cluster name>/<database name>"
         ]
      },
      {
         "Sid": "VisualEditor1",
         "Effect": "Allow",
         "Action": "redshift:DescribeClusters",
         "Resource": "*"
      }
   ]
}
```

Step 2: Use the IAM-based JDBC URL as follows. Specify a new option DbUser with the Amazon Redshift user name that you're connecting with.

```
conn_options = {
                   // IAM-based JDBC URL
```
"url": "jdbc:redshift:iam://<cluster name>:<region>/<database name>",
"dbtable": dbtable,
"redshiftTmpDir": redshiftTmpDir,
"aws_iam_role": aws_iam_role,
"DbUser": "<Redshift User name>" // required for IAM-based JDBC URL
}

redshift_write = glueContext.write_dynamic_frame.from_options(
    frame=dyf,
    connection_type="redshift",
    connection_options=conn_options
)

redshift_read = glueContext.create_dynamic_frame.from_options(
    connection_type="redshift",
    connection_options=conn_options
)

---

**Note**

A DataFrame currently only supports an IAM-based JDBC URL with a **DbUser** in the GlueContext.create_dynamic_frame.from_options workflow.

---

**Migrating from AWS Glue version 3.0 to version 4.0**

In AWS Glue 4.0, ETL jobs have access to a new Amazon Redshift Spark connector and a new JDBC driver with different options and configuration. The new Amazon Redshift connector and driver are written with performance in mind, and keep transactional consistency of your data. These products are documented in the Amazon Redshift documentation. For more information, see:

- [Amazon Redshift integration for Apache Spark](#)
- [Amazon Redshift JDBC driver, version 2.1](#)

**Table/column names and identifiers restriction**

The new Amazon Redshift Spark connector and driver have a more restricted requirement for the Redshift table name. For more information, see [Names and identifiers](#) to define your Amazon Redshift table name. The job bookmark workflow might not work with a table name that doesn't match the rules and with certain characters, such as a space.
If you have legacy tables with names that don't conform to the Names and identifiers rules and see issues with bookmarks (jobs reprocessing old Amazon Redshift table data), we recommend that you rename your table names. For more information, see ALTER TABLE examples.

**Default tempformat change in Dataframe**

The AWS Glue version 3.0 Spark connector defaults the tempformat to CSV while writing to Amazon Redshift. To be consistent, in AWS Glue version 3.0, the DynamicFrame still defaults the tempformat to use CSV. If you've previously used Spark Dataframe APIs directly with the Amazon Redshift Spark connector, you can explicitly set the tempformat to CSV in the DataframeReader/Writer options. Otherwise, tempformat defaults to AVRO in the new Spark connector.

**Behavior change: map Amazon Redshift data type REAL to Spark data type FLOAT instead of DOUBLE**

In AWS Glue version 3.0, Amazon Redshift REAL is converted to a Spark DOUBLE type. The new Amazon Redshift Spark connector has updated the behavior so that the Amazon Redshift REAL type is converted to, and back from, the Spark FLOAT type. If you have a legacy use case where you still want the Amazon Redshift REAL type to be mapped to a Spark DOUBLE type, you can use the following workaround:

- For a DynamicFrame, map the Float type to a Double type with DynamicFrame.ApplyMapping. For a Dataframe, you need to use cast.

Code example:

```python
dyf_cast = dyf.apply_mapping([('a', 'long', 'a', 'long'), ('b', 'float', 'b', 'double')])
```

**Kafka connections**

Designates a connection to a Kafka cluster or an Amazon Managed Streaming for Apache Kafka cluster.

You can use the following methods under the GlueContext object to consume records from a Kafka streaming source:

- getCatalogSource
- getSource
If you use getCatalogSource, then the job has the Data Catalog database and table name information, and can use that to obtain some basic parameters for reading from the Apache Kafka stream. If you use getSource, getSourceWithFormat, or createDataFrameFromOptions you must explicitly specify these parameters:

You can specify these options using connectionOptions with getSource or createDataFrameFromOptions, options with getSourceWithFormat, or additionalOptions with getCatalogSource.

For notes and restrictions about streaming ETL jobs, consult the section called “Streaming ETL notes and restrictions”.

Configure Kafka

There are no AWS prerequisites to connecting to Kafka streams available through the internet.

You can create a AWS Glue Kafka connection to manage your connection credentials. For more information, see the section called “Creating a connection for a Kafka data stream”. In your AWS Glue job configuration, provide connectionName as an Additional network connection, then, in your method call, provide connectionName to the connectionName parameter.

In certain cases, you will need to configure additional prerequisites:

- If using Amazon Managed Streaming for Apache Kafka with IAM authentication, you will need appropriate IAM configuration.
- If using Amazon Managed Streaming for Apache Kafka within an Amazon VPC, you will need appropriate Amazon VPC configuration. You will need to create a AWS Glue connection that provides Amazon VPC connection information. You will need your job configuration to include the AWS Glue connection as an Additional network connection.

For more information about Streaming ETL job prerequisites, consult the section called “Streaming ETL jobs”.

Example: Reading from Kafka streams

Used in conjunction with the section called “forEachBatch”.

Features and optimizations
Example for Kafka streaming source:

```python
kafka_options = {
    "connectionName": "ConfluentKafka",
    "topicName": "kafka-auth-topic",
    "startingOffsets": "earliest",
    "inferSchema": "true",
    "classification": "json"
}
data_frame_datasource0 = glueContext.create_data_frame.from_options(connection_type="kafka",
                                                     connection_options=kafka_options)
```

**Kafka connection option reference**

Use the following connection options with "connectionType": "kafka":

- "bootstrap.servers" (Required) A list of bootstrap server URLs, for example, as b-1.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094. This option must be specified in the API call or defined in the table metadata in the Data Catalog.
- "security.protocol" (Required) The protocol used to communicate with brokers. The possible values are "SSL" or "PLAINTEXT".
- "topicName" (Required) A comma-separated list of topics to subscribe to. You must specify one and only one of "topicName", "assign" or "subscribePattern".
- "assign": (Required) A JSON string specifying the specific TopicPartitions to consume. You must specify one and only one of "topicName", "assign" or "subscribePattern".
  
  Example: '{"topicA": [0,1], "topicB": [2,4]}'
- "subscribePattern": (Required) A Java regex string that identifies the topic list to subscribe to. You must specify one and only one of "topicName", "assign" or "subscribePattern".
  
  Example: 'topic.*'
- "classification" (Required) The file format used by the data in the record. Required unless provided through the Data Catalog.
- "delimiter" (Optional) The value separator used when classification is CSV. Default is ",".
- "startingOffsets": (Optional) The starting position in the Kafka topic to read data from. The possible values are "earliest" or "latest". The default value is "latest".
• "startingTimestamp": (Optional, supported only for AWS Glue version 4.0 or later) The Timestamp of the record in the Kafka topic to read data from. The possible value is a Timestamp string in UTC format in the pattern yyyy-mm-ddTHH:MM:SSZ (where Z represents a UTC timezone offset with a +/-). For example: "2023-04-04T08:00:00-04:00").

Note: Only one of 'startingOffsets' or 'startingTimestamp' can be present in the Connection Options list of the AWS Glue streaming script, including both these properties will result in job failure.

• "endingOffsets": (Optional) The end point when a batch query is ended. Possible values are either "latest" or a JSON string that specifies an ending offset for each TopicPartition.

For the JSON string, the format is {"topicA":{"0":23,"1":-1},"topicB":{"0":-1}}. The value -1 as an offset represents "latest".

• "pollTimeoutMs": (Optional) The timeout in milliseconds to poll data from Kafka in Spark job executors. The default value is 512.

• "numRetries": (Optional) The number of times to retry before failing to fetch Kafka offsets. The default value is 3.

• "retryIntervalMs": (Optional) The time in milliseconds to wait before retrying to fetch Kafka offsets. The default value is 10.

• "maxOffsetsPerTrigger": (Optional) The rate limit on the maximum number of offsets that are processed per trigger interval. The specified total number of offsets is proportionally split across topicPartitions of different volumes. The default value is null, which means that the consumer reads all offsets until the known latest offset.

• "minPartitions": (Optional) The desired minimum number of partitions to read from Kafka. The default value is null, which means that the number of spark partitions is equal to the number of Kafka partitions.

• "includeHeaders": (Optional) Whether to include the Kafka headers. When the option is set to "true", the data output will contain an additional column named "glue_streaming_kafka_headers" with type Array[Struct(key: String, value: String)]. The default value is "false". This option is available in AWS Glue version 3.0 or later.

• "schema": (Required when inferSchema set to false) The schema to use to process the payload. If classification is avro the provided schema must be in the Avro schema format. If the classification is not avro the provided schema must be in the DDL schema format.

The following are schema examples.
Example in DDL schema format

'column1' INT, 'column2' STRING, 'column3' FLOAT

Example in Avro schema format

```json
{
  "type": "array",
  "items": [
    {
      "type": "record",
      "name": "test",
      "fields": [
        {
          "name": "_id",
          "type": "string"
        },
        {
          "name": "index",
          "type": [
            "int",
            "string",
            "float"
          ]
        }
      ]
    }
  ]
}
```

- "inferSchema": (Optional) The default value is 'false'. If set to 'true', the schema will be detected at runtime from the payload within foreachbatch.

- "avroSchema": (Deprecated) Parameter used to specify a schema of Avro data when Avro format is used. This parameter is now deprecated. Use the schema parameter.

- "addRecordTimestamp": (Optional) When this option is set to 'true', the data output will contain an additional column named "__src_timestamp" that indicates the time when the corresponding record received by the topic. The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.
"emitConsumerLagMetrics": (Optional) When the option is set to 'true', for each batch, it will emit the metrics for the duration between the oldest record received by the topic and the time it arrives in AWS Glue to CloudWatch. The metric's name is "glue.driver.streaming.maxConsumerLagInMs". The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

Azure Cosmos DB connections

You can use AWS Glue for Spark to read from and write to existing containers in Azure Cosmos DB using the NoSQL API in AWS Glue 4.0 and later versions. You can define what to read from Azure Cosmos DB with a SQL query. You connect to Azure Cosmos DB using an Azure Cosmos DB Key stored in AWS Secrets Manager through a AWS Glue connection.

For more information about Azure Cosmos DB for NoSQL, consult the Azure documentation.

Configuring Azure Cosmos DB connections

To connect to Azure Cosmos DB from AWS Glue, you will need to create and store your Azure Cosmos DB Key in a AWS Secrets Manager secret, then associate that secret with a Azure Cosmos DB AWS Glue connection.

Prerequisites:

- In Azure, you will need to identify or generate an Azure Cosmos DB Key for use by AWS Glue, cosmosKey. For more information, see Secure access to data in Azure Cosmos DB in the Azure documentation.

To configure a connection to Azure Cosmos DB:

1. In AWS Secrets Manager, create a secret using your Azure Cosmos DB Key. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.

   - When selecting Key/value pairs, create a pair for the key spark.cosmos.accountKey with the value cosmosKey.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for future use in AWS Glue.
• When selecting a **Connection type**, select Azure Cosmos DB.

• When selecting an **AWS Secret**, provide `secretName`.

After creating a AWS Glue Azure Cosmos DB connection, you will need to perform the following steps before running your AWS Glue job:

• Grant the IAM role associated with your AWS Glue job permission to read `secretName`.

• In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

**Reading from Azure Cosmos DB for NoSQL containers**

**Prerequisites:**

• A Azure Cosmos DB for NoSQL container you would like to read from. You will need identification information for the container.

An Azure Cosmos for NoSQL container is identified by its database and container. You must provide the database, `cosmosDBName`, and container, `cosmosContainerName`, names when connecting to the Azure Cosmos for NoSQL API.

• A AWS Glue Azure Cosmos DB connection configured to provide auth and network location information. To acquire this, complete the steps in the previous procedure, *To configure a connection to Azure Cosmos DB*. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
azurecosmos_read = glueContext.create_dynamic_frame.from_options(
    connection_type="azurecosmos",
    connection_options={
        "connectionName": connectionName,
        "spark.cosmos.database": cosmosDBName,
        "spark.cosmos.container": cosmosContainerName,
    }
)
```
You can also provide a SELECT SQL query, to filter the results returned to your DynamicFrame. You will need to configure `query`.

For example:

```python
azurecosmos_read_query = glueContext.create_dynamic_frame.from_options(
    connection_type="azurecosmos",
    connection_options={
        "connectionName": "connectionName",
        "spark.cosmos.database": cosmosDBName,
        "spark.cosmos.container": cosmosContainerName,
        "spark.cosmos.read.customQuery": "query"
    }
)
```

**Writing to Azure Cosmos DB for NoSQL containers**

This example writes information from an existing DynamicFrame, `dynamicFrame` to Azure Cosmos DB. If the container already has information, AWS Glue will append data from your DynamicFrame. If the information in the container has a different schema from the information you write, you will run into errors.

**Prerequisites:**

- A Azure Cosmos DB table you would like to write to. You will need identification information for the container. **You must create the container before calling the connection method.**

  An Azure Cosmos for NoSQL container is identified by its database and container. You must provide the database, `cosmosDBName`, and container, `cosmosContainerName`, names when connecting to the Azure Cosmos for NoSQL API.

- A AWS Glue Azure Cosmos DB connection configured to provide auth and network location information. To acquire this, complete the steps in the previous procedure, *To configure a connection to Azure Cosmos DB*. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
azurecosmos_write = glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="azurecosmos",
)
connection_options={
  "connectionName": connectionName,
  "spark.cosmos.database": cosmosDBName,
  "spark.cosmos.container": cosmosContainerName
}

Azure Cosmos DB connection option reference

- **connectionName** — Required. Used for Read/Write. The name of a AWS Glue Azure Cosmos DB connection configured to provide auth and network location information to your connection method.
- **spark.cosmos.container** — Required. Used for Read/Write. Valid Values: container names. Azure Cosmos DB for NoSQL container name.
- **spark.cosmos.read.customQuery** — Used for Read. Valid Values: SELECT SQL queries. Custom query to select documents to be read.

Azure SQL connections

You can use AWS Glue for Spark to read from and write to tables on Azure SQL Managed Instances in AWS Glue 4.0 and later versions. You can define what to read from Azure SQL with a SQL query. You connect to Azure SQL using user and password credentials stored in AWS Secrets Manager through a AWS Glue connection.

For more information about Azure SQL, consult the [Azure SQL documentation](#).

Configuring Azure SQL connections

To connect to Azure SQL from AWS Glue, you will need to create and store your Azure SQL credentials in a AWS Secrets Manager secret, then associate that secret with a Azure SQL AWS Glue connection.

**To configure a connection to Azure SQL:**

1. In AWS Secrets Manager, create a secret using your Azure SQL credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.
When selecting **Key/value pairs**, create a pair for the key `user` with the value `azuresqlUsername`.

- When selecting **Key/value pairs**, create a pair for the key `password` with the value `azuresqlPassword`.

2. In the AWS Glue console, create a connection by following the steps in the section called "Adding an AWS Glue connection". After creating the connection, keep the connection name, `connectionName`, for future use in AWS Glue.

- When selecting a **Connection type**, select Azure SQL.
- When providing **Azure SQL URL**, provide a JDBC endpoint URL.

The URL must be in the following format:
```
jdbc:sqlserver://databaseServerName:databasePort;databaseName=azuresqlDBname
```

AWS Glue requires the following URL properties:
- `databaseName` – A default database in Azure SQL to connect to.

For more information about JDBC URLs for Azure SQL Managed Instances, see the Microsoft documentation.

- When selecting an **AWS Secret**, provide `secretName`.

After creating an AWS Glue Azure SQL connection, you will need to perform the following steps before running your AWS Glue job:

- Grant the IAM role associated with your AWS Glue job permission to read `secretName`.
- In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

**Reading from Azure SQL tables**

**Prerequisites:**

- A Azure SQL table you would like to read from. You will need identification information for the table, `databaseName` and `tableIdentifier`.

An Azure SQL table is identified by its database, schema and table name. You must provide the database name and table name when connecting to Azure SQL. You also must provide
the schema if it is not the default, "public". Database is provided through a URL property in connectionName, schema and table name through the dbtable.

- A AWS Glue Azure SQL connection configured to provide auth information. Complete the steps in the previous procedure, To configure a connection to Azure SQL to configure your auth information. You will need the name of the AWS Glue connection, connectionName.

For example:

```python
azuresql_read_table = glueContext.create_dynamic_frame.from_options(
    connection_type="azuresql",
    connection_options={
        "connectionName": "connectionName",
        "dbtable": "tableIdentifier"
    }
)
```

You can also provide a SELECT SQL query, to filter the results returned to your DynamicFrame. You will need to configure query.

For example:

```python
azuresql_read_query = glueContext.create_dynamic_frame.from_options(
    connection_type="azuresql",
    connection_options={
        "connectionName": "connectionName",
        "query": "query"
    }
)
```

**Writing to Azure SQL tables**

This example writes information from an existing DynamicFrame, dynamicFrame to Azure SQL. If the table already has information, AWS Glue will append data from your DynamicFrame.

**Prerequisites:**

- A Azure SQL table you would like to write to. You will need identification information for the table, databaseName and tableIdentifier.
An Azure SQL table is identified by its database, schema and table name. You must provide the database name and table name when connecting to Azure SQL. You also must provide the schema if it is not the default, "public". Database is provided through a URL property in `connectionName`, schema and table name through the `dbtable`.

- Azure SQL auth information. Complete the steps in the previous procedure, To configure a connection to Azure SQL to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
azuresql_write = glueContext.write_dynamic_frame.from_options(  
    connection_type="azuresql",  
    connection_options={  
        "connectionName": "connectionName",  
        "dbtable": "tableIdentifier"  
    }  
)
```

Azure SQL connection option reference

- `connectionName` — Required. Used for Read/Write. The name of a AWS Glue Azure SQL connection configured to provide auth information to your connection method.

- `databaseName` — Used for Read/Write. Valid Values: Azure SQL database names. The name of the database in Azure SQL to connect to.

- `dbtable` — Required for writing, required for reading unless `query` is provided. Used for Read/Write. Valid Values: Names of Azure SQL tables, or period separated schema/table name combinations. Used to specify the table and schema that identify the table to connect to. The default schema is "public". If your table is in a non-default schema, provide this information in the form `schemaName.tableName`.

- `query` — Used for Read. A Transact-SQL SELECT query defining what should be retrieved when reading from Azure SQL. For more information, see the Microsoft documentation.
BigQuery connections

You can use AWS Glue for Spark to read from and write to tables in Google BigQuery in AWS Glue 4.0 and later versions. You can read from BigQuery with a Google SQL query. You connect to BigQuery using credentials stored in AWS Secrets Manager through a AWS Glue connection.

For more information about Google BigQuery, see the Google Cloud BigQuery website.

Configuring BigQuery connections

To connect to Google BigQuery from AWS Glue, you will need to create and store your Google Cloud Platform credentials in a AWS Secrets Manager secret, then associate that secret with a Google BigQuery AWS Glue connection.

To configure a connection to BigQuery:

1. In Google Cloud Platform, create and identify relevant resources:
   - Create or identify a GCP project containing BigQuery tables you would like to connect to.
   - Enable the BigQuery API. For more information, see Use the BigQuery Storage Read API to read table data.

2. In Google Cloud Platform, create and export service account credentials:

   You can use the BigQuery credentials wizard to expedite this step: Create credentials.

   To create a service account in GCP, follow the tutorial available in Create service accounts.

   - When selecting project, select the project containing your BigQuery table.
   - When selecting GCP IAM roles for your service account, add or create a role that would grant appropriate permissions to run BigQuery jobs to read, write or create BigQuery tables.

   To create credentials for your service account, follow the tutorial available in Create a service account key.

   - When selecting key type, select JSON.

   You should now have downloaded a JSON file with credentials for your service account. It should look similar to the following:

   ```
   {
   ```
3. base64 encode your downloaded credentials file. On an AWS CloudShell session or similar, you can do this from the command line by running `cat credentialsFile.json | base64 -w 0`. Retain the output of this command, `credentialString`.

4. In AWS Secrets Manager, create a secret using your Google Cloud Platform credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `credentials` with the value `credentialString`.

5. In the AWS Glue Data Catalog, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select Google BigQuery.
   - When selecting an **AWS Secret**, provide `secretName`.

6. Grant the IAM role associated with your AWS Glue job permission to read `secretName`.

7. In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

**Reading from BigQuery tables**

**Prerequisites:**

- A BigQuery table you would like to read from. You will need the BigQuery table and dataset names, in the form `[dataset].[table]`. Let's call this `tableName`. 

---

[type]: "service_account",
"project_id": "*****",
"private_key_id": "*****",
"private_key": "*****",
"client_email": "*****",
"client_id": "*****",
"auth_uri": "https://accounts.google.com/o/oauth2/auth",
"token_uri": "https://oauth2.googleapis.com/token",
"auth_provider_x509_cert_url": "https://www.googleapis.com/oauth2/v1/certs",
"client_x509_cert_url": "*****",
"universe_domain": "googleapis.com"
}
• The billing project for the BigQuery table. You will need the name of the project, `parentProject`. If there is no billing parent project, use the project containing the table.

• BigQuery auth information. Complete the steps To manage your connection credentials with AWS Glue to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
bigquery_read = glueContext.create_dynamic_frame.from_options(
    connection_type="bigquery",
    connection_options={
        "connectionName": "connectionName",
        "parentProject": "parentProject",
        "sourceType": "table",
        "table": "tableName",
    }
)
```

You can also provide a query, to filter the results returned to your DynamicFrame. You will need to configure `query`, `sourceType`, `viewsEnabled` and `materializationDataset`.

For example:

**Additional prerequisites:**

You will need to create or identify a BigQuery dataset, `materializationDataset`, where BigQuery can write materialized views for your queries.

You will need to grant appropriate GCP IAM permissions to your service account to create tables in `materializationDataset`.

```python
glueContext.create_dynamic_frame.from_options(
    connection_type="bigquery",
    connection_options={
        "connectionName": "connectionName",
        "materializationDataset": "materializationDataset",
        "parentProject": "parentProject",
        "viewsEnabled": "true",
        "sourceType": "query",
        "query": "select * from bqtest.test"
    }
)```
Writing to BigQuery tables

This example writes directly to the BigQuery service. BigQuery also supports the "indirect" writing method. For more information about configuring indirect writes, see the section called “Using indirect write with Google BigQuery”.

Prerequisites:

- A BigQuery table you would like to write to. You will need the BigQuery table and dataset names, in the form `[dataset].[table]`. You can also provide a new table name that will automatically be created. Let's call this `tableName`.
- The billing project for the BigQuery table. You will need the name of the project, `parentProject`. If there is no billing parent project, use the project containing the table.
- BigQuery auth information. Complete the steps To manage your connection credentials with AWS Glue to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
bigquery_write = glueContext.write_dynamic_frame.from_options(
    frame=frameToWrite,
    connection_type="bigquery",
    connection_options={
        "connectionName": "connectionName",
        "parentProject": "parentProject",
        "writeMethod": "direct",
        "table": "tableName",
    }
)
```

BigQuery connection option reference

- **project** — Default: Google Cloud service account default. Used for Read/Write. The name of a Google Cloud project associated with your table.
- **table** — (Required) Used for Read/Write. The name of your BigQuery table in the format `[project:]dataset.].`
- **dataset** — Required when not defined through the table option. Used for Read/Write. The name of the dataset containing your BigQuery table.

- **parentProject** — Default: Google Cloud service account default. Used for Read/Write. The name of a Google Cloud project associated with project used for billing.

- **sourceType** — Used for Read. Required when reading. Valid Values: table, query. Informs AWS Glue of whether you will read by table or by query.

- **materializationDataset** — Used for Read. Valid Values: strings. The name of a BigQuery dataset used to store materializations for views.

- **viewsEnabled** — Used for Read. Default: false. Valid Values: true, false. Configures whether BigQuery will use views.

- **query** — Used for Read. Used when viewsEnabled is true. A GoogleSQL DQL query.

- **temporaryGcsBucket** — Used for Write. Required when writeMethod is set to default (indirect). Name of a Google Cloud Storage bucket used to store an intermediate form of your data while writing to BigQuery.

- **writeMethod** — Default: indirect. Valid Values: direct, indirect. Used for Write. Specifies the method used to write your data.
  - If set to direct, your connector will write using the BigQuery Storage Write API.
  - If set to indirect, you connector will write to Google Cloud Storage, then transfer it to BigQuery using a load operation. Your Google Cloud service account will need appropriate GCS permissions.

**Using indirect write with Google BigQuery**

This example uses indirect write, which writes data to Google Cloud Storage and copies it to Google BigQuery.

**Prerequisites:**

You will need a temporary Google Cloud Storage bucket, `temporaryBucket`.

The GCP IAM role for AWS Glue's GCP service account will need appropriate GCS permissions to access `temporaryBucket`.

**Additional Configuration:**
To configure indirect write with BigQuery:

1. Assess the section called “Configuring BigQuery” and locate or redownload your GCP credentials JSON file. Identify `secretName`, the AWS Secrets Manager secret for the Google BigQuery AWS Glue connection used in your job.

2. Upload your credentials JSON file to an appropriately secure Amazon S3 location. Retain the path to the file, `s3secretpath` for future steps.

3. Edit `secretName`, adding the `spark.hadoop.google.cloud.auth.service.account.json.keyfile` key. Set the value to `s3secretpath`.

4. Grant your AWS Glue job Amazon S3 IAM permissions to access `s3secretpath`.

You can now provide your temporary GCS bucket location to your write method. You do not need to provide `writeMethod`, as `indirect` is historically the default.

```python
bigquery_write = glueContext.write_dynamic_frame.from_options(
    frame=frameToWrite,
    connection_type="bigquery",
    connection_options={
        "connectionName": "connectionName",
        "parentProject": "parentProject",
        "temporaryGcsBucket": "temporaryBucket",
        "table": "tableName",
    }
)
```

JDBC connections

Certain, typically relational, database types support connecting through the JDBC standard. For more information about JDBC, see the Java JDBC API documentation. AWS Glue natively supports connecting to certain databases through their JDBC connectors - the JDBC libraries are provided in AWS Glue Spark jobs. When connecting to these database types using AWS Glue libraries, you have access to a standard set of options.

The JDBC `connectionType` values include the following:

- "connectionType": "sqlserver": Designates a connection to a Microsoft SQL Server database.
- "connectionType": "mysql": Designates a connection to a MySQL database.
- "connectionType": "oracle": Designates a connection to an Oracle database.
- "connectionType": "postgresql": Designates a connection to a PostgreSQL database.
- "connectionType": "redshift": Designates a connection to an Amazon Redshift database. For more information, see the section called “Redshift connections”.

The following table lists the JDBC driver versions that AWS Glue supports.

<table>
<thead>
<tr>
<th>Product</th>
<th>JDBC driver versions for Glue 4.0</th>
<th>JDBC driver versions for Glue 3.0</th>
<th>JDBC driver versions for Glue 0.9, 1.0, 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft SQL Server</td>
<td>9.4.0</td>
<td>7.x</td>
<td>6.x</td>
</tr>
<tr>
<td>MySQL</td>
<td>8.0.23</td>
<td>8.0.23</td>
<td>5.1</td>
</tr>
<tr>
<td>Oracle Database</td>
<td>21.7</td>
<td>21.1</td>
<td>11.2</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>42.3.6</td>
<td>42.2.18</td>
<td>42.1.x</td>
</tr>
<tr>
<td>MongoDB</td>
<td>4.7.2</td>
<td>4.0.0</td>
<td>2.0.0</td>
</tr>
<tr>
<td>Amazon Redshift *</td>
<td>redshift-jdbc42-2.1.0.16</td>
<td>redshift-jdbc41-1.2.12.1017</td>
<td>redshift-jdbc41-1.2.12.1017</td>
</tr>
</tbody>
</table>

* For the Amazon Redshift connection type, all other option name/value pairs that are included in connection options for a JDBC connection, including formatting options, are passed directly to the underlying SparkSQL DataSource. In AWS Glue with Spark jobs in AWS Glue 4.0 and later versions, the AWS Glue native connector for Amazon Redshift uses the Amazon Redshift integration for Apache Spark. For more information see Amazon Redshift integration for Apache Spark. In previous versions, see Amazon Redshift data source for Spark.

To configure your Amazon VPC to connect to Amazon RDS data stores using JDBC, refer to the section called “Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue”.

Features and optimizations
Note

AWS Glue jobs are only associated with one subnet during a run. This may impact your ability to connect to multiple data sources through the same job. This behavior is not limited to JDBC sources.

Topics

- JDBC connection option reference
- Use sampleQuery
- Use custom JDBC driver
- Reading from JDBC tables in parallel
- Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue

JDBC connection option reference

If you already have a JDBC AWS Glue connection defined, you can reuse the configuration properties defined in it, such as: url, user and password; so you don't have to specify them in the code as connection options. This feature is available in AWS Glue 3.0 and later versions. To do so, use the following connection properties:

- "useConnectionProperties": Set it to "true" to indicate you want to use the configuration from a connection.
- "connectionName": Enter the connection name to retrieve the configuration from, the connection must be defined in the same region as the job.

Use these connection options with JDBC connections:

- "url": (Required) The JDBC URL for the database.
- "dbtable": (Required) The database table to read from. For JDBC data stores that support schemas within a database, specify `schema.table-name`. If a schema is not provided, then the default "public" schema is used.
- "user": (Required) The user name to use when connecting.
- "password": (Required) The password to use when connecting.
(Optional) The following options allow you to supply a custom JDBC driver. Use these options if you must use a driver that AWS Glue does not natively support.

ETL jobs can use different JDBC driver versions for the data source and target, even if the source and target are the same database product. This allows you to migrate data between source and target databases with different versions. To use these options, you must first upload the JAR file of the JDBC driver to Amazon S3.

- "customJdbcDriverS3Path": The Amazon S3 path of the custom JDBC driver.
- "customJdbcDriverClassName": The class name of JDBC driver.
- "bulkSize": (Optional) Used to configure parallel inserts for speeding up bulk loads into JDBC targets. Specify an integer value for the degree of parallelism to use when writing or inserting data. This option is helpful for improving the performance of writes into databases such as the Arch User Repository (AUR).
- "hashfield" (Optional) A string, used to specify the name of a column in the JDBC table to be used to divide the data into partitions when reading from JDBC tables in parallel. Provide "hashfield" OR "hashexpression". For more information, see the section called “Reading from JDBC in parallel”.
- "hashexpression" (Optional) A SQL select clause returning a whole number. Used to divide the data in a JDBC table into partitions when reading from JDBC tables in parallel. Provide "hashfield" OR "hashexpression". For more information, see the section called “Reading from JDBC in parallel”.
- "hashpartitions" (Optional) A positive integer. Used to specify the number of parallel reads of the JDBC table when reading from JDBC tables in parallel. Default: 7. For more information, see the section called “Reading from JDBC in parallel”.
- "sampleQuery": (Optional) A custom SQL query statement. Used to specify a subset of information in a table to retrieve a sample of the table contents. When configured without regard to your data, it can be less efficient than DynamicFrame methods, causing timeouts or out of memory errors. For more information, see the section called “Use sampleQuery”.
- "enablePartitioningForSampleQuery": (Optional) A boolean. Default: false. Used to enable reading from JDBC tables in parallel when specifying sampleQuery. If set to true, sampleQuery must end with "where" or "and" for AWS Glue to append partitioning conditions. For more information, see the section called “Use sampleQuery”.
- "sampleSize": (Optional) A positive integer. Limits the number of rows returned by the sample query. Works only when enablePartitioningForSampleQuery is true. If partitioning is not
enabled, you should instead directly add "limit x" in the sampleQuery to limit the size. For more information, see the section called “Use sampleQuery”.

Use sampleQuery

This section explains how to use sampleQuery, sampleSize and enablePartitioningForSampleQuery.

sampleQuery can be an efficient way to sample a few rows of your dataset. By default, the query is run by a single executor. When configured without regard to your data, it can be less efficient than DynamicFrame methods, causing timeouts or out of memory errors. Running SQL on the underlying database as part of your ETL pipeline is generally only needed for performance purposes. If you are trying to preview a few rows of your dataset, consider using the section called “show”. If you are trying to transform your dataset using SQL, consider using the section called “toDF” to define a SparkSQL transform against your data in a DataFrame form.

While your query may manipulate a variety of tables, dbtable remains required.

Using sampleQuery to retrieve a sample of your table

When using default sampleQuery behavior to retrieve a sample of your data, AWS Glue does not expect substantial throughput, so it runs your query on a single executor. In order to limit the data you provide and not cause performance problems, we suggest you provide SQL with a LIMIT clause.

Example Use sampleQuery without partitioning

The following code example shows how to use sampleQuery without partitioning.

```scala
//A full sql query statement.
val query = "select name from $tableName where age > 0 limit 1"
val connectionOptions = JsonOptions(Map(  "url" -> url,
     "dbtable" -> tableName,
     "user" -> user,
     "password" -> password,
     "sampleQuery" -> query ))
val dyf = glueContext.getSource("mysql", connectionOptions).getDynamicFrame()
```

Using sampleQuery against larger datasets
If you're reading a large dataset, you might need to enable JDBC partitioning to query a table in parallel. For more information, see the section called “Reading from JDBC in parallel”. To use sampleQuery with JDBC partitioning, set enablePartitioningForSampleQuery to true. Enabling this feature requires you to make some changes to your sampleQuery.

When using JDBC partitioning with sampleQuery, your query must end with "where" or "and" for AWS Glue to append partitioning conditions.

If you would like to limit the results of your sampleQuery when reading from JDBC tables in parallel, set the "sampleSize" parameter rather than specifying a LIMIT clause.

Example Use sampleQuery with JDBC partitioning

The following code example shows how to use sampleQuery with JDBC partitioning.

```scala
//note that the query should end with "where" or "and" if use with JDBC partitioning. 
val query = "select name from $tableName where age > 0 and"

//Enable JDBC partitioning by setting hashfield. 
//to use sampleQuery with partitioning, set enablePartitioningForSampleQuery. 
//use sampleSize to limit the size of returned data. 
val connectionOptions = JsonOptions(Map( 
  "url" -> url, 
  "dbtable" -> tableName, 
  "user" -> user, 
  "password" -> password, 
  "hashfield" -> primaryKey, 
  "sampleQuery" -> query, 
  "enablePartitioningForSampleQuery" -> true, 
  "sampleSize" -> "1" ))
val dyf = glueContext.getSource("mysql", connectionOptions) 
  .getDynamicFrame()
```

Notes and Restrictions:

Sample queries cannot be used together with job bookmarks. The bookmark state will be ignored when configuration for both are provided.

Use custom JDBC driver

The following code examples show how to read from and write to JDBC databases with custom JDBC drivers. They demonstrate reading from one version of a database product, and writing to a later version of the same product.
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext, SparkConf
from awsglue.context import GlueContext
from awsglue.job import Job
import time
from pyspark.sql.types import StructType, StructField, IntegerType, StringType

c = SparkContext()
g = GlueContext(sc)
s = g.spark_session

# Construct JDBC connection options
connection_mysql5_options = {
    "url": "jdbc:mysql://<jdbc-host-name>:3306/db",
    "dbtable": "test",
    "user": "admin",
    "password": "pwd"
}

connection_mysql8_options = {
    "url": "jdbc:mysql://<jdbc-host-name>:3306/db",
    "dbtable": "test",
    "user": "admin",
    "password": "pwd",
    "customJdbcDriverS3Path": "s3://DOC-EXAMPLE-BUCKET/mysql-connector-java-8.0.17.jar",
    "customJdbcDriverClassName": "com.mysql.cj.jdbc.Driver"
}

connection_oracle11_options = {
    "url": "jdbc:oracle:thin:@//<jdbc-host-name>:1521/ORCL",
    "dbtable": "test",
    "user": "admin",
    "password": "pwd"
}

connection_oracle18_options = {
    "url": "jdbc:oracle:thin:@//<jdbc-host-name>:1521/ORCL",
    "dbtable": "test",
    "user": "admin",
    "password": "pwd",
    "customJdbcDriverS3Path": "s3://DOC-EXAMPLE-BUCKET/ojdbc10.jar",
    "customJdbcDriverClassName": "oracle.jdbc.OracleDriver"}
# Read from JDBC databases with custom driver

df_mysql8 = glueContext.create_dynamic_frame.from_options(connection_type="mysql",
connection_options=connection_mysql8_options)

dataframe_mysql5 = glueContext.create_dynamic_frame.from_options(connection_type="mysql",
connection_options=connection_mysql5_options)

glueContext.write_from_options(frame_or_dfc=dataframe_mysql5, connection_type="mysql",
connection_options=connection_mysql8_options)

# Read DynamicFrame from MySQL 5 and write to MySQL 8

df_mysql5 = glueContext.create_dynamic_frame.from_options(connection_type="mysql",
connection_options=connection_mysql5_options)

++
glueContext.write_from_options(frame_or_dfc=df_mysql5, connection_type="mysql",
connection_options=connection_mysql8_options)

# Read DynamicFrame from Oracle 11 and write to Oracle 18

df_oracle11 =

++
glueContext.create_dynamic_frame.from_options(connection_type="oracle",
connection_options=connection_oracle11_options)

glueContext.write_from_options(frame_or_dfc=df_oracle11, connection_type="oracle",
connection_options=connection_oracle18_options)

Scala

import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamicFrame
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._

object GlueApp {

  val MYSQL_5_URI: String = "jdbc:mysql://<jdbc-host-name>:3306/db"
  val MYSQL_8_URI: String = "jdbc:mysql://<jdbc-host-name>:3306/db"
  val ORACLE_11_URI: String = "jdbc:oracle:thin:@//<jdbc-host-name>:1521/ORCL"
  val ORACLE_18_URI: String = "jdbc:oracle:thin:@//<jdbc-host-name>:1521/ORCL"

  // Construct JDBC connection options
  lazy val mysql5JsonOption = jsonOptions(MYSQL_5_URI)
lazy val mysql8JsonOption = customJDBCDriverJsonOptions(MYSQL_8_URI, "s3://DOC-EXAMPLE-BUCKET/mysql-connector-java-8.0.17.jar", "com.mysql.cj.jdbc.Driver")

lazy val oracle11JsonOption = jsonOptions(ORACLE_11_URI)

lazy val oracle18JsonOption = customJDBCDriverJsonOptions(ORACLE_18_URI, "s3://DOC-EXAMPLE-BUCKET/ojdbc10.jar", "oracle.jdbc.OracleDriver")

```scala
def main(sysArgs: Array[String]): Unit = {
  val spark: SparkContext = new SparkContext()
  val glueContext: GlueContext = new GlueContext(spark)
  val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
  Job.init(args("JOB_NAME"), glueContext, args.asJava)

  // Read from JDBC database with custom driver
  val df_mysql8: DynamicFrame = glueContext.getSource("mysql", mysql8JsonOption).getDynamicFrame()

  // Read DynamicFrame from MySQL 5 and write to MySQL 8
  val df_mysql5: DynamicFrame = glueContext.getSource("mysql", mysql5JsonOption).getDynamicFrame()
  glueContext.getSink("mysql", mysql8JsonOption).writeDynamicFrame(df_mysql5)

  // Read DynamicFrame from Oracle 11 and write to Oracle 18
  glueContext.getSink("oracle", oracle18JsonOption).writeDynamicFrame(df_oracle11)

  Job.commit()
}
```

private def jsonOptions(url: String): JsonOptions = {
  new JsonOptions(
    s""""{
      "url": "${url}",
      "dbtable": "test",
      "user": "admin",
      "password": "pwd"}"
    ).stripMargin
  )
}

private def customJDBCDriverJsonOptions(url: String, customJdbcDriverS3Path: String, customJdbcDriverClassName: String): JsonOptions = {
  new JsonOptions(
    s""""{
      "url": "${url}",
      "dbtable": "test",
      "user": "admin",
      "password": "pwd",
      "customJdbcDriverS3Path": "${customJdbcDriverS3Path}",
      "customJdbcDriverClassName": "${customJdbcDriverClassName}"}"
    ).stripMargin
  )
}
Reading from JDBC tables in parallel

You can set properties of your JDBC table to enable AWS Glue to read data in parallel. When you set certain properties, you instruct AWS Glue to run parallel SQL queries against logical partitions of your data. You can control partitioning by setting a hash field or a hash expression. You can also control the number of parallel reads that are used to access your data.

To enable parallel reads, you can set key-value pairs in the parameters field of your table structure. Use JSON notation to set a value for the parameter field of your table. For more information about editing the properties of a table, see Viewing and editing table details. You can also enable parallel reads when you call the ETL (extract, transform, and load) methods create_dynamic_frame_from_options and create_dynamic_frame_from_catalog. For more information about specifying options in these methods, see from_options and from_catalog.

You can use this method for JDBC tables, that is, most tables whose base data is a JDBC data store. These properties are ignored when reading Amazon Redshift and Amazon S3 tables.

hashfield

Set hashfield to the name of a column in the JDBC table to be used to divide the data into partitions. For best results, this column should have an even distribution of values to spread the data between partitions. This column can be of any data type. AWS Glue generates non-overlapping queries that run in parallel to read the data partitioned by this column. For example, if your data is evenly distributed by month, you can use the month column to read each month of data in parallel.

'hashfield': 'month'

AWS Glue creates a query to hash the field value to a partition number and runs the query for all partitions in parallel. To use your own query to partition a table read, provide a hashexpression instead of a hashfield.
hashexpression

Set hashexpression to an SQL expression (conforming to the JDBC database engine grammar) that returns a whole number. A simple expression is the name of any numeric column in the table. AWS Glue generates SQL queries to read the JDBC data in parallel using the hashexpression in the WHERE clause to partition data.

For example, use the numeric column customerID to read data partitioned by a customer number.

```
'hashexpression': 'customerID'
```

To have AWS Glue control the partitioning, provide a hashfield instead of a hashexpression.

hashpartitions

Set hashpartitions to the number of parallel reads of the JDBC table. If this property is not set, the default value is 7.

For example, set the number of parallel reads to 5 so that AWS Glue reads your data with five queries (or fewer).

```
'hashpartitions': '5'
```

Setting up a VPC to connect to Amazon RDS data stores over JDBC for AWS Glue

To enable AWS Glue components to communicate, you must set up access to your Amazon RDS data stores in Amazon VPC. To enable AWS Glue to communicate between its components, specify a security group with a self-referencing inbound rule for all TCP ports. By creating a self-referencing rule, you can restrict the source to the same security group in the VPC, and it's not open to all networks. The default security group for your VPC might already have a self-referencing inbound rule for ALL Traffic.
To set up access for Amazon RDS data stores

1. Sign in to the AWS Management Console and open the Amazon RDS console at https://console.aws.amazon.com/rds/.
2. In the left navigation pane, choose Instances.
3. Choose the Amazon RDS Engine and DB Instance name that you want to access from AWS Glue.
4. From Instance Actions, choose See Details. On the Details tab, find the Security Groups name you will access from AWS Glue. Record the name of the security group for future reference.
5. Choose the security group to open the Amazon EC2 console.
6. Confirm that your Group ID from Amazon RDS is chosen, then choose the Inbound tab.
7. Add a self-referencing rule to allow AWS Glue components to communicate. Specifically, add or confirm that there is a rule of Type All TCP, Protocol is TCP, Port Range includes all ports, and whose Source is the same security group name as the Group ID.

The inbound rule looks similar to this:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>database-security-group</td>
</tr>
</tbody>
</table>

For example:

8. Add a rule for outbound traffic also. Either open outbound traffic to all ports, for example:
Or create a self-referencing rule where **Type** All TCP, **Protocol** is TCP, **Port Range** includes all ports, and whose **Destination** is the same security group name as the **Group ID**. If using an Amazon S3 VPC endpoint, also add an HTTPS rule for Amazon S3 access. The `s3-prefix-list-id` is required in the security group rule to allow traffic from the VPC to the Amazon S3 VPC endpoint.

For example:

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Port range</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>All TCP</td>
<td>TCP</td>
<td>0–65535</td>
<td>security-group</td>
</tr>
<tr>
<td>HTTPS</td>
<td>TCP</td>
<td>443</td>
<td>s3-prefix-list-id</td>
</tr>
</tbody>
</table>

**MongoDB connections**

You can use AWS Glue for Spark to read from and write to tables in MongoDB and MongoDB Atlas in AWS Glue 4.0 and later versions. You can connect to MongoDB using username and password credentials stored in AWS Secrets Manager through a AWS Glue connection.

For more information about MongoDB, consult the [MongoDB documentation](#).

**Configuring MongoDB connections**

To connect to MongoDB from AWS Glue, you will need your MongoDB credentials, `mongodbUser` and `mongodbPass`.

To connect to MongoDB from AWS Glue, you may need some prerequisites:

- If your MongoDB instance is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the MongoDB instance without traffic traversing the public internet.
In Amazon VPC, identify or create a **VPC**, **Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your MongoDB instance and this location. Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

You can then proceed to configure AWS Glue for use with MongoDB.

**To configure a connection to MongoDB:**

1. Optionally, in AWS Secrets Manager, create a secret using your MongoDB credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](https://docs.aws.amazon.com/secretsmanager/latest/userguide/create-secrets-manually.html) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, *secretName* for the next step.

   - When selecting **Key/value pairs**, create a pair for the key *username* with the value *mongodbUser*.

   - When selecting **Key/value pairs**, create a pair for the key *password* with the value *mongodbPass*.

2. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, *connectionName*, for future use in AWS Glue.

   - When selecting a **Connection type**, select **MongoDB** or **MongoDB Atlas**.

   - When selecting **MongoDB URL** or **MongoDB Atlas URL**, provide the hostname of your MongoDB instance.

     A MongoDB URL is provided in the format `mongodb://mongoHost:mongoPort/mongoDBname`.

     A MongoDB Atlas URL is provided in the format `mongodb+srv://mongoHost:mongoPort/mongoDBname`.

     Providing the default database for the connection, *mongoDBname* is optional.

   - If you chose to create an Secrets Manager secret, choose the AWS Secrets Manager **Credential type**.
Then, in **AWS Secret** provide `secretName`.

- If you choose to provide **Username and password**, provide `mongodbUser` and `mongodbPass`.

3. In the following situations, you may require additional configuration:

   - For MongoDB instances hosted on AWS in an Amazon VPC
     - You will need to provide Amazon VPC connection information to the AWS Glue connection that defines your MongoDB security credentials. When creating or updating your connection, set **VPC, Subnet** and **Security groups** in **Network options**.

After creating a AWS Glue MongoDB connection, you will need to perform the following actions before calling your connection method:

- If you chose to create an Secrets Manager secret, grant the IAM role associated with your AWS Glue job permission to read `secretName`.
- In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

To use your AWS Glue MongoDB connection in AWS Glue for Spark, provide the `connectionName` option in your connection method call. Alternatively, you can follow the steps in the section called “Integrating with MongoDB” to use the connection in conjunction with the AWS Glue Data Catalog.

### Reading from MongoDB using a AWS Glue connection

#### Prerequisites:

- A MongoDB collection you would like to read from. You will need identification information for the collection.

  A MongoDB collection is identified by a database name and a collection name, `mongodbName`, `mongodbCollection`.

- A AWS Glue MongoDB connection configured to provide auth information. Complete the steps in the previous procedure, *To configure a connection to MongoDB* to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:
Writing to MongoDB tables

This example writes information from an existing DynamicFrame, `dynamicFrame` to MongoDB.

Prerequisites:

- A MongoDB collection you would like to write to. You will need identification information for the collection.

  A MongoDB collection is identified by a database name and a collection name, `mongodbName`, `mongodbCollection`.

- A AWS Glue MongoDB connection configured to provide auth information. Complete the steps in the previous procedure, To configure a connection to MongoDB to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
glueContext.write_dynamic_frame.from_options(    frame=dynamicFrame,    connection_type="mongodb",    connection_options={        "connectionName": "connectionName",        "database": "mongodbName",        "collection": "mongodbCollection",        "disableUpdateUri": "false",        "retryWrites": "false",    },
)```
Reading and writing to MongoDB tables

This example writes information from an existing DynamicFrame, `dynamicFrame` to MongoDB.

**Prerequisites:**

- A MongoDB collection you would like to read from. You will need identification information for the collection.

A MongoDB collection you would like to write to. You will need identification information for the collection.

A MongoDB collection is identified by a database name and a collection name, `mongodbName`, `mongodbCollection`.

- MongoDB auth information, `mongodbUser` and `mongodbPassword`.

For example:

**Python**

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext, SparkConf
from awsglue.context import GlueContext
from awsglue.job import Job
import time

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

job = Job(glueContext)
job.init(args['JOB_NAME'], args)

output_path = "s3://some_bucket/output/" + str(time.time()) + "/"
mongo_uri = "mongodb://<mongo-instanced-ip-address>:27017"
```
mongo_ssl_uri = "mongodb://<mongo-instanced-ip-address>:27017"
write_uri = "mongodb://<mongo-instanced-ip-address>:27017"

read_mongo_options = {
    "uri": mongo_uri,
    "database": "mongodbName",
    "collection": "mongodbCollection",
    "username": "mongodbUsername",
    "password": "mongodbPassword",
    "partitioner": "MongoSamplePartitioner",
    "partitionerOptions.partitionSizeMB": "10",
    "partitionerOptions.partitionKey": "_id"
}

ssl_mongo_options = {
    "uri": mongo_ssl_uri,
    "database": "mongodbName",
    "collection": "mongodbCollection",
    "ssl": "true",
    "ssl.domain_match": "false"
}

write_mongo_options = {
    "uri": write_uri,
    "database": "mongodbName",
    "collection": "mongodbCollection",
    "username": "mongodbUsername",
    "password": "mongodbPassword",
}

# Get DynamicFrame from MongoDB
dynamic_frame =
glueContext.create_dynamic_frame.from_options(connection_type="mongodb",
    connection_options=read_mongo_options)

# Write DynamicFrame to MongoDB
glueContext.write_dynamic_frame.from_options(dynamicFrame,
    connection_type="mongodb", connection_options=write_mongo_options)

job.commit()
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.DynamicFrame
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._

object GlueApp {
  val DEFAULT_URI: String = "mongodb://<mongo-instanced-ip-address>:27017"
  val WRITE_URI: String = "mongodb://<mongo-instanced-ip-address>:27017"

  lazy val defaultJsonOption = jsonOptions(DEFAULT_URI)
  lazy val writeJsonOption = jsonOptions(WRITE_URI)

  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)

    // Get DynamicFrame from MongoDB
    val dynamicFrame: DynamicFrame = glueContext.getSource("mongodb", defaultJsonOption).getDynamicFrame()

    // Write DynamicFrame to MongoDB
    glueContext.getSink("mongodb", writeJsonOption).writeDynamicFrame(dynamicFrame)
    Job.commit()
  }

  private def jsonOptions(uri: String): JsonOptions = {
    new JsonOptions(
      s""""{"uri": "${uri}",
        |"database":"mongodbName",
        |"collection":"mongodbCollection",
        |"username": "mongodbUsername",
        |"password": "mongodbPassword",
        |"ssl":"true",
        |"ssl.domain_match":"false",
        |"partitioner": "MongoSamplePartitioner",
        |"partitionerOptions.partitionSizeMB": "10",
    )
  }
}
MongoDB connection option reference

Designates a connection to MongoDB. Connection options differ for a source connection and a sink connection.

These connection properties are shared between source and sink connections:

- **connectionName** — Used for Read/Write. The name of a AWS Glue MongoDB connection configured to provide auth and networking information to your connection method. When a AWS Glue connection is configured as described in the previous section, the section called “Configuring MongoDB”, providing connectionName will replace the need to provide the "uri", "username" and "password" connection options.

- **"uri"**: (Required) The MongoDB host to read from, formatted as mongodb://<host>:<port>. Used in AWS Glue versions prior to AWS Glue 4.0.

- **"connection.uri"**: (Required) The MongoDB host to read from, formatted as mongodb://<host>:<port>. Used in AWS Glue 4.0 and later versions.

- **"username"**: (Required) The MongoDB user name.

- **"password"**: (Required) The MongoDB password.

- **"database"**: (Required) The MongoDB database to read from. This option can also be passed in additional_options when calling glue_context.create_dynamic_frame_from_catalog in your job script.

- **"collection"**: (Required) The MongoDB collection to read from. This option can also be passed in additional_options when calling glue_context.create_dynamic_frame_from_catalog in your job script.

"connectionType": "mongodb" as source

Use the following connection options with "connectionType": "mongodb" as a source:

- **"ssl"**: (Optional) If true, initiates an SSL connection. The default is false.
- **"ssl.domain_match"**: (Optional) If true and ssl is true, domain match check is performed. The default is true.
• "batchSize": (Optional): The number of documents to return per batch, used within the cursor of internal batches.

• "partitioner": (Optional): The class name of the partitioner for reading input data from MongoDB. The connector provides the following partitioners:
  • MongoDefaultPartitioner (default) (Not supported in AWS Glue 4.0)
  • MongoSamplePartitioner (Requires MongoDB 3.2 or later) (Not supported in AWS Glue 4.0)
  • MongoShardedPartitioner (Not supported in AWS Glue 4.0)
  • MongoSplitVectorPartitioner (Not supported in AWS Glue 4.0)
  • MongopaginateByCountPartitioner (Not supported in AWS Glue 4.0)
  • MongoPaginateBySizePartitioner (Not supported in AWS Glue 4.0)
  • com.mongodb.spark.sql.connector.read.partitioner.SinglePartitionPartitioner
  • com.mongodb.spark.sql.connector.read.partitioner.ShardedPartitioner
  • com.mongodb.spark.sql.connector.read.partitioner.PaginateIntoPartitionsPartitioner

• "partitionerOptions" (Optional): Options for the designated partitioner. The following options are supported for each partitioner:
  • MongoSamplePartitioner: partitionKey, partitionSizeMB, samplesPerPartition
  • MongoShardedPartitioner: shardkey
  • MongoSplitVectorPartitioner: partitionKey, partitionSizeMB
  • MongoPaginateByCountPartitioner: partitionKey, numberOfPartitions
  • MongoPaginateBySizePartitioner: partitionKey, partitionSizeMB

For more information about these options, see [Partitioner Configuration](#) in the MongoDB documentation.

"connectionType": "mongodb" as sink

Use the following connection options with "connectionType": "mongodb" as a sink:

• "ssl": (Optional) If true, initiates an SSL connection. The default is false.

• "ssl.domain_match": (Optional) If true and ssl is true, domain match check is performed. The default is true.

• "extendedBsonTypes": (Optional) If true, allows extended BSON types when writing data to MongoDB. The default is true.
• "replaceDocument": (Optional) If true, replaces the whole document when saving datasets that contain an _id field. If false, only fields in the document that match the fields in the dataset are updated. The default is true.

• "maxBatchSize": (Optional): The maximum batch size for bulk operations when saving data. The default is 512.

• "retryWrites": (Optional): Automatically retry certain write operations a single time if AWS Glue encounters a network error.

**SAP HANA connections**

You can use AWS Glue for Spark to read from and write to tables in SAP HANA in AWS Glue 4.0 and later versions. You can define what to read from SAP HANA with a SQL query. You connect to SAP HANA using JDBC credentials stored in AWS Secrets Manager through a AWS Glue SAP HANA connection.

For more information about SAP HANA JDBC, consult the [SAP HANA documentation](https://www.sap.com/).

**Configuring SAP HANA connections**

To connect to SAP HANA from AWS Glue, you will need to create and store your SAP HANA credentials in a AWS Secrets Manager secret, then associate that secret with a SAP HANA AWS Glue connection. You will need to configure network connectivity between your SAP HANA service and AWS Glue.

To connect to SAP HANA, you may need some prerequisites:

• If your SAP HANA service is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the SAP HANA service without traffic traversing the public internet.

  In Amazon VPC, identify or create a **VPC, Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your SAP HANA endpoint and this location. Your job will need to establish a TCP connection with your SAP HANA JDBC port. For more information about SAP HANA ports, see the [SAP HANA documentation](https://www.sap.com/). Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

• There are no additional prerequisites if your SAP HANA endpoint is internet accessible.
To configure a connection to SAP HANA:

1. In AWS Secrets Manager, create a secret using your SAP HANA credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `user` with the value `saphanaUsername`.
   - When selecting **Key/value pairs**, create a pair for the key `password` with the value `saphanaPassword`.

2. In the AWS Glue console, create a connection by following the steps in [the section called “Adding an AWS Glue connection”](#). After creating the connection, keep the connection name, `connectionName`, for future use in AWS Glue.

   - When selecting a **Connection type**, select SAP HANA.
   - When providing **SAP HANA URL**, provide the URL for your instance.

   SAP HANA JDBC URLs are in the form
   ```
jdbc:sap://saphanaHostname:saphanaPort/?databaseName=saphanaDBname,ParameterName=ParameterValue
   ```

   AWS Glue requires the following JDBC URL parameters:
   - `databaseName` – A default database in SAP HANA to connect to.
   - When selecting an **AWS Secret**, provide `secretName`.

After creating a AWS Glue SAP HANA connection, you will need to perform the following steps before running your AWS Glue job:

- Grant the IAM role associated with your AWS Glue job permission to read `secretName`.
- In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

**Reading from SAP HANA tables**

**Prerequisites:**
A SAP HANA table you would like to read from. You will need identification information for the table.

A table can be specified with a SAP HANA table name and schema name, in the form `schemaName.tableName`. The schema name and "." separator are not required if the table is in the default schema, "public". Call this `tableIdentifier`. Note that the database is provided as a JDBC URL parameter in `connectionName`.

A AWS Glue SAP HANA connection configured to provide auth information. Complete the steps in the previous procedure, *To configure a connection to SAP HANA* to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
saphana_read_table = glueContext.create_dynamic_frame.from_options(
    connection_type="saphana",
    connection_options={
        "connectionName": "connectionName",
        "dbtable": "tableIdentifier",
    }
)
```

You can also provide a SELECT SQL query, to filter the results returned to your DynamicFrame. You will need to configure `query`.

For example:

```python
saphana_read_query = glueContext.create_dynamic_frame.from_options(
    connection_type="saphana",
    connection_options={
        "connectionName": "connectionName",
        "query": "query"
    }
)
```

**Writing to SAP HANA tables**

This example writes information from an existing DynamicFrame, `dynamicFrame` to SAP HANA. If the table already has information, AWS Glue will error.

**Prerequisites:**
• A SAP HANA table you would like to write to.

A table can be specified with a SAP HANA table name and schema name, in the form `schemaName.tableName`. The schema name and "." separator are not required if the table is in the default schema, "public". Call this `tableIdentifier`. Note that the database is provided as a JDBC URL parameter in `connectionName`.

• SAP HANA auth information. Complete the steps in the previous procedure, To configure a connection to SAP HANA to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.

For example:

```python
options = {
    "connectionName": "connectionName",
    "dbtable": 'tableIdentifier'
}

saphana_write = glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="saphana",
    connection_options=options
)
```

**SAP HANA connection option reference**

• `connectionName` — Required. Used for Read/Write. The name of a AWS Glue SAP HANA connection configured to provide auth and networking information to your connection method.

• `databaseName` — Used for Read/Write. Valid Values: names of databases in SAP HANA. Name of database to connect to.

• `dbtable` — Required for writing, required for reading unless `query` is provided. Used for Read/Write. Valid Values: contents of a SAP HANA SQL FROM clause. Identifies a table in SAP HANA to connect to. You may also provide other SQL than a table name, such as a subquery. For more information, see the `From clause` in the SAP HANA documentation.

• `query` — Used for Read. A SAP HANA SQL SELECT query defining what should be retrieved when reading from SAP HANA.
Snowflake connections

You can use AWS Glue for Spark to read from and write to tables in Snowflake in AWS Glue 4.0 and later versions. You can read from Snowflake with a SQL query. You can connect to Snowflake using a user and password. You can refer to Snowflake credentials stored in AWS Secrets Manager through the AWS Glue Data Catalog. Data Catalog Snowflake credentials for AWS Glue for Spark are stored separately from Data Catalog Snowflake credentials for crawlers. You must choose a SNOWFLAKE type connection and not a JDBC type connection configured to connect to Snowflake.

For more information about Snowflake, see the Snowflake website. For more information about Snowflake on AWS, see Snowflake Data Warehouse on Amazon Web Services.

Configuring Snowflake connections

There are no AWS prerequisites to connecting to Snowflake databases available through the internet.

Optionally, you can perform the following configuration to manage your connection credentials with AWS Glue.

To manage your connection credentials with AWS Glue

1. In Snowflake, generate a user, snowflakeUser and password, snowflakePassword.

2. In AWS Secrets Manager, create a secret using your Snowflake credentials. To create a secret in Secrets Manager, follow the tutorial available in Create an AWS Secrets Manager secret in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, secretName for the next step.

   - When selecting Key/value pairs, create a pair for snowflakeUser with the key sfUser.
   - When selecting Key/value pairs, create a pair for snowflakePassword with the key sfPassword.
   - When selecting Key/value pairs, you can provide your Snowflake warehouse with the key sfWarehouse.

3. In the AWS Glue Data Catalog, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, connectionName, for the next step.

   - When selecting a Connection type, select Snowflake.
• When selecting **Snowflake URL**, provide the URL of your Snowflake instance. The URL will use a hostname in the form `account_identifier.snowflakecomputing.com`.

• When selecting an **AWS Secret**, provide `secretName`.

4. In your AWS Glue job configuration, provide `connectionName` as an **Additional network connection**.

In the following situations, you may require the following:

• For Snowflake hosted on AWS in an Amazon VPC
  • You will need appropriate Amazon VPC configuration for Snowflake. For more information on how to configure your Amazon VPC, consult [AWS PrivateLink & Snowflake](#) in the Snowflake documentation.
  • You will need appropriate Amazon VPC configuration for AWS Glue. [The section called “VPC endpoints (AWS PrivateLink)”](#).
  • You will need to create a AWS Glue Data Catalog connection that provides Amazon VPC connection information (in addition to the id of an AWS Secrets Manager secret that defines your Snowflake security credentials). Your URL will change when using AWS PrivateLink, as described in the Snowflake documentation linked in a previous item.
  • You will need your job configuration in include the Data Catalog connection as an **Additional network connection**.

**Reading from Snowflake tables**

**Prerequisites:** A Snowflake table you would like to read from. You will need the Snowflake table name, `tableName`. You will need your Snowflake url `snowflakeUrl`, username `snowflakeUser` and password `snowflakePassword`. If your Snowflake user does not have a default namespace set, you will need the Snowflake database name, `databaseName` and the schema name `schemaName`. Additionally, if your Snowflake user does not have a default warehouse set, you will need a warehouse name `warehouseName`.

For example:

**Additional Prerequisites:** Complete the steps To manage your connection credentials with AWS Glue to configure `snowflakeUrl`, `snowflakeUsername` and `snowflakePassword`. To review these steps, see [the section called “Configuring Snowflake”](#), the previous section. To select which **Additional network connection** to connect with, we will use the `connectionName` parameter.
```python
snowflake_read = glueContext.create_dynamic_frame.from_options(
    connection_type="snowflake",
    connection_options={
        "connectionName": "connectionName",
        "dbtable": "tableName",
        "sfDatabase": "databaseName",
        "sfSchema": "schemaName",
        "sfWarehouse": "warehouseName",
    }
)
```

Additionally, you can use the autopushdown and query parameters to read a portion of a Snowflake table. This can be substantially more efficient than filtering your results after they have been loaded into Spark. Consider an example where all sales are stored in the same table, but you only need to analyze sales from a certain store on holidays. If that information is stored in the table, you could use predicate pushdown to retrieve the results as follows:

```python
snowflake_node = glueContext.create_dynamic_frame.from_options(
    connection_type="snowflake",
    connection_options={
        "autopushdown": "on",
        "query": "select * from sales where store='1' and IsHoliday='TRUE'",
        "connectionName": "snowflake-glue-conn",
        "sfDatabase": "databaseName",
        "sfSchema": "schemaName",
        "sfWarehouse": "warehouseName",
    }
)
```

---

**Writing to Snowflake tables**

**Prerequisites:** A Snowflake database you would like to write to. You will need a current or desired table name, `tableName`. You will need your Snowflake url `snowflakeUrl`, username `snowflakeUser` and password `snowflakePassword`. If your Snowflake user does not have a default namespace set, you will need the Snowflake database name, `databaseName` and the schema name `schemaName`. Additionally, if your Snowflake user does not have a default warehouse set, you will need a warehouse name `warehouseName`.

For example:
Additional Prerequisites: Complete the steps To manage your connection credentials with AWS Glue to configure `snowflakeUrl`, `snowflakeUsername` and `snowflakePassword`. To review these steps, see the section called “Configuring Snowflake”, the previous section. To select which Additional network connection to connect with, we will use the connectionName parameter.

```python
    glueContext.write_dynamic_frame.from_options(  
        connection_type="snowflake",  
        connection_options={  
            "connectionName": "connectionName",
            "dbtable": "tableName",
            "sfDatabase": "databaseName",
            "sfSchema": "schemaName",
            "sfWarehouse": "warehouseName",
        },
    )
```

Snowflake connection option reference

The Snowflake connection type takes the following connection options:

You can retrieve some of the parameters in this section from a Data Catalog connection (`sfUrl`, `sfUser`, `sfPassword`), in which case you are not required to provide them. You can do this by providing the parameter `connectionName`.

You can retrieve some of the parameters in this section from an AWS Secrets Manager secret (`sfUser`, `sfPassword`), in which case you are not required to provide them. The secret must provide the content under the `sfUser` and `sfPassword` keys. You can do this by providing the parameter `secretId`.

The following parameters are used generally when connecting to Snowflake.

- `sfDatabase` — Required if a user default is not set in Snowflake. Used for Read/Write. The database to use for the session after connecting.
- `sfSchema` — Required if a user default is not set in Snowflake. Used for Read/Write. The schema to use for the session after connecting.
- `sfWarehouse` — Required if a user default is not set in Snowflake. Used for Read/Write. The default virtual warehouse to use for the session after connecting.
- `sfRole` — Required if a user default is not set in Snowflake. Used for Read/Write. The default security role to use for the session after connecting.
• **sfUrl** — (Required) Used for Read/Write. Specifies the hostname for your account in the following format: `account_identifier.snowflakecomputing.com`. For more information about account identifiers, see [Account Identifiers](#) in the Snowflake documentation.

• **sfUser** — (Required) Used for Read/Write. Login name for the Snowflake user.

• **sfPassword** — (Required unless `pem_private_key` provided) Used for Read/Write. Password for the Snowflake user.

• **dbtable** — Required when working with full tables. Used for Read/Write. The name of the table to be read or the table to which data is written. When reading, all columns and records are retrieved.

• **pem_private_key** — Used for Read/Write. An unencrypted b64-encoded private key string. The private key for the Snowflake user. It is common to copy this out of a PEM file. For more information, see [Key-pair authentication and key-pair rotation](#) in the Snowflake documentation.

• **query** — Required when reading with a query. Used for Read. The exact query (SELECT statement) to run

The following options are used to configure specific behaviors during the process of connecting to Snowflake.

• **preactions** — Used for Read/Write. Valid Values: Semicolon separated list of SQL statements as String. SQL statements run before data is transferred between AWS Glue and Snowflake. If a statement contains `%s`, the `%s` is replaced with the table name referenced for the operation.

• **postactions** — Used for Read/Write. SQL statements run after data is transferred between AWS Glue and Snowflake. If a statement contains `%s`, the `%s` is replaced with the table name referenced for the operation.

• **autopushdown** — Default: "on". Valid Values: "on", "off". This parameter controls whether automatic query pushdown is enabled. If pushdown is enabled, then when a query is run on Spark, if part of the query can be "pushed down" to the Snowflake server, it is pushed down. This improves performance of some queries. For information about whether your query can be pushed down, consult [Pushdown](#) in the Snowflake documentation.

Additionally, some of the options available on the Snowflake Spark connector may be supported in AWS Glue. For more information about options available on the Snowflake Spark connector, see [Setting Configuration Options for the Connector](#) in the Snowflake documentation.
Snowflake connector limitations

Connecting to Snowflake with AWS Glue for Spark is subject to the following limitations.

- This connector does not support job bookmarks. For more information about job bookmarks, see the section called “Tracking processed data using job bookmarks”.
- This connector does not support Snowflake reads and writes through tables in the AWS Glue Data Catalog using the `create_dynamic_frame.from_catalog` and `write_dynamic_frame.from_catalog` methods.
- This connector does not support connecting to Snowflake with credentials other than user and password.
- This connector is not supported within streaming jobs.
- This connector supports SELECT statement based queries when retrieving information (such as with the query parameter). Other kind of queries (such as SHOW, DESC, or DML statements) are not supported.
- Snowflake limits the size of query text (i.e. SQL statements) submitted through Snowflake clients to 1 MB per statement. For more details, see Limits on Query Text Size.

Teradata Vantage connections

You can use AWS Glue for Spark to read from and write to existing tables in Teradata Vantage in AWS Glue 4.0 and later versions. You can define what to read from Teradata with a SQL query. You can connect to Teradata using username and password credentials stored in AWS Secrets Manager through a AWS Glue connection.

For more information about Teradata, consult the Teradata documentation

Configuring Teradata connections

To connect to Teradata from AWS Glue, you will need to create and store your Teradata credentials in an AWS Secrets Manager secret, then associate that secret with a AWS Glue Teradata connection. If your Teradata instance is in an Amazon VPC, you will also need to provide networking options to your AWS Glue Teradata connection.

To connect to Teradata from AWS Glue, you may need some prerequisites:

- If you are accessing your Teradata environment through Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the Teradata environment. We discourage accessing the Teradata environment over the public internet.
In Amazon VPC, identify or create a **VPC**, **Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit network traffic between your Teradata instance and this location. Your job will need to establish a TCP connection with your Teradata client port. For more information about Teradata ports, see the [Teradata documentation](#).

Based on your network layout, secure VPC connectivity may require changes in Amazon VPC and other networking services. For more information about AWS connectivity, consult [AWS Connectivity Options](#) in the Teradata documentation.

**To configure a AWS Glue Teradata connection:**

1. In your Teradata configuration, identify or create a user and password AWS Glue will connect with, `teradataUser` and `teradataPassword`. For more information, consult [Vantage Security Overview](#) in the Teradata documentation.

2. In AWS Secrets Manager, create a secret using your Teradata credentials. To create a secret in Secrets Manager, follow the tutorial available in [Create an AWS Secrets Manager secret](#) in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, `secretName` for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `user` with the value `teradataUsername`.
   - When selecting **Key/value pairs**, create a pair for the key `password` with the value `teradataPassword`.

3. In the AWS Glue console, create a connection by following the steps in the section called “Adding an AWS Glue connection”. After creating the connection, keep the connection name, `connectionName`, for the next step.

   - When selecting a **Connection type**, select Teradata.
   - When providing **JDBC URL**, provide the URL for your instance. You can also hardcode certain comma separated connection parameters in your JDBC URL. The URL must conform to the following format: `jdbc:teradata://teradataHostname/ParameterName=ParameterValue,ParameterName=ParameterValue,...` Supported URL parameters include:

     - DATABASE_NAME—name of database on host to access by default.
• DBS_PORT – the database port, used when running on a nonstandard port.

• When selecting a Credential type, select AWS Secrets Manager, then set AWS Secret to *secretName*.

4. In the following situations, you may require additional configuration:

• For Teradata instances hosted on AWS in an Amazon VPC
  • You will need to provide Amazon VPC connection information to the AWS Glue connection that defines your Teradata security credentials. When creating or updating your connection, set **VPC**, **Subnet** and **Security groups** in **Network options**.

After creating a AWS Glue Teradata connection, you will need to perform the following steps before calling your connection method.

• Grant the IAM role associated with your AWS Glue job permission to read *secretName*.

• In your AWS Glue job configuration, provide *connectionName* as an **Additional network connection**.

**Reading from Teradata**

**Prerequisites:**

• A Teradata table you would like to read from. You will need the table name, *tableName*.

• A AWS Glue Teradata connection configured to provide auth information. Complete the steps To *configure a connection to Teradata* to configure your auth information. You will need the name of the AWS Glue connection, *connectionName*.

For example:

```python
teradata_read_table = glueContext.create_dynamic_frame.from_options(
    connection_type="teradata",
    connection_options={
        "connectionName": "connectionName",
        "dbtable": "tableName"
    }
)```
You can also provide a SELECT SQL query, to filter the results returned to your DynamicFrame. You will need to configure `query`.

For example:

```python
teradata_read_query = glueContext.create_dynamic_frame.from_options(
    connection_type="teradata",
    connection_options={
        "connectionName": "connectionName",
        "query": "query"
    }
)
```

**Writing to Teradata tables**

**Prerequisites:** A Teradata table you would like to write to, `tableName`. You must create the table before calling the connection method.

For example:

```python
teradata_write = glueContext.write_dynamic_frame.from_options(
    connection_type="teradata",
    connection_options={
        "connectionName": "connectionName",
        "dbtable": "tableName"
    }
)
```

**Teradata connection option reference**

- `connectionName` — Required. Used for Read/Write. The name of a AWS Glue Teradata connection configured to provide auth and networking information to your connection method.

- `dbtable` — Required for writing, required for reading unless `query` is provided. Used for Read/Write. The name of a table your connection method will interact with.

- `query` — Used for Read. A SELECT SQL query defining what should be retrieved when reading from Teradata.
Vertica connections

You can use AWS Glue for Spark to read from and write to tables in Vertica in AWS Glue 4.0 and later versions. You can define what to read from Vertica with a SQL query. You connect to Vertica using username and password credentials stored in AWS Secrets Manager through a AWS Glue connection.

For more information about Vertica, consult the [Vertica documentation](#).

Configuring Vertica connections

To connect to Vertica from AWS Glue, you will need to create and store your Vertica credentials in a AWS Secrets Manager secret, then associate that secret with a Vertica AWS Glue connection. If your Vertica instance is in an Amazon VPC, you will also need to provide networking options to your AWS Glue Vertica connection. You will need an Amazon S3 bucket or folder to use for temporary storage when reading from and writing to the database.

To connect to Vertica from AWS Glue, you will need some prerequisites:

- An Amazon S3 bucket or folder to use for temporary storage when reading from and writing to the database, referred to by `tempS3Path`.

  **Note**
  
  When using Vertica in AWS Glue job data previews, temporary files may not be automatically removed from `tempS3Path`. To ensure the removal of temporary files, directly end the data preview session by choosing **End session** in the **Data preview** pane. If you cannot guarantee the data preview session is ended directly, consider setting Amazon S3 Lifecycle configuration to remove old data. We recommend removing data older than 49 hours, based on maximum job runtime plus a margin. For more information about configuring Amazon S3 Lifecycle, see [Managing your storage lifecycle](#) in the Amazon S3 documentation.

- An IAM policy with appropriate permissions to your Amazon S3 path you can associate with your AWS Glue job role.

- If your Vertica instance is in an Amazon VPC, configure Amazon VPC to allow your AWS Glue job to communicate with the Vertica instance without traffic traversing the public internet.

  In Amazon VPC, identify or create a **VPC, Subnet** and **Security group** that AWS Glue will use while executing the job. Additionally, you need to ensure Amazon VPC is configured to permit
network traffic between your Vertica instance and this location. Your job will need to establish a TCP connection with your Vertica client port, (default 5433). Based on your network layout, this may require changes to security group rules, Network ACLs, NAT Gateways and Peering connections.

You can then proceed to configure AWS Glue for use with Vertica.

To configure a connection to Vertica:

1. In AWS Secrets Manager, create a secret using your Vertica credentials, *verticaUsername* and *verticaPassword*. To create a secret in Secrets Manager, follow the tutorial available in _Create an AWS Secrets Manager secret_ in the AWS Secrets Manager documentation. After creating the secret, keep the Secret name, *secretName* for the next step.

   - When selecting **Key/value pairs**, create a pair for the key `user` with the value `verticaUsername`.
   - When selecting **Key/value pairs**, create a pair for the key `password` with the value `verticaPassword`.

2. In the AWS Glue console, create a connection by following the steps in _the section called “Adding an AWS Glue connection”_. After creating the connection, keep the connection name, *connectionName*, for the next step.

   - When selecting a **Connection type**, select Vertica.
   - When selecting **Vertica Host**, provide the hostname of your Vertica installation.
   - When selecting **Vertica Port**, the port your Vertica installation is available through.
   - When selecting an **AWS Secret**, provide *secretName*.

3. In the following situations, you may require additional configuration:

   - For Vertica instances hosted on AWS in an Amazon VPC
     - Provide Amazon VPC connection information to the AWS Glue connection that defines your Vertica security credentials. When creating or updating your connection, set **VPC**, **Subnet** and **Security groups** in **Network options**.

After creating a AWS Glue Vertica connection, you will need to perform the following steps before calling your connection method.
- Grant the IAM role associated with your AWS Glue job permissions to `tempS3Path`.
- Grant the IAM role associated with your AWS Glue job permission to read `secretName`.
- In your AWS Glue job configuration, provide `connectionName` as an Additional network connection.

Reading from Vertica

Prerequisites:

- A Vertica table you would like to read from. You will need the Vertica database name, `dbName` and the table name, `tableName`.
- A AWS Glue Vertica connection configured to provide auth information. Complete the steps in the previous procedure, To configure a connection to Vertica to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.
- A Amazon S3 bucket or folder to use for temporary storage, mentioned previously. You will need the name, `tempS3Path`. You will need to connect to this location using the s3a protocol.

For example:

```python
dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="vertica",
    connection_options={
        "connectionName": "connectionName",
        "staging_fs_url": "s3a://tempS3Path",
        "db": "dbName",
        "table": "tableName",
    }
)
```

You can also provide a SELECT SQL query, to filter the results returned to your DynamicFrame or to access a dataset from multiple tables.

For example:

```python
dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="vertica",
    connection_options={
        "connectionName": "connectionName",
        "staging_fs_url": "s3a://tempS3Path",
```

Features and optimizations
Writing to Vertica tables

This example writes information from an existing DynamicFrame, `dynamicFrame` to Vertica. If the table already has information, AWS Glue will append data from your DynamicFrame.

Prerequisites:

- A current or desired table name, `tableName`, you would like to write to. You will also need the corresponding Vertica database name, `dbName`.
- A AWS Glue Vertica connection configured to provide auth information. Complete the steps in the previous procedure, To configure a connection to Vertica to configure your auth information. You will need the name of the AWS Glue connection, `connectionName`.
- A Amazon S3 bucket or folder to use for temporary storage, mentioned previously. You will need the name, `tempS3Path`. You will need to connect to this location using the s3a protocol.

For example:

```python
glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="vertica",
    connection_options={
        "connectionName": "connectionName",
        "staging_fs_url": "s3a://tempS3Path",
        "db": "dbName",
        "table": "tableName",
    }
)
```

Vertica connection option reference

- `connectionName` — Required. Used for Read/Write. The name of a AWS Glue Vertica connection configured to provide auth and networking information to your connection method.
- `db` — Required. Used for Read/Write. The name of a database in Vertica your connection method will interact with.
• dbSchema — Required if needed to identify your table. Used for Read/Write. Default: public. The name of a schema your connection method will interact with.
• table — Required for writing, required for reading unless query is provided. Used for Read/Write. The name of a table your connection method will interact with.
• query — Used for Read. A SELECT SQL query defining what should be retrieved when reading from Teradata.
• staging_fs_url — Required. Used for Read/Write. Valid Values: s3a URLs. The URL of a Amazon S3 bucket or folder to use for temporary storage.

Custom and AWS Marketplace connectionType values

These include the following:

• "connectionType": "marketplace.athena": Designates a connection to an Amazon Athena data store. The connection uses a connector from AWS Marketplace.
• "connectionType": "marketplace.spark": Designates a connection to an Apache Spark data store. The connection uses a connector from AWS Marketplace.
• "connectionType": "marketplace.jdbc": Designates a connection to a JDBC data store. The connection uses a connector from AWS Marketplace.
• "connectionType": "custom.athena": Designates a connection to an Amazon Athena data store. The connection uses a custom connector that you upload to AWS Glue Studio.
• "connectionType": "custom.spark": Designates a connection to an Apache Spark data store. The connection uses a custom connector that you upload to AWS Glue Studio.
• "connectionType": "custom.jdbc": Designates a connection to a JDBC data store. The connection uses a custom connector that you upload to AWS Glue Studio.

Connection options for type custom.jdbc or marketplace.jdbc

• className – String, required, driver class name.
• connectionName – String, required, name of the connection that is associated with the connector.
• url – String, required, JDBC URL with placeholders (${}) which are used to build the connection to the data source. The placeholder ${secretKey} is replaced with the secret of the same name in AWS Secrets Manager. Refer to the data store documentation for more information about constructing the URL.
- secretId or user/password – String, required, used to retrieve credentials for the URL.

- dbTable or query – String, required, the table or SQL query to get the data from. You can specify either dbTable or query, but not both.

- partitionColumn – String, optional, the name of an integer column that is used for partitioning. This option works only when it's included with lowerBound, upperBound, and numPartitions. This option works the same way as in the Spark SQL JDBC reader. For more information, see JDBC To Other Databases in the Apache Spark SQL, DataFrames and Datasets Guide.

The lowerBound and upperBound values are used to decide the partition stride, not for filtering the rows in table. All rows in the table are partitioned and returned.

**Note**

When using a query instead of a table name, you should validate that the query works with the specified partitioning condition. For example:

- If your query format is "SELECT col1 FROM table1", then test the query by appending a WHERE clause at the end of the query that uses the partition column.

- If your query format is "SELECT col1 FROM table1 WHERE col2=val", then test the query by extending the WHERE clause with AND and an expression that uses the partition column.

- lowerBound – Integer, optional, the minimum value of partitionColumn that is used to decide partition stride.

- upperBound – Integer, optional, the maximum value of partitionColumn that is used to decide partition stride.

- numPartitions – Integer, optional, the number of partitions. This value, along with lowerBound (inclusive) and upperBound (exclusive), form partition strides for generated WHERE clause expressions that are used to split the partitionColumn.

**Important**

Be careful with the number of partitions because too many partitions might cause problems on your external database systems.
• `filterPredicate` – String, optional, extra condition clause to filter data from source. For example:

```
BillingCity='Mountain View'
```

When using a `query` instead of a `table` name, you should validate that the query works with the specified `filterPredicate`. For example:

• If your query format is "SELECT col1 FROM table1", then test the query by appending a `WHERE` clause at the end of the query that uses the filter predicate.

• If your query format is "SELECT col1 FROM table1 WHERE col2=val", then test the query by extending the `WHERE` clause with `AND` and an expression that uses the filter predicate.

• `dataTypeMapping` – Dictionary, optional, custom data type mapping that builds a mapping from a `JDBC` data type to a `Glue` data type. For example, the option "dataTypeMapping": {"FLOAT": "STRING"} maps data fields of JDBC type `FLOAT` into the Java `String` type by calling the `ResultSet.getString()` method of the driver, and uses it to build AWS Glue records. The `ResultSet` object is implemented by each driver, so the behavior is specific to the driver you use. Refer to the documentation for your JDBC driver to understand how the driver performs the conversions.

• The AWS Glue data types supported currently are:
  - DATE
  - STRING
  - TIMESTAMP
  - INT
  - FLOAT
  - LONG
  - BIGDECIMAL
  - BYTE
  - SHORT
  - DOUBLE

The JDBC data types supported are [Java8 java.sql.types](https://docs.oracle.com/en/java/javase/11/docs/api/java.sql/index.html).

The default data type mappings (from JDBC to AWS Glue) are:
• VARCHAR -> STRING
• CHAR -> STRING
• LONGNVARCHAR -> STRING
• TIMESTAMMP -> TIMESTAMMP
• INTEGER -> INT
• FLOAT -> FLOAT
• REAL -> FLOAT
• BIT -> BOOLEAN
• BOOLEAN -> BOOLEAN
• BIGINT -> LONG
• DECIMAL -> BIGDECIMAL
• NUMERIC -> BIGDECIMAL
• TINYINT -> SHORT
• SMALLINT -> SHORT
• DOUBLE -> DOUBLE

If you use a custom data type mapping with the option dataTypeMapping, then you can override a default data type mapping. Only the JDBC data types listed in the dataTypeMapping option are affected; the default mapping is used for all other JDBC data types. You can add mappings for additional JDBC data types if needed. If a JDBC data type is not included in either the default mapping or a custom mapping, then the data type converts to the AWS Glue STRING data type by default.

The following Python code example shows how to read from JDBC databases with AWS Marketplace JDBC drivers. It demonstrates reading from a database and writing to an S3 location.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])
```
sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)
## @type: DataSource
## @args: 
  connection_type = "marketplace.jdbc",
  connection_options =
  {"dataTypeMapping":{"INTEGER":"STRING"},
   "upperBound":"200","query":"select id,
   name, department from department where id < 200","numPartitions":"4",
   "partitionColumn":"id","lowerBound":"0","connectionName":"test-connection-jdbc"},
  transformation_ctx = "DataSource0"
## @return: DataSource0
## @inputs: []
DataSource0 = glueContext.create_dynamic_frame.from_options(connection_type =
  "marketplace.jdbc",
  connection_options =
  {"dataTypeMapping":{"INTEGER":"STRING"},
   "upperBound":"200","query":"select id,
   name, department from department where id < 200","numPartitions":"4","partitionColumn":"id","lowerBound":"0",
   "connectionName":"test-connection-jdbc"},
  transformation_ctx = "DataSource0"
## @type: ApplyMapping
## @args: 
  mappings = [{"department", "string", "department", "string"},
   ("name", "string",
   "name", "string"), ("id", "int", "id", "int")],
  transformation_ctx = "Transform0"
## @return: Transform0
## @inputs: [frame = DataSource0]
Transform0 = ApplyMapping.apply(frame = DataSource0,
  mappings = [{"department", "string",
   "department", "string"},
   ("name", "string", "name", "string"), ("id", "int", "id", "int")],
  transformation_ctx = "Transform0"
## @type: DataSink
## @args: 
  connection_type = "s3",
  format = "json",
  connection_options =
  {"path": "s3://<S3 path>/", "partitionKeys": []},
  transformation_ctx = "DataSink0"
## @return: DataSink0
## @inputs: [frame = Transform0]
DataSink0 = glueContext.write_dynamic_frame.from_options(frame = Transform0,
  connection_type = "s3",
  format = "json",
  connection_options =
  {"path": "s3://<S3 path>/", "partitionKeys": []},
  transformation_ctx = "DataSink0"
job.commit()
Connection options for type custom.athena or marketplace.athena

• className – String, required, driver class name. When you're using the Athena-CloudWatch connector, this parameter value is the prefix of the class Name (for example, "com.amazonaws.athena.connectors"). The Athena-CloudWatch connector is composed of two classes: a metadata handler and a record handler. If you supply the common prefix here, then the API loads the correct classes based on that prefix.

• tableName – String, required, the name of the CloudWatch log stream to read. This code snippet uses the special view name all_log_streams, which means that the dynamic data frame returned will contain data from all log streams in the log group.

• schemaName – String, required, the name of the CloudWatch log group to read from. For example, /aws-glue/jobs/output.

• connectionName – String, required, name of the connection that is associated with the connector.

For additional options for this connector, see the Amazon Athena CloudWatch Connector README file on GitHub.

The following Python code example shows how to read from an Athena data store using an AWS Marketplace connector. It demonstrates reading from Athena and writing to an S3 location.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

## @type: DataSource
## @args: [connection_type = "marketplace.athena", connection_options = {
  "tableName": "all_logStreams", 
  "schemaName": "/aws-glue/jobs/output",
...]
Connection options for type custom.spark or marketplace.spark

- **className** – String, required, connector class name.
- **secretId** – String, optional, used to retrieve credentials for the connector connection.
- **connectionName** – String, required, name of the connection that is associated with the connector.

Other options depend on the data store. For example, OpenSearch configuration options start with the prefix `es`, as described in the [Elasticsearch for Apache Hadoop](https://docs.aws.amazon.com/glue/latest/dg/data-access-athena.html) documentation. Spark connections to Snowflake use options such as `sfUser` and `sfPassword`, as described in [Using the Spark Connector](https://docs.aws.amazon.com/glue/latest/dg/connect-snowflake.html) in the [Connecting to Snowflake](https://docs.aws.amazon.com/glue/latest/dg/connect-snowflake.html) guide.
The following Python code example shows how to read from an OpenSearch data store using a `marketplace.spark` connection.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

## @params: [JOB_NAME]
args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()

## @type: DataSource
## @args: [connection_type = "marketplace.spark", connection_options =

## @return: DataSource0
## @inputs: []

DataSource0 = glueContext.create_dynamic_frame.from_options(connection_type =
    "marketplace.spark", connection_options = 
    
    "connectionName": "test-spark-es", "es.port": "443"),
    transformation_ctx = "DataSource0"

## @type: DataSink
## @args: [connection_type = "s3", format = "json", connection_options =

## @return: DataSink0
## @inputs: [frame = DataSource0]

DataSink0 = glueContext.write_dynamic_frame.from_options(frame = DataSource0,
    connection_type = "s3", format = "json", connection_options =
    "s3://<S3 path>/", "partitionKeys": []),
    transformation_ctx = "DataSink0"

job.commit()
```
General options

The options in this section are provided as `connection_options`, but do not specifically apply to one connector.

The following parameters are used generally when configuring bookmarks. They may apply to Amazon S3 or JDBC workflows. For more information, see the section called “Using job bookmarks”.

- `jobBookmarkKeys` — Array of column names.
- `jobBookmarkKeysSortOrder` — String defining how to compare values based on sort order. Valid values: "asc", "desc".
- `useS3ListImplementation` — Used to manage memory performance when listing Amazon S3 bucket contents. For more information, see Optimize memory management in AWS Glue.

Data format options for inputs and outputs in AWS Glue for Spark

These pages offer information about feature support and configuration parameters for data formats supported by AWS Glue for Spark. See the following for a description of the usage and applicability of this information.

Feature support across data formats in AWS Glue

Each data format may support different AWS Glue features. The following common features may or may not be supported based on your format type. Refer to the documentation for your data format to understand how to leverage our features to meet your requirements.

<table>
<thead>
<tr>
<th>Read</th>
<th>AWS Glue can recognize and interpret this data format without additional resources, such as connectors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td>AWS Glue can write data in this format without additional resources. You can include third-party libraries in your job and use standard Apache Spark functions to write data, as you would in other Spark environments. For more information about including</td>
</tr>
</tbody>
</table>
Streaming read

AWS Glue can recognize and interpret this data format from an Apache Kafka, Amazon Managed Streaming for Apache Kafka or Amazon Kinesis message stream. We expect streams to present data in a consistent format, so they are read in as DataFrames.

Group small files

AWS Glue can group files together to batch work sent to each node when performing AWS Glue transforms. This can significantly improve performance for workloads involving large amounts of small files. For more information, see the section called “Grouping input files”.

Job bookmarks

AWS Glue can track the progress of transforms performing the same work on the same dataset across job runs with job bookmarks. This can improve performance for workloads involving datasets where work only needs to be done on new data since the last job run. For more information, see the section called “Tracking processed data using job bookmarks”.

Parameters used to interact with data formats in AWS Glue

Certain AWS Glue connection types support multiple format types, requiring you to specify information about your data format with a format_options object when using methods like GlueContext.write_dynamic_frame.from_options.

- s3 – For more information, see Connection types and options for ETL in AWS Glue: S3 connection parameters. You can also view the documentation for the methods facilitating this connection type: the section called “create_dynamic_frame_from_options” and the section called...
“write_dynamic_frame_from_options” in Python and the corresponding Scala methods the section called “getSourceWithFormat” and the section called “getSinkWithFormat”.

- **kinesis** – For more information, see Connection types and options for ETL in AWS Glue: [Kinesis connection parameters](#). You can also view the documentation for the method facilitating this connection type: the section called “create_data_frame_from_options” and the corresponding Scala method the section called “createDataFrameFromOptions”.

- **kafka** – For more information, see Connection types and options for ETL in AWS Glue: [Kafka connection parameters](#). You can also view the documentation for the method facilitating this connection type: the section called “create_data_frame_from_options” and the corresponding Scala method the section called “createDataFrameFromOptions”.

Some connection types do not require format_options. For example, in normal use, a JDBC connection to a relational database retrieves data in a consistent, tabular data format. Therefore, reading from a JDBC connection would not require format_options.

Some methods to read and write data in glue do not require format_options. For example, using GlueContext.create_dynamic_frame.from_catalog with AWS Glue crawlers. Crawlers determine the shape of your data. When using crawlers, a AWS Glue classifier will examine your data to make smart decisions about how to represent your data format. It will then store a representation of your data in the AWS Glue Data Catalog, which can be used within a AWS Glue ETL script to retrieve your data with the GlueContext.create_dynamic_frame.from_catalog method. Crawlers remove the need to manually specify information about your data format.

For jobs that access AWS Lake Formation governed tables, AWS Glue supports reading and writing all formats supported by Lake Formation governed tables. For the current list of supported formats for AWS Lake Formation governed tables, see [Notes and Restrictions for Governed Tables](#) in the [AWS Lake Formation Developer Guide](#).

⚠️ **Note**

For writing Apache Parquet, AWS Glue ETL only supports writing to a governed table by specifying an option for a custom Parquet writer type optimized for Dynamic Frames. When writing to a governed table with the parquet format, you should add the key `useGlueParquetWriter` with a value of `true` in the table parameters.
Using the CSV format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the CSV data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the comma-separated value (CSV) format. This format is a minimal, row-based data format. CSVs often don't strictly conform to a standard, but you can refer to RFC 4180 and RFC 7111 for more information.

You can use AWS Glue to read CSVs from Amazon S3 and from streaming sources as well as write CSVs to Amazon S3. You can read and write bzip and gzip archives containing CSV files from S3. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

The following table shows which common AWS Glue features support the CSV format option.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
</tbody>
</table>
Example: Read CSV files or folders from S3

Prerequisites: You will need the S3 paths (s3path) to the CSV files or folders that you want to read.

Configuration: In your function options, specify format="csv". In your connection_options, use the paths key to specify s3path. You can configure how the reader interacts with S3 in connection_options. For details, see Connection types and options for ETL in AWS Glue: S3 connection parameters. You can configure how the reader interprets CSV files in your format_options. For details, see CSV Configuration Reference.

The following AWS Glue ETL script shows the process of reading CSV files or folders from S3.

We provide a custom CSV reader with performance optimizations for common workflows through the optimizePerformance configuration key. To determine if this reader is right for your workload, see the section called “Using optimized CSV reader”.

Python

For this example, use the create_dynamic_frame.from_options method.

```python
# Example: Read CSV from S3
# For show, we handle a CSV with a header row. Set the withHeader option.
# Consider whether optimizePerformance is right for your workflow.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    connection_options={"paths": ["s3://s3path"]},
    format="csv",
    format_options={
        "withHeader": True,
        # "optimizePerformance": True,
    },
)```

Features and optimizations

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You can also use DataFrames in a script (`pyspark.sql.DataFrame`).

```python
dataFrame = spark.read
    .format("csv")
    .option("header", "true")
    .load("s3://s3path")
```

**Scala**

For this example, use the `getSourceWithFormat` operation.

```scala
// Example: Read CSV from S3
// For show, we handle a CSV with a header row. Set the withHeader option.
// Consider whether optimizePerformance is right for your workflow.

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
    def main(sysArgs: Array[String]): Unit = {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)

        val dynamicFrame = glueContext.getSourceWithFormat(
            formatOptions=JsonOptions("""{"withHeader": true}""""),
            connectionType="s3",
            format="csv",
            options=JsonOptions("""{"paths": ["s3://s3path"], "recurse": true}"""")
        ).getDynamicFrame()
    }
}
```

You can also use DataFrames in a script (`org.apache.spark.sql.DataFrame`).

```scala
val dataFrame = spark.read
    .option("header","true")
    .format("csv")
    .load("s3://s3path")
```
Example: Write CSV files and folders to S3

**Prerequisites:** You will need an initialized DataFrame (dataFrame) or a DynamicFrame (dynamicFrame). You will also need your expected S3 output path, s3path.

**Configuration:** In your function options, specify format="csv". In your connection_options, use the paths key to specify s3path. You can configure how the writer interacts with S3 in connection_options. For details, see Connection types and options for ETL in AWS Glue: S3 connection parameters. You can configure how your operation writes the contents of your files in format_options. For details, see CSV Configuration Reference. The following AWS Glue ETL script shows the process of writing CSV files and folders to S3.

**Python**

For this example, use the `write_dynamic_frame.from_options` method.

```python
# Example: Write CSV to S3
# For show, customize how we write string type values. Set quoteChar to -1 so our values are not quoted.

from pyspark.context import SparkContext
from awsglue.context import GlueContext
from pyspark.sql import SparkSession

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="s3",
    connection_options={"path": "s3://s3path"},
    format="csv",
    format_options={
        "quoteChar": -1,
    },
)

You can also use DataFrames in a script (pyspark.sql.DataFrame).

```python
dataFrame.write
    .format("csv")
    .option("quote", None)
    .mode("append")
```
Scala

For this example, use the `getSinkWithFormat` method.

```scala
// Example: Write CSV to S3
// For show, customize how we write string type values. Set quoteChar to -1 so our
// values are not quoted.

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    glueContext.getSinkWithFormat(
      connectionType="s3",
      options=JsonOptions("{"path": "s3://s3path"}"
    ).format="csv"
      ).writeDynamicFrame(dynamicFrame)
  }
}
```

You can also use DataFrames in a script (org.apache.spark.sql.DataFrame).

```scala
dataFrame.write
  .format("csv")
  .option("quote", null)
  .mode("Append")
  .save("s3://s3path")
```

**CSV configuration reference**

You can use the following `format_options` wherever AWS Glue libraries specify `format="csv":`:

- `separator` – Specifies the delimiter character. The default is a comma, but any other character can be specified.
• **Type:** Text, **Default:** ",,"

- **escaper** – Specifies a character to use for escaping. This option is used only when reading CSV files, not writing. If enabled, the character that immediately follows is used as-is, except for a small set of well-known escapes (\n, \r, \t, and \0).
  
  • **Type:** Text, **Default:** none

- **quoteChar** – Specifies the character to use for quoting. The default is a double quote. Set this to -1 to turn off quoting entirely.
  
  • **Type:** Text, **Default:** '\''

- **multiLine** – Specifies whether a single record can span multiple lines. This can occur when a field contains a quoted new-line character. You must set this option to True if any record spans multiple lines. Enabling multiLine might decrease performance because it requires more cautious file-splitting while parsing.
  
  • **Type:** Boolean, **Default:** false

- **withHeader** – Specifies whether to treat the first line as a header. This option can be used in the DynamicFrameReader class.
  
  • **Type:** Boolean, **Default:** false

- **writeHeader** – Specifies whether to write the header to output. This option can be used in the DynamicFrameWriter class.
  
  • **Type:** Boolean, **Default:** true

- **skipFirst** – Specifies whether to skip the first data line.
  
  • **Type:** Boolean, **Default:** false

- **optimizePerformance** – Specifies whether to use the advanced SIMD CSV reader along with Apache Arrow–based columnar memory formats. Only available in AWS Glue 3.0+.
  
  • **Type:** Boolean, **Default:** false

- **strictCheckForQuoting** – When writing CSVs, Glue may add quotes to values it interprets as strings. This is done to prevent ambiguity in what is written out. To save time when deciding what to write, Glue may quote in certain situations where quotes are not necessary. Enabling a strict check will perform a more intensive computation and will only quote when strictly necessary. Only available in AWS Glue 3.0+.
  
  • **Type:** Boolean, **Default:** false
Optimize read performance with vectorized SIMD CSV reader

AWS Glue version 3.0 adds an optimized CSV reader that can significantly speed up overall job performance compared to row-based CSV readers.

The optimized reader:

- Uses CPU SIMD instructions to read from disk
- Immediately writes records to memory in a columnar format (Apache Arrow)
- Divides the records into batches

This saves processing time when records would be batched or converted to a columnar format later on. Some examples are when changing schemas or retrieving data by column.

To use the optimized reader, set "optimizePerformance" to true in the format_options or table property.

```python
glueContext.create_dynamic_frame.from_options(
    frame = datasource1,
    connection_type = "s3",
    connection_options = {"paths": ["s3://s3path"]},
    format = "csv",
    format_options={
        "optimizePerformance": True,
        "separator": ",",
    },
    transformation_ctx = "datasink2"
)
```

Limitations for the vectorized CSV reader

Note the following limitations of the vectorized CSV reader:

- It doesn't support the multiLine and escaper format options. It uses the default escaper of double quote char '"'. When these options are set, AWS Glue automatically falls back to using the row-based CSV reader.
- It doesn't support creating a DynamicFrame with `ChoiceType`.
- It doesn't support creating a DynamicFrame with error records.
- It doesn't support reading CSV files with multibyte characters such as Japanese or Chinese characters.
Using the Parquet format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the Parquet data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the Parquet format. This format is a performance-oriented, column-based data format. For an introduction to the format by the standard authority see, Apache Parquet Documentation Overview.

You can use AWS Glue to read Parquet files from Amazon S3 and from streaming sources as well as write Parquet files to Amazon S3. You can read and write bzip and gzip archives containing Parquet files from S3. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

The following table shows which common AWS Glue features support the Parquet format option.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Unsupported</td>
<td>Supported*</td>
</tr>
</tbody>
</table>

* Supported in AWS Glue version 1.0+

Example: Read Parquet files or folders from S3

**Prerequisites:** You will need the S3 paths (s3path) to the Parquet files or folders that you want to read.

**Configuration:** In your function options, specify format="parquet". In your connection_options, use the paths key to specify your s3path.

You can configure how the reader interacts with S3 in the connection_options. For details, see Connection types and options for ETL in AWS Glue: S3 connection parameters.

You can configure how the reader interprets Parquet files in your format_options. For details, see Parquet Configuration Reference.

The following AWS Glue ETL script shows the process of reading Parquet files or folders from S3:
Python

For this example, use the `create_dynamic_frame.from_options` method.

```python
# Example: Read Parquet from S3

from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type = "s3",
    connection_options = {"paths": ["s3://s3path/"],
    format = "parquet"
)
```

You can also use DataFrames in a script (`pyspark.sql.DataFrame`).

```python
dataFrame = spark.read.parquet("s3://s3path/")
```

Scala

For this example, use the `getSourceWithFormat` method.

```scala
// Example: Read Parquet from S3

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    val dynamicFrame = glueContext.getSourceWithFormat(
      connectionType="s3",
      format="parquet",
```
You can also use DataFrames in a script (org.apache.spark.sql.DataFrame).

```python
spark.read.parquet("s3://s3path/")
```

**Example: Write Parquet files and folders to S3**

**Prerequisites:** You will need an initialized DataFrame (dataFrame) or DynamicFrame (dynamicFrame). You will also need your expected S3 output path, s3path.

**Configuration:** In your function options, specify format="parquet". In your connection_options, use the paths key to specify s3path.

You can further alter how the writer interacts with S3 in the connection_options. For details, see Connection types and options for ETL in AWS Glue: S3 connection parameters. You can configure how your operation writes the contents of your files in format_options. For details, see Parquet Configuration Reference.

The following AWS Glue ETL script shows the process of writing Parquet files and folders to S3.

We provide a custom Parquet writer with performance optimizations for DynamicFrames, through the useGlueParquetWriter configuration key. To determine if this writer is right for your workload, see Glue Parquet Writer.

**Python**

For this example, use the `write_dynamic_frame.from_options` method.

```python
# Example: Write Parquet to S3
# Consider whether useGlueParquetWriter is right for your workflow.
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
```
glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="s3",
    format="parquet",
    connection_options={
        "path": "s3://s3path",
    },
    format_options={
        # "useGlueParquetWriter": True,
    },
)

You can also use DataFrames in a script (pyspark.sql.DataFrame).

df.write.parquet("s3://s3path/")

Scala

For this example, use the getSinkWithFormat method.

// Example: Write Parquet to S3
// Consider whether useGlueParquetWriter is right for your workflow.

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    glueContext.getSinkWithFormat(
      connectionType="s3",
      options=JsonOptions("
          "path": "s3://s3path"
      "),
      format="parquet"
    ).writeDynamicFrame(dynamicFrame)
  }
}

You can also use DataFrames in a script (org.apache.spark.sql.DataFrame).
Parquet configuration reference

You can use the following `format_options` wherever AWS Glue libraries specify `format="parquet"`:

- `useGlueParquetWriter` – Specifies the use of a custom Parquet writer that has performance optimizations for DynamicFrame workflows. For usage details, see [Glue Parquet Writer](#).
  - **Type:** Boolean, **Default:** false

- `compression` – Specifies the compression codec used. Values are fully compatible with `org.apache.parquet.hadoop.metadata.CompressionCodecName`.
  - **Type:** Enumerated Text, **Default:** "snappy"
  - Values: "uncompressed", "snappy", "gzip", and "lzo"

- `blockSize` – Specifies the size in bytes of a row group being buffered in memory. You use this for tuning performance. Size should divide exactly into a number of megabytes.
  - **Type:** Numerical, **Default:** 134217728
  - The default value is equal to 128 MB.

- `pageSize` – Specifies the size in bytes of a page. You use this for tuning performance. A page is the smallest unit that must be read fully to access a single record.
  - **Type:** Numerical, **Default:** 1048576
  - The default value is equal to 1 MB.

---

**Note**

Additionally, any options that are accepted by the underlying SparkSQL code can be passed to this format by way of the `connection_options` map parameter. For example, you can set a Spark configuration such as `mergeSchema` for the AWS Glue Spark reader to merge the schema for all files.
Optimize write performance with AWS Glue Parquet writer

The AWS Glue Parquet writer has historically been accessed through the glueparquet format type. This access pattern is no longer advocated. Instead, use the parquet type with useGlueParquetWriter enabled.

The AWS Glue Parquet writer has performance enhancements that allow faster Parquet file writes. The traditional writer computes a schema before writing. The Parquet format doesn't store the schema in a quickly retrievable fashion, so this might take some time. With the AWS Glue Parquet writer, a pre-computed schema isn't required. The writer computes and modifies the schema dynamically, as data comes in.

Note the following limitations when you specify useGlueParquetWriter:

- The writer supports only schema evolution (such as adding or removing columns), but not changing column types, such as with ResolveChoice.
- The writer isn't able to store an empty DataFrame—for example, to write a schema-only file.

If your transform doesn't require these limitations, turning on the AWS Glue Parquet writer should increase performance.

Using the XML format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the XML data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the XML format. This format represents highly configurable, rigidly defined data structures that aren't row or column based. XML is highly standardized. For an introduction to the format by the standard authority, see XML Essentials.

You can use AWS Glue to read XML files from Amazon S3, as well as bzip and gzip archives containing XML files. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

The following table shows which common AWS Glue features support the XML format option.
Example: Read XML from S3

The XML reader takes an XML tag name. It examines elements with that tag within its input to infer a schema and populates a DataFrame with corresponding values. The AWS Glue XML functionality behaves similarly to the XML Data Source for Apache Spark. You might be able to gain insight around basic behavior by comparing this reader to that project's documentation.

Prerequisites: You will need the S3 paths (s3path) to the XML files or folders that you want to read, and some information about your XML file. You will also need the tag for the XML element you want to read, xmlTag.

Configuration: In your function options, specify format="xml". In your connection_options, use the paths key to specify s3path. You can further configure how the reader interacts with S3 in the connection_options. For details, see Connection types and options for ETL in AWS Glue: S3 connection parameters. In your format_options, use the rowTag key to specify xmlTag. You can further configure how the reader interprets XML files in your format_options. For details, see XML Configuration Reference.

The following AWS Glue ETL script shows the process of reading XML files or folders from S3.

Python

For this example, use the create_dynamic_frame.from_options method.

```
# Example: Read XML from S3
# Set the rowTag option to configure the reader.

from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    
```
You can also use DataFrames in a script (pyspark.sql.DataFrame).

```python
dataFrame = spark.read
    .format("xml")
    .option("rowTag", "xmlTag")
    .load("s3://s3path")
```

**Scala**

For this example, use the `getSourceWithFormat` operation.

```scala
// Example: Read XML from S3
// Set the rowTag option to configure the reader.

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.sql.SparkSession

val glueContext = new GlueContext(SparkContext.getOrCreate())
val sparkSession: SparkSession = glueContext.getSparkSession

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val dynamicFrame = glueContext.getSourceWithFormat(
      formatOptions=JsonOptions("{"rowTag": "xmlTag"}"),
      connectionType="s3",
      format="xml",
      options=JsonOptions("{"paths": ["s3://s3path"], "recurse": true}"))
      .getDynamicFrame()
  }
}

You can also use DataFrames in a script (org.apache.spark.sql.DataFrame).

```scala
val dataFrame = spark.read
  .option("rowTag", "xmlTag")
  .format("xml")
  .load("s3://s3path")
```
XML configuration reference

You can use the following format_options wherever AWS Glue libraries specify format="xml":

- **rowTag** – Specifies the XML tag in the file to treat as a row. Row tags cannot be self-closing.
  - **Type:** Text, **Required**
- **encoding** – Specifies the character encoding. It can be the name or alias of a Charset supported by our runtime environment. We don't make specific guarantees around encoding support, but major encodings should work.
  - **Type:** Text, **Default:** "UTF-8"
- **excludeAttribute** – Specifies whether you want to exclude attributes in elements or not.
  - **Type:** Boolean, **Default:** false
- **treatEmptyValuesAsNulls** – Specifies whether to treat white space as a null value.
  - **Type:** Boolean, **Default:** false
- **attributePrefix** – A prefix for attributes to differentiate them from child element text. This prefix is used for field names.
  - **Type:** Text, **Default:** "_"
- **valueTag** – The tag used for a value when there are attributes in the element that have no child.
  - **Type:** Text, **Default:** "_VALUE"
- **ignoreSurroundingSpaces** – Specifies whether the white space that surrounds values should be ignored.
  - **Type:** Boolean, **Default:** false
- **withSchema** – Contains the expected schema, in situations where you want to override the inferred schema. If you don't use this option, AWS Glue infers the schema from the XML data.
  - **Type:** Text, **Default:** Not applicable
  - The value should be a JSON object that represents a StructType.

Manually specify the XML schema

Manual XML schema example
This is an example of using the withSchema format option to specify the schema for XML data.

```python
from awsglue.gluetypes import *

schema = StructType([  
    Field("id", IntegerType()),  
    Field("name", StringType()),  
    Field("nested", StructType([  
        Field("x", IntegerType()),  
        Field("y", StringType()),  
        Field("z", ChoiceType([IntegerType(), StringType()]))  
    ]))])

datasource0 = create_dynamic_frame_from_options(  
    connection_type,  
    connection_options={"paths": ["s3://xml_bucket/someprefix"]},  
    format="xml",  
    format_options={"withSchema": json.dumps(schema.jsonValue())},  
    transformation_ctx = ""
)
```

### Using the Avro format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the Avro data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the Avro format. This format is a performance-oriented, row-based data format. For an introduction to the format by the standard authority see, [Apache Avro 1.8.2 Documentation](#).

You can use AWS Glue to read Avro files from Amazon S3 and from streaming sources as well as write Avro files to Amazon S3. You can read and write bzip2 and gzip archives containing Avro files from S3. Additionally, you can write deflate, snappy, and xz archives containing Avro files. You configure compression behavior on the [S3 connection parameters](#) instead of in the configuration discussed on this page.

The following table shows which common AWS Glue operations support the Avro format option.
### Supported with restrictions. For more information, see the section called “Notes and restrictions for Avro streaming sources”.

**Example: Read Avro files or folders from S3**

**Prerequisites:** You will need the S3 paths (s3path) to the Avro files or folders that you want to read.

**Configuration:** In your function options, specify `format="avro"`. In your `connection_options`, use the `paths` key to specify `s3path`. You can configure how the reader interacts with S3 in the `connection_options`. For details, see Data format options for ETL inputs and outputs in AWS Glue: the section called “S3 connection parameters”. You can configure how the reader interprets Avro files in your `format_options`. For details, see Avro Configuration Reference.

The following AWS Glue ETL script shows the process of reading Avro files or folders from S3:

**Python**

For this example, use the `create_dynamic_frame.from_options` method.

```python
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    connection_options={"paths": ["s3://s3path"]},
    format="avro"
)
```

**Scala**

For this example, use the `getSourceWithFormat` operation.
```scala
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.sql.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    val dynamicFrame = glueContext.getSourceWithFormat(
      connectionType="s3",
      format="avro",
      options=JsonOptions("""{"paths": ["s3://s3path"]}""
    ).getDynamicFrame()
  }
}
```

**Example: Write Avro files and folders to S3**

**Prerequisites:** You will need an initialized DataFrame (DataFrame) or DynamicFrame (dynamicFrame). You will also need your expected S3 output path, s3path.

**Configuration:** In your function options, specify format="avro". In your connection_options, use the paths key to specify your s3path. You can further alter how the writer interacts with S3 in the connection_options. For details, see Data format options for ETL inputs and outputs in AWS Glue: the section called “S3 connection parameters”. You can alter how the writer interprets Avro files in your format_options. For details, see Avro Configuration Reference.

The following AWS Glue ETL script shows the process of writing Avro files or folders to S3.

**Python**

For this example, use the `write_dynamic_frame.from_options` method.

```python
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

glueContext.write_dynamic_frame.from_options(
  frame=dynamicFrame,
  
```
For this example, use the `getSinkWithFormat` method.

```scala
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    glueContext.getSinkWithFormat(
      connectionType="s3",
      options=JsonOptions("{"path": "s3://s3path"}
    ).format="avro"
    ).writeDynamicFrame(dynamicFrame)
  }
}
```

### Avro configuration reference

You can use the following `format_options` values wherever AWS Glue libraries specify `format="avro"`:

- **version** — Specifies the version of Apache Avro reader/writer format to support. The default is "1.7". You can specify `format_options={"version": "1.8"}` to enable Avro logical type reading and writing. For more information, see the [Apache Avro 1.7.7 Specification](http://avro.apache.org/docs/1.7.7/specification.html) and [Apache Avro 1.8.2 Specification](http://avro.apache.org/docs/1.8.2/specification.html).

The Apache Avro 1.8 connector supports the following logical type conversions:
For the reader: this table shows the conversion between Avro data type (logical type and Avro primitive type) and AWS Glue *DynamicFrame* data type for Avro reader 1.7 and 1.8.

<table>
<thead>
<tr>
<th>Avro Data Type: Logical Type</th>
<th>Avro Data Type: Avro Primitive Type</th>
<th>GlueDynamicFrame Data Type: Avro Reader 1.7</th>
<th>GlueDynamicFrame Data Type: Avro Reader 1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal</td>
<td>bytes</td>
<td>BINARY</td>
<td>Decimal</td>
</tr>
<tr>
<td>Decimal</td>
<td>fixed</td>
<td>BINARY</td>
<td>Decimal</td>
</tr>
<tr>
<td>Date</td>
<td>int</td>
<td>INT</td>
<td>Date</td>
</tr>
<tr>
<td>Time (millisecond)</td>
<td>int</td>
<td>INT</td>
<td>INT</td>
</tr>
<tr>
<td>Time (microsecond)</td>
<td>long</td>
<td>LONG</td>
<td>LONG</td>
</tr>
<tr>
<td>Timestamp (millisecond)</td>
<td>long</td>
<td>LONG</td>
<td>Timestamp</td>
</tr>
<tr>
<td>Timestamp (microsecond)</td>
<td>long</td>
<td>LONG</td>
<td>LONG</td>
</tr>
<tr>
<td>Duration (not a logical type)</td>
<td>fixed of 12</td>
<td>BINARY</td>
<td>BINARY</td>
</tr>
</tbody>
</table>

For the writer: this table shows the conversion between AWS Glue *DynamicFrame* data type and Avro data type for Avro writer 1.7 and 1.8.

<table>
<thead>
<tr>
<th>AWS Glue DynamicFrame Data Type</th>
<th>Avro Data Type: Avro Writer 1.7</th>
<th>Avro Data Type: Avro Writer 1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal</td>
<td>String</td>
<td>decimal</td>
</tr>
<tr>
<td>Date</td>
<td>String</td>
<td>date</td>
</tr>
<tr>
<td>Timestamp</td>
<td>String</td>
<td>timestamp-micros</td>
</tr>
</tbody>
</table>
Avro Spark DataFrame support

In order to use Avro from the Spark DataFrame API, you need to install the Spark Avro plugin for the corresponding Spark version. The version of Spark available in your job is determined by your AWS Glue version. For more information about Spark versions, see the section called “AWS Glue versions”. This plugin is maintained by Apache, we do not make specific guarantees of support.

In AWS Glue 2.0 - use version 2.4.3 of the Spark Avro plugin. You can find this JAR on Maven Central, see org.apache.spark:spark-avro_2.12:2.4.3.

In AWS Glue 3.0 - use version 3.1.1 of the Spark Avro plugin. You can find this JAR on Maven Central, see org.apache.spark:spark-avro_2.12:3.1.1.

To include extra JARs in a AWS Glue ETL job, use the --extra-jars job parameter. For more information about job parameters, see the section called “Job parameters”. You can also configure this parameter in the AWS Management Console.

Using the grokLog format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in a loosely structured plaintext format, this document introduces you available features for using your data in AWS Glue through Grok patterns.

AWS Glue supports using Grok patterns. Grok patterns are similar to regular expression capture groups. They recognize patterns of character sequences in a plaintext file and give them a type and purpose. In AWS Glue, their primary purpose is to read logs. For an introduction to the Grok by the authors, see Logstash Reference: Grok filter plugin.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Not Applicable</td>
<td>Supported</td>
<td>Supported</td>
<td>Unsupported</td>
</tr>
</tbody>
</table>

grokLog configuration reference

You can use the following format_options values with format="grokLog":

- logFormat — Specifies the Grok pattern that matches the log's format.
- **customPatterns** — Specifies additional Grok patterns used here.
- **MISSING** — Specifies the signal to use in identifying missing values. The default is '-'.
- **LineCount** — Specifies the number of lines in each log record. The default is '1', and currently only single-line records are supported.
- **StrictMode** — A Boolean value that specifies whether strict mode is turned on. In strict mode, the reader doesn't do automatic type conversion or recovery. The default value is "false".

### Using the Ion format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the Ion data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the Ion format. This format represents data structures (that aren't row or column based) in interchangeable binary and plaintext representations. For an introduction to the format by the authors, see [Amazon Ion](https://aws.amazon.com/ion/). (For more information, see the [Amazon Ion Specification](https://docs.aws.amazon.com/ion/latest/developerguide/).

You can use AWS Glue to read Ion files from Amazon S3. You can read bzip and gzip archives containing Ion files from S3. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

The following table shows which common AWS Glue operations support the Ion format option.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Unsupported</td>
<td>Unsupported</td>
<td>Supported</td>
<td>Unsupported</td>
</tr>
</tbody>
</table>

### Example: Read Ion files and folders from S3

**Prerequisites:** You will need the S3 paths (s3path) to the Ion files or folders that you want to read.

**Configuration:** In your function options, specify `format="json"`. In your connection_options, use the paths key to specify your s3path. You can configure how the reader interacts with S3 in the connection_options. For details, see Connection types and options for ETL in AWS Glue: the section called “S3 connection parameters”.
The following AWS Glue ETL script shows the process of reading Ion files or folders from S3:

**Python**

For this example, use the `create_dynamic_frame.from_options` method.

```python
# Example: Read ION from S3
from pyspark.context import SparkContext
from awsglue.context import GlueContext
sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    connection_options={"paths": ["s3://s3path"],
                        "recurse": true,
                        "format": "ion"},
)
```

**Scala**

For this example, use the `getSourceWithFormat` operation.

```scala
// Example: Read ION from S3
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext
object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    val dynamicFrame = glueContext.getSourceWithFormat(
      connectionType="s3",
      format="ion",
      options=JsonOptions("{"paths": ["s3://s3path"], "recurse": true}""
    ).getDynamicFrame()
  }
}
```
Ion configuration reference

There are no format_options values for format="ion".

Using the JSON format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the JSON data format, this document introduces you to available features for using your data in AWS Glue.

AWS Glue supports using the JSON format. This format represents data structures with consistent shape but flexible contents, that aren't row or column based. JSON is defined by parallel standards issued by several authorities, one of which is ECMA-404. For an introduction to the format by a commonly referenced source, see Introducing JSON.

You can use AWS Glue to read JSON files from Amazon S3, as well as bzip and gzip compressed JSON files. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
</tbody>
</table>

Example: Read JSON files or folders from S3

Prerequisites: You will need the S3 paths (s3path) to the JSON files or folders you would like to read.

Configuration: In your function options, specify format="json". In your connection_options, use the paths key to specify your s3path. You can further alter how your read operation will traverse s3 in the connection options, consult the section called “S3 connection parameters” for details. You can configure how the reader interprets JSON files in your format_options. For details, see JSON Configuration Reference.

The following AWS Glue ETL script shows the process of reading JSON files or folders from S3:

Python

For this example, use the create_dynamic_frame.from_options method.
# Example: Read JSON from S3
# For show, we handle a nested JSON file that we can limit with the JsonPath parameter
# For show, we also handle a JSON where a single entry spans multiple lines
# Consider whether optimizePerformance is right for your workflow.

from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)
spark = glueContext.spark_session

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    connection_options={"paths": ["s3://s3path"]},
    format="json",
    format_options=
        "jsonPath": ".id",
        "multiline": True,
        # "optimizePerformance": True, -> not compatible with JsonPath, multiline
)

You can also use DataFrames in a script (pyspark.sql.DataFrame).

dataFrame = spark.read
  .option("multiline", "true")
  .json("s3://s3path")

Scala

For this example, use the `getSourceWithFormat` operation.

// Example: Read JSON from S3
// For show, we handle a nested JSON file that we can limit with the JsonPath parameter
// For show, we also handle a JSON where a single entry spans multiple lines
// Consider whether optimizePerformance is right for your workflow.

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    val dynamicFrame = glueContext.getSourceWithFormat(
      formatOptions=JsonOptions("{""jsonPath": ".id", "multiline": true,
      "optimizePerformance":false}""),
      connectionType="s3",
      format="json",
      options=JsonOptions("{""paths": ["s3://s3path"], "recurse": true}""
    ).getDynamicFrame()
  }
}

You can also use DataFrames in a script (pyspark.sql.DataFrame).

val dataFrame = spark.read
  .option("multiline", "true")
  .json("s3://s3path")

**Example: Write JSON files and folders to S3**

**Prerequisites:** You will need an initialized DataFrame (dataFrame) or DynamicFrame (dynamicFrame). You will also need your expected S3 output path, s3path.

**Configuration:** In your function options, specify format="json". In your connection_options, use the paths key to specify s3path. You can further alter how the writer interacts with S3 in the connection_options. For details, see Data format options for ETL inputs and outputs in AWS Glue: the section called “S3 connection parameters”. You can configure how the writer interprets JSON files in your format_options. For details, see JSON Configuration Reference.

The following AWS Glue ETL script shows the process of writing JSON files or folders from S3:

**Python**

For this example, use the [write_dynamic_frame.from_options](https://spark.apache.org/docs/latest/api/python/api/pyspark.sql.html#pyspark.sql.DataFrame.write_dynamic_frame) method.

```python
# Example: Write JSON to S3
```
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="s3",
    connection_options={"path": "s3://s3path"},
    format="json"
)

You can also use DataFrames in a script (pyspark.sql.DataFrame).

df.write.json("s3://s3path")

Scala

For this example, use the getSinkWithFormat method.

// Example: Write JSON to S3

import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
    def main(sysArgs: Array[String]): Unit = {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)

        glueContext.getSinkWithFormat(
            connectionType="s3",
            options=JsonOptions("{"path": "s3://s3path"}",
            format="json"
        ).writeDynamicFrame(dynamicFrame)
    }
}

You can also use DataFrames in a script (pyspark.sql.DataFrame).
df.write.json("s3://s3path")

Json configuration reference

You can use the following format_options values with format="json":

- **jsonPath** — A [JsonPath](#) expression that identifies an object to be read into records. This is particularly useful when a file contains records nested inside an outer array. For example, the following JsonPath expression targets the `id` field of a JSON object.

  ```python
  format="json", format_options={"jsonPath": ".id"}
  ```

- **multiLine** — A Boolean value that specifies whether a single record can span multiple lines. This can occur when a field contains a quoted new-line character. You must set this option to "true" if any record spans multiple lines. The default value is "false", which allows for more aggressive file-splitting during parsing.

- **optimizePerformance** — A Boolean value that specifies whether to use the advanced SIMD JSON reader along with Apache Arrow based columnar memory formats. Only available in AWS Glue 3.0. Not compatible with multiLine or jsonPath. Providing either of those options will instruct AWS Glue to fall back to the standard reader.

- **withSchema** — A String value that specifies a table schema in the format described in the [section called “Specify XML schema”](#). Only used with optimizePerformance when reading from non-Catalog connections.

Using vectorized SIMD JSON reader with Apache Arrow columnar format

AWS Glue version 3.0 adds a vectorized reader for JSON data. It performs 2x faster under certain conditions, compared to the standard reader. This reader comes with certain limitations users should be aware of before use, documented in this section.

To use the optimized reader, set "optimizePerformance" to True in the format_options or table property. You will also need to provide withSchema unless reading from the catalog. withSchema expects an input as described in the [section called “Specify XML schema”](#)

```python
// Read from S3 data source
glueContext.create_dynamic_frame.from_options(
```
connection_type = "s3",
connection_options = {"paths": ["s3://s3path"]},
format = "json",
format_options={
    "optimizePerformance": True,
    "withSchema": SchemaString
})

// Read from catalog table
glueContext.create_dynamic_frame.from_catalog(
    database = database,
    table_name = table,
    additional_options = {
        // The vectorized reader for JSON can read your schema from a catalog table property.
        "optimizePerformance": True,
    })

Limitations for the vectorized CSV reader

Note the following limitations:

- JSON elements with nested objects or array values are not supported. If provided, AWS Glue will fall back to the standard reader.
- A schema must be provided, either from the Catalog or with withSchema.
- Not compatible with multiLine or jsonPath. Providing either of those options will instruct AWS Glue to fall back to the standard reader.
- Providing input records that do not match the input schema will cause the reader to fail.
- Error records will not be created.
- JSON files with multi-byte characters (such as Japanese or Chinese characters) are not supported.

Using the ORC format in AWS Glue

AWS Glue retrieves data from sources and writes data to targets stored and transported in various data formats. If your data is stored or transported in the ORC data format, this document introduces you available features for using your data in AWS Glue.

AWS Glue supports using the ORC format. This format is a performance-oriented, column-based data format. For an introduction to the format by the standard authority see, Apache Orc.
You can use AWS Glue to read ORC files from Amazon S3 and from streaming sources as well as write ORC files to Amazon S3. You can read and write bzip and gzip archives containing ORC files from S3. You configure compression behavior on the S3 connection parameters instead of in the configuration discussed on this page.

The following table shows which common AWS Glue operations support the ORC format option.

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Streaming read</th>
<th>Group small files</th>
<th>Job bookmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Unsupported</td>
<td>Supported*</td>
</tr>
</tbody>
</table>

*Supported in AWS Glue version 1.0+

**Example: Read ORC files or folders from S3**

**Prerequisites:** You will need the S3 paths (s3path) to the ORC files or folders that you want to read.

**Configuration:** In your function options, specify format="orc". In your connection_options, use the paths key to specify your s3path. You can configure how the reader interacts with S3 in the connection_options. For details, see Connection types and options for ETL in AWS Glue: the section called “S3 connection parameters”.

The following AWS Glue ETL script shows the process of reading ORC files or folders from S3:

**Python**

For this example, use the create_dynamic_frame.from_options method.

```python
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

dynamicFrame = glueContext.create_dynamic_frame.from_options(
    connection_type="s3",
    connection_options={"paths": ["s3://s3path"],
    format="orc"
)
```
You can also use DataFrames in a script (`pyspark.sql.DataFrame`).

```python
dataFrame = spark.read
    .orc("s3://s3path")
```

**Scala**

For this example, use the `getSourceWithFormat` operation.

```scala
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.sql.SparkContext

object GlueApp {
    def main(sysArgs: Array[String]): Unit = {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)

        val dynamicFrame = glueContext.getSourceWithFormat(
            connectionType="s3",
            format="orc",
            options=JsonOptions("""{"paths": ["s3://s3path"]}"")
        ).getDynamicFrame()
    }
}
```

You can also use DataFrames in a script (`pyspark.sql.DataFrame`).

```scala
val dataFrame = spark.read
    .orc("s3://s3path")
```

**Example: Write ORC files and folders to S3**

**Prerequisites:** You will need an initialized DataFrame (dataFrame) or DynamicFrame (dynamicFrame). You will also need your expected S3 output path, `s3path`.

**Configuration:** In your function options, specify `format="orc"`. In your connection options, use the `paths` key to specify `s3path`. You can further alter how the writer interacts with S3 in the `connection_options`. For details, see Data format options for ETL inputs and outputs in AWS Glue: the section called “S3 connection parameters”. The following code example shows the process:
Python

For this example, use the `write_dynamic_frame.from_options` method.

```python
from pyspark.context import SparkContext
from awsglue.context import GlueContext

sc = SparkContext.getOrCreate()
glueContext = GlueContext(sc)

glueContext.write_dynamic_frame.from_options(
    frame=dynamicFrame,
    connection_type="s3",
    format="orc",
    connection_options={
        "path": "s3://s3path"
    }
)
```

You can also use DataFrames in a script (`pyspark.sql.DataFrame`).

```python
df.write.orc("s3://s3path/")
```

Scala

For this example, use the `getSinkWithFormat` method.

```scala
import com.amazonaws.services.glue.util.JsonOptions
import com.amazonaws.services.glue.{DynamicFrame, GlueContext}
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)

    glueContext.getSinkWithFormat(
        connectionType="s3",
        options=JsonOptions("""{"path": "s3://s3path"}""),
        format="orc"
    ).writeDynamicFrame(dynamicFrame)
  }
}
You can also use DataFrames in a script (pyspark.sql.DataFrame).

df.write.orc("s3://s3path/")

**ORC configuration reference**

There are no format_options values for format="orc". However, any options that are accepted by the underlying SparkSQL code can be passed to it by way of the connection_options map parameter.

**Using data lake frameworks with AWS Glue ETL jobs**

Open-source data lake frameworks simplify incremental data processing for files that you store in data lakes built on Amazon S3. AWS Glue 3.0 and later supports the following open-source data lake frameworks:

- Apache Hudi
- Linux Foundation Delta Lake
- Apache Iceberg

We provide native support for these frameworks so that you can read and write data that you store in Amazon S3 in a transactionally consistent manner. There's no need to install a separate connector or complete extra configuration steps in order to use these frameworks in AWS Glue ETL jobs.

When you manage datasets through the AWS Glue Data Catalog, you can use AWS Glue methods to read and write data lake tables with Spark DataFrames. You can also read and write Amazon S3 data using the Spark DataFrame API.

In this video, you can learn about the basics of how Apache Hudi, Apache Iceberg, and Delta Lake work. You'll see how to insert, update, and delete data in your data lake and how each of these frameworks works.

**Topics**

- [Limitations](#)
- [Using the Hudi framework in AWS Glue](#)
- Using the Delta Lake framework in AWS Glue
- Using the Iceberg framework in AWS Glue

Limitations

Consider the following limitations before you use data lake frameworks with AWS Glue.

- The following AWS Glue GlueContext methods for DynamicFrame don't support reading and writing data lake framework tables. Use the GlueContext methods for DataFrame or Spark DataFrame API instead.
  - The following GlueContext methods for DynamicFrame are not supported with Lake Formation permission control:
    - create_dynamic_frame.from_catalog
    - write_dynamic_frame.from_catalog
    - getDynamicFrame
    - writeDynamicFrame
  - The following GlueContext methods for DataFrame are supported with Lake Formation permission control:
    - create_data_frame.from_catalog
    - write_data_frame.from_catalog
    - getDataFrame
    - writeDataFrame
- Grouping small files is not supported.
- Job bookmarks are not supported.
- Apache Hudi 0.10.1 for AWS Glue 3.0 doesn't support Hudi Merge on Read (MoR) tables.
- ALTER TABLE ... RENAME TO is not available for Apache Iceberg 0.13.1 for AWS Glue 3.0.

Limitations for data lake format tables managed by Lake Formation permissions

The data lake formats are integrated with AWS Glue ETL via Lake Formation permissions. Creating a DynamicFrame using create_dynamic_frame is not supported. For more information, see the following examples:

- Example: Read and write Iceberg table with Lake Formation permission control
• **Example: Read and write Hudi table with Lake Formation permission control**

• **Example: Read and write Delta Lake table with Lake Formation permission control**

Apache Iceberg has the best integration with AWS Glue ETL via Lake Formation permissions. It supports almost all operations and includes SQL support.

Hudi supports most basic operations with the exception of administrative operations. This is because these options generally are done via writing of dataframes and specified via additional_options. You need to use AWS Glue APIs to create DataFrames for your operations as SparkSQL is not supported.

Delta Lake only supports the reading and appending and overwriting of table data. Delta Lake requires the use of their own libraries to be able to perform various tasks such as updates.

The following features are not available for Iceberg tables managed by Lake Formation permissions.

- Compaction using AWS Glue ETL
- Spark SQL support via AWS Glue ETL

The following are limitations of Hudi tables managed by Lake Formation permissions:

- Removal of orphaned files

The following are limitations of Delta Lake tables managed by Lake Formation permissions:

- All features other than inserting and reading from Delta Lake tables.

**Using the Hudi framework in AWS Glue**

AWS Glue 3.0 and later supports Apache Hudi framework for data lakes. Hudi is an open-source data lake storage framework that simplifies incremental data processing and data pipeline development. This topic covers available features for using your data in AWS Glue when you transport or store your data in a Hudi table. To learn more about Hudi, see the official [Apache Hudi documentation](#).
You can use AWS Glue to perform read and write operations on Hudi tables in Amazon S3, or work with Hudi tables using the AWS Glue Data Catalog. Additional operations including insert, update, and all of the Apache Spark operations are also supported.

Note: Apache Hudi 0.10.1 for AWS Glue 3.0 doesn't support Hudi Merge on Read (MoR) tables.

The following table lists the Hudi version that is included in each AWS Glue version.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported Hudi version</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>0.12.1</td>
</tr>
<tr>
<td>3.0</td>
<td>0.10.1</td>
</tr>
</tbody>
</table>

To learn more about the data lake frameworks that AWS Glue supports, see Using data lake frameworks with AWS Glue ETL jobs.

Enabling Hudi

To enable Hudi for AWS Glue, complete the following tasks:

- Specify hudi as a value for the --datalake-formats job parameter. For more information, see AWS Glue job parameters.
- Create a key named --conf for your AWS Glue job, and set it to the following value. Alternatively, you can set the following configuration using SparkConf in your script. These settings help Apache Spark correctly handle Hudi tables.

```
spark.serializer=org.apache.spark.serializer.KryoSerializer --conf
spark.sql.hive.convertMetastoreParquet=false
```

- Lake Formation permission support for Hudi is enabled by default for AWS Glue 4.0. No additional configuration is needed for reading/writing to Lake Formation-registered Hudi tables. To read a registered Hudi table, the AWS Glue job IAM role must have the SELECT permission. To write to a registered Hudi table, the AWS Glue job IAM role must have the SUPER permission. To learn more about managing Lake Formation permissions, see Granting and revoking permissions on Data Catalog resources.
Using a different Hudi version

To use a version of Hudi that AWS Glue doesn't support, specify your own Hudi JAR files using the --extra-jars job parameter. Do not include hudi as a value for the --datalake-formats job parameter.

Example: Write a Hudi table to Amazon S3 and register it in the AWS Glue Data Catalog

This example script demonstrates how to write a Hudi table to Amazon S3 and register the table to the AWS Glue Data Catalog. The example uses the Hudi Hive Sync tool to register the table.

⚠️ Note

This example requires you to set the --enable-glue-datacatalog job parameter in order to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To learn more, see AWS Glue job parameters.

Python

```python
# Example: Create a Hudi table from a DataFrame
# and register the table to Glue Data Catalog

additional_options={
    "hoodie.table.name": "<your_table_name>",
    "hoodie.datasource.write.storage.type": "COPY_ON_WRITE",
    "hoodie.datasource.write.operation": "upsert",
    "hoodie.datasource.write.recordkey.field": "<your_recordkey_field>",
    "hoodie.datasource.write.precombine.field": "<your_precombine_field>",
    "hoodie.datasource.write.partitionpath.field": "<your_partitionkey_field>",
    "hoodie.datasource.write.hive_style_partitioning": "true",
    "hoodie.datasource.hive_sync.enable": "true",
    "hoodie.datasource.hive_sync.database": "<your_database_name>",
    "hoodie.datasource.hive_sync.table": "<your_table_name>",
    "hoodie.datasource.hive_sync.partition_fields": "<your_partitionkey_field>",
    "hoodie.datasource.hive_sync.partition_extractor_class": "org.apache.hudi.hive.MultipartKeysValueExtractor",
    "hoodie.datasource.hive_sync.use_jdbc": "false",
    "hoodie.datasource.hive_sync.mode": "hms",
    "path": "s3://<s3Path>"
}
```
dataFrame.write.format("hudi")
    .options(**additional_options)
    .mode("overwrite")
    .save()

Scala

// Example: Example: Create a Hudi table from a DataFrame
// and register the table to Glue Data Catalog

val additionalOptions = Map(
    "hoodie.table.name" -> "<your_table_name>",
    "hoodie.datasource.write.storage.type" -> "COPY_ON_WRITE",
    "hoodie.datasource.write.operation" -> "upsert",
    "hoodie.datasource.write.recordkey.field" -> "<your_recordkey_field>",
    "hoodie.datasource.write.precombine.field" -> "<your_precombine_field>",
    "hoodie.datasource.write.partitionpath.field" -> "<your_partitionkey_field>",
    "hoodie.datasource.write.hive_style_partitioning" -> "true",
    "hoodie.datasource.hive_sync.enable" -> "true",
    "hoodie.datasource.hive_sync.database" -> "<your_database_name>",
    "hoodie.datasource.hive_sync.table" -> "<your_table_name>",
    "hoodie.datasource.hive_sync.partition_fields" -> "<your_partitionkey_field>",
    "hoodie.datasource.hive_sync.partition_extractor_class" -> "org.apache.hudi.hive.MultipartKeysValueExtractor",
    "hoodie.datasource.hive_sync.use_jdbc" -> "false",
    "hoodie.datasource.hive_sync.mode" -> "hms",
    "path" -> "s3://<s3Path/>")

dataFrame.write.format("hudi")
    .options(additionalOptions)
    .mode("append")
    .save()

Example: Read a Hudi table from Amazon S3 using the AWS Glue Data Catalog

This example reads the Hudi table that you created in the Example: Write a Hudi table to Amazon S3 and register it in the AWS Glue Data Catalog from Amazon S3.
**Note**

This example requires you to set the `--enable-glue-datacatalog` job parameter in order to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To learn more, see [AWS Glue job parameters](https://docs.aws.amazon.com/glue/latest/dg/job-parameters.html).

### Python

For this example, use the `GlueContext.create_data_frame.from_catalog()` method.

```python
# Example: Read a Hudi table from Glue Data Catalog

from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)

dataFrame = glueContext.create_data_frame.from_catalog(
    database = "<your_database_name>",
    table_name = "<your_table_name>"
)
```

### Scala

For this example, use the `getCatalogSource` method.

```
// Example: Read a Hudi table from Glue Data Catalog

import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext

object GlueApp {
    def main(sysArgs: Array[String]): Unit = {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)

        val dataframe = glueContext.getCatalogSource(
            database = "<your_database_name>",
            tableName = "<your_table_name>"
        ).getDataFrame()
    }
}
Example: Update and insert a DataFrame into a Hudi table in Amazon S3

This example uses the AWS Glue Data Catalog to insert a DataFrame into the Hudi table that you created in Example: Write a Hudi table to Amazon S3 and register it in the AWS Glue Data Catalog.

### Note

This example requires you to set the `--enable-glue-datacatalog` job parameter in order to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To learn more, see AWS Glue job parameters.

Python

For this example, use the `GlueContext.write_data_frame.from_catalog()` method.

```python
# Example: Upsert a Hudi table from Glue Data Catalog

from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)

glueContext.write_data_frame.from_catalog(
    frame = dataframe,
    database = "<your_database_name>",
    table_name = "<your_table_name>",
    additional_options={
        "hoodie.table.name": "<your_table_name>",
        "hoodie.datasource.write.storage.type": "COPY_ON_WRITE",
        "hoodie.datasource.write.operation": "upsert",
        "hoodie.datasource.write.recordkey.field": "<your_recordkey_field>",
        "hoodie.datasource.write.precombine.field": "<your_precombine_field>",
        "hoodie.datasource.write.partitionpath.field": "<your_partitionkey_field>",
        "hoodie.datasource.write.hive_style_partitioning": "true",
        "hoodie.datasource.hive_sync.enable": "true",
        "hoodie.datasource.hive_sync.database": "<your_database_name>",
```
Scala

For this example, use the `getCatalogSink` method.

```scala
// Example: Upsert a Hudi table from Glue Data Catalog

import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.util.JsonOptions
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    glueContext.getCatalogSink("<your_database_name>", "<your_table_name>",
      additionalOptions = JsonOptions(Map(
        "hoodie.table.name" -> "<your_table_name>",
        "hoodie.datasource.write.storage.type" -> "COPY_ON_WRITE",
        "hoodie.datasource.write.operation" -> "upsert",
        "hoodie.datasource.write.recordkey.field" -> "<your_recordkey_field>",
        "hoodie.datasource.write.precombine.field" -> "<your_precombine_field>",
        "hoodie.datasource.write.partitionpath.field" ->
          "<your_partitionkey_field>",
        "hoodie.datasource.write.hive_style_partitioning" -> "true",
        "hoodie.datasource.hive_sync.enable" -> "true",
        "hoodie.datasource.hive_sync.database" -> "<your_database_name>",
        "hoodie.datasource.hive_sync.table" -> "<your_table_name>",
        "hoodie.datasource.hive_sync.partition_fields" ->
          "<your_partitionkey_field>",
        "org.apache.hudi.hive.MultiPartKeysValueExtractor",
        "hoodie.datasource.hive_sync.use_jdbc" -> "false",
        "hoodie.datasource.hive_sync.mode" -> "hms"
      )))
    .writeDataFrame(dataFrame, glueContext)
  }
}
```
Example: Read a Hudi table from Amazon S3 using Spark

This example reads a Hudi table from Amazon S3 using the Spark DataFrame API.

Python

```python
# Example: Read a Hudi table from S3 using a Spark DataFrame
dataFrame = spark.read.format("hudi").load("s3://<s3path/>")
```

Scala

```scala
// Example: Read a Hudi table from S3 using a Spark DataFrame
val dataFrame = spark.read.format("hudi").load("s3://<s3path/>")
```

Example: Write a Hudi table to Amazon S3 using Spark

This example writes a Hudi table to Amazon S3 using Spark.

Python

```python
# Example: Write a Hudi table to S3 using a Spark DataFrame
dataFrame.write.format("hudi")
  .options(**additional_options)
  .mode("overwrite")
  .save("s3://<s3Path/>")
```

Scala

```scala
// Example: Write a Hudi table to S3 using a Spark DataFrame
dataFrame.write.format("hudi")
  .options(additionalOptions)
  .mode("overwrite")
```
**Example: Read and write Hudi table with Lake Formation permission control**

This example reads and writes a Hudi table with Lake Formation permission control.

1. Create a Hudi table and register it in Lake Formation.
   a. To enable Lake Formation permission control, you’ll first need to register the table Amazon S3 path on Lake Formation. For more information, see [Registering an Amazon S3 location](#). You can register it either from the Lake Formation console or by using the AWS CLI:

   ```bash
   aws lakeformation register-resource --resource-arn arn:aws:s3:::<s3-bucket>/<s3-folder> --use-service-linked-role --region <REGION>
   ```

   Once you register an Amazon S3 location, any AWS Glue table pointing to the location (or any of its child locations) will return the value for the IsRegisteredWithLakeFormation parameter as true in the GetTable call.
   
   b. Create a Hudi table that points to the registered Amazon S3 path through the Spark dataframe API:

   ```python
   hudi_options = {
       'hoodie.table.name': table_name,
       'hoodie.datasource.write.storage.type': 'COPY_ON_WRITE',
       'hoodie.datasource.write.recordkey.field': 'product_id',
       'hoodie.datasource.write.table.name': table_name,
       'hoodie.datasource.write.operation': 'upsert',
       'hoodie.datasource.write.precombine.field': 'updated_at',
       'hoodie.datasource.write.hive_style_partitioning': 'true',
       'hoodie.upsert.shuffle.parallelism': 2,
       'hoodie.insert.shuffle.parallelism': 2,
       'path': <S3_TABLE_LOCATION>,
       'hoodie.datasource.hive_sync.enable': 'true',
       'hoodie.datasource.hive_sync.database': database_name,
       'hoodie.datasource.hive_sync.table': table_name,
       'hoodie.datasource.hive_sync.use_jdbc': 'false',
       'hoodie.datasource.hive_sync.mode': 'hms'
   }

   df_products.write.format("hudi") .options(**hudi_options) \
   .save("s3://<s3path/>")
   ```
2. Grant Lake Formation permission to the AWS Glue job IAM role. You can either grant permissions from the Lake Formation console, or using the AWS CLI. For more information, see [Granting table permissions using the Lake Formation console and the named resource method](#).

3. Read the Hudi table registered in Lake Formation. The code is same as reading a non-registered Hudi table. Note that the AWS Glue job IAM role needs to have the SELECT permission for the read to succeed.

   ```scala
   val dataframe = glueContext.getCatalogSource(
       database = "<your_database_name>",
       tableName = "<your_table_name>"
   ).getDataFrame()
   ```

4. Write to a Hudi table registered in Lake Formation. The code is same as writing to a non-registered Hudi table. Note that the AWS Glue job IAM role needs to have the SUPER permission for the write to succeed.

   ```scala
   glueContext.getCatalogSink("<your_database_name>", "<your_table_name>",
       additionalOptions = JsonOptions(Map(
       "hoodie.table.name" -> "<your_table_name>",
       "hoodie.datasource.write.storage.type" -> "COPY_ON_WRITE",
       "hoodie.datasource.write.operation" -> "<write_operation>",
       "hoodie.datasource.write.recordkey.field" -> "<your_recordkey_field>",
       "hoodie.datasource.write.precombine.field" -> "<your_precombine_field>",
       "hoodie.datasource.write.partitionpath.field" -> "<your_partitionkey_field>",
       "hoodie.datasource.write.hive_style_partitioning" -> "true",
       "hoodie.datasource.hive_sync.enable" -> "true",
       "hoodie.datasource.hive_sync.database" -> "<your_database_name>",
       "hoodie.datasource.hive_sync.table" -> "<your_table_name>",
       "hoodie.datasource.hive_sync.partition_fields" -> "<your_partitionkey_field>",
       "hoodie.datasource.hive_sync.partition_extractor_class" -> "org.apache.hudi.hive.MultiPartKeysValueExtractor",
       "hoodie.datasource.hive_sync.use_jdbc" -> "false",
       "hoodie.datasource.hive_sync.mode" -> "hms"
       ))
   .writeDataFrame(dataFrame, glueContext)
   ```
Using the Delta Lake framework in AWS Glue

AWS Glue 3.0 and later supports the Linux Foundation Delta Lake framework. Delta Lake is an open-source data lake storage framework that helps you perform ACID transactions, scale metadata handling, and unify streaming and batch data processing. This topic covers available features for using your data in AWS Glue when you transport or store your data in a Delta Lake table. To learn more about Delta Lake, see the official Delta Lake documentation.

You can use AWS Glue to perform read and write operations on Delta Lake tables in Amazon S3, or work with Delta Lake tables using the AWS Glue Data Catalog. Additional operations such as insert, update, and Table batch reads and writes are also supported. When you use Delta Lake tables, you also have the option to use methods from the Delta Lake Python library such as DeltaTable.forPath. For more information about the Delta Lake Python library, see Welcome to Delta Lake's Python documentation page.

The following table lists the version of Delta Lake included in each AWS Glue version.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported Delta Lake version</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>2.1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>1.0.0</td>
</tr>
</tbody>
</table>

To learn more about the data lake frameworks that AWS Glue supports, see Using data lake frameworks with AWS Glue ETL jobs.

Enabling Delta Lake for AWS Glue

To enable Delta Lake for AWS Glue, complete the following tasks:

- Specify delta as a value for the --datalake-formats job parameter. For more information, see AWS Glue job parameters.

- Create a key named --conf for your AWS Glue job, and set it to the following value. Alternatively, you can set the following configuration using SparkConf in your script. These settings help Apache Spark correctly handle Delta Lake tables.

  ```bash
  spark.sql.extensions=io.delta.sql.DeltaSparkSessionExtension --conf
  spark.sql.catalog.spark_catalog=org.apache.spark.sql.delta.catalog.DeltaCatalog
  ```
Lake Formation permission support for Delta tables is enabled by default for AWS Glue 4.0. No additional configuration is needed for reading/writing to Lake Formation-registered Delta tables. To read a registered Delta table, the AWS Glue job IAM role must have the SELECT permission. To write to a registered Delta table, the AWS Glue job IAM role must have the SUPER permission. To learn more about managing Lake Formation permissions, see [Granting and revoking permissions on Data Catalog resources](#).

### Using a different Delta Lake version

To use a version of Delta lake that AWS Glue doesn't support, specify your own Delta Lake JAR files using the `--extra-jars` job parameter. Do not include delta as a value for the `--datalake-formats` job parameter. To use the Delta Lake Python library in this case, you must specify the library JAR files using the `--extra-py-files` job parameter. The Python library comes packaged in the Delta Lake JAR files.

**Example: Write a Delta Lake table to Amazon S3 and register it to the AWS Glue Data Catalog**

The following AWS Glue ETL script demonstrates how to write a Delta Lake table to Amazon S3 and register the table to the AWS Glue Data Catalog.

**Python**

```python
# Example: Create a Delta Lake table from a DataFrame
# and register the table to Glue Data Catalog

additional_options = {
    "path": "s3://<s3Path>"
}

dataFrame.write \
    .format("delta") \
    .options(**additional_options) \
    .mode("append") \
    .partitionBy("<your_partitionkey_field>") \
    .saveAsTable("<your_database_name>.<your_table_name>")
```

**Scala**

```scala
// Example: Create a Delta Lake table from a DataFrame
```

---

**Note:** The examples provided are illustrative and may require modifications based on specific use cases and environments.
Example: Read a Delta Lake table from Amazon S3 using the AWS Glue Data Catalog

The following AWS Glue ETL script reads the Delta Lake table that you created in Example: Write a Delta Lake table to Amazon S3 and register it to the AWS Glue Data Catalog.

Python

For this example, use the create_data_frame.from_catalog method.

```python
# Example: Read a Delta Lake table from Glue Data Catalog
from awsglue.context import GlueContext
from pyspark.context import SparkContext
sc = SparkContext()
glueContext = GlueContext(sc)
df = glueContext.create_data_frame.from_catalog(
    database="<your_database_name>",
    table_name="<your_table_name>",
    additional_options=additional_options
)
```

Scala

For this example, use the getCatalogSource method.

```scala
// Example: Read a Delta Lake table from Glue Data Catalog
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext
```
object GlueApp {
    def main(sysArgs: Array[String]): Unit = {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)
        val df = glueContext.getCatalogSource("<your_database_name>",
            "<your_table_name>",
            additionalOptions = additionalOptions
        .getDataFrame()
    }
}

**Example: Insert a DataFrame into a Delta Lake table in Amazon S3 using the AWS Glue Data Catalog**

This example inserts data into the Delta Lake table that you created in **Example: Write a Delta Lake table to Amazon S3 and register it to the AWS Glue Data Catalog**.

⚠️ **Note**

This example requires you to set the `--enable-glue-datacatalog` job parameter in order to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To learn more, see [AWS Glue job parameters](#).

**Python**

For this example, use the `write_data_frame.from_catalog` method.

```python
# Example: Insert into a Delta Lake table in S3 using Glue Data Catalog

from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)

glueContext.write_data_frame.from_catalog(
    frame=dataFrame,
    database="<your_database_name>",
    table_name="<your_table_name>"
,```
For this example, use the `getCatalogSink` method.

```scala
// Example: Insert into a Delta Lake table in S3 using Glue Data Catalog
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    glueContext.getCatalogSink("<your_database_name>", "<your_table_name>",
      additionalOptions = additionalOptions)
      .writeDataFrame(dataFrame, glueContext)
  }
}
```

**Example: Read a Delta Lake table from Amazon S3 using the Spark API**

This example reads a Delta Lake table from Amazon S3 using the Spark API.

**Python**

```python
# Example: Read a Delta Lake table from S3 using a Spark DataFrame
dataFrame = spark.read.format("delta").load("s3://<s3path/>")
```

**Scala**

```scala
// Example: Read a Delta Lake table from S3 using a Spark DataFrame
val dataFrame = spark.read.format("delta").load("s3://<s3path/>")
```

**Example: Write a Delta Lake table to Amazon S3 using Spark**

This example writes a Delta Lake table to Amazon S3 using Spark.
Example: Write a Delta Lake table to S3 using a Spark DataFrame

```python
# Example: Write a Delta Lake table to S3 using a Spark DataFrame

dataFrame.write.format("delta") \ 
  .options(**additional_options) \ 
  .mode("overwrite") \ 
  .partitionBy("<your_partitionkey_field>") \ 
  .save("s3://<s3Path>")
```

```scala
// Example: Write a Delta Lake table to S3 using a Spark DataFrame

dataFrame.write.format("delta")
  .options(additionalOptions)
  .mode("overwrite")
  .partitionBy("<your_partitionkey_field>")
  .save("s3://<s3path/>")
```

Example: Read and write Delta Lake table with Lake Formation permission control

This example reads and writes a Delta Lake table with Lake Formation permission control.

1. Create a Delta table and register it in Lake Formation

   a. To enable Lake Formation permission control, you’ll first need to register the table Amazon S3 path on Lake Formation. For more information, see [Registering an Amazon S3 location](https://docs.aws.amazon.com/lambda/latest/dg/glue-lakeformation.html). You can register it either from the Lake Formation console or by using the AWS CLI:

   ```
   aws lakeformation register-resource --resource-arn arn:aws:s3::<s3-bucket>/<s3-folder> --use-service-linked-role --region <REGION>
   ```

   Once you register an Amazon S3 location, any AWS Glue table pointing to the location (or any of its child locations) will return the value for the IsRegisteredWithLakeFormation parameter as true in the GetTable call.

   b. Create a Delta table that points to the registered Amazon S3 path through Spark:
After the data has been written to Amazon S3, use the AWS Glue crawler to create a new Delta catalog table. For more information, see [Introducing native Delta Lake table support with AWS Glue crawlers](https://docs.aws.amazon.com/glue/latest/dg/transform-data-with-delta-lake-crawlers.html).

You can also create the table manually through the AWS Glue `CreateTable` API.

2. Grant Lake Formation permission to the AWS Glue job IAM role. You can either grant permissions from the Lake Formation console, or using the AWS CLI. For more information, see [Granting table permissions using the Lake Formation console and the named resource method](https://docs.aws.amazon.com/lakeformation/latest/dg/how-to-permissions-mgmt.html).

3. Read the Delta table registered in Lake Formation. The code is same as reading a non-registered Delta table. Note that the AWS Glue job IAM role needs to have the SELECT permission for the read to succeed.

   ```python
   # Example: Read a Delta Lake table from Glue Data Catalog
   
   df = glueContext.create_data_frame.from_catalog(
       database="<your_database_name>",
       table_name="<your_table_name>",
       additional_options=additional_options
   )
   ```

4. Write to a Delta table registered in Lake Formation. The code is same as writing to a non-registered Delta table. Note that the AWS Glue job IAM role needs to have the SUPER permission for the write to succeed.

   By default AWS Glue uses Append as saveMode. You can change it by setting the saveMode option in `additional_options`. For information about saveMode support in Delta tables, see [Write to a table](https://docs.aws.amazon.com/glue/latest/dg/transform-data-with-delta-lake-crawlers.html).
Using the Iceberg framework in AWS Glue

AWS Glue 3.0 and later supports the Apache Iceberg framework for data lakes. Iceberg provides a high-performance table format that works just like a SQL table. This topic covers available features for using your data in AWS Glue when you transport or store your data in an Iceberg table. To learn more about Iceberg, see the official Apache Iceberg documentation.

You can use AWS Glue to perform read and write operations on Iceberg tables in Amazon S3, or work with Iceberg tables using the AWS Glue Data Catalog. Additional operations including insert, update, and all Spark Queries Spark Writes are also supported.

Note

ALTER TABLE ... RENAME TO is not available for Apache Iceberg 0.13.1 for AWS Glue 3.0.

The following table lists the version of Iceberg included in each AWS Glue version.

<table>
<thead>
<tr>
<th>AWS Glue version</th>
<th>Supported Iceberg version</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>1.0.0</td>
</tr>
<tr>
<td>3.0</td>
<td>0.13.1</td>
</tr>
</tbody>
</table>

To learn more about the data lake frameworks that AWS Glue supports, see Using data lake frameworks with AWS Glue ETL jobs.

Enabling the Iceberg framework

To enable Iceberg for AWS Glue, complete the following tasks:
• Specify iceberg as a value for the --datalake-formats job parameter. For more information, see AWS Glue job parameters.

• Create a key named --conf for your AWS Glue job, and set it to the following value. Alternatively, you can set the following configuration using SparkConf in your script. These settings help Apache Spark correctly handle Iceberg tables.

```
spark.sql.extensions=org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions
--conf spark.sql.catalog.glue_catalog=org.apache.iceberg.spark.SparkCatalog
--conf spark.sql.catalog.glue_catalog.warehouse=s3://<your-warehouse-dir>/
--conf spark.sql.catalog.glue_catalog.catalog-impl=org.apache.iceberg.aws.glue.GlueCatalog
```

If you are reading or writing to Iceberg tables that are registered with Lake Formation, add the following configuration to enable Lake Formation support. Note that only AWS Glue 4.0 supports Iceberg tables registered with Lake Formation:

```
--conf spark.sql.catalog.glue_catalog.glue.lakeformation-enabled=true
--conf spark.sql.catalog.glue_catalog.glue.id=<table-catalog-id>
```

If you use AWS Glue 3.0 with Iceberg 0.13.1, you must set the following additional configurations to use Amazon DynamoDB lock manager to ensure atomic transaction. AWS Glue 4.0 uses optimistic locking by default. For more information, see Iceberg AWS Integrations in the official Apache Iceberg documentation.

```
--conf spark.sql.catalog.glue_catalog.lock-impl=org.apache.iceberg.aws.glue.DynamoLockManager
--conf spark.sql.catalog.glue_catalog.lock.table=<your-dynamodb-table-name>
```

**Using a different Iceberg version**

To use a version of Iceberg that AWS Glue doesn't support, specify your own Iceberg JAR files using the --extra-jars job parameter. Do not include iceberg as a value for the --datalake-formats parameter.

**Enabling encryption for Iceberg tables**
Note

Iceberg tables have their own mechanisms to enable server-side encryption. You should enable this configuration in addition to AWS Glue's security configuration.

To enable server-side encryption on Iceberg tables, review the guidance from the Iceberg documentation.

Example: Write an Iceberg table to Amazon S3 and register it to the AWS Glue Data Catalog

This example script demonstrates how to write an Iceberg table to Amazon S3. The example uses Iceberg AWS Integrations to register the table to the AWS Glue Data Catalog.

Python

```python
# Example: Create an Iceberg table from a DataFrame
# and register the table to Glue Data Catalog

dataFrame.createOrReplaceTempView("tmp_<your_table_name>")

query = f""
CREATE TABLE glue_catalog.<your_database_name>.<your_table_name>
USING iceberg
TBLPROPERTIES ("format-version"="2")
AS SELECT * FROM tmp_<your_table_name>
""
spark.sql(query)
```

Scala

```scala
// Example: Create an Iceberg table from a DataFrame
// and register the table to Glue Data Catalog

dataFrame.createOrReplaceTempView("tmp_<your_table_name>")

val query = ""
CREATE TABLE glue_catalog.<your_database_name>.<your_table_name>
USING iceberg
TBLPROPERTIES ("format-version"="2")
AS SELECT * FROM tmp_<your_table_name>
""
spark.sql(query)
```
Alternatively, you can write an Iceberg table to Amazon S3 and the Data Catalog using Spark methods.

Prerequisites: You will need to provision a catalog for the Iceberg library to use. When using the AWS Glue Data Catalog, AWS Glue makes this straightforward. The AWS Glue Data Catalog is pre-configured for use by the Spark libraries as glue_catalog. Data Catalog tables are identified by a `databaseName` and a `tableName`. For more information about the AWS Glue Data Catalog, see Data Catalog and crawlers.

If you are not using the AWS Glue Data Catalog, you will need to provision a catalog through the Spark APIs. For more information, see Spark Configuration in the Iceberg documentation.

This example writes an Iceberg table to Amazon S3 and the Data Catalog using Spark.

**Python**

```python
# Example: Write an Iceberg table to S3 on the Glue Data Catalog

dataFrame.writeTo("glue_catalog.databaseName.tableName")
    .tableProperty("format-version", "2")
    .create()

# Append (equivalent to INSERT INTO)
dataFrame.writeTo("glue_catalog.databaseName.tableName")
    .tableProperty("format-version", "2")
    .append()
```

**Scala**

```scala
// Example: Write an Iceberg table to S3 on the Glue Data Catalog

// Create (equivalent to CREATE TABLE AS SELECT)
dataFrame.writeTo("glue_catalog.databaseName.tableName")
    .tableProperty("format-version", "2")
    .create()

// Append (equivalent to INSERT INTO)
dataFrame.writeTo("glue_catalog.databaseName.tableName")
    .tableProperty("format-version", "2")
    .append()
```
Example: Read an Iceberg table from Amazon S3 using the AWS Glue Data Catalog

This example reads the Iceberg table that you created in Example: Write an Iceberg table to Amazon S3 and register it to the AWS Glue Data Catalog.

Python

For this example, use the `GlueContext.create_data_frame.from_catalog()` method.

```python
# Example: Read an Iceberg table from Glue Data Catalog
from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)

df = glueContext.create_data_frame.from_catalog(
    database="<your_database_name>",
    table_name="<your_table_name>",
    additional_options=additional_options
)
```

Scala

For this example, use the `getCatalogSource` method.

```scala
// Example: Read an Iceberg table from Glue Data Catalog
import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext

object GlueApp {
  def main(sysArgs: Array[String]): Unit = {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val df = glueContext.getCatalogSource("<your_database_name>",
      "<your_table_name>",
      additionalOptions = additionalOptions
    ).getDataFrame()
  }
}
```
Example: Insert a DataFrame into an Iceberg table in Amazon S3 using the AWS Glue Data Catalog

This example inserts data into the Iceberg table that you created in Example: Write an Iceberg table to Amazon S3 and register it to the AWS Glue Data Catalog.

ℹ️ Note

This example requires you to set the --enable-glue-datacatalog job parameter in order to use the AWS Glue Data Catalog as an Apache Spark Hive metastore. To learn more, see AWS Glue job parameters.

Python

For this example, use the `GlueContext.write_data_frame.from_catalog()` method.

```python
# Example: Insert into an Iceberg table from Glue Data Catalog

from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()
glueContext = GlueContext(sc)

glueContext.write_data_frame.from_catalog(
    frame=dataFrame,
    database="<your_database_name>",
    table_name="<your_table_name>",
    additional_options=additional_options
)
```

Scala

For this example, use the `getCatalogSink` method.

```scala
// Example: Insert into an Iceberg table from Glue Data Catalog

import com.amazonaws.services.glue.GlueContext
import org.apache.spark.SparkContext
```
Example: Read an Iceberg table from Amazon S3 using Spark

Prerequisites: You will need to provision a catalog for the Iceberg library to use. When using the AWS Glue Data Catalog, AWS Glue makes this straightforward. The AWS Glue Data Catalog is pre-configured for use by the Spark libraries as glue_catalog. Data Catalog tables are identified by a `databaseName` and a `tableName`. For more information about the AWS Glue Data Catalog, see Data Catalog and crawlers.

If you are not using the AWS Glue Data Catalog, you will need to provision a catalog through the Spark APIs. For more information, see Spark Configuration in the Iceberg documentation.

This example reads an Iceberg table in Amazon S3 from the Data Catalog using Spark.

Python

```python
# Example: Read an Iceberg table on S3 as a DataFrame from the Glue Data Catalog
dataFrame = spark.read.format("iceberg").load("glue_catalog.databaseName.tableName")
```

Scala

```scala
// Example: Read an Iceberg table on S3 as a DataFrame from the Glue Data Catalog
val dataFrame =
spark.read.format("iceberg").load("glue_catalog.databaseName.tableName")
```

Example: Read and write Iceberg table with Lake Formation permission control

This example reads and writes an Iceberg table with Lake Formation permission control.
1. Create an Iceberg table and register it in Lake Formation:

   a. To enable Lake Formation permission control, you’ll first need to register the table Amazon S3 path on Lake Formation. For more information, see Registering an Amazon S3 location. You can register it either from the Lake Formation console or by using the AWS CLI:

   ```shell
   aws lakeformation register-resource --resource-arn arn:aws:s3::<s3-bucket>/<s3-folder> --use-service-linked-role --region <REGION>
   ```

   Once you register an Amazon S3 location, any AWS Glue table pointing to the location (or any of its child locations) will return the value for the IsRegisteredWithLakeFormation parameter as true in the GetTable call.

   b. Create an Iceberg table that points to the registered path through Spark SQL:

   ```python
   Note
   The following are Python examples.
   ```

   ```python
dataFrame.createOrReplaceTempView("tmp_<your_table_name>"")

   query = f""
   CREATE TABLE glue_catalog.<your_database_name>.<your_table_name>
   USING iceberg
   AS SELECT * FROM tmp_<your_table_name>
   ""
   spark.sql(query)
   ```

   You can also create the table manually through AWS Glue CreateTable API. For more information, see Creating Apache Iceberg tables.

2. Grant Lake Formation permission to the job IAM role. You can either grant permissions from the Lake Formation console, or using the AWS CLI. For more information, see: https://docs.aws.amazon.com/lake-formation/latest/dg/granting-table-permissions.html

3. Read an Iceberg table registered with Lake Formation. The code is same as reading a non-registered Iceberg table. Note that your AWS Glue job IAM role needs to have the SELECT permission for the read to succeed.

   ```python
   # Example: Read an Iceberg table from the AWS Glue Data Catalog
   ```
from awsglue.context import GlueContext
from pyspark.context import SparkContext

sc = SparkContext()

# Create a GlueContext

glueContext = GlueContext(sc)

df = glueContext.create_data_frame.from_catalog(
    database="<your_database_name>",
    table_name="<your_table_name>",
    additional_options=additional_options
)

4. Write to an Iceberg table registered with Lake Formation. The code is same as writing to a non-registered Iceberg table. Note that your AWS Glue job IAM role needs to have the SUPER permission for the write to succeed.

```python

# Write data frame to Iceberg table

# Create a GlueContext

# Create a data frame

# Write data frame to Iceberg table

glueContext.write_data_frame.from_catalog(
    frame=dataFrame,
    database="<your_database_name>",
    table_name="<your_table_name>",
    additional_options=additional_options
)
```

**Shared configuration reference**

You can use the following `format_options` values with any format type.

- **attachFilename** — A string in the appropriate format to be used as a column name. If you provide this option, the name of the source file for the record will be appended to the record. The parameter value will be used as the column name.

- **attachTimestamp** — A string in the appropriate format to be used as a column name. If you provide this option, the modification time of the source file for the record will be appended to the record. The parameter value will be used as the column name.

**AWS Glue Data Catalog support for Spark SQL jobs**

The AWS Glue Data Catalog is an Apache Hive metastore-compatible catalog. You can configure your AWS Glue jobs and development endpoints to use the Data Catalog as an external Apache Hive metastore. You can then directly run Apache Spark SQL queries against the tables stored in...
the Data Catalog. AWS Glue dynamic frames integrate with the Data Catalog by default. However, with this feature, Spark SQL jobs can start using the Data Catalog as an external Hive metastore.

This feature requires network access to the AWS Glue API endpoint. For AWS Glue jobs with connections located in private subnets, you must configure either a VPC endpoint or NAT gateway to provide the network access. For information about configuring a VPC endpoint, see Setting up network access to data stores. To create a NAT gateway, see NAT Gateways in the Amazon VPC User Guide.

You can configure AWS Glue jobs and development endpoints by adding the "--enable-glue-datacatalog": "" argument to job arguments and development endpoint arguments respectively. Passing this argument sets certain configurations in Spark that enable it to access the Data Catalog as an external Hive metastore. It also enables Hive support in the SparkSession object created in the AWS Glue job or development endpoint.

To enable the Data Catalog access, check the Use AWS Glue Data Catalog as the Hive metastore check box in the Catalog options group on the Add job or Add endpoint page on the console. Note that the IAM role used for the job or development endpoint should have glue:CreateDatabase permissions. A database called "default" is created in the Data Catalog if it does not exist.

Let's look at an example of how you can use this feature in your Spark SQL jobs. The following example assumes that you have crawled the US legislators dataset available at s3://awsglue-datasets/examples/us-legislators.

To serialize/deserialize data from the tables defined in the AWS Glue Data Catalog, Spark SQL needs the Hive SerDe class for the format defined in the AWS Glue Data Catalog in the classpath of the spark job.

SerDes for certain common formats are distributed by AWS Glue. The following are the Amazon S3 links for these:

- **JSON**
- **XML**
- **Grok**

Add the JSON SerDe as an extra JAR to the development endpoint. For jobs, you can add the SerDe using the --extra-jars argument in the arguments field. For more information, see AWS Glue job parameters.
Here is an example input JSON to create a development endpoint with the Data Catalog enabled for Spark SQL.

```json
{
  "EndpointName": "Name",
  "RoleArn": "role_ARN",
  "PublicKey": "public_key_contents",
  "NumberOfNodes": 2,
  "Arguments": {
    "--enable-glue-datacatalog": ""
  },
  "ExtraJarsS3Path": "s3://crawler-public/json/serde/json-serde.jar"
}
```

Now query the tables created from the US legislators dataset using Spark SQL.

```python
>>> spark.sql("use legislators")
DataFrame[]
>>> spark.sql("show tables").show()
+-----------+------------------+-----------+
|   database|         tableName|isTemporary|
+-----------+------------------+-----------+
|legislators|        areas_json|      false|
|legislators|    countries_json|      false|
|legislators|       events_json|      false|
|legislators|  memberships_json|      false|
|legislators|organizations_json|      false|
|legislators|      persons_json|      false|
+-----------+------------------+-----------+
>>> spark.sql("describe memberships_json").show()
+--------------------+---------+-----------------+
|            col_name|data_type|          comment|
+--------------------+---------+-----------------+
|             area_id|   string|from deserializer|
|on_behalf_of_id|   string|from deserializer|
|  organization_id|   string|from deserializer|
|             role|   string|from deserializer|
|          person_id|   string|from deserializer|
|legislative_period|   string|from deserializer|
|          start_date|   string|from deserializer|
|            end_date|   string|from deserializer|
```
If the SerDe class for the format is not available in the job's classpath, you will see an error similar to the following.

```python
>>> spark.sql("describe memberships_json").show()
Caused by: MetaException(message:java.lang.ClassNotFoundException Class
org.openx.data.jsonserde.JsonSerDe not found)
at
org.apache.hadoop.hive.metastore.MetaStoreUtils.getDeserializer(MetaStoreUtils.java:399)
at
org.apache.hadoop.hive.ql.metadata.Table.getDeserializerFromMetaStore(Table.java:276)
... 64 more
```

To view only the distinct `organization_id` from the `memberships` table, run the following SQL query.

```python
>>> spark.sql("select distinct organization_id from memberships_json").show()
+-------------------+
| organization_id |
+-------------------+
| d56acebe-8fdce-47b... |
| 8fa6c3d2-71dc-478... |
+-------------------+
```

If you need to do the same with dynamic frames, run the following.

```python
>>> memberships = glueContext.create_dynamic_frame.from_catalog(database="legislators", table_name="memberships_json")
>>> memberships.toDF().createOrReplaceTempView("memberships")
>>> spark.sql("select distinct organization_id from memberships").show()
+-------------------+
| organization_id |
+-------------------+
| d56acebe-8fdce-47b... |
| 8fa6c3d2-71dc-478... |
+-------------------+
```
While DynamicFrames are optimized for ETL operations, enabling Spark SQL to access the Data Catalog directly provides a concise way to run complex SQL statements or port existing applications.

**Using job bookmarks**

AWS Glue for Spark uses job bookmarks to track data that has already been processed. For a summary of the job bookmarks feature and what it supports, see the section called “Tracking processed data using job bookmarks”. When programming a AWS Glue job with bookmarks, you have access to flexibility unavailable in visual jobs.

- When reading from JDBC, you can specify the column(s) to use as bookmark keys in your AWS Glue script.
- You can chose which `transformation_ctx` to apply to each method call.

*Always have `job.init()` in the beginning of the script and the `job.commit()` in the end of the script.* These two functions initialize the bookmark service and update the state change to the service. Bookmarks won’t work without calling them.

**Specify bookmark keys**

For JDBC workflows, the bookmark keeps track of which rows your job has read by comparing the values of key fields to a bookmarked value. This is not necessary or applicable for Amazon S3 workflows. When writing a AWS Glue script without the visual editor, you can specify which column to track with bookmarks. You can also specify multiple columns. Gaps in the sequence of values are permitted when specifying user-defined bookmark keys.

⚠️ **Warning**

If user-defined bookmarks keys are used, they must each be strictly monotonically increasing or decreasing. When selecting additional fields for a compound key, fields for concepts like "minor versions" or "revision numbers" do not meet this criteria, since their values are reused throughout your dataset.

You can specify `jobBookmarkKeys` and `jobBookmarkKeysSortOrder` in the following ways:

- `create_dynamic_frame.from_catalog` — Use `additional_options`.
- `create_dynamic_frame.from_options` — Use `connection_options`.
**Transformation context**

Many of the AWS Glue PySpark dynamic frame methods include an optional parameter named `transformation_ctx`, which is a unique identifier for the ETL operator instance. The `transformation_ctx` parameter is used to identify state information within a job bookmark for the given operator. Specifically, AWS Glue uses `transformation_ctx` to index the key to the bookmark state.

⚠️ **Warning**

The `transformation_ctx` serves as the key to search the bookmark state for a specific source in your script. For the bookmark to work properly, you should always keep the source and the associated `transformation_ctx` consistent. Changing the source property or renaming the `transformation_ctx` may make the previous bookmark invalid and the time stamp based filtering may not yield the correct result.

For job bookmarks to work properly, enable the job bookmark parameter and set the `transformation_ctx` parameter. If you don't pass in the `transformation_ctx` parameter, then job bookmarks are not enabled for a dynamic frame or a table used in the method. For example, if you have an ETL job that reads and joins two Amazon S3 sources, you might choose to pass the `transformation_ctx` parameter only to those methods that you want to enable bookmarks. If you reset the job bookmark for a job, it resets all transformations that are associated with the job regardless of the `transformation_ctx` used.

For more information about the `DynamicFrameReader` class, see [DynamicFrameReader class](#). For more information about PySpark extensions, see [AWS Glue PySpark extensions reference](#).

**Examples**

**Example**

The following is an example of a generated script for an Amazon S3 data source. The portions of the script that are required for using job bookmarks are shown in italics. For more information about these elements see the [GlueContext class](#) API, and the [DynamicFrameWriter class](#) API.

```python
# Sample Script
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
```
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

args = getResolvedOptions(sys.argv, ['JOB_NAME'])
sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

datasource0 = glueContext.create_dynamic_frame.from_catalog(
    database = "database",
    table_name = "relatedqueries_csv",
    transformation_ctx = "datasource0"
)

applymapping1 = ApplyMapping.apply(
    frame = datasource0,
    mappings = ["col0", "string", "name", "string"], ("col1", "string", "number", "string"),
    transformation_ctx = "applymapping1"
)

datasink2 = glueContext.write_dynamic_frame.from_options(
    frame = applymapping1,
    connection_type = "s3",
    connection_options = {"path": "s3://input_path"},
    format = "json",
    transformation_ctx = "datasink2"
)

job.commit()

Example

The following is an example of a generated script for a JDBC source. The source table is an employee table with the empno column as the primary key. Although by default the job uses a sequential primary key as the bookmark key if no bookmark key is specified, because empno is not necessarily sequential—there could be gaps in the values—it does not qualify as a default bookmark key. Therefore, the script explicitly designates empno as the bookmark key. That portion of the code is shown in italics.
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

args = getResolvedOptions(sys.argv, ['JOB_NAME'])

sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

datasource0 = glueContext.create_dynamic_frame.from_catalog(
    database = "hr",
    table_name = "emp",
    transformation_ctx = "datasource0",
    additional_options = {
        "jobBookmarkKeys": ["empno"],
        "jobBookmarkKeysSortOrder": "asc"
    }
)

applymapping1 = ApplyMapping.apply(
    frame = datasource0,
    mappings = [(
        "ename", "string",
        "hrly_rate", "decimal(38,0)",
        "comm", "decimal(7,2)",
        "hiredate", "timestamp",
        "empno", "decimal(5,0)",
        "mgr", "decimal(5,0)",
        "photo", "string",
        "job", "string",
        "deptno", "decimal(3,0)"
    ), ]
)

datasink2 = glueContext.write_dynamic_frame.from_options(
    frame = applymapping1,
    connection_type = "s3",
    connection_options = {
        "path": "s3://hr/employees"
    },
    format = "csv",
    transformation_ctx = "datasink2"
)

job.commit()
Optimizing reads with pushdown in AWS Glue ETL

Pushdown is an optimization technique that pushes logic about retrieving data closer to the source of your data. The source could be a database or a file system such as Amazon S3. When executing certain operations directly on the source, you can save time and processing power by not bringing all the data over the network to the Spark engine managed by AWS Glue.

Predicate pushdown on files stored on Amazon S3

When working with files on Amazon S3 that have been organized by prefix, you can filter your target Amazon S3 paths by defining a pushdown predicate. Rather than reading the complete dataset and applying filters within a DynamicFrame, you can directly apply the filter to the partition metadata stored in the AWS Glue Data Catalog. This approach allows you to selectively list and read only the necessary data. For more information about this process, including writing to a bucket by partitions, see the section called “Managing partitions”.

You achieve predicate pushdown in Amazon S3 by using the push_down_predicate parameter. Consider a bucket in Amazon S3 you’ve partitioned by year, month and day. If you want to retrieve customer data for June of 2022, you can instruct AWS Glue to read only relevant Amazon S3 paths. The push_down Predicate in this case is year='2022' and month='06'. Putting it all together, the read operation can be achieved as below:

Python

```python
customer_records = glueContext.create_dynamic_frame.from_catalog(
    database = "customer_db",
    table_name = "customer_tbl",
    push_down_predicate = "year='2022' and month='06'"
)
```

Scala

```scala
val customer_records = glueContext.getCatalogSource(
    database="customer_db",
    tableName="customer_tbl",
    pushDownPredicate="year='2022' and month='06'"
).getDynamicFrame()
```

In the previous scenario, push_down_predicate retrieves a list of all partitions from the AWS Glue Data Catalog and filters them before reading the underlying Amazon S3 files. Though this
helps in most cases, when working with datasets that have millions of partitions, the process of listing partitions can be time consuming. To address this issue, server-side pruning of partitions can be used to improve performance. This is done by building a Partition index for your data in the AWS Glue Data Catalog. For more information about partition indices, see the section called “Working with partition indexes”. You can then use the catalogPartitionPredicate option to reference the index. For an example retrieving partitions with catalogPartitionPredicate, see the section called “Catalog partition predicates”.

**Pushdown when working with JDBC sources**

The AWS Glue JDBC reader used in the GlueContext supports pushdown on supported databases by providing custom SQL queries that can run directly on the source. This can be achieved by setting the sampleQuery parameter. Your sample query can specify which columns to select as well as provide a pushdown predicate to limit the data transferred to the Spark engine.

By default, sample queries operate on a single node, which can result in job failures when dealing with large data volumes. To use this feature to query data at scale, you should configure query partitioning by setting enablePartitioningForSampleQuery to true, which will distribute the query to multiple nodes across a key of your choice. Query partitioning also requires a few other necessary configuration parameters. For more information about query partitioning, see the section called “Reading from JDBC in parallel”.

When setting enablePartitioningForSampleQuery, AWS Glue will combine your pushdown predicate with a partitioning predicate when querying your database. Your sampleQuery must end with an AND for AWS Glue to append partitioning conditions. (If you do not provide a pushdown predicate, sampleQuery must end with an WHERE). See an example below, where we push down a predicate to only retrieve rows whose id is greater than 1000. This sampleQuery will only return the name and location columns for rows where id is greater than the specified value:

**Python**

```python
sample_query = "select name, location from customer_tbl WHERE id>=1000 AND"
customer_records = glueContext.create_dynamic_frame.from_catalog(
    database="customer_db",
    table_name="customer_tbl",
    sample_query = "select name, location from customer_tbl WHERE id>=1000 AND",
    additional_options = {
        "hashpartitions": 36 ,
        "hashfield":"id",
```
Scala

```scala
val additionalOptions = Map(
    "hashpartitions" -> "36",
    "hashfield" -> "id",
    "enablePartitioningForSampleQuery" -> "true",
    "sampleQuery" -> "select name, location from customer_tbl WHERE id >= 1000 AND"
)

val customer_records = glueContext.getCatalogSource(
    database="customer_db",
    tableName="customer_tbl" ).getDynamicFrame()
```

You can also query against JDBC tables without integrating with the AWS Glue Data Catalog. Instead of providing username and password as parameters to the method, you can reuse credentials from a preexisting connection by providing `useConnectionProperties` and `connectionName`. In this example, we retrieve credentials from a connection called `my_postgre_connection`.

Python

```python
collection_options_dict = {
    "useConnectionProperties": True,
    "connectionName": "my_postgre_connection",
    "dbtable": "customer_tbl",
    "sampleQuery": "select name, location from customer_tbl WHERE id >= 1000 AND",
    "enablePartitioningForSampleQuery": True,
    "hashfield": "id",
    "hashpartitions": 36
}

customer_records = glueContext.create_dynamic_frame.from_options(
    connection_type="postgresql",
    connection_options=connection_options_dict
)```
Scala

```scala
val connectionOptionsJson = ""
{
    "useConnectionProperties": true,
    "connectionName": "my_postgre_connection",
    "dbtable": "customer_tbl",
    "sampleQuery": "select name, location from customer_tbl WHERE id>=1000 AND",
    "enablePartitioningForSampleQuery": true,
    "hashfield": "id",
    "hashpartitions": 36
}
"

val connectionOptions = new JsonOptions(connectionOptionsJson)

val dyf = glueContext.getSource("postgresql", connectionOptions).getDynamicFrame()
```

**Notes and limitations for pushdown in AWS Glue**

Pushdown, as a concept, is applicable when reading from non-streaming sources. AWS Glue supports a variety of sources - the ability to pushdown depends on the source and connector.

- When connecting to Snowflake, you can use the `query` option. Similar functionality exists in the Redshift connector in AWS Glue 4.0 and later versions. For more information about reading from Snowflake with `query`, see the section called “Read from Snowflake”.
- The DynamoDB ETL reader does not support filters or pushdown predicates. MongoDB and DocumentDB also do not support this sort of functionality.
- When reading from data stored in Amazon S3 in open table formats, the partitioning method for files in Amazon S3 is no longer sufficient. To read and write from partitions using open table formats, consult documentation for the format.
- DynamicFrame methods do not perform Amazon S3 projection pushdown. All columns will be read from files that pass the predicate filter.
- When working with custom.jdbc connectors in AWS Glue, the ability to pushdown depends on the source and connector. Please review the appropriate connector documentation to confirm if and how it supports pushdown in AWS Glue.
Using Sensitive Data Detection outside AWS Glue Studio

AWS Glue Studio allows you to detect sensitive data, however, you can also use the Sensitive Data Detection functionality outside of AWS Glue Studio.

For a full list of managed sensitive data types, see Managed data types.

Detecting Sensitive Data Detection using AWS Managed PII types

AWS Glue provides two APIs in a AWS Glue ETL job. These are `detect()` and `classifyColumns()`:

```scala
detect(frame: DynamicFrame,
       entityTypeToDetect: Seq[String],
       outputColumnName: String = "DetectedEntities",
       detectionSensitivity: String = "LOW"): DynamicFrame

detect(frame: DynamicFrame,
       detectionParameters: JsonOptions,
       outputColumnName: String = "DetectedEntities",
       detectionSensitivity: String = "LOW"): DynamicFrame

classifyColumns(frame: DynamicFrame,
                entityTypeToDetect: Seq[String],
                sampleFraction: Double = 0.1,
                thresholdFraction: Double = 0.1,
                detectionSensitivity: String = "LOW")
```

You can use the `detect()` API to identify AWS Managed PII types and custom entity types. A new column is automatically created with the detection result. The `classifyColumns()` API returns a map where keys are column names and values are list of detected entity types. `SampleFraction` indicates the fraction of the data to sample when scanning for PII entities whereas `ThresholdFraction` indicates the fraction of the data that must be met in order for a column to be identified as PII data.

Row-level detection

In the example, the job is performing the following actions using the `detect()` and `classifyColumns()` APIs:
AWS Glue

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• reading data from an Amazon S3 bucket and turns it into a dynamicFrame
• detecting instances of "Email" and "Credit Card" in the dynamicFrame
• returning a dynamicFrame with original values plus one column which encompasses detection
result for each row
• writing the returned dynamicFrame in another Amazon S3 path

import
import
import
import
import
import
import

com.amazonaws.services.glue.GlueContext
com.amazonaws.services.glue.MappingSpec
com.amazonaws.services.glue.errors.CallSite
com.amazonaws.services.glue.util.GlueArgParser
com.amazonaws.services.glue.util.Job
com.amazonaws.services.glue.util.JsonOptions
org.apache.spark.SparkContext

import scala.collection.JavaConverters._
import com.amazonaws.services.glue.ml.EntityDetector
object GlueApp {
def main(sysArgs: Array[String]) {
val spark: SparkContext = new SparkContext()
val glueContext: GlueContext = new GlueContext(spark)
val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
Job.init(args("JOB_NAME"), glueContext, args.asJava)
val frame=
glueContext.getSourceWithFormat(formatOptions=JsonOptions("""{"quoteChar": "\"",
"withHeader": true, "separator": ","}"""), connectionType="s3", format="csv",
options=JsonOptions("""{"paths": ["s3://pathToSource"], "recurse": true}"""),
transformationContext="AmazonS3_node1650160158526").getDynamicFrame()
val frameWithDetectedPII = EntityDetector.detect(frame, Seq("EMAIL",
"CREDIT_CARD"))
glueContext.getSinkWithFormat(connectionType="s3",
options=JsonOptions("""{"path": "s3://pathToOutput/", "partitionKeys": []}"""),
transformationContext="someCtx",
format="json").writeDynamicFrame(frameWithDetectedPII)
Job.commit()
}
}

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Row-level detection with fine-grained actions

In the example, the job is performing the following actions using the `detect()` APIs:

- reading data from an Amazon S3 bucket and turns it into a `dynamicFrame`
- detecting sensitive data types for “USA_PTIN”, “BANK_ACCOUNT”, “USA_SSN”, “USA_PASSPORT_NUMBER”, and “PHONE_NUMBER” in the `dynamicFrame`
- returning a `dynamicFrame` with modified masked values plus one column which encompasses detection result for each row
- writing the returned `dynamicFrame` in another Amazon S3 path

In contrast with the above `detect()` API, this uses fine-grained actions for entity types to detect. For more information, see [Detection parameters for using `detect()`](#).
"USA_DRIVING_LICENSE": [
    "action": "PARTIAL_REDACT",
    "sourceColumns": ["Driving License"],
    "actionOptions": {
        "matchPattern": "[0-9]",
        "redactChar": "*
    }
],
"BANK_ACCOUNT": [
    "action": "DETECT",
    "sourceColumns": ["*
]
],
"USA_SSN": [
    "action": "SHA256_HASH",
    "sourceColumns": ["SSN"
]
],
"IP_ADDRESS": [
    "action": "REDACT",
    "sourceColumns": ["IP Address"],
    "actionOptions": {"redactText": "*****"}
],
"PHONE_NUMBER": [
    "action": "PARTIAL_REDACT",
    "sourceColumns": ["Phone Number"],
    "actionOptions": {
        "numLeftCharsToExclude": 1,
        "numRightCharsToExclude": 0,
        "redactChar": "*
    }
]
"

val frameWithDetectedPII = EntityDetector.detect(frame, detectionParameters, "DetectedEntities", "HIGH")

    glueContext.getSinkWithFormat(connectionType="s3", options=JsonOptions(""""{"path": "s3://pathToOutput/", "partitionKeys": []}"
    transformationContext="AmazonS3_node_target",
    format="json"").writeDynamicFrame(frameWithDetectedPII)

    Job.commit()
Column-level detection

In the example, the job is performing the following actions using the `classifyColumns()` APIs:

- reading data from an Amazon S3 bucket and turns it into a dynamicFrame
- detecting instances of "Email" and "Credit Card" in the dynamicFrame
- set parameters to sample 100% of the column, mark an entity as detected if it is in 10% of cells, and have “LOW” sensitivity
- returns a map where keys are column names and values are list of detected entity types
- writing the returned dynamicFrame in another Amazon S3 path

```java
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._
import com.amazonaws.services.glue.DynamicFrame
import com.amazonaws.services.glue.ml.EntityDetector

object GlueApp {
  def main(sysArgs: Array[String]) {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)
    val frame =
      glueContext.getSourceWithFormat(formatOptions=JsonOptions("{"quoteChar": \"\", "withHeader": true, "separator": ",", "optimizePerformance": false}\""),
      connectionType="s3", format="csv", options=JsonOptions("{"paths": ["s3:// pathToSource"], "recurse": true}\""), transformationContext="frame").getDynamicFrame()
      .import glueContext.sparkSession.implicits._

    val detectedDataFrame = EntityDetector.classifyColumns(
      ...)
  }
```
Detecting Sensitive Data Detection using AWS CustomEntityType PII types

You can define custom entities through AWS Studio. However, to use this feature out of AWS Studio, you have to first define the custom entity types and then add the defined custom entity types to the list of entityTypesToDetect.

If you have specific sensitive data types in your data (such as 'Employee Id'), you can create custom entities by calling the CreateCustomEntityType() API. The following example defines the custom entity type 'EMPLOYEE_ID' to the CreateCustomEntityType() API with the request parameters:

```json
{
    "name": "EMPLOYEE_ID",
    "regexString": "\d{4}-\d{3}"
    "contextWords": ["employee"]
}
```

Then, modify the job to use the new custom sensitive data type by adding the custom entity type (EMPLOYEE_ID) to the EntityDetector() API:
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import com.amazonaws.services.glue.util.JsonOptions
import org.apache.spark.SparkContext
import scala.collection.JavaConverters_
import com.amazonaws.services.glue.ml.EntityDetector

object GlueApp {
  def main(sysArgs: Array[String]) {
    val spark: SparkContext = new SparkContext()
    val glueContext: GlueContext = new GlueContext(spark)
    val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
    Job.init(args("JOB_NAME"), glueContext, args.asJava)
    val frame =
      glueContext.getSourceWithFormat(formatOptions=JsonOptions("{"quoteChar": ",", "withHeader": true, "separator": ","}", connectionType="s3", format="csv",
        options=JsonOptions("{"paths": ["s3://pathToSource"], "recurse": true}"),
        transformationContext="AmazonS3_node1650160158526").getDynamicFrame()

    val frameWithDetectedPII = EntityDetector.detect(frame, Seq("EMAIL", "CREDIT_CARD", "EMPLOYEE_ID"))

    glueContext.getSinkWithFormat(connectionType="s3",
        options=JsonOptions("{"path": "s3://pathToOutput/", "partitionKeys": []}"),
        transformationContext="someCtx",
        format="json").writeDynamicFrame(frameWithDetectedPII)

    Job.commit()
  }
}

---

⚠️ **Note**

If a custom sensitive data type is defined with the same name as an existing managed entity type, then the custom sensitive data type will take precedent and overwrite the managed entity type's logic.
Detection parameters for using `detect()`

This method is used for detecting entities in a DynamicFrame. It returns a new DataFrame with original values and an additional column `outputColumnName` that has PII detection metadata. Custom masking can be done after this DynamicFrame is returned within the AWS Glue script, or the `detect()` with fine-grained actions API can be used instead.

```scala
detect(frame: DynamicFrame,
       entityTypesToDetect: Seq[String],
       outputColumnName: String = "DetectedEntities",
       detectionSensitivity: String = "LOW"): DynamicFrame
```

Parameters:

- **frame** – (type: DynamicFrame) The input DynamicFrame containing the data to be processed.
- **entityTypesToDetect** – (type: [Seq[String]]) List of entity types to detect. Can be either Managed Entity Types or Custom Entity Types.
- **outputColumnName** – (type: String, default: "DetectedEntities") The name of the column where detected entities will be stored. If not provided, the default column name is "DetectedEntities".
- **detectionSensitivity** – (type: String, options: "LOW" or "HIGH", default: "LOW") Specifies the sensitivity of the detection process. Valid options are "LOW" or "HIGH". If not provided, the default sensitivity is set to "LOW".

outputColumnName settings:

The name of the column where detected entities will be stored. If not provided, the default column name is "DetectedEntities". For each row in the output column, the supplementary column includes a map of the column name to the detected entity metadata with the following key-value pairs:

- **entityType** – The detected entity type.
- **start** – The starting position of the detected entity in the original data.
- **end** – The ending position of the detected entity in the original data.
- **actionUsed** – The action performed on the detected entity (e.g., "DETECT," "REDACT," "PARTIAL_REDACT," "SHA256_HASH").
Detecting Entities

This method is used for detecting entities in a DynamicFrame using specified parameters. It returns a new DataFrame with original values replaced with masked sensitive data and an additional column `outputColumnName` that has PII detection metadata.

detect(frame: DynamicFrame, detectionParameters: JsonOptions, outputColumnName: String = "DetectedEntities", detectionSensitivity: String = "LOW"): DynamicFrame
Parameters:

- **frame** – (type: DynamicFrame): The input DynamicFrame containing the data to be processed.
- **detectionParameters** – (type: JsonOptions): JSON options specifying parameters for the detection process.
- **outputColumnName** – (type: String, default: "DetectedEntities"): The name of the column where detected entities will be stored. If not provided, the default column name is "DetectedEntities".
- **detectionSensitivity** – (type: String, options: "LOW" or "HIGH", default: "LOW"): Specifies the sensitivity of the detection process. Valid options are "LOW" or "HIGH". If not provided, the default sensitivity is set to "LOW".

**detectionParameters settings**

If no settings are included, default values will be used.

- **action** – (type: String, options: "DETECT", "REDACT", "PARTIAL_REDACT", "SHA256_HASH") Specifies the action to be performed on the entity. Required. Note that actions that perform masking (all but "DETECT") can only perform one action per column. This is a preventative measure for masking coalesced entities.
- **sourceColumns** – (type: List[String], default: ["*"]) List of source column names to perform detection on for the entity. Defaults to ["*"] if not present. Raises IllegalArgumentException if an invalid column name is used.
- **sourceColumnsToExclude** – (type: List[String]) List of source column names to to perform detection on for the entity. Use either sourceColumns or sourceColumnsToExclude. Raises IllegalArgumentException if an invalid column name is used.
- **actionOptions** – Additional options based on the specified action:
  - For "DETECT" and "SHA256_HASH", no options are allowed.
  - For "REDACT":
    - **redactText** – (type: String, default: "*****") Text to replace the detected entity.
  - For "PARTIAL_REDACT":
    - **redactChar** – (type: String, default: ") Character to replace each detected character in the entity.
    - **matchPattern** – (type: String) Regex pattern for partial redaction. Cannot be combined with numLeftCharsToExclude or numRightCharsToExclude.
• **numLeftCharsToExclude** – (type: String, integer) Number of left characters to exclude. Cannot be combined with matchPattern, but can be used with numRightCharsToExclude.

• **numRightCharsToExclude** – (type: String, integer) Number of right characters to exclude. Cannot be combined with matchPattern, but can be used with numRightCharsToExclude.

outputColumnName settings

See outputColumnName settings

Detection Parameters for classifyColumns()

This method is used for detecting entities in a DynamicFrame. It returns a map where keys are column names and values are list of detected entity types. Custom masking can be done after this is returned within the AWS Glue script.

```
classifyColumns(frame: DynamicFrame,
                entityTypesToDetect: Seq[String],
                sampleFraction: Double = 0.1,
                thresholdFraction: Double = 0.1,
                detectionSensitivity: String = "LOW")
```

Parameters:

• **frame** – (type: DynamicFrame) The input DynamicFrame containing the data to be processed.

• **entityTypesToDetect** – (type: Seq[String]) List of entity types to detect. Can be either Managed Entity Types or Custom Entity Types.

• **sampleFraction** – (type: Double, default: 10%) The fraction of the data to sample when scanning for PII entities.

• **thresholdFraction** – (type: Double, default: 10%): The fraction of the data that must be met in order for a column to be identified as PII data.

• **detectionSensitivity** – (type: String, options: "LOW" or "HIGH", default: "LOW") Specifies the sensitivity of the detection process. Valid options are "LOW" or "HIGH". If not provided, the default sensitivity is set to "LOW".
# Managed Sensitive Data Types

## Global entities

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSON_NAME</td>
<td>Universal</td>
<td>The name of the person.</td>
</tr>
<tr>
<td>EMAIL</td>
<td>Personal</td>
<td>The email address.</td>
</tr>
<tr>
<td>IP_ADDRESS</td>
<td>Computer</td>
<td>The IP address</td>
</tr>
<tr>
<td>MAC_ADDRESS</td>
<td>Personal</td>
<td>The MAC address.</td>
</tr>
</tbody>
</table>

## US data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BANK_ACCOUNT</td>
<td>The bank account number. Not specific to a country or region, however, only US and Canadian account formats are detected.</td>
</tr>
<tr>
<td>CREDIT_CARD</td>
<td>The credit card number.</td>
</tr>
<tr>
<td>PHONE_NUMBER</td>
<td>The phone number. Not specific to a country or region, however, only US and Canadian phone numbers are detected at this time.</td>
</tr>
<tr>
<td>USA_ATIN</td>
<td>The US Adoption Taxpayer Identification Number issued by the Internal Revenue Service.</td>
</tr>
<tr>
<td>USA_CPT_CODE</td>
<td>The CPT Code (US specific).</td>
</tr>
<tr>
<td>USA_DEA_NUMBER</td>
<td>The DEA number (US specific).</td>
</tr>
<tr>
<td>USA_DRIVING_LICENSE</td>
<td>The driver license number (US specific).</td>
</tr>
<tr>
<td>USA_HCPCS_CODE</td>
<td>The HCPCS code (US specific).</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>USA_HEALTH_INSURANCECLAIM_NUMBER</td>
<td>Health Insurance Claim Number (US specific).</td>
</tr>
<tr>
<td>USA_ITIN</td>
<td>The ITIN (for US persons or entities).</td>
</tr>
<tr>
<td>USA_MEDICARE_BENEFICIARY_IDENTIFIER</td>
<td>Medicare Beneficiary Identifier (US specific).</td>
</tr>
<tr>
<td>USA_NATIONAL_DRUG_CODE</td>
<td>The NDC code (US specific).</td>
</tr>
<tr>
<td>USA_NATIONAL_PROVIDER_IDENTIFIER</td>
<td>The National Provider Identifier number (US specific).</td>
</tr>
<tr>
<td>USA_PASSPORT_NUMBER</td>
<td>The passport number (for US persons).</td>
</tr>
<tr>
<td>USA_PTIN</td>
<td>The US Preparer Tax Identification Number issued by the Internal Revenue Service.</td>
</tr>
<tr>
<td>USA_SSN</td>
<td>The social security number (for US persons).</td>
</tr>
</tbody>
</table>

**Argentina data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARGENTINA_TAX_IDENTIFICATION_NUMBER</td>
<td>Argentina Tax Identification Number. Also known as CUIT or CUIL.</td>
</tr>
</tbody>
</table>

**Australian data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRALIA_BUSINESS_NUMBER</td>
<td>Australia Business Number (ABN). A unique identifier issued by the Australian Business Register (ABR) to identify businesses to the government and community.</td>
</tr>
</tbody>
</table>
### AUSTRALIA data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRALIA_COMPANY_NUMBER</td>
<td>Australia Company Number (ACN). Unique identifier issued by the Australian Securities and Investments Commission.</td>
</tr>
<tr>
<td>AUSTRALIA_DRIVING_LICENSE</td>
<td>A driver’s license number for Australia.</td>
</tr>
<tr>
<td>AUSTRALIA_MEDICARE_NUMBER</td>
<td>Australian Medicare Number. Personal identifier issued by the Australian Health Insurance Commission.</td>
</tr>
<tr>
<td>AUSTRALIA_PASSPORT_NUMBER</td>
<td>Australian passport number.</td>
</tr>
<tr>
<td>AUSTRALIA_TAX_FILE_NUMBER</td>
<td>Australia Tax File Number (TFN). Issued by the Australian Taxation Office (ATO) to taxpayers (individual, company, etc) for tax dealings.</td>
</tr>
</tbody>
</table>

### Austria data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRIA_DRIVING_LICENSE</td>
<td>The driver license number (Austria specific).</td>
</tr>
<tr>
<td>AUSTRIA_PASSPORT_NUMBER</td>
<td>The passport number (Austria specific).</td>
</tr>
<tr>
<td>AUSTRIA_SSN</td>
<td>The social security number (for Austria persons).</td>
</tr>
<tr>
<td>AUSTRIA_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Austria specific).</td>
</tr>
<tr>
<td>AUSTRIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Austria specific).</td>
</tr>
</tbody>
</table>

### Balkans data types
<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSNIA_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Bosnia-Herzegovina citizens.</td>
</tr>
<tr>
<td>KOSOVO_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Kosovo.</td>
</tr>
<tr>
<td>MACEDONIA_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number for Macedonia.</td>
</tr>
<tr>
<td>MONTENEGRO_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Montenegro.</td>
</tr>
<tr>
<td>SERBIA_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Serbia.</td>
</tr>
<tr>
<td>SERBIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Serbia specific).</td>
</tr>
<tr>
<td>VOJVODINA_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Vojvodina.</td>
</tr>
</tbody>
</table>

**Belgium data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELGIUM_DRIVING_LICENSE</td>
<td>The driver license number (Belgium specific).</td>
</tr>
<tr>
<td>BELGIUM_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The Belgian National Number (BNN).</td>
</tr>
<tr>
<td>BELGIUM_PASSPORT_NUMBER</td>
<td>The passport number (Belgium specific).</td>
</tr>
<tr>
<td>BELGIUM_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Belgium specific).</td>
</tr>
<tr>
<td>BELGIUM_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Belgium specific).</td>
</tr>
</tbody>
</table>

**Brazil data types**
## Brazil data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL_BANK_ACCOUNT</td>
<td>The bank account number (Brazil specific).</td>
</tr>
<tr>
<td>BRAZIL_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Brazil specific).</td>
</tr>
<tr>
<td>BRAZIL_NATIONAL_REGISTRY_OF_LEGAL_ENTITIES_NUMBER</td>
<td>The identification number issued to companies (Brazil specific), also known as the CNPJ.</td>
</tr>
<tr>
<td>BRAZIL_NATURAL_PERSON_REGISTRY_NUMBER</td>
<td>Natural Person Registry Number, also known as CPF.</td>
</tr>
</tbody>
</table>

## Bulgaria data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BULGARIA_DRIVING_LICENSE</td>
<td>The driver license number (Bulgaria specific).</td>
</tr>
<tr>
<td>BULGARIA_UNIFORM_CIVIL_NUMBER</td>
<td>Unified Civil Number (EGN) that serves as a national identification number.</td>
</tr>
<tr>
<td>BULGARIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Bulgaria specific).</td>
</tr>
</tbody>
</table>

## Canada data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANADA_DRIVING_LICENSE</td>
<td>The driver license number (Canada specific).</td>
</tr>
<tr>
<td>CANADA_GOVERNMENT_IDENTIFICATION_CARD_NUMBER</td>
<td>The national identifier (Canada specific).</td>
</tr>
<tr>
<td>CANADA_PASSPORT_NUMBER</td>
<td>The passport number (Canada specific).</td>
</tr>
<tr>
<td>CANADA_PERMANENT_RESIDENCE_NUMBER</td>
<td>Permanent residence number (PR Card number).</td>
</tr>
</tbody>
</table>
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANADA_PERSONAL_HEALTH_NUMBER</td>
<td>The unique identifier for healthcare (PHN number).</td>
</tr>
<tr>
<td>CANADA_SOCIAL_INSURANCE_NUMBER</td>
<td>The social insurance number (SIN) in Canada.</td>
</tr>
</tbody>
</table>

**Chile data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHILE_DRIVING_LICENSE</td>
<td>The driver license number (Chile specific).</td>
</tr>
<tr>
<td>CHILE_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The Chile national identifier, also known as RUT or RUN.</td>
</tr>
</tbody>
</table>

**China, Hong Kong, Macau, and Taiwan data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHINA_IDENTIFICATION</td>
<td>The China identifier.</td>
</tr>
<tr>
<td>CHINA_LICENSE_PLATE_NUMBER</td>
<td>The driver license number (China specific).</td>
</tr>
<tr>
<td>CHINA_MAINLAND_TRAVEL_PERMIT_ID_HONG_KONG_MACAU</td>
<td>The Mainland Travel Permit for Hong Kong and Macao Residents.</td>
</tr>
<tr>
<td>CHINA_MAINLAND_TRAVEL_PERMIT_ID_TAIWAN</td>
<td>The Mainland Travel Permit for Taiwan Residents issued by Government of the People's Republic of China (PRC).</td>
</tr>
<tr>
<td>CHINA_PASSPORT_NUMBER</td>
<td>The passport number (China specific).</td>
</tr>
<tr>
<td>CHINA_PHONE_NUMBER</td>
<td>The phone number (China specific).</td>
</tr>
<tr>
<td>HONG_KONG_IDENTITY_CARD</td>
<td>The official identity document issued by the Immigration Department of Hong Kong.</td>
</tr>
</tbody>
</table>
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACAU_RESIDENT_IDENTITY_CARD</td>
<td>The Macau Resident Identity Card or BIR is an official identity card issued by the Identification Services Bureau of Macau.</td>
</tr>
<tr>
<td>TAIWAN_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Taiwan specific).</td>
</tr>
<tr>
<td>TAIWAN_PASSPORT_NUMBER</td>
<td>The passport number (Taiwan specific).</td>
</tr>
</tbody>
</table>

### Colombia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOMBIA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>Unique identifier assigned to Colombians at birth.</td>
</tr>
<tr>
<td>COLOMBIA_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Colombia specific).</td>
</tr>
</tbody>
</table>

### Croatia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROATIA_DRIVING_LICENSE</td>
<td>The driver license number (Croatia specific).</td>
</tr>
<tr>
<td>CROATIA_IDENTITY_NUMBER</td>
<td>The national identifier (Croatia specific).</td>
</tr>
<tr>
<td>CROATIA_PASSPORT_NUMBER</td>
<td>The passport number (Croatia specific).</td>
</tr>
<tr>
<td>CROATIA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (OIB).</td>
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</tbody>
</table>

### Cyprus data types

Features and optimizations
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYPRUS_DRIVING_LICENSE</td>
<td>The driver license number (Cyprus specific).</td>
</tr>
<tr>
<td>CYPRUS_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The Cypriot identity card.</td>
</tr>
<tr>
<td>CYPRUS_PASSPORT_NUMBER</td>
<td>The passport number (Cyprus specific).</td>
</tr>
<tr>
<td>CYPRUS_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Cyprus specific).</td>
</tr>
<tr>
<td>CYPRUS_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Cyprus specific).</td>
</tr>
</tbody>
</table>

### Czechia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CZECHIA_DRIVING_LICENSE</td>
<td>The driver license number (Czechia specific).</td>
</tr>
<tr>
<td>CZECHIA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (Czechia specific).</td>
</tr>
<tr>
<td>CZECHIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Czechia specific).</td>
</tr>
</tbody>
</table>

### Denmark data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENMARK_DRIVING_LICENSE</td>
<td>The driver license number (Denmark specific).</td>
</tr>
<tr>
<td>DENMARK_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (Denmark specific).</td>
</tr>
<tr>
<td>DENMARK_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Denmark specific).</td>
</tr>
<tr>
<td>DENMARK_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Denmark specific).</td>
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</tbody>
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### Estonia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESTONIA_DRIVING_LICENSE</td>
<td>The driver license number (Estonia specific).</td>
</tr>
<tr>
<td>ESTONIA_PASSPORT_NUMBER</td>
<td>The passport number (Estonia specific).</td>
</tr>
<tr>
<td>ESTONIA_PERSONAL_IDENTIFICATION_CODE</td>
<td>The personal identifier number (Estonia specific).</td>
</tr>
<tr>
<td>ESTONIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Estonia specific).</td>
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</tbody>
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### Finland data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINLAND_DRIVING_LICENSE</td>
<td>The driver license number (Finland specific).</td>
</tr>
<tr>
<td>FINLAND_HEALTH_INSURANCE_NUMBER</td>
<td>The health insurance number (Finland specific).</td>
</tr>
<tr>
<td>FINLAND_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Finland specific).</td>
</tr>
<tr>
<td>FINLAND_PASSPORT_NUMBER</td>
<td>The passport number (Finland specific).</td>
</tr>
<tr>
<td>FINLAND_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Finland specific).</td>
</tr>
</tbody>
</table>

### France data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRANCE_BANK_ACCOUNT</td>
<td>The bank account number (France specific).</td>
</tr>
<tr>
<td>FRANCE_DRIVING_LICENSE</td>
<td>The driver license number (France specific).</td>
</tr>
<tr>
<td>FRANCE_HEALTH_INSURANCE_NUMBER</td>
<td>France health insurance number.</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>FRANCE_INSEE_CODE</td>
<td>France social security, SSN, or NIR number.</td>
</tr>
<tr>
<td>FRANCE_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>France national identifier number (CNI).</td>
</tr>
<tr>
<td>FRANCE_PASSPORT_NUMBER</td>
<td>The passport number (France specific).</td>
</tr>
<tr>
<td>FRANCE_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (France specific).</td>
</tr>
<tr>
<td>FRANCE_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (France specific).</td>
</tr>
</tbody>
</table>

**Germany data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMANY_BANK_ACCOUNT</td>
<td>The bank account number (Germany specific).</td>
</tr>
<tr>
<td>GERMANY_DRIVING_LICENSE</td>
<td>The driver license number (Germany specific).</td>
</tr>
<tr>
<td>GERMANY_PASSPORT_NUMBER</td>
<td>The passport number (Germany specific).</td>
</tr>
<tr>
<td>GERMANY_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identification number (Germany specific).</td>
</tr>
<tr>
<td>GERMANY_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Germany specific).</td>
</tr>
<tr>
<td>GERMANY_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Germany specific).</td>
</tr>
</tbody>
</table>

**Greece data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREECE_DRIVING_LICENSE</td>
<td>The driver license number (Greece specific).</td>
</tr>
<tr>
<td>GREECE_PASSPORT_NUMBER</td>
<td>The passport number (Greece specific).</td>
</tr>
</tbody>
</table>
### GREECE data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREECE_SSN</td>
<td>The social security number (for Greece persons).</td>
</tr>
<tr>
<td>GREECE_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Greece specific).</td>
</tr>
<tr>
<td>GREECE_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Greece specific).</td>
</tr>
</tbody>
</table>

### Hungary data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUNGARY_DRIVING_LICENSE</td>
<td>The driver license number (Hungary specific).</td>
</tr>
<tr>
<td>HUNGARY_PASSPORT_NUMBER</td>
<td>The passport number (Hungary specific).</td>
</tr>
<tr>
<td>HUNGARY_SSN</td>
<td>The social security number (for Hungary persons).</td>
</tr>
<tr>
<td>HUNGARY_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Hungary specific).</td>
</tr>
<tr>
<td>HUNGARY_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Hungary specific).</td>
</tr>
</tbody>
</table>

### Iceland data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICELAND_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Iceland specific).</td>
</tr>
<tr>
<td>ICELAND_PASSPORT_NUMBER</td>
<td>The passport number (Iceland specific).</td>
</tr>
<tr>
<td>ICELAND_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Iceland specific).</td>
</tr>
</tbody>
</table>

### India data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
</table>

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Features and optimizations
### India data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDIA_AADHAAR_NUMBER</td>
<td>Aadhaar identification number issued by the Unique Identification Authority of India.</td>
</tr>
<tr>
<td>INDIA_PERMANENT_ACCOUNT_NUMBER</td>
<td>India Permanent Account Number (PAN).</td>
</tr>
</tbody>
</table>

### Indonesia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDONESIA_IDENTITY_CARD_NUMBER</td>
<td>The national identifier (Indonesia specific).</td>
</tr>
</tbody>
</table>

### Ireland data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRELAND_DRIVING_LICENSE</td>
<td>The driver license number (Ireland specific).</td>
</tr>
<tr>
<td>IRELAND_PASSPORT_NUMBER</td>
<td>The passport number (Ireland specific).</td>
</tr>
<tr>
<td>IRELAND_PERSONAL_PUBLIC_SERVICE_NUMBER</td>
<td>Ireland personal public service number (PPS).</td>
</tr>
<tr>
<td>IRELAND_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Ireland specific).</td>
</tr>
<tr>
<td>IRELAND_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Ireland specific).</td>
</tr>
</tbody>
</table>

### Israel data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISRAEL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Israel specific).</td>
</tr>
</tbody>
</table>

### Italy data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
</table>
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITALY_BANK_ACCOUNT</td>
<td>The bank account number (Italy specific).</td>
</tr>
<tr>
<td>ITALY_DRIVING_LICENSE</td>
<td>The driver license number (Italy specific).</td>
</tr>
<tr>
<td>ITALY_FISCAL_CODE</td>
<td>The identifier number, also known as the Italian Codice Fiscale.</td>
</tr>
<tr>
<td>ITALY_PASSPORT_NUMBER</td>
<td>The passport number (Italy specific).</td>
</tr>
<tr>
<td>ITALY_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Italy specific).</td>
</tr>
</tbody>
</table>

### Japan data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAPAN_BANK_ACCOUNT</td>
<td>Japan bank account.</td>
</tr>
<tr>
<td>JAPAN_DRIVING_LICENSE</td>
<td>A driver's license number for Japan.</td>
</tr>
<tr>
<td>JAPAN_MY_NUMBER</td>
<td>The unique identifier for Japan citizens or corporations used for tax administration, social security administration, and disaster response</td>
</tr>
<tr>
<td>JAPAN_PASSPORT_NUMBER</td>
<td>Japan passport number.</td>
</tr>
</tbody>
</table>

### Korea data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KOREA_PASSPORT_NUMBER</td>
<td>The passport number (Korea specific).</td>
</tr>
<tr>
<td>KOREA_RESIDENCE_REGISTRATIO_NUMBER_FOR_CITIZENS</td>
<td>Korea residence registrant number for residents.</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>KOREA_RESIDENCE_REGISTRATION_NUMBER_FOR_FOREIGNERS</td>
<td>Korea residence registrant number for foreigners.</td>
</tr>
</tbody>
</table>

**Latvia data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATVIA_DRIVING_LICENSE</td>
<td>The driver license number (Latvia specific).</td>
</tr>
<tr>
<td>LATVIA_PASSPORT_NUMBER</td>
<td>The passport number (Latvia specific).</td>
</tr>
<tr>
<td>LATVIA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (Latvia specific).</td>
</tr>
<tr>
<td>LATVIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Latvia specific).</td>
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</tbody>
</table>

**Liechtenstein data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIECHTENSTEIN_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Liechtenstein specific).</td>
</tr>
<tr>
<td>LIECHTENSTEIN_PASSPORT_NUMBER</td>
<td>The passport number (Liechtenstein specific).</td>
</tr>
<tr>
<td>LIECHTENSTEIN_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Liechtenstein specific).</td>
</tr>
</tbody>
</table>

**Lithuania data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LITHUANIA_DRIVING_LICENSE</td>
<td>The driver license number (Lithuania specific).</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>LITHUANIA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (Lithuania specific).</td>
</tr>
<tr>
<td>LITHUANIA_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Lithuania specific).</td>
</tr>
<tr>
<td>LITHUANIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Lithuania specific).</td>
</tr>
</tbody>
</table>

**Luxembourg data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUXEMBOURG_DRIVING_LICENSE</td>
<td>The driver license number (Luxembourg specific).</td>
</tr>
<tr>
<td>LUXEMBOURG_NATIONAL_INDIVIDUAL_NUMBER</td>
<td>The national identifier (Luxembourg specific).</td>
</tr>
<tr>
<td>LUXEMBOURG_PASSPORT_NUMBER</td>
<td>The passport number (Luxembourg specific).</td>
</tr>
<tr>
<td>LUXEMBOURG_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Luxembourg specific).</td>
</tr>
<tr>
<td>LUXEMBOURG_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Luxembourg specific).</td>
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**Malaysia data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALAYSIA_MYKAD_NUMBER</td>
<td>The national identifier (Malaysia specific).</td>
</tr>
<tr>
<td>MALAYSIA_PASSPORT_NUMBER</td>
<td>The passport number (Malaysia specific).</td>
</tr>
</tbody>
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**Malta data types**
### Data Type

<table>
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<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALTA_DRIVING_LICENSE</td>
<td>The driver license number (Malta specific).</td>
</tr>
<tr>
<td>MALTA_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Malta specific).</td>
</tr>
<tr>
<td>MALTA_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Malta specific).</td>
</tr>
<tr>
<td>MALTA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Malta specific).</td>
</tr>
</tbody>
</table>

**Mexico data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEXICO_CLABE_NUMBER</td>
<td>Mexico CLABE (Clave Bancaria Estandarizada) bank number).</td>
</tr>
<tr>
<td>MEXICO_DRIVING_LICENSE</td>
<td>The driver license number (Mexico specific).</td>
</tr>
<tr>
<td>MEXICO_PASSPORT_NUMBER</td>
<td>The passport number (Mexico specific).</td>
</tr>
<tr>
<td>MEXICO_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Mexico specific).</td>
</tr>
<tr>
<td>MEXICO_UNIQUE_POPULATION_REGISTRY_CODE</td>
<td>The Clave Única de Registro de Población (CURP) unique identity code for Mexico.</td>
</tr>
</tbody>
</table>

**Netherlands data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETHERLANDS_CITIZEN_SERVICE_NUMBER</td>
<td>Netherlands citizen number (BSN, burgerser vicenummer).</td>
</tr>
<tr>
<td>NETHERLANDS_DRIVING_LICENSE</td>
<td>The driver license number (Netherlands specific).</td>
</tr>
<tr>
<td>NETHERLANDS_PASSPORT_NUMBER</td>
<td>The passport number (Netherlands specific).</td>
</tr>
</tbody>
</table>
## Data Type Descriptions

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETHERLANDS_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Netherlands specific).</td>
</tr>
<tr>
<td>NETHERLANDS_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Netherlands specific).</td>
</tr>
<tr>
<td>NETHERLANDS_BANK_ACCOUNT</td>
<td>The bank account number (Netherlands specific).</td>
</tr>
</tbody>
</table>

### New Zealand data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW_ZEALAND_DRIVING_LICENSE</td>
<td>The driver license number (New Zealand specific).</td>
</tr>
<tr>
<td>NEW_ZEALAND_NATIONAL_HEALTH_INDEX_NUMBER</td>
<td>New Zealand national health index number.</td>
</tr>
<tr>
<td>NEW_ZEALAND_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number, also known as inland revenue number (New Zealand specific).</td>
</tr>
</tbody>
</table>

### Norway data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORWAY_BIRTH_NUMBER</td>
<td>Norwegian national identity number.</td>
</tr>
<tr>
<td>NORWAY_DRIVING_LICENSE</td>
<td>The driver license number (Norway specific).</td>
</tr>
<tr>
<td>NORWAY_HEALTH_INSURANCE_NUMBER</td>
<td>Norway health insurance number.</td>
</tr>
<tr>
<td>NORWAY_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Norway specific).</td>
</tr>
<tr>
<td>NORWAY_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Norway specific).</td>
</tr>
</tbody>
</table>
## Philippines data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHILIPPINES_DRIVING_LICENSE</td>
<td>The driver license number (Philippines specific).</td>
</tr>
<tr>
<td>PHILIPPINES_PASSPORT_NUMBER</td>
<td>The passport number (Philippines specific).</td>
</tr>
</tbody>
</table>

## Poland data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLAND_DRIVING_LICENSE</td>
<td>The driver license number (Poland specific).</td>
</tr>
<tr>
<td>POLAND_IDENTIFICATION_NUMBER</td>
<td>The Poland identifier.</td>
</tr>
<tr>
<td>POLAND_PASSPORT_NUMBER</td>
<td>The passport number (Poland specific).</td>
</tr>
<tr>
<td>POLAND_REGON_NUMBER</td>
<td>The REGON identifier number, also known as the Statistical Identification Number.</td>
</tr>
<tr>
<td>POLAND_SSN</td>
<td>The social security number (for Poland persons).</td>
</tr>
<tr>
<td>POLAND_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Poland specific).</td>
</tr>
<tr>
<td>POLAND_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Poland specific).</td>
</tr>
</tbody>
</table>

## Portugal data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PORTUGAL_DRIVING_LICENSE</td>
<td>The driver license number (Portugal specific).</td>
</tr>
<tr>
<td>PORTUGAL_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Portugal specific).</td>
</tr>
</tbody>
</table>
## Data Type Descriptions

### Portugal data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PORTUGAL_PASSPORT_NUMBER</td>
<td>The passport number (Portugal specific).</td>
</tr>
<tr>
<td>PORTUGAL_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Portugal specific).</td>
</tr>
<tr>
<td>PORTUGAL_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Portugal specific).</td>
</tr>
</tbody>
</table>

### Romania data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROMANIA_DRIVING_LICENSE</td>
<td>The driver license number (Romania specific).</td>
</tr>
<tr>
<td>ROMANIA_NUMERICAL_PERSONAL_CODE</td>
<td>The personal identifier number (Romania specific).</td>
</tr>
<tr>
<td>ROMANIA_PASSPORT_NUMBER</td>
<td>The passport number (Romania specific).</td>
</tr>
<tr>
<td>ROMANIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Romania specific).</td>
</tr>
</tbody>
</table>

### Singapore data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGAPORE_DRIVING_LICENSE</td>
<td>The driver license number (Singapore specific).</td>
</tr>
<tr>
<td>SINGAPORE_NATIONAL_REGISTRY_IDENTIFICATION_NUMBER</td>
<td>The national registration identity card for Singapore.</td>
</tr>
<tr>
<td>SINGAPORE_PASSPORT_NUMBER</td>
<td>The passport number (Singapore specific).</td>
</tr>
<tr>
<td>SINGAPORE_UNIQUE_ENTITY_NUMBER</td>
<td>The Unique Entity Number for Singapore.</td>
</tr>
</tbody>
</table>

### Slovakia data types

---

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### SLOVAKIA data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOVAKIA_DRIVING_LICENSE</td>
<td>The driver license number (Slovakia specific).</td>
</tr>
<tr>
<td>SLOVAKIA_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Slovakia specific).</td>
</tr>
<tr>
<td>SLOVAKIA_PASSPORT_NUMBER</td>
<td>The passport number (Slovakia specific).</td>
</tr>
<tr>
<td>SLOVAKIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Slovakia specific).</td>
</tr>
</tbody>
</table>

### Slovenia data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOVENIA_DRIVING_LICENSE</td>
<td>The driver license number (Slovenia specific).</td>
</tr>
<tr>
<td>SLOVENIA_PASSPORT_NUMBER</td>
<td>The passport number (Slovenia specific).</td>
</tr>
<tr>
<td>SLOVENIA_TAX_IDENTIFICATION_NUMBER</td>
<td>Tax identification number (Slovenia specific).</td>
</tr>
<tr>
<td>SLOVENIA_UNIQUE_MASTER_CITIZEN_NUMBER</td>
<td>Unique master citizen number (JMBG) for Slovenia citizens.</td>
</tr>
<tr>
<td>SLOVENIA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Slovenia specific).</td>
</tr>
</tbody>
</table>

### South Africa data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUTH_AFRICA_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (South Africa specific).</td>
</tr>
</tbody>
</table>

### Spain data types
### SPAIN data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAIN_BANK_ACCOUNT</td>
<td>The bank account number (Spain specific).</td>
</tr>
<tr>
<td>SPAIN_DNI</td>
<td>The national identity card (Documento Nacional de Identidad) of Spain.</td>
</tr>
<tr>
<td>SPAIN_DRIVING_LICENSE</td>
<td>The driver license number (Spain specific).</td>
</tr>
<tr>
<td>SPAIN_NIE</td>
<td>The foreigner identity number (Spain specific), also known as the NIE.</td>
</tr>
<tr>
<td>SPAIN_NIF</td>
<td>Tax identification number (Spain specific), also known as the NIF.</td>
</tr>
<tr>
<td>SPAIN_PASSPORT_NUMBER</td>
<td>The passport number (Spain specific).</td>
</tr>
<tr>
<td>SPAIN_SSN</td>
<td>The social security number (for Spain persons).</td>
</tr>
<tr>
<td>SPAIN_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Spain specific).</td>
</tr>
</tbody>
</table>

### Sri Lanka data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRI_LANKA_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier (Sri Lanka specific).</td>
</tr>
</tbody>
</table>

### Sweden data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWEDEN_DRIVING_LICENSE</td>
<td>The driver license number (Sweden specific).</td>
</tr>
<tr>
<td>SWEDEN_PASSPORT_NUMBER</td>
<td>The passport number (Sweden specific).</td>
</tr>
<tr>
<td>SWEDEN_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Sweden specific).</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SWEDEN_TAX_IDENTIFICATION_NUMBER</td>
<td>Sweden tax identification number (personnummer).</td>
</tr>
<tr>
<td>SWEDEN_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Sweden specific).</td>
</tr>
</tbody>
</table>

### Switzerland data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWITZERLAND_AHV</td>
<td>The social security number for Swiss persons (AHV).</td>
</tr>
<tr>
<td>SWITZERLAND_HEALTH_INSURANCE_NUMBER</td>
<td>Swiss health insurance number.</td>
</tr>
<tr>
<td>SWITZERLAND_PASSPORT_NUMBER</td>
<td>The passport number (Switzerland specific).</td>
</tr>
<tr>
<td>SWITZERLAND_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Switzerland specific).</td>
</tr>
</tbody>
</table>

### Thailand data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>THAILAND_PASSPORT_NUMBER</td>
<td>The passport number (Thailand specific).</td>
</tr>
<tr>
<td>THAILAND_PERSONAL_IDENTIFICATION_NUMBER</td>
<td>The personal identifier number (Thailand specific).</td>
</tr>
</tbody>
</table>

### Turkey data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TURKEY_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Turkey specific).</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>TURKEY_PASSPORT_NUMBER</td>
<td>The passport number (Turkey specific).</td>
</tr>
<tr>
<td>TURKEY_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Turkey specific).</td>
</tr>
</tbody>
</table>

**Ukraine data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKRAINE_INDIVIDUAL_IDENTIFICATION_NUMBER</td>
<td>The unique identifier (Ukraine specific).</td>
</tr>
<tr>
<td>UKRAINE_PASSPORT_NUMBER_DOMESTIC</td>
<td>The domestic passport number (Ukraine specific).</td>
</tr>
<tr>
<td>UKRAINE_PASSPORT_NUMBER_INTERNATIONAL</td>
<td>The international passport number (Ukraine specific).</td>
</tr>
</tbody>
</table>

**United Arab Emirates (UAE) data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNITED_ARAB_EMIRATES_PERSONAL_NUMBER</td>
<td>The personal identifier number (UAE specific).</td>
</tr>
</tbody>
</table>

**UK data types**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK_BANK_ACCOUNT</td>
<td>United Kingdom (UK) bank account.</td>
</tr>
<tr>
<td>UK_BANK_SORT_CODE</td>
<td>United Kingdom (UK) bank sort code. Sort codes are bank codes used to route money transfers between banks within their respective</td>
</tr>
<tr>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>countries via their respective clearance organizations.</td>
</tr>
<tr>
<td>UK_DRIVING_LICENSE</td>
<td>The driver's license number for the United Kingdom of Great Britain and Northern Ireland (UK specific)</td>
</tr>
<tr>
<td>UK_ELECTORAL_ROLL_NUMBER</td>
<td>The Electoral Roll Number (ERN) is the identification number issued to an individual for UK election registration. The format of this number is specified by the UK Government Standards of the UK Cabinet Office.</td>
</tr>
<tr>
<td>UK_NATIONAL_HEALTH_SERVICE_NUMBER</td>
<td>The National Health Service (NHS) number is the unique number allocated to a registered user of public health services in the United Kingdom.</td>
</tr>
<tr>
<td>UK_NATIONAL_INSURANCE_NUMBER</td>
<td>The National Insurance number (NINO) is a number used in the United Kingdom (UK) to identify an individual for the national insurance program or social security system. The number is sometimes referred to as NI No or NINO.</td>
</tr>
<tr>
<td>UK_PASSPORT_NUMBER</td>
<td>United Kingdom (UK) passport number.</td>
</tr>
<tr>
<td>UK_UNIQUE_TAXPAYER_REFERENCE_NUMBER</td>
<td>The United Kingdom (UK) Unique Taxpayer Reference (UTR) number. An identifier used by the UK government to manage the taxation system.</td>
</tr>
</tbody>
</table>
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK_VALUE_ADDED_TAX</td>
<td>VAT is a consumption tax that is borne by the end consumer. VAT is paid for each transaction in the manufacturing and distribution process. For the United Kingdom, the VAT number is issued by the VAT office for the region in which the business is established.</td>
</tr>
<tr>
<td>UK_PHONENUMBER</td>
<td>United Kingdom (UK) phone number.</td>
</tr>
</tbody>
</table>

### Venezuela data types

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VENEZUELA_DRIVING_LICENSE</td>
<td>The driver license number (Venezuela specific).</td>
</tr>
<tr>
<td>VENEZUELA_NATIONAL_IDENTIFICATION_NUMBER</td>
<td>The national identifier number (Venezuela specific).</td>
</tr>
<tr>
<td>VENEZUELA_VALUE_ADDED_TAX</td>
<td>Value-Added Tax (Venezuela specific).</td>
</tr>
</tbody>
</table>

### Using fine-grained sensitive data detection

**Note**

Fine-grained actions is only available in AWS Glue 3.0 and 4.0. This includes the AWS Glue Studio experience. The persistent audit log changes are also not available in 2.0. All AWS Glue Studio 3.0 and 4.0 visual jobs will have a script created that automatically uses fine-grained actions APIs.

The Detect Sensitive Data transform provides the ability to detect, mask, or remove entities that you define, or are pre-defined by AWS Glue. Fine-grained actions further allows you to apply a specific action per entity. Additional benefits include:

- Improved performance as actions are being applied as soon data is detected.
• The option to include or exclude specific columns.
• The ability to use partial masking. This allows you to mask detected sensitive data entities partially, rather than masking the entire string. Both simple params with offsets and regex are supported.

The following are code snippets of sensitive data detection APIs and fine-grained actions used in the sample jobs referenced in the next section.

**Detect API** – fine-grained actions use the new `detectionParameters` parameter:

```java
def detect(
    frame: DynamicFrame,
    detectionParameters: JsonOptions,
    outputColumnName: String = "DetectedEntities",
    detectionSensitivity: String = "LOW"
): DynamicFrame = {}
```

**Using Sensitive Data Detection APIs with fine-grained actions**

Sensitive data detection APIs using `detect` analyzes the data given, determines if the rows or columns are Sensitive Data Entity Types, and will run actions specified by the user for each Entity type.

**Using the detect API with fine-grained actions**

Use the `detect` API and specify the `outputColumnName` and `detectionParameters`.

```java
object GlueApp {
    def main(sysArgs: Array[String]) {

        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)

        // @params: [JOB_NAME]
        val args = GlueArgParser.getResolvedOptions(sysArgs, Seq("JOB_NAME").toArray)
        Job.init(args("JOB_NAME"), glueContext, args.asJava)

        // Script generated for node S3 bucket. Creates DataFrame from data stored in S3.
```
val S3bucket_node1 =
glueContext.getSourceWithFormat(formatOptions=JsonOptions("""{"quoteChar": ",", "withHeader": true, "separator": ",", "optimizePerformance": false}""""),
connectionType="s3", format="csv", options=JsonOptions("""{"paths": ["s3://189657479688-ddevansh-pii-test-bucket/tiny_pii.csv"""", "recurse": true}""""),
transformationContext="S3bucket_node1").getDynamicFrame()

// Script generated for node Detect Sensitive Data. Will run detect API for the
DataFrame
// detectionParameter contains information on which EntityType are being
detected
// and what actions are being applied to them when detected.
val DetectSensitiveData_node2 = EntityDetector.detect(
  frame = S3bucket_node1,
  detectionParameters = JsonOptions(
    """
      {
        "PHONE_NUMBER": [
          {
            "action": "PARTIAL_REDACT",
            "actionOptions": {
              "numLeftCharsToExclude": "3",
              "numRightCharsToExclude": "4",
              "redactChar": "#"
            },
            "sourceColumnsToExclude": [ "Passport No", "DL NO#" ]
          }
        ],
        "USA_PASSPORT_NUMBER": [
          {
            "action": "SHA256_HASH",
            "sourceColumns": [ "Passport No" ]
          }
        ],
        "USA_DRIVING_LICENSE": [
          {
            "action": "REDACT",
            "actionOptions": {
              "redactText": "USA_DL"
            },
            "sourceColumns": [ "DL NO#" ]
          }
        ]
      }
    )
  )
)
The above script will create a DataFrame from a location in Amazon S3 and then it will run the detect API. Since the detect API requires the field detectionParameters (a map of the entity name to a list all of the action settings to be used for that entity) is represented by AWS Glue's JsonOptions object, it will also allow us to extend the functionality of the API.

For each action specified per entity, enter a list of all column names to which to apply the entity/action combination. This allows you to customize the entities to detect for every column in your dataset and skip entities that you know are not in a specific column. This also allows your jobs to be more performant by not performing unnecessary detection calls those entities and allows you to perform actions unique to each column and entity combination.

Taking a closer look at the detectionParameters, there are three entity types in the sample job. These are Phone Number, USA_PASSPORT_NUMBER, and USA_DRIVING_LICENSE. For each of these entity types AWS Glue will run different actions which are either PARTIAL_REDACT, SHA256_HASH, REDACT, and DETECT. Each of the Entity Types also have sourceColumns to apply to and/or sourceColumnsToExclude if detected.

Note

Only one edit-in-place action (PARTIAL_REDACT, SHA256_HASH, or REDACT) can be used per column but the DETECT action can be used with any of these actions.

The detectionParameters field has the below layout:
The types of actions and actionOptions are listed below:

**DETECT**

```
{  
# Required
 "action": "DETECT",
# Optional, depending on action chosen
 "actionOptions": {  
  // There are no actionOptions for DETECT
 },
# 1 of below required, both can also used
 "sourceColumns": [  
  "COL_1", "COL_2", ..., "COL_N"
 ],
 "sourceColumnsToExclude": [  
  "COL_5"
 ]
}
```

**SHA256_HASH**

```
{  
# Required
 "action": "SHA256_HASH",
# Required or optional, depending on action chosen
 "actionOptions": {  
  // There are no actionOptions for SHA256_HASH
 },
# 1 of below required, both can also used
```
"sourceColumns": ["COL_1", "COL_2", ..., "COL_N"],
"sourceColumnsToExclude": ["COL_5"
]
}

REDACT
{
    # Required
    "action": "REDACT",
    # Required or optional, depending on action chosen
    "actionOptions": {
        // The text that is being replaced
        "redactText": "USA_DL"
    },

    # 1 of below required, both can also used
    "sourceColumns": ["COL_1", "COL_2", ..., "COL_N"],
    "sourceColumnsToExclude": ["COL_5"
]
}

PARTIAL_REDACT
{
    # Required
    "action": "PARTIAL_REDACT",
    # Required or optional, depending on action chosen
    "actionOptions": {
        // number of characters to not redact from the left side
        "numLeftCharsToExclude": "3",
        // number of characters to not redact from the right side
        "numRightCharsToExclude": "4",
        // the partial redact will be made with this redacted character
        "redactChar": "#",
        // regex pattern for partial redaction
        "matchPattern": "[0-9]"
    },

    # 1 of below required, both can also used
"sourceColumns": [ "COL_1", "COL_2", ..., "COL_N" ],
"sourceColumnsToExclude": [ "COL_5" ]
}

Once the script runs, results are output to the given Amazon S3 location. You can view your data in Amazon S3 but with the selected entity types being sensitized based on the selected action. In the case, we would have a rows that would have that looked like this:

```
{
   "Name": "Colby Schuster",
   "Address": "39041 Antonietta Vista, South Rodgerside, Nebraska 24151",
   "Car Owned": "Fiat",
   "Email": "Kitty46@gmail.com",
   "Company": "O'Reilly Group",
   "Job Title": "Dynamic Functionality Facilitator",
   "ITIN": "991-22-2906",
   "Username": "Cassandre.Kub43",
   "SSN": "914-22-2906",
   "DOB": "2020-08-27",
   "Phone Number": "1-2####1718",
   "Bank Account No": "69741187",
   "Credit Card Number": "6441-6289-6867-2162-2711",
   "Passport No": "94f311e93a623c72cc86fca46cf55b0265ccc42c5117498a0f27fd4c43b4711e",
   "DL NO#": "USA_DL"
}
```

In the above script, the Phone Number was partially redacted with #. The Passport No was changed into a SHA256 hash. The DL NO# was detected as a USA driver license number and was redacted to “USA_DL” just like it was stated in the detectionParameters.

**Note**

The classifyColumns API is not available for use with fine-grained actions due to the nature of the API. This API performs column sampling (adjustable by the user but has default...
values) to perform detection more quickly. Fine-grained actions require iterating over every value for this reason.

Persistent Audit Log

A new feature introduced with fine-grained actions (but also available when using the normal APIs) is the presence of a persistent audit log. Currently, running the detect API adds an additional column (defaults to DetectedEntities but customizable through the outputColumnName) parameter with PII detection metadata. This now has an “actionUsed” metadata key, which is one of DETECT, PARTIAL_REDACT, SHA256_HASH, REDACT.

```
"DetectedEntities": {
    "Credit Card Number": [
        {
            "entityType": "CREDIT_CARD",
            "actionUsed": "DETECT",
            "start": 0,
            "end": 19
        }
    ],
    "Phone Number": [
        {
            "entityType": "PHONE_NUMBER",
            "actionUsed": "REDACT",
            "start": 0,
            "end": 14
        }
    ]
}
```

Even customers using APIs without fine-grained actions such as detect(entityTypesToDetect, outputColumnName) will see this persistent audit log in the resulting dataframe.

Customers using APIs with fine-grained actions will see all of the actions, regardless of if they are redacted or not. Example:
If you do not want to see the **DetectedEntities** column, you can simply drop the additional column in a custom script.

**AWS Glue Visual Job API**

AWS Glue provides an API that allows customers to create data integration jobs using the AWS Glue API from a JSON object that represents a visual step workflow. Customers can then use the visual editor in AWS Glue Studio to work with these jobs.

For more information on Visual Job API data types, see [Visual Job API](#).

**Topics**

- [API design and CRUD APIs](#)
- [Getting started](#)
- [Visual job limitations](#)
API design and CRUD APIs

The CreateJob and UpdateJob APIs now support an additional optional parameter, codeGenConfigurationNodes. Providing a non-empty JSON structure for this field will result in the DAG being registered in AWS Glue Studio for the created job and the associated code being generated. A null value or empty string for this field on job create will be ignored.

Updates to the codeGenConfigurationNodes field will be done through the UpdateJob AWS Glue API in a similar way as CreateJob. The entire field should be specified in UpdateJob where the DAG has been changed as desired. A null value provided will be ignored and no update to the DAG would be performed. An empty structure or string will cause the codeGenConfigurationNodes to be set as empty and any previous DAG removed. The GetJob API will return a DAG if one exists. The DeleteJob API will also delete any associated DAG.

Getting started

To create a job, use the CreateJob action. The CreateJob request input will have an additional field ‘codeGenConfigurationNodes’ where you can get specify the DAG object in JSON.

Things to keep in mind:

- The ‘codeGenConfigurationNodes’ field is a map of nodeid to node.
- Each node begins with a key identifying what kind of node it is.
- There can only be one key specified since a node can only be of one type.
- The input field contains the parent nodes of the current node.

The following is a JSON representation of a CreateJob input.

```json
{
    "node-1": {
        "S3CatalogSource": {
            "Table": "csvFormattedTable",
            "PartitionPredicate": "",
            "Name": "S3 bucket",
            "AdditionalOptions": {},
            "Database": "myDatabase"
        }
    },
    "node-3": {
        "S3DirectTarget": {
        ...
```
Since `UpdateJob` will also have a `codegenConfigurationNodes` field, the input format will be the same. See `UpdateJob` Action.

The `GetJob` action will return a `codegenConfigurationNodes` field in the same format as well. See `GetJob` Action.

**Visual job limitations**

Since the `codegenConfigurationNodes` parameter has been added to existing APIs, any limitations in those APIs will be inherited. In addition, the `codegenConfigurationNodes` and some nodes will be limited in size. See `Job Structure` for more information.

**Programming Ray scripts**

AWS Glue makes it easy to write and run Ray scripts. This section describes the supported Ray capabilities that are available in AWS Glue for Ray. You program Ray scripts in Python.

Your custom script must be compatible with the version of Ray that’s defined by the `Runtime` field in your job definition. For more information about `Runtime` in the Jobs API, see the section called “Jobs”. For information about each runtime environment, see the section called “Supported Ray runtime environments”.

**Topics**

- Tutorial: Writing an ETL script in AWS Glue for Ray
- Using Ray Core and Ray Data in AWS Glue for Ray
- Providing files and Python libraries to Ray jobs
- Connecting to data in Ray jobs

**Tutorial: Writing an ETL script in AWS Glue for Ray**

Ray gives you the ability to write and scale distributed tasks natively in Python. AWS Glue for Ray offers serverless Ray environments that you can access from both jobs and interactive sessions (Ray interactive sessions are in preview). The AWS Glue job system provides a consistent way to manage and run your tasks—on a schedule, from a trigger, or from the AWS Glue console.

Combining these AWS Glue tools creates a powerful toolchain that you can use for extract, transform, and load (ETL) workloads, a popular use case for AWS Glue. In this tutorial, you will learn the basics of putting together this solution.
We also support using AWS Glue for Spark for your ETL workloads. For a tutorial on writing a AWS Glue for Spark script, see the section called “Tutorial: Writing a Spark script”. For more information about available engines, see the section called “AWS Glue for Spark and AWS Glue for Ray”. Ray is capable of addressing many different kinds of tasks in analytics, machine learning (ML), and application development.

In this tutorial, you will extract, transform, and load a Parquet dataset that is hosted in Amazon Simple Storage Service (Amazon S3). You will begin with the Amazon Customer Reviews Dataset, which is stored in a public Amazon S3 bucket. For more information about this dataset, see Amazon Customer Reviews Dataset.

You will transform your data with predefined transforms that are available in the Ray Data library. Ray Data is a dataset preparation library designed by Ray and included by default in AWS Glue for Ray environments. For more information about libraries included by default, see the section called “Modules provided with Ray jobs”. You will then write your transformed data to an Amazon S3 bucket that you control.

**Prerequisites** – For this tutorial, you need an AWS account with access to AWS Glue and Amazon S3.

**Step 1: Create a bucket in Amazon S3 to hold your output data**

You will need an Amazon S3 bucket that you control to serve as a sink for data created in this tutorial. You can create this bucket with the following procedure.

- **Note**
  If you want to write your data to an existing bucket that you control, you can skip this step. Take note of `yourBucketName`, the existing bucket's name, to use in later steps.

**To create a bucket for your Ray job output**

- Create a bucket by following the steps in Creating a bucket in the Amazon S3 User Guide.
  - When choosing a bucket name, take note of `yourBucketName`, which you will refer to in later steps.
  - For other configuration, the suggested settings provided in the Amazon S3 console should work fine in this tutorial.
As an example, the bucket creation dialog box might look like this in the Amazon S3 console.

### Step 2: Create an IAM role and policy for your Ray job

Your job will need an AWS Identity and Access Management (IAM) role with the following:

- Permissions granted by the `AWSGlueServiceRole` managed policy. These are the basic permissions that are necessary to run an AWS Glue job.
- Read access level permissions for the `amazon-reviews-pds/*` Amazon S3 resource.
- Write access level permissions for the `yourBucketName/*` Amazon S3 resource.
- A trust relationship that allows the `glue.amazonaws.com` principal to assume the role.

You can create this role with the following procedure.

### To create an IAM role for your AWS Glue for Ray job

#### Note

You can create an IAM role by following many different procedures. For more information or options about how to provision IAM resources, see the [AWS Identity and Access Management documentation](https://docs.aws.amazon.com/IAM/latest/UserGuide/).
1. Create a policy that defines the previously outlined Amazon S3 permissions by following the steps in Creating IAM policies (console) with the visual editor in the IAM User Guide.

   - When selecting a service, choose Amazon S3.
   - When selecting permissions for your policy, attach the following sets of actions for the following resources (mentioned previously):
     - Read access level permissions for the `amazon-reviews-pds/*` Amazon S3 resource.
     - Write access level permissions for the `yourBucketName/*` Amazon S3 resource.
   - When selecting the policy name, take note of `YourPolicyName`, which you will refer to in a later step.

2. Create a role for your AWS Glue for Ray job by following the steps in Creating a role for an AWS service (console) in the IAM User Guide.

   - When selecting a trusted AWS service entity, choose Glue. This will automatically populate the necessary trust relationship for your job.
   - When selecting policies for the permissions policy, attach the following policies:
     - AWSGlueServiceRole
     - `YourPolicyName`
   - When selecting the role name, take note of `YourRoleName`, which you will refer to in later steps.

**Step 3: Create and run an AWS Glue for Ray job**

In this step, you create an AWS Glue job using the AWS Management Console, provide it with a sample script, and run the job. When you create a job, it creates a place in the console for you to store, configure, and edit your Ray script. For more information about creating jobs, see the section called “Signing in to the console”.

In this tutorial, we address the following ETL scenario: you would like to read from the Wireless partition of the Amazon Customer Reviews Dataset, add a new column (`helpful_votes_ratio`) to the dataset by combining data in existing columns, then remove a number of columns that aren't relevant to your current analysis, and then you would like to write the results to `yourBucketName`. The following Ray script performs these steps:

```python
import ray
import pandas
```
from ray import data

ray.init('auto')

ds = ray.data.read_parquet("s3://amazon-reviews-pds/parquet/product_category=Wireless")

# Add the given new column to the dataset and show the sample record after adding a new column
ds = ds.add_column( "helpful_votes_ratio", lambda df: df["helpful_votes"] / df["total_votes"])

# Dropping few columns from the underlying Dataset
ds = ds.drop_columns(["review_body", "vine", "product_parent", "verified_purchase", "review_headline")

ds.write_parquet("s3://yourBucketName/ray/tutorial/output")

To create and run an AWS Glue for Ray job

1. In the AWS Management Console, navigate to the AWS Glue landing page.
2. In the side navigation pane, choose ETL Jobs.
3. In Create job, choose Ray script editor, and then choose Create, as in the following illustration.

4. Paste the full text of the script into the Script pane, and replace any existing text.
5. Navigate to Job details and set the IAM Role property to YourRoleName.
6. Choose **Save**, and then choose **Run**.

### Step 4: Inspect your output

After running your AWS Glue job, you should validate that the output matches the expectations of this scenario. You can do so with the following procedure.

#### To validate whether your Ray job ran successfully

1. On the job details page, navigate to **Runs**.
2. After a few minutes, you should see a run with a **Run status** of **Succeeded**.
3. Navigate to the Amazon S3 console at [https://console.aws.amazon.com/s3/](https://console.aws.amazon.com/s3/) and inspect **yourBucketName**. You should see files written to your output bucket.
4. Read the Parquet files and verify their contents. You can do this with your existing tools. If you don't have a process for validating Parquet files, you can do this in the AWS Glue console with an AWS Glue interactive session, using either Spark or Ray (in preview).

   In an interactive session, you have access to Ray Data, Spark, or pandas libraries, which are provided by default (based on your choice of engine). To verify your file contents, you can use common inspection methods that are available in those libraries—methods like `count`, `schema`, and `show`. For more information about interactive sessions in the console, see [Using notebooks with AWS Glue Studio and AWS Glue](#).

   Because you have confirmed that files have been written to the bucket, you can say with relative certainty that if your output has problems, they are not related to IAM configuration. Configure your session with **yourRoleName** to have access to the relevant files.

If you don't see the expected outcomes, examine the troubleshooting content in this guide to identify and remediate the source of the error. To interpret job run error states, see [the section called “Job run statuses”](#). You can find the troubleshooting content in the [Troubleshooting AWS Glue](#) chapter. For specific errors that are related to Ray jobs, see [the section called “Troubleshooting Ray errors”](#) in the troubleshooting chapter.

### Next steps

You have now seen and performed an ETL process using AWS Glue for Ray from end to end. You can use the following resources to understand what tools AWS Glue for Ray provides to transform and interpret your data at scale.
For more information about Ray's task model, see the section called “Using Ray Core and Ray Data in AWS Glue for Ray”. For more experience in using Ray tasks, follow the examples in the Ray Core documentation. See Ray Core: Ray Tutorials and Examples (2.4.0) in the Ray documentation.

For guidance about available data management libraries in AWS Glue for Ray, see the section called “Connecting to data”. For more experience using Ray Data to transform and write datasets, follow the examples in the Ray Data documentation. See Ray Data: Examples (2.4.0).

For more information about configuring AWS Glue for Ray jobs, see the section called “Working with Ray jobs”.

For more information about writing AWS Glue for Ray scripts, continue reading the documentation in this section.

Using Ray Core and Ray Data in AWS Glue for Ray

Ray is a framework for scaling up Python scripts by distributing work across a cluster. You can use Ray as a solution to many sorts of problems, so Ray provides libraries to optimize certain tasks. In AWS Glue, we focus on using Ray to transform large datasets. AWS Glue offers support for Ray Data and parts of Ray Core to facilitate this task.

What is Ray Core?

The first step of building a distributed application is identifying and defining work that can be performed concurrently. Ray Core contains the parts of Ray that you use to define tasks that can be performed concurrently. Ray provides reference and quick start information that you can use to learn the tools they provide. For more information, see What is Ray Core? and Ray Core Quick Start. For more information about effectively defining concurrent tasks in Ray, see Tips for first-time users.

Ray tasks and actors

In AWS Glue for Ray documentation, we might refer to tasks and actors, which are core concepts in Ray.

Ray uses Python functions and classes as the building blocks of a distributed computing system. Much like when Python functions and variables become "methods" and "attributes" when used in a class, functions become "tasks" and classes become "actors" when they're used in Ray to send code to workers. You can identify functions and classes that might be used by Ray by the @ray.remote annotation.
Tasks and actors are configurable, they have a lifecycle, and they take up compute resources throughout their life. Code that throws errors can be traced back to a task or actor when you're finding the root cause of problems. Thus, these terms might come up when you're learning how to configure, monitor, or debug AWS Glue for Ray jobs. To begin learning how to effectively use tasks and actors to build a distributed application, see Key Concepts in the Ray docs.

Ray Core in AWS Glue for Ray

AWS Glue for Ray environments manage cluster formation and scaling, as well as collecting and visualizing logs. Because we manage these concerns, we consequently limit access to and support for the APIs in Ray Core that would be used to address these concerns in an open-source cluster.

In the managed Ray2.4 runtime environment, we do not support:

- Ray Core CLI
- Ray State CLI
- ray.util.metrics Prometheus metric utility methods:
  - Counter
  - Gauge
  - Histogram
- Other debugging tools:
  - ray.util.pdb.set_trace
  - ray.util.inspect_serializability
  - ray.timeline

What is Ray Data?

When you're connecting to data sources and destinations, handling datasets, and initiating common transforms, Ray Data is a straightforward methodology for using Ray to solve problems transforming Ray datasets. For more information about using Ray Data, see Ray Datasets: Distributed Data Preprocessing.

You can use Ray Data or other tools to access your data. For more information on accessing your data in Ray, see the section called “Connecting to data”.

Ray Data in AWS Glue for Ray

Ray Data is supported and provided by default in the managed Ray2.4 runtime environment. For more information about provided modules, see the section called “Modules provided with Ray jobs”.

Providing files and Python libraries to Ray jobs

This section provides information that you need for using Python libraries with AWS Glue Ray jobs. You can use certain common libraries included by default in all Ray jobs. You can also provide your own Python libraries to your Ray job.

Modules provided with Ray jobs

You can perform data integration workflows in a Ray job with the following provided packages. These packages are available by default in Ray jobs.

AWS Glue version 4.0

In AWS Glue 4.0, the Ray (Ray2.4 runtime) environment provides the following packages:

- boto3 == 1.26.133
- ray == 2.4.0
- pyarrow == 11.0.0
- pandas == 1.5.3
- numpy == 1.24.3
- fsspec == 2023.4.0

This list includes all packages that would be installed with ray[data] == 2.4.0. Ray Data is supported out of box.

Providing files to your Ray job

You can provide files to your Ray job with the --working-dir parameter. Provide this parameter with a path to a .zip file hosted on Amazon S3. Within the .zip file, your files must be contained in a single top-level directory. No other files should be at the top level.
Your files will be distributed to each Ray node before your script begins to run. Consider how this might impact the disk space that's available to each Ray node. Available disk space is determined by the WorkerType set in the job configuration. If you want to provide your job data at scale, this mechanism is not the right solution. For more information on providing data to your job, see the section called “Connecting to data”.

Your files will be accessible as if the directory was provided to Ray through the working_dir parameter. For example, to read a file named sample.txt in your .zip file's top-level directory, you could call:

```python
@ray.remote
def do_work():
    f = open("sample.txt", "r")
    print(f.read())
```

For more information about working_dir, see the Ray documentation. This feature behaves similarly to Ray's native capabilities.

### Additional Python modules for Ray jobs

#### Additional modules from PyPI

Ray jobs use the Python Package Installer (pip3) to install additional modules to be used by a Ray script. You can use the --pip-install parameter with a list of comma-separated Python modules to add a new module or change the version of an existing module.

For example, to update or add a new scikit-learn module, use the following key-value pair:

"--pip-install", "scikit-learn==0.21.3"

If you have custom modules or custom patches, you can distribute your own libraries from Amazon S3 with the --s3-py-modules parameter. Before uploading your distribution, it might need to be repackaged and rebuilt. Follow the guidelines in the section called “Including Python code in Ray jobs”.

#### Custom distributions from Amazon S3

Custom distributions should adhere to Ray packaging guidelines for dependencies. You can find out how to build these distributions in the following section. For more information about how Ray sets up dependencies, see Environment Dependencies in the Ray documentation.
To include a custom distributable after assessing its contents, upload your distributable to a bucket available to the job's IAM role. Specify the Amazon S3 path to a Python zip archive in your parameter configuration. If you're providing multiple distributables, separate them by comma. For example:

"--s3-py-modules", "s3://s3bucket/pythonPackage.zip"

**Limitations**

Ray jobs do not support compiling native code in the job environment. You can be limited by this if your Python dependencies transitively depend on native, compiled code. Ray jobs can run provided binaries, but they must be compiled for Linux on ARM64. This means you might be able to use the contents of aarch64 manylinux wheels. You can provide your native dependencies in a compiled form by repackaging a wheel to Ray standards. Typically, this means removing dist-info folders so that there is only one folder at the root at the archive.

You cannot upgrade the version of ray or ray[data] using this parameter. In order to use a new version of Ray, you will need to change the runtime field on your job, after we have released support for it. For more information about supported Ray versions, see [the section called “AWS Glue versions”](#).

**Including Python code in Ray jobs**

The Python Software Foundation offers standardized behaviors for packaging Python files for use across different runtimes. Ray introduces limitations to packaging standards that you should be aware of. AWS Glue does not specify packaging standards beyond those specified to Ray. The following instructions provide standard guidance on packaging simple Python packages.

Package your files in a .zip archive. A directory should be at the root of the archive. **There should be no other files at the root level of the archive, or this may lead to unexpected behavior.** The root directory is the package, and its name is used to refer to your Python code when importing it.

If you provide a distribution in this form to a Ray job with --s3-py-modules, you will be able to import Python code from your package in your Ray script.

Your package can provide a single Python module with some Python files, or you can package together many modules. When repackaging dependencies, such as libraries from PyPI, **check for hidden files and metadata directories** inside of those packages.
The following procedures assume you are interacting with your files in Amazon Linux 2 or a similar OS that provides a distribution of the Info-ZIP zip and zipinfo utilities. We recommend using these tools to prevent unexpected behaviors.

To package Python files for use in Ray

1. Create a temporary directory with your package name, then confirm your working directory is its parent directory. You can do this with the following commands:

   ```
   cd parent_directory
   mkdir temp_dir
   ```

2. Copy your files into the temporary directory, then confirm your directory structure. The contents of this directory will be directly accessed as your Python module. You can do this with the following command:

   ```
   ls -AR temp_dir
   # my_file_1.py
   # my_file_2.py
   ```

3. Compress your temporary folder using zip. You can do this with the following commands:

   ```
   zip -r zip_file.zip temp_dir
   ```

4. Confirm your file is properly packaged. `zip_file.zip` should now be found in your working directory. You can inspect it with the following command:

   ```
   zipinfo -1 zip_file.zip
   # temp_dir/
   # temp_dir/my_file_1.py
   ```
To repackage a Python package for use in Ray.

1. Create a temporary directory with your package name, then confirm your working directory is its parent directory. You can do this with the following commands:

   ```bash
   cd parent_directory
   mkdir temp_dir
   ```

2. Decompress your package and copy the contents into your temporary directory. Remove files related to your previous packaging standard, leaving only the contents of the module. Confirm your file structure looks correct with the following command:

   ```bash
   ls -AR temp_dir
   # my_module
   # my_module/__init__.py
   # my_module/my_file_1.py
   # my_module/my_submodule/__init__.py
   # my_module/my_submodule/my_file_2.py
   # my_module/my_submodule/my_file_3.py
   ```

3. Compress your temporary folder using zip. You can do this with the following commands:

   ```bash
   zip -r zip_file.zip temp_dir
   ```

4. Confirm your file is properly packaged. *zip_file*.zip should now be found in your working directory. You can inspect it with the following command:

   ```bash
   zipinfo -1 zip_file.zip
   # temp_dir/my_module/
   # temp_dir/my_module/__init__.py
   # temp_dir/my_module/my_file_1.py
   # temp_dir/my_module/my_submodule/
   # temp_dir/my_module/my_submodule/__init__.py
   # temp_dir/my_module/my_submodule/my_file_2.py
   # temp_dir/my_module/my_submodule/my_file_3.py
   ```
Connecting to data in Ray jobs

AWS Glue Ray jobs can use a broad array of Python packages that are designed for you to quickly integrate data. We provide a minimal set of dependencies in order to not clutter your environment. For more information about what is included by default, see the section called “Modules provided with Ray jobs”.

**Note**

AWS Glue extract, transform, and load (ETL) provides the DynamicFrame abstraction to streamline ETL workflows where you resolve schema differences between rows in your dataset. AWS Glue ETL provides additional features—job bookmarks and grouping input files. We don't currently provide corresponding features in Ray jobs.

AWS Glue for Spark provides direct support for connecting to certain data formats, sources and sinks. In Ray, AWS SDK for pandas and current third-party libraries substantively cover that need. You will need to consult those libraries to understand what capabilities are available.

AWS Glue for Ray integration with Amazon VPC is not currently available. Resources in Amazon VPC will not be accessible without a public route. For more information about using AWS Glue with Amazon VPC, see the section called “VPC endpoints (AWS PrivateLink)”.

Common libraries for working with data in Ray

**Ray Data** – Ray Data provides methods to handle common data formats, sources and sinks. For more information about supported formats and sources in Ray Data, see Input/Output in the Ray Data documentation. Ray Data is an opinionated library, rather than a general-purpose library, for handling datasets.

Ray provides certain guidance around use cases where Ray Data might be the best solution for your job. For more information, see What should I use Ray Datasets for? in the Ray documentation.

**AWS SDK for pandas (awswrangler)** – AWS SDK for pandas is an AWS product that delivers clean, tested solutions for reading from and writing to AWS services when your transformations manage data with pandas DataFrames. For more information about supported formats and sources in the AWS SDK for pandas, see the API Reference in the AWS SDK for pandas documentation.
For examples of how to read and write data with the AWS SDK for pandas, see Quick Start in the AWS SDK for pandas documentation. The AWS SDK for pandas doesn't provide transforms for your data. It only provides support for reading and writing from sources.

**Modin** – Modin is a Python library that implements common pandas operations in a distributable way. For more information about Modin, see the Modin documentation. Modin itself doesn't provide support for reading and writing from sources. It provides distributed implementations of common transforms. Modin is supported by the AWS SDK for pandas.

When you run Modin and the AWS SDK for pandas together in a Ray environment, you can perform common ETL tasks with performant results. For more information about using Modin with the AWS SDK for pandas, see At scale in the AWS SDK for pandas documentation.

**Other frameworks** – For more information about frameworks that Ray supports, see Integrations in the Ray documentation. We don't provide support for other frameworks in AWS Glue for Ray.

**Connecting to data through the Data Catalog**

Managing your data through the Data Catalog in conjunction with Ray jobs is supported with the AWS SDK for pandas. For more information, see Glue Catalog on the AWS SDK for pandas website.
# Using this service with an AWS SDK

AWS software development kits (SDKs) are available for many popular programming languages. Each SDK provides an API, code examples, and documentation that make it easier for developers to build applications in their preferred language.

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For examples specific to this service, see [AWS Glue API code examples using AWS SDKs](#).

> **Example availability**
> Can't find what you need? Request a code example by using the **Provide feedback** link at the bottom of this page.
AWS Glue API

This section describes data types and primitives used by AWS Glue SDKs and Tools. There are three general ways to interact with AWS Glue programmatically outside of the AWS Management Console, each with its own documentation:

- Language SDK libraries allow you to access AWS resources from common programming languages. Find more information at [Tools to Build on AWS](#).
- The AWS CLI allows you to access AWS resources from the command line. Find more information at [AWS CLI Command Reference](#).
- AWS CloudFormation allows you to define a set of AWS resources to be provisioned together consistently. Find more information at [AWS CloudFormation: AWS Glue resource type reference](#).

This section documents shared primitives independently of these SDKs and Tools. Tools use the [AWS Glue Web API Reference](#) to communicate with AWS.

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Security APIs in AWS Glue

The Security API describes the security data types, and the API related to security in AWS Glue.

Data types

- DataCatalogEncryptionSettings structure
- EncryptionAtRest structure
- ConnectionPasswordEncryption structure
- EncryptionConfiguration structure
- S3Encryption structure
- CloudWatchEncryption structure
- JobBookmarksEncryption structure
- SecurityConfiguration structure
- GluePolicy structure

DataCatalogEncryptionSettings structure

Contains configuration information for maintaining Data Catalog security.

Fields

- EncryptionAtRest – An EncryptionAtRest object.
  
  Specifies the encryption-at-rest configuration for the Data Catalog.

- ConnectionPasswordEncryption – A ConnectionPasswordEncryption object.
  
  When connection password protection is enabled, the Data Catalog uses a customer-provided key to encrypt the password as part of CreateConnection or UpdateConnection and store it in the ENCRYPTED_PASSWORD field in the connection properties. You can enable catalog encryption or only password encryption.

EncryptionAtRest structure

Specifies the encryption-at-rest configuration for the Data Catalog.
Fields

- **CatalogEncryptionMode** – *Required:* UTF-8 string (valid values: DISABLED | SSE-KMS="SSEKMS").
  The encryption-at-rest mode for encrypting Data Catalog data.
- **SseAwsKmsKeyId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The ID of the AWS KMS key to use for encryption at rest.

**ConnectionPasswordEncryption structure**

The data structure used by the Data Catalog to encrypt the password as part of CreateConnection or UpdateConnection and store it in the ENCRYPTED_PASSWORD field in the connection properties. You can enable catalog encryption or only password encryption.

When a CreationConnection request arrives containing a password, the Data Catalog first encrypts the password using your AWS KMS key. It then encrypts the whole connection object again if catalog encryption is also enabled.

This encryption requires that you set AWS KMS key permissions to enable or restrict access on the password key according to your security requirements. For example, you might want only administrators to have decrypt permission on the password key.

Fields

- **ReturnConnectionPasswordEncrypted** – *Required:* Boolean.
  When the ReturnConnectionPasswordEncrypted flag is set to "true", passwords remain encrypted in the responses of GetConnection and GetConnections. This encryption takes effect independently from catalog encryption.
- **AwsKmsKeyId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  An AWS KMS key that is used to encrypt the connection password.
If connection password protection is enabled, the caller of CreateConnection and UpdateConnection needs at least kms:Encrypt permission on the specified AWS KMS key, to encrypt passwords before storing them in the Data Catalog.

You can set the decrypt permission to enable or restrict access on the password key according to your security requirements.

**EncryptionConfiguration structure**

Specifies an encryption configuration.

**Fields**

- **S3Encryption** – An array of [S3Encryption](#) objects.

  The encryption configuration for Amazon Simple Storage Service (Amazon S3) data.

- **CloudWatchEncryption** – A [CloudWatchEncryption](#) object.

  The encryption configuration for Amazon CloudWatch.


  The encryption configuration for job bookmarks.

**S3Encryption structure**

Specifies how Amazon Simple Storage Service (Amazon S3) data should be encrypted.

**Fields**

- **S3EncryptionMode** – UTF-8 string (valid values: DISABLED | SSE-KMS="SSEKMS" | SSE-S3="SSES3").

  The encryption mode to use for Amazon S3 data.

- **KmsKeyArn** – UTF-8 string, matching the [Custom string pattern #19](#).

  The Amazon Resource Name (ARN) of the KMS key to be used to encrypt the data.
CloudWatchEncryption structure

Specifies how Amazon CloudWatch data should be encrypted.

Fields

- **CloudWatchEncryptionMode** – UTF-8 string (valid values: DISABLED | SSE-KMS="SSEKMS").
  
  The encryption mode to use for CloudWatch data.
- **KmsKeyArn** – UTF-8 string, matching the [Custom string pattern #19](#).
  
  The Amazon Resource Name (ARN) of the KMS key to be used to encrypt the data.

JobBookmarksEncryption structure

Specifies how job bookmark data should be encrypted.

Fields

- **JobBookmarksEncryptionMode** – UTF-8 string (valid values: DISABLED | CSE-KMS="CSEKMS").
  
  The encryption mode to use for job bookmarks data.
- **KmsKeyArn** – UTF-8 string, matching the [Custom string pattern #19](#).
  
  The Amazon Resource Name (ARN) of the KMS key to be used to encrypt the data.

SecurityConfiguration structure

Specifies a security configuration.

Fields

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the security configuration.
- **CreatedTimeStamp** – Timestamp.
  
  The time at which this security configuration was created.
• **EncryptionConfiguration** – An `EncryptionConfiguration` object.

  The encryption configuration associated with this security configuration.

**GluePolicy structure**

A structure for returning a resource policy.

**Fields**

• **PolicyInJson** – UTF-8 string, at least 2 bytes long.

  Contains the requested policy document, in JSON format.

• **PolicyHash** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Contains the hash value associated with this policy.

• **CreateTime** – Timestamp.

  The date and time at which the policy was created.

• **UpdateTime** – Timestamp.

  The date and time at which the policy was last updated.

**Operations**

• **GetDataCatalogEncryptionSettings action (Python: get_data_catalog_encryption_settings)**

• **PutDataCatalogEncryptionSettings action (Python: put_data_catalog_encryption_settings)**

• **PutResourcePolicy action (Python: put_resource_policy)**

• **GetResourcePolicy action (Python: get_resource_policy)**

• **DeleteResourcePolicy action (Python: delete_resource_policy)**

• **CreateSecurityConfiguration action (Python: create_security_configuration)**

• **DeleteSecurityConfiguration action (Python: delete_security_configuration)**

• **GetSecurityConfiguration action (Python: get_security_configuration)**

• **GetSecurityConfigurations action (Python: get_security_configurations)**

• **GetResourcePolicies action (Python: get_resource_policies)**
GetDataCatalogEncryptionSettings action (Python: get_data_catalog_encryption_settings)

Retrieves the security configuration for a specified catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog to retrieve the security configuration for. If none is provided, the AWS account ID is used by default.

Response

- DataCatalogEncryptionSettings – A DataCatalogEncryptionSettings object.

  The requested security configuration.

Errors

- InternalServiceException
- InvalidInputException
- OperationTimeoutException

PutDataCatalogEncryptionSettings action (Python: put_data_catalog_encryption_settings)

Sets the security configuration for a specified catalog. After the configuration has been set, the specified encryption is applied to every catalog write thereafter.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog to set the security configuration for. If none is provided, the AWS account ID is used by default.
• **DataCatalogEncryptionSettings** – *Required:* A [DataCatalogEncryptionSettings](#) object.

  The security configuration to set.

**Response**

• *No Response parameters.*

**Errors**

• InternalServiceException
• InvalidInputException
• OperationTimeoutException

**PutResourcePolicy action** *(Python: put_resource_policy)*

Sets the Data Catalog resource policy for access control.

**Request**

• **PolicyInJson** – *Required:* UTF-8 string, at least 2 bytes long.

  Contains the policy document to set, in JSON format.

• **ResourceArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  Do not use. For internal use only.

• **PolicyHashCondition** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The hash value returned when the previous policy was set using `PutResourcePolicy`. Its purpose is to prevent concurrent modifications of a policy. Do not use this parameter if no previous policy has been set.

• **PolicyExistsCondition** – UTF-8 string (valid values: `MUST_EXIST` | `NOT_EXIST` | `NONE`).

  A value of `MUST_EXIST` is used to update a policy. A value of `NOT_EXIST` is used to create a new policy. If a value of `NONE` or a null value is used, the call does not depend on the existence of a policy.
EnableHybrid – UTF-8 string (valid values: TRUE | FALSE).

If 'TRUE', indicates that you are using both methods to grant cross-account access to Data Catalog resources:

- By directly updating the resource policy with PutResourcePolicy
- By using the Grant permissions command on the AWS Management Console.

Must be set to 'TRUE' if you have already used the Management Console to grant cross-account access, otherwise the call fails. Default is 'FALSE'.

Response

- PolicyHash – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

A hash of the policy that has just been set. This must be included in a subsequent call that overwrites or updates this policy.

Errors

- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException
- ConditionCheckFailureException

GetResourcePolicy action (Python: get_resource_policy)

Retrieves a specified resource policy.

Request

- ResourceArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.
The ARN of the AWS Glue resource for which to retrieve the resource policy. If not supplied, the Data Catalog resource policy is returned. Use GetResourcePolicies to view all existing resource policies. For more information see Specifying AWS Glue Resource ARNs.

Response

- PolicyInJson – UTF-8 string, at least 2 bytes long.

  Contains the requested policy document, in JSON format.

- PolicyHash – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Contains the hash value associated with this policy.

- CreateTime – Timestamp.

  The date and time at which the policy was created.

- UpdateTime – Timestamp.

  The date and time at which the policy was last updated.

Errors

- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException

DeleteResourcePolicy action (Python: delete_resource_policy)

Deletes a specified policy.

Request

- PolicyHashCondition – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The hash value returned when this policy was set.
ResourceArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

The ARN of the AWS Glue resource for the resource policy to be deleted.

Response

• No Response parameters.

Errors

• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException
• InvalidInputException
• ConditionCheckFailureException

CreateSecurityConfiguration action (Python: create_security_configuration)

Creates a new security configuration. A security configuration is a set of security properties that can be used by AWS Glue. You can use a security configuration to encrypt data at rest. For information about using security configurations in AWS Glue, see Encrypting Data Written by Crawlers, Jobs, and Development Endpoints.

Request

• Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name for the new security configuration.

• EncryptionConfiguration – Required: An EncryptionConfiguration object.

  The encryption configuration for the new security configuration.
Response

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name assigned to the new security configuration.
- **CreatedTimestamp** – Timestamp.
  
  The time at which the new security configuration was created.

Errors

- AlreadyExistsException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceeded

DeleteSecurityConfiguration action (Python: delete_security_configuration)

Deletes a specified security configuration.

Request

- **Name** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the security configuration to delete.

Response

- No Response parameters.

Errors

- EntityNotFoundException
GetSecurityConfiguration action (Python: get_security_configuration)

Retrieves a specified security configuration.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the security configuration to retrieve.

Response

- SecurityConfiguration – A SecurityConfiguration object.

  The requested security configuration.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException

GetSecurityConfigurations action (Python: get_security_configurations)

Retrieves a list of all security configurations.

Request

- MaxResults – Number (integer), not less than 1 or more than 1000.

  The maximum number of results to return.
• NextToken – UTF-8 string.

A continuation token, if this is a continuation call.

Response

• SecurityConfigurations – An array of SecurityConfiguration objects.

A list of security configurations.

• NextToken – UTF-8 string.

A continuation token, if there are more security configurations to return.

Errors

• EntityNotFoundException
• InvalidInputException
• InternalServiceException
• OperationTimeoutException

GetResourcePolicies action (Python: get_resource_policies)

Retrieves the resource policies set on individual resources by AWS Resource Access Manager during cross-account permission grants. Also retrieves the Data Catalog resource policy.

If you enabled metadata encryption in Data Catalog settings, and you do not have permission on the AWS KMS key, the operation can't return the Data Catalog resource policy.

Request

• NextToken – UTF-8 string.

A continuation token, if this is a continuation request.

• MaxResults – Number (integer), not less than 1 or more than 1000.

The maximum size of a list to return.
Response

- **GetResourcePoliciesResponseList** – An array of `GluePolicy` objects.
  A list of the individual resource policies and the account-level resource policy.
- **NextToken** – UTF-8 string.
  A continuation token, if the returned list does not contain the last resource policy available.

Errors

- `InternalServiceException`
- `OperationTimeoutException`
- `InvalidInputException`
- `GlueEncryptionException`

Catalog API

The Catalog API describes the data types and API related to working with catalogs in AWS Glue.

Topics

- **Database API**
- **Table API**
- **Partition API**
- **Connection API**
- **User-defined Function API**
- **Importing an Athena catalog to AWS Glue**

Database API

The Database API describes database data types, and includes the API for creating, deleting, locating, updating, and listing databases.

Data types

- **Database structure**
- DatabaseInput structure
- PrincipalPermissions structure
- DataLakePrincipal structure
- DatabaseIdentifier structure
- FederatedDatabase structure

Database structure

The Database object represents a logical grouping of tables that might reside in a Hive metastore or an RDBMS.

Fields

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the database. For Hive compatibility, this is folded to lowercase when it is stored.

- **Description** – Description string, not more than 2048 bytes long, matching the **URI address multi-line string pattern**.

  A description of the database.

- **LocationUri** – Uniform resource identifier (uri), not less than 1 or more than 1024 bytes long, matching the **URI address multi-line string pattern**.

  The location of the database (for example, an HDFS path).

- **Parameters** – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  Each value is a UTF-8 string, not more than 512000 bytes long.

  These key-value pairs define parameters and properties of the database.

- **CreateTime** – Timestamp.

  The time at which the metadata database was created in the catalog.

- **CreateTableDefaultPermissions** – An array of **PrincipalPermissions** objects.
Creates a set of default permissions on the table for principals. Used by AWS Lake Formation. Not used in the normal course of AWS Glue operations.

- **TargetDatabase** – A [DatabaseIdentifier](#) object.

  A DatabaseIdentifier structure that describes a target database for resource linking.

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog in which the database resides.

- **FederatedDatabase** – A [FederatedDatabase](#) object.

  A FederatedDatabase structure that references an entity outside the AWS Glue Data Catalog.

**DatabaseInput structure**

The structure used to create or update a database.

**Fields**

- **Name** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the database. For Hive compatibility, this is folded to lowercase when it is stored.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address [multi-line string pattern](#).

  A description of the database.

- **LocationUri** – Uniform resource identifier (uri), not less than 1 or more than 1024 bytes long, matching the URI address [multi-line string pattern](#).

  The location of the database (for example, an HDFS path).

- **Parameters** – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string, not more than 512000 bytes long.
These key-value pairs define parameters and properties of the database.

- **CreateTableDefaultPermissions** – An array of `PrincipalPermissions` objects.

  Creates a set of default permissions on the table for principals. Used by AWS Lake Formation. Not used in the normal course of AWS Glue operations.

- **TargetDatabase** – A `DatabaseIdentifier` object.

  A `DatabaseIdentifier` structure that describes a target database for resource linking.

- **FederatedDatabase** – A `FederatedDatabase` object.

  A `FederatedDatabase` structure that references an entity outside the AWS Glue Data Catalog.

### PrincipalPermissions structure

Permissions granted to a principal.

**Fields**

- **Principal** – A `DataLakePrincipal` object.

  The principal who is granted permissions.

- **Permissions** – An array of UTF-8 strings.

  The permissions that are granted to the principal.

### DataLakePrincipal structure

The AWS Lake Formation principal.

**Fields**

- **DataLakePrincipalIdentifier** – UTF-8 string, not less than 1 or more than 255 bytes long.

  An identifier for the AWS Lake Formation principal.
Databaseldentifier structure

A structure that describes a target database for resource linking.

Fields

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog in which the database resides.
- DatabaseName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the catalog database.
- Region – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Region of the target database.

FederatedDatabase structure

A database that points to an entity outside the AWS Glue Data Catalog.

Fields

- Identifier – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Single-line string pattern.
  
  A unique identifier for the federated database.
- ConnectionName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the connection to the external metastore.

Operations

- CreateDatabase action (Python: create_database)
- UpdateDatabase action (Python: update_database)
CreateDatabase action (Python: create_database)

Creates a new database in a Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog in which to create the database. If none is provided, the AWS account ID is used by default.
- DatabaseInput – Required: A DatabaseInput object.
  
  The metadata for the database.
- Tags – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags you assign to the database.

Response

- No Response parameters.

Errors

- InvalidInputException
- AlreadyExistsException
- ResourceNumberLimitExceededException
- InternalServiceException
- OperationTimeoutException
UpdateDatabase action (Python: update_database)

Updates an existing database definition in a Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog in which the metadata database resides. If none is provided, the AWS account ID is used by default.

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the database to update in the catalog. For Hive compatibility, this is folded to lowercase.

- DatabaseInput – Required: A DatabaseInput object.

A DatabaseInput object specifying the new definition of the metadata database in the catalog.

Response

- No Response parameters.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException
- ConcurrentModificationException
DeleteDatabase action (Python: delete_database)

Removes a specified database from a Data Catalog.

---

Note

After completing this operation, you no longer have access to the tables (and all table versions and partitions that might belong to the tables) and the user-defined functions in the deleted database. AWS Glue deletes these "orphaned" resources asynchronously in a timely manner, at the discretion of the service.

To ensure the immediate deletion of all related resources, before calling DeleteDatabase, use DeleteTableVersion or BatchDeleteTableVersion, DeletePartition or BatchDeletePartition, DeleteUserDefinedFunction, and DeleteTable or BatchDeleteTable, to delete any resources that belong to the database.

---

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which the database resides. If none is provided, the AWS account ID is used by default.

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the database to delete. For Hive compatibility, this must be all lowercase.

---

Response

- No Response parameters.

---

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
• OperationTimeoutException
• ConcurrentModificationException

GetDatabase action (Python: get_database)

Retrieves the definition of a specified database.

Request

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog in which the database resides. If none is provided, the AWS account ID is used by default.

• Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the database to retrieve. For Hive compatibility, this should be all lowercase.

Response

• Database – A Database object.

The definition of the specified database in the Data Catalog.

Errors

• InvalidInputException
• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException
• GlueEncryptionException
• FederationSourceException

GetDatabases action (Python: get_databases)

Retrieves all databases defined in a given Data Catalog.
Request

• **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog from which to retrieve Databases. If none is provided, the AWS account ID is used by default.

• **NextToken** – UTF-8 string.

  A continuation token, if this is a continuation call.

• **MaxResults** – Number (integer), not less than 1 or more than 100.

  The maximum number of databases to return in one response.

• **ResourceShareType** – UTF-8 string (valid values: FOREIGN | ALL | FEDERATED).

  Allows you to specify that you want to list the databases shared with your account. The allowable values are FEDERATED, FOREIGN or ALL.

  • If set to FEDERATED, will list the federated databases (referencing an external entity) shared with your account.
  
  • If set to FOREIGN, will list the databases shared with your account.
  
  • If set to ALL, will list the databases shared with your account, as well as the databases in your local account.

Response

• **DatabaseList** – **Required**: An array of Database objects.

  A list of Database objects from the specified catalog.

• **NextToken** – UTF-8 string.

  A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.

Errors

• **InvalidInputException**

• **InternalServiceException**
• OperationTimeoutException
• GlueEncryptionException

Table API

The Table API describes data types and operations associated with tables.

Data types

• Table structure
• TableInput structure
• FederatedTable structure
• Column structure
• StorageDescriptor structure
• SchemaReference structure
• SerDeInfo structure
• Order structure
• SkewedInfo structure
• TableVersion structure
• TableError structure
• TableVersionError structure
• SortCriterion structure
• TableIdentifier structure
• KeySchemaElement structure
• PartitionIndex structure
• PartitionIndexDescriptor structure
• BackfillError structure
• IcebergInput structure
• OpenTableFormatInput structure

Table structure

Represents a collection of related data organized in columns and rows.
Fields

- **Name** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The table name. For Hive compatibility, this must be entirely lowercase.

- **DatabaseName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the database where the table metadata resides. For Hive compatibility, this must be all lowercase.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the table.

- **Owner** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The owner of the table.

- **CreateTime** – Timestamp.

  The time when the table definition was created in the Data Catalog.

- **UpdateTime** – Timestamp.

  The last time that the table was updated.

- **LastAccessTime** – Timestamp.

  The last time that the table was accessed. This is usually taken from HDFS, and might not be reliable.

- **LastAnalyzedTime** – Timestamp.

  The last time that column statistics were computed for this table.

- **Retention** – Number (integer), not more than None.

  The retention time for this table.

- **StorageDescriptor** – A StorageDescriptor object.

  A storage descriptor containing information about the physical storage of this table.
• **PartitionKeys** – An array of [Column](#) objects.

A list of columns by which the table is partitioned. Only primitive types are supported as partition keys.

When you create a table used by Amazon Athena, and you do not specify any `partitionKeys`, you must at least set the value of `partitionKeys` to an empty list. For example:

"PartitionKeys": []

• **ViewOriginalText** – UTF-8 string, not more than 409600 bytes long.

Included for Apache Hive compatibility. Not used in the normal course of AWS Glue operations. If the table is a VIRTUAL_VIEW, certain Athena configuration encoded in base64.

• **ViewExpandedText** – UTF-8 string, not more than 409600 bytes long.

Included for Apache Hive compatibility. Not used in the normal course of AWS Glue operations.

• **TableType** – UTF-8 string, not more than 255 bytes long.

The type of this table. AWS Glue will create tables with the EXTERNAL_TABLE type. Other services, such as Athena, may create tables with additional table types.

AWS Glue related table types:

EXTERNAL_TABLE

Hive compatible attribute - indicates a non-Hive managed table.

GOVERNED

Used by AWS Lake Formation. The AWS Glue Data Catalog understands GOVERNED.

• **Parameters** – A map array of key-value pairs.

Each key is a Key string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

Each value is a UTF-8 string, not more than 512000 bytes long.

These key-value pairs define properties associated with the table.

• **CreatedBy** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The person or entity who created the table.

- **IsRegisteredWithLakeFormation** – Boolean.

  Indicates whether the table has been registered with AWS Lake Formation.

- **TargetTable** – A TableIdentifier object.

  A TableIdentifier structure that describes a target table for resource linking.

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which the table resides.

- **VersionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the table version.

- **FederatedTable** – A FederatedTable object.

  A FederatedTable structure that references an entity outside the AWS Glue Data Catalog.

**TableInput structure**

A structure used to define a table.

**Fields**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The table name. For Hive compatibility, this is folded to lowercase when it is stored.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the table.

- **Owner** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The table owner. Included for Apache Hive compatibility. Not used in the normal course of AWS Glue operations.
• **LastAccessTime** – Timestamp.
  The last time that the table was accessed.

• **LastAnalyzedTime** – Timestamp.
  The last time that column statistics were computed for this table.

• **Retention** – Number (integer), not more than None.
  The retention time for this table.

• **StorageDescriptor** – A [StorageDescriptor](#) object.
  A storage descriptor containing information about the physical storage of this table.

• **PartitionKeys** – An array of [Column](#) objects.
  A list of columns by which the table is partitioned. Only primitive types are supported as partition keys.

  When you create a table used by Amazon Athena, and you do not specify any `partitionKeys`, you must at least set the value of `partitionKeys` to an empty list. For example:

  "PartitionKeys": []

• **ViewOriginalText** – UTF-8 string, not more than 409600 bytes long.
  Included for Apache Hive compatibility. Not used in the normal course of AWS Glue operations. If the table is a VIRTUAL_VIEW, certain Athena configuration encoded in base64.

• **ViewExpandedText** – UTF-8 string, not more than 409600 bytes long.
  Included for Apache Hive compatibility. Not used in the normal course of AWS Glue operations.

• **TableType** – UTF-8 string, not more than 255 bytes long.
  The type of this table. AWS Glue will create tables with the EXTERNAL_TABLE type. Other services, such as Athena, may create tables with additional table types.

  AWS Glue related table types:

  EXTERNAL_TABLE

  Hive compatible attribute - indicates a non-Hive managed table.
GOVERNED

Used by AWS Lake Formation. The AWS Glue Data Catalog understands GOVERNED.

- Parameters – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string, not more than 512000 bytes long.

  These key-value pairs define properties associated with the table.

- TargetTable – A TableIdentifier object.

  A TableIdentifier structure that describes a target table for resource linking.

FederatedTable structure

A table that points to an entity outside the AWS Glue Data Catalog.

Fields

- Identifier – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Single-line string pattern.

  A unique identifier for the federated table.

- DatabaseIdentifier – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Single-line string pattern.

  A unique identifier for the federated database.

- ConnectionName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the connection to the external metastore.

Column structure

A column in a Table.
Fields

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#). The name of the column.

- **Type** – UTF-8 string, not more than 131072 bytes long, matching the [Single-line string pattern](#). The data type of the column.

- **Comment** – Comment string, not more than 255 bytes long, matching the [Single-line string pattern](#). A free-form text comment.

- **Parameters** – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Each value is a UTF-8 string, not more than 512000 bytes long.

  These key-value pairs define properties associated with the column.

StorageDescriptor structure

Describes the physical storage of table data.

Fields

- **Columns** – An array of [Column](#) objects.

  A list of the columns in the table.

- **Location** – Location string, not more than 2056 bytes long, matching the [URI address multiline string pattern](#). The physical location of the table. By default, this takes the form of the warehouse location, followed by the database location in the warehouse, followed by the table name.

- **AdditionalLocations** – An array of UTF-8 strings.

  A list of locations that point to the path where a Delta table is located.
• InputFormat – Format string, not more than 128 bytes long, matching the Single-line string pattern.

The input format: SequenceFileInputFormat (binary), or TextInputFormat, or a custom format.

• OutputFormat – Format string, not more than 128 bytes long, matching the Single-line string pattern.

The output format: SequenceFileOutputFormat (binary), or IgnoreKeyTextOutputFormat, or a custom format.

• Compressed – Boolean.

True if the data in the table is compressed, or False if not.

• NumberOfBuckets – Number (integer).

Must be specified if the table contains any dimension columns.

• SerdeInfo – A SerDeInfo object.

The serialization/deserialization (SerDe) information.

• BucketColumns – An array of UTF-8 strings.

A list of reducer grouping columns, clustering columns, and bucketing columns in the table.

• SortColumns – An array of Order objects.

A list specifying the sort order of each bucket in the table.

• Parameters – A map array of key-value pairs.

Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Each value is a UTF-8 string, not more than 512000 bytes long.

The user-supplied properties in key-value form.

• SkewedInfo – A SkewedInfo object.

The information about values that appear frequently in a column (skewed values).

• StoredAsSubDirectories – Boolean.
True if the table data is stored in subdirectories, or False if not.

- **SchemaReference** – A [SchemaReference](#) object.

  An object that references a schema stored in the AWS Glue Schema Registry.

  When creating a table, you can pass an empty list of columns for the schema, and instead use a schema reference.

**SchemaReference structure**

An object that references a schema stored in the AWS Glue Schema Registry.

**Fields**

- **SchemaId** – A [SchemaId](#) object.

  A structure that contains schema identity fields. Either this or the SchemaVersionId has to be provided.

- **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the [Custom string pattern #12](#).

  The unique ID assigned to a version of the schema. Either this or the SchemaId has to be provided.

- **SchemaVersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.

**SerDeInfo structure**

Information about a serialization/deserialization program (SerDe) that serves as an extractor and loader.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Name of the SerDe.
• SerializationLibrary – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Usually the class that implements the SerDe. An example is org.apache.hadoop.hive.serde2.columnar.ColumnarSerDe.

• Parameters – A map array of key-value pairs.

Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Each value is a UTF-8 string, not more than 512000 bytes long.

These key-value pairs define initialization parameters for the SerDe.

Order structure

Specifies the sort order of a sorted column.

Fields

• Column – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the column.

• SortOrder – Required: Number (integer), not more than 1.

Indicates that the column is sorted in ascending order (== 1), or in descending order (==0).

SkewedInfo structure

Specifies skewed values in a table. Skewed values are those that occur with very high frequency.

Fields

• SkewedColumnNames – An array of UTF-8 strings.

A list of names of columns that contain skewed values.

• SkewedColumnValues – An array of UTF-8 strings.

A list of values that appear so frequently as to be considered skewed.
• SkewedColumnValueLocationMaps – A map array of key-value pairs.

    Each key is a UTF-8 string.

    Each value is a UTF-8 string.

    A mapping of skewed values to the columns that contain them.

**TableVersion structure**

Specifies a version of a table.

**Fields**

• **Table** – A [Table](#) object.

    The table in question.

• **VersionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

    The ID value that identifies this table version. A VersionId is a string representation of an integer. Each version is incremented by 1.

**TableError structure**

An error record for table operations.

**Fields**

• **TableName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

    The name of the table. For Hive compatibility, this must be entirely lowercase.

• **ErrorDetail** – An [ErrorDetail](#) object.

    The details about the error.

**TableVersionError structure**

An error record for table-version operations.
Fields

- **TableName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#). The name of the table in question.

- **VersionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#). The ID value of the version in question. A VersionID is a string representation of an integer. Each version is incremented by 1.

- **ErrorDetail** – An [ErrorDetail](#) object. The details about the error.

SortCriterion structure

Specifies a field to sort by and a sort order.

**Fields**

- **FieldName** – Value string, not more than 1024 bytes long. The name of the field on which to sort.

- **Sort** – UTF-8 string (valid values: ASC="ASCENDING" | DESC="DESCENDING"). An ascending or descending sort.

TableIdentifier structure

A structure that describes a target table for resource linking.

**Fields**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#). The ID of the Data Catalog in which the table resides.
• DatabaseName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

The name of the catalog database that contains the target table.

• Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

The name of the target table.

• Region – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

Region of the target table.

**KeySchemaElement structure**

A partition key pair consisting of a name and a type.

**Fields**

• Name – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

The name of a partition key.

• Type – **Required**: UTF-8 string, not more than 131072 bytes long, matching the **Single-line string pattern**.

The type of a partition key.

**PartitionIndex structure**

A structure for a partition index.

**Fields**

• Keys – **Required**: An array of UTF-8 strings, at least 1 string.

The keys for the partition index.

• IndexName – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.
The name of the partition index.

**PartitionIndexDescriptor structure**

A descriptor for a partition index in a table.

**Fields**

- **IndexName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the partition index.

- **Keys** – *Required*: An array of `KeySchemaElement` objects, at least 1 structure.

  A list of one or more keys, as KeySchemaElement structures, for the partition index.

- **IndexStatus** – *Required*: UTF-8 string (valid values: CREATING | ACTIVE | DELETING | FAILED).

  The status of the partition index.

  The possible statuses are:

  - CREATING: The index is being created. When an index is in a CREATING state, the index or its table cannot be deleted.
  - ACTIVE: The index creation succeeds.
  - FAILED: The index creation fails.
  - DELETING: The index is deleted from the list of indexes.

- **BackfillErrors** – An array of `BackfillError` objects.

  A list of errors that can occur when registering partition indexes for an existing table.

**BackfillError structure**

A list of errors that can occur when registering partition indexes for an existing table.

These errors give the details about why an index registration failed and provide a limited number of partitions in the response, so that you can fix the partitions at fault and try registering the index again. The most common set of errors that can occur are categorized as follows:

- EncryptedPartitionError: The partitions are encrypted.
• InvalidPartitionTypeDataError: The partition value doesn't match the data type for that partition column.

• MissingPartitionValueError: The partitions are encrypted.

• UnsupportedPartitionCharacterError: Characters inside the partition value are not supported. For example: U+0000, U+0001, U+0002.

• InternalError: Any error which does not belong to other error codes.

Fields


  The error code for an error that occurred when registering partition indexes for an existing table.

• Partitions – An array of PartitionValueList objects.

  A list of a limited number of partitions in the response.

IcebergInput structure

A structure that defines an Apache Iceberg metadata table to create in the catalog.

Fields

• MetadataOperation – Required: UTF-8 string (valid values: CREATE).

  A required metadata operation. Can only be set to CREATE.

• Version – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The table version for the Iceberg table. Defaults to 2.

OpenTableFormatInput structure

A structure representing an open format table.
Fields

- **IcebergInput** – An [IcebergInput](#) object.

  Specifies an IcebergInput structure that defines an Apache Iceberg metadata table.

Operations

- **CreateTable action (Python: create_table)**
- **UpdateTable action (Python: update_table)**
- **DeleteTable action (Python: delete_table)**
- **BatchDeleteTable action (Python: batch_delete_table)**
- **GetTable action (Python: get_table)**
- **GetTables action (Python: get_tables)**
- **GetTableVersion action (Python: get_table_version)**
- **GetTableVersions action (Python: get_table_versions)**
- **DeleteTableVersion action (Python: delete_table_version)**
- **BatchDeleteTableVersion action (Python: batch_delete_table_version)**
- **SearchTables action (Python: search_tables)**
- **GetPartitionIndexes action (Python: get_partition_indexes)**
- **CreatePartitionIndex action (Python: create_partition_index)**
- **DeletePartitionIndex action (Python: delete_partition_index)**
- **GetColumnStatisticsForTable action (Python: get_column_statistics_for_table)**
- **UpdateColumnStatisticsForTable action (Python: update_column_statistics_for_table)**
- **DeleteColumnStatisticsForTable action (Python: delete_column_statistics_for_table)**

**CreateTable action (Python: create_table)**

Creates a new table definition in the Data Catalog.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The ID of the Data Catalog in which to create the Table. If none is supplied, the AWS account ID is used by default.

- **DatabaseName** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The catalog database in which to create the new table. For Hive compatibility, this name is entirely lowercase.

- **TableInput** – *Required: A TableInput object.*

  The TableInput object that defines the metadata table to create in the catalog.

- **PartitionIndexes** – An array of PartitionIndex objects, not more than 3 structures.

  A list of partition indexes, PartitionIndex structures, to create in the table.

- **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #11.

  The ID of the transaction.

- **OpenTableFormatInput** – An OpenTableFormatInput object.

  Specifies an OpenTableFormatInput structure when creating an open format table.

**Response**

- *No Response parameters.*

**Errors**

- AlreadyExistsException
- InvalidInputException
- EntityNotFoundException
- ResourceNumberLimitExceededException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException
- ConcurrentModificationException
ResourceNotReadyException

**UpdateTable action (Python: update_table)**

Updates a metadata table in the Data Catalog.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
The ID of the Data Catalog where the table resides. If none is provided, the AWS account ID is used by default.
- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
The name of the catalog database in which the table resides. For Hive compatibility, this name is entirely lowercase.
- **TableInput** – *Required*: A TableInput object.
  
  An updated TableInput object to define the metadata table in the catalog.
- **SkipArchive** – Boolean.
  
  By default, UpdateTable always creates an archived version of the table before updating it. However, if skipArchive is set to true, UpdateTable does not create the archived version.
- **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #11.
  
The transaction ID at which to update the table contents.
- **VersionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
The version ID at which to update the table contents.

**Response**

- *No Response parameters.*
Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ConcurrentModificationException
- ResourceNumberLimitExceededException
- GlueEncryptionException
- ResourceNotReadyException

DeleteTable action (Python: delete_table)

Removes a table definition from the Data Catalog.

⚠️ Note

After completing this operation, you no longer have access to the table versions and partitions that belong to the deleted table. AWS Glue deletes these "orphaned" resources asynchronously in a timely manner, at the discretion of the service. To ensure the immediate deletion of all related resources, before calling DeleteTable, use DeleteTableVersion or BatchDeleteTableVersion, and DeletePartition or BatchDeletePartition, to delete any resources that belong to the table.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the table resides. If none is provided, the AWS account ID is used by default.

- DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database in which the table resides. For Hive compatibility, this name is entirely lowercase.
• **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the table to be deleted. For Hive compatibility, this name is entirely lowercase.

• **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #11](#).

  The transaction ID at which to delete the table contents.

**Response**

• *No Response parameters.*

**Errors**

• `EntityNotFoundException`
• `InvalidInputException`
• `InternalServiceException`
• `OperationTimeoutException`
• `ConcurrentModificationException`
• `ResourceNotReadyException`

**BatchDeleteTable action (Python: batch_delete_table)**

Deletes multiple tables at once.

ℹ️ **Note**

After completing this operation, you no longer have access to the table versions and partitions that belong to the deleted table. AWS Glue deletes these "orphaned" resources asynchronously in a timely manner, at the discretion of the service.

To ensure the immediate deletion of all related resources, before calling `BatchDeleteTable`, use `DeleteTableVersion` or `BatchDeleteTableVersion`, and `DeletePartition` or `BatchDeletePartition`, to delete any resources that belong to the table.
Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the table resides. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database in which the tables to delete reside. For Hive compatibility, this name is entirely lowercase.

- **TablesToDelete** – *Required*: An array of UTF-8 strings, not more than 100 strings.

  A list of the table to delete.

- **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #11.

  The transaction ID at which to delete the table contents.

Response

- **Errors** – An array of `TableError` objects.

  A list of errors encountered in attempting to delete the specified tables.

Errors

- `InvalidInputException`
- `EntityNotFoundException`
- `InternalServiceException`
- `OperationTimeoutException`
- `GlueEncryptionException`
- `ResourceNotReadyException`
GetTable action (Python: get_table)

Retrieves the Table definition in a Data Catalog for a specified table.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The ID of the Data Catalog where the table resides. If none is provided, the AWS account ID is used by default.
- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the database in the catalog in which the table resides. For Hive compatibility, this name is entirely lowercase.
- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the table for which to retrieve the definition. For Hive compatibility, this name is entirely lowercase.
- **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #11](#).
  
  The transaction ID at which to read the table contents.
- **QueryAsOfTime** – Timestamp.
  
  The time as of when to read the table contents. If not set, the most recent transaction commit time will be used. Cannot be specified along with TransactionId.

Response

- **Table** – A [Table](#) object.
  
  The Table object that defines the specified table.

Errors

- **EntityNotFoundException**
• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• GlueEncryptionException
• ResourceNotReadyException
• FederationSourceException
• FederationSourceRetryableException

GetTables action (Python: get_tables)

Retrieves the definitions of some or all of the tables in a given Database.

Request

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the tables reside. If none is provided, the AWS account ID is used by default.

• DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The database in the catalog whose tables to list. For Hive compatibility, this name is entirely lowercase.

• Expression – UTF-8 string, not more than 2048 bytes long, matching the Single-line string pattern.

  A regular expression pattern. If present, only those tables whose names match the pattern are returned.

• NextToken – UTF-8 string.

  A continuation token, included if this is a continuation call.

• MaxResults – Number (integer), not less than 1 or more than 100.

  The maximum number of tables to return in a single response.

• TransactionId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #11.
The transaction ID at which to read the table contents.
- QueryAsOfTime – Timestamp.

The time as of when to read the table contents. If not set, the most recent transaction commit time will be used. Cannot be specified along with TransactionId.

Response
- TableList – An array of Table objects.

A list of the requested Table objects.
- NextToken – UTF-8 string.

A continuation token, present if the current list segment is not the last.

Errors
- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- GlueEncryptionException
- FederationSourceException
- FederationSourceRetryableException

GetTableVersion action (Python: get_table_version)

Retrieves a specified version of a table.

Request
- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog where the tables reside. If none is provided, the AWS account ID is used by default.
• **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The database in the catalog in which the table resides. For Hive compatibility, this name is entirely lowercase.

• **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the table. For Hive compatibility, this name is entirely lowercase.

• **VersionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID value of the table version to be retrieved. A VersionID is a string representation of an integer. Each version is incremented by 1.

**Response**

• **TableVersion** – A [TableVersion](#) object.

  The requested table version.

**Errors**

• EntityNotFoundException
• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• GlueEncryptionException

**GetTableVersions action (Python: get_table_versions)**

Retrieves a list of strings that identify available versions of a specified table.

**Request**

• **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The ID of the Data Catalog where the tables reside. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The database in the catalog in which the table resides. For Hive compatibility, this name is entirely lowercase.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the table. For Hive compatibility, this name is entirely lowercase.

- **NextToken** – UTF-8 string.

  A continuation token, if this is not the first call.

- **MaxResults** – Number (integer), not less than 1 or more than 100.

  The maximum number of table versions to return in one response.

### Response

- **TableVersions** – An array of [TableVersion](#) objects.

  A list of strings identifying available versions of the specified table.

- **NextToken** – UTF-8 string.

  A continuation token, if the list of available versions does not include the last one.

### Errors

- **EntityNotFoundException**
- **InvalidInputException**
- **InternalServiceException**
- **OperationTimeoutException**
- **GlueEncryptionException**
DeleteTableVersion action (Python: delete_table_version)

Deletes a specified version of a table.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the tables reside. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The database in the catalog in which the table resides. For Hive compatibility, this name is entirely lowercase.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table. For Hive compatibility, this name is entirely lowercase.

- **VersionId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the table version to be deleted. A VersionID is a string representation of an integer. Each version is incremented by 1.

Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
BatchDeleteTableVersion action (Python: batch_delete_table_version)

Deletes a specified batch of versions of a table.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the tables reside. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The database in the catalog in which the table resides. For Hive compatibility, this name is entirely lowercase.

- **TableName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table. For Hive compatibility, this name is entirely lowercase.

- **VersionIds** – **Required**: An array of UTF-8 strings, not more than 100 strings.

  A list of the IDs of versions to be deleted. A VersionId is a string representation of an integer. Each version is incremented by 1.

Response

- **Errors** – An array of TableVersionError objects.

  A list of errors encountered while trying to delete the specified table versions.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
SearchTables action (Python: search_tables)

Searches a set of tables based on properties in the table metadata as well as on the parent database. You can search against text or filter conditions.

You can only get tables that you have access to based on the security policies defined in Lake Formation. You need at least a read-only access to the table for it to be returned. If you do not have access to all the columns in the table, these columns will not be searched against when returning the list of tables back to you. If you have access to the columns but not the data in the columns, those columns and the associated metadata for those columns will be included in the search.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  A unique identifier, consisting of `account_id`.

- **NextToken** – UTF-8 string.
  
  A continuation token, included if this is a continuation call.

- **Filters** – An array of `PropertyPredicate` objects.
  
  A list of key-value pairs, and a comparator used to filter the search results. Returns all entities matching the predicate.

  The `Comparator` member of the `PropertyPredicate` struct is used only for time fields, and can be omitted for other field types. Also, when comparing string values, such as when `Key=Name`, a fuzzy match algorithm is used. The `Key` field (for example, the value of the `Name` field) is split on certain punctuation characters, for example, -, ;, #, etc. into tokens. Then each token is exact-match compared with the `Value` member of `PropertyPredicate`. For example, if `Key=Name` and `Value=link`, tables named `customer-link` and `xx-link-yy` are returned, but `xxlinkyy` is not returned.

- **SearchText** – Value string, not more than 1024 bytes long.
  
  A string used for a text search.

  Specifying a value in quotes filters based on an exact match to the value.

- **SortCriteria** – An array of `SortCriterion` objects, not more than 1 structures.
A list of criteria for sorting the results by a field name, in an ascending or descending order.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum number of tables to return in a single response.

- **ResourceShareType** – UTF-8 string (valid values: FOREIGN | ALL | FEDERATED).

  Allows you to specify that you want to search the tables shared with your account. The allowable values are FOREIGN or ALL.

  - If set to FOREIGN, will search the tables shared with your account.
  - If set to ALL, will search the tables shared with your account, as well as the tables in your local account.

**Response**

- **NextToken** – UTF-8 string.

  A continuation token, present if the current list segment is not the last.

- **TableList** – An array of **Table** objects.

  A list of the requested **Table** objects. The **SearchTables** response returns only the tables that you have access to.

**Errors**

- InternalServiceException
- InvalidInputException
- OperationTimeoutException

**GetPartitionIndexes action (Python: get_partition_indexes)**

Retrieves the partition indexes associated with a table.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The catalog ID where the table resides.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Specifies the name of a database from which you want to retrieve partition indexes.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Specifies the name of a table for which you want to retrieve the partition indexes.

- **NextToken** – UTF-8 string.

  A continuation token, included if this is a continuation call.

**Response**

- **PartitionIndexDescriptorList** – An array of [PartitionIndexDescriptor](#) objects.

  A list of index descriptors.

- **NextToken** – UTF-8 string.

  A continuation token, present if the current list segment is not the last.

**Errors**

- `InternalServiceException`
- `OperationTimeoutException`
- `InvalidInputException`
- `EntityNotFoundException`
- `ConflictException`

**CreatePartitionIndex action (Python: create_partition_index)**

Creates a specified partition index in an existing table.
Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The catalog ID where the table resides.

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Specifies the name of a database in which you want to create a partition index.

- **TableName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Specifies the name of a table in which you want to create a partition index.

- **PartitionIndex** – *Required*: A PartitionIndex object.

  Specifies a PartitionIndex structure to create a partition index in an existing table.

Response

- **No Response parameters.**

Errors

- AlreadyExistsException
- InvalidInputException
- EntityNotFoundException
- ResourceNumberLimitExceeded Exception
- InternalService Exception
- OperationTimeoutException
- GlueEncryptionException

**DeletePartitionIndex action (Python: delete_partition_index)**

Deletes a specified partition index from an existing table.
Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The catalog ID where the table resides.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Specifies the name of a database from which you want to delete a partition index.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Specifies the name of a table from which you want to delete a partition index.

- **IndexName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the partition index to be deleted.

Response

- *No Response parameters.*

Errors

- **InternalServiceException**
- **OperationTimeoutException**
- **InvalidInputException**
- **EntityNotFoundException**
- **ConflictException**
- **GlueEncryptionException**

**GetColumnStatisticsForTable action (Python: get_column_statistics_for_table)**

Retrieves table statistics of columns.

The Identity and Access Management (IAM) permission required for this operation is GetTable.
Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

- **DatabaseName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the catalog database where the partitions reside.

- **TableName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the partitions' table.

- **ColumnNames** – **Required**: An array of UTF-8 strings, not more than 100 strings.

  A list of the column names.

Response

- **ColumnStatisticsList** – An array of [ColumnStatistics](#) objects.

  List of ColumnStatistics.

- **Errors** – An array of [ColumnError](#) objects.

  List of ColumnStatistics that failed to be retrieved.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException
UpdateColumnStatisticsForTable action (Python: `update_column_statistics_for_table`)

Creates or updates table statistics of columns.

The Identity and Access Management (IAM) permission required for this operation is UpdateTable.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the catalog database where the partitions reside.

- **TableName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the partitions' table.

- **ColumnStatisticsList** – *Required*: An array of [ColumnStatistics](#) objects, not more than 25 structures.
  
  A list of the column statistics.

**Response**

- **Errors** – An array of [ColumnStatisticsError](#) objects.
  
  List of ColumnStatisticsErrors.

**Errors**

- `EntityNotFoundException`
- `InvalidInputException`
• InternalServiceException
• OperationTimeoutException
• GlueEncryptionException

DeleteColumnStatisticsForTable action (Python: delete_column_statistics_for_table)

Retrieves table statistics of columns.

The Identity and Access Management (IAM) permission required for this operation is DeleteTable.

Request

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

• DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database where the partitions reside.

• TableName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the partitions' table.

• ColumnName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the column.

Response

• No Response parameters.
Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException

Partition API

The Partition API describes data types and operations used to work with partitions.

Data types

- Partition structure
- PartitionInput structure
- PartitionSpecWithSharedStorageDescriptor structure
- PartitionListComposingSpec structure
- PartitionSpecProxy structure
- PartitionValueList structure
- Segment structure
- PartitionError structure
- BatchUpdatePartitionFailureEntry structure
- BatchUpdatePartitionRequestEntry structure
- StorageDescriptor structure
- SchemaReference structure
- SerDeInfo structure
- SkewedInfo structure

Partition structure

Represents a slice of table data.
Fields

- **Values** – An array of UTF-8 strings.
  
  The values of the partition.
- **DatabaseName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the catalog database in which to create the partition.
- **TableName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the database table in which to create the partition.
- **CreationTime** – Timestamp.
  
  The time at which the partition was created.
- **LastAccessTime** – Timestamp.
  
  The last time at which the partition was accessed.
- **StorageDescriptor** – A StorageDescriptor object.
  
  Provides information about the physical location where the partition is stored.
- **Parameters** – A map array of key-value pairs.
  
  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Each value is a UTF-8 string, not more than 512000 bytes long.
  
  These key-value pairs define partition parameters.
- **LastAnalyzedTime** – Timestamp.
  
  The last time at which column statistics were computed for this partition.
- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog in which the partition resides.
PartitionInput structure

The structure used to create and update a partition.

Fields

• Values – An array of UTF-8 strings.

  The values of the partition. Although this parameter is not required by the SDK, you must specify this parameter for a valid input.

  The values for the keys for the new partition must be passed as an array of String objects that must be ordered in the same order as the partition keys appearing in the Amazon S3 prefix. Otherwise AWS Glue will add the values to the wrong keys.

• LastAccessTime – Timestamp.

  The last time at which the partition was accessed.

• StorageDescriptor – A StorageDescriptor object.

  Provides information about the physical location where the partition is stored.

• Parameters – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string, not more than 512000 bytes long.

  These key-value pairs define partition parameters.

• LastAnalyzedTime – Timestamp.

  The last time at which column statistics were computed for this partition.

PartitionSpecWithSharedStorageDescriptor structure

A partition specification for partitions that share a physical location.

Fields

• StorageDescriptor – A StorageDescriptor object.
The shared physical storage information.

- **Partitions** – An array of [Partition](#) objects.
  
  A list of the partitions that share this physical location.

### PartitionListComposingSpec structure

Lists the related partitions.

**Fields**

- **Partitions** – An array of [Partition](#) objects.
  
  A list of the partitions in the composing specification.

### PartitionSpecProxy structure

Provides a root path to specified partitions.

**Fields**

- **DatabaseName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The catalog database in which the partitions reside.

- **TableName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the table that contains the partitions.

- **RootPath** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The root path of the proxy for addressing the partitions.

- **PartitionSpecWithSharedSD** – A [PartitionSpecWithSharedStorageDescriptor](#) object.
  
  A specification of partitions that share the same physical storage location.

  
  Specifies a list of partitions.
PartitionValueList structure

Contains a list of values defining partitions.

Fields

• Values – Required: An array of UTF-8 strings.
  The list of values.

Segment structure

Defines a non-overlapping region of a table's partitions, allowing multiple requests to be run in parallel.

Fields

• SegmentNumber – Required: Number (integer), not more than None.
  The zero-based index number of the segment. For example, if the total number of segments is 4, SegmentNumber values range from 0 through 3.

• TotalSegments – Required: Number (integer), not less than 1 or more than 10.
  The total number of segments.

PartitionError structure

Contains information about a partition error.

Fields

• PartitionValues – An array of UTF-8 strings.
  The values that define the partition.

• ErrorDetail – An ErrorDetail object.
  The details about the partition error.
BatchUpdatePartitionFailureEntry structure

Contains information about a batch update partition error.

**Fields**

- **PartitionValueList** – An array of UTF-8 strings, not more than 100 strings.
  
  A list of values defining the partitions.
- **ErrorDetail** – An ErrorDetail object.
  
  The details about the batch update partition error.

BatchUpdatePartitionRequestEntry structure

A structure that contains the values and structure used to update a partition.

**Fields**

- **PartitionValueList** – *Required:* An array of UTF-8 strings, not more than 100 strings.
  
  A list of values defining the partitions.
- **PartitionInput** – *Required:* A PartitionInput object.
  
  The structure used to update a partition.

StorageDescriptor structure

Describes the physical storage of table data.

**Fields**

- **Columns** – An array of Column objects.
  
  A list of the Columns in the table.
- **Location** – Location string, not more than 2056 bytes long, matching the URI address multi-line string pattern.
  
  The physical location of the table. By default, this takes the form of the warehouse location, followed by the database location in the warehouse, followed by the table name.
- **AdditionalLocations** – An array of UTF-8 strings.

  A list of locations that point to the path where a Delta table is located.

- **InputFormat** – Format string, not more than 128 bytes long, matching the *Single-line string pattern*.

  The input format: `SequenceFileInputFormat` (binary), or `TextInputFormat`, or a custom format.

- **OutputFormat** – Format string, not more than 128 bytes long, matching the *Single-line string pattern*.

  The output format: `SequenceFileOutputFormat` (binary), or `IgnoreKeyTextOutputFormat`, or a custom format.

- **Compressed** – Boolean.

  True if the data in the table is compressed, or False if not.

- **NumberOfBuckets** – Number (integer).

  Must be specified if the table contains any dimension columns.

- **SerdeInfo** – A [SerDeInfo](#) object.

  The serialization/deserialization (SerDe) information.

- **BucketColumns** – An array of UTF-8 strings.

  A list of reducer grouping columns, clustering columns, and bucketing columns in the table.

- **SortColumns** – An array of [Order](#) objects.

  A list specifying the sort order of each bucket in the table.

- **Parameters** – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  Each value is a UTF-8 string, not more than 512000 bytes long.

  The user-supplied properties in key-value form.

- **SkewedInfo** – A [SkewedInfo](#) object.
The information about values that appear frequently in a column (skewed values).

- **StoredAsSubDirectories** – Boolean.

  True if the table data is stored in subdirectories, or False if not.

- **SchemaReference** – A [SchemaReference](#) object.

  An object that references a schema stored in the AWS Glue Schema Registry.

  When creating a table, you can pass an empty list of columns for the schema, and instead use a schema reference.

**SchemaReference structure**

An object that references a schema stored in the AWS Glue Schema Registry.

**Fields**

- **SchemaId** – A [SchemaId](#) object.

  A structure that contains schema identity fields. Either this or the SchemaVersionId has to be provided.

- **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the [Custom string pattern #12](#).

  The unique ID assigned to a version of the schema. Either this or the SchemaId has to be provided.

- **SchemaVersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.

**SerDeInfo structure**

Information about a serialization/deserialization program (SerDe) that serves as an extractor and loader.
Fields

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  Name of the SerDe.

- **SerializationLibrary** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  Usually the class that implements the SerDe. An example is `org.apache.hadoop.hive.serde2.columnar.ColumnarSerDe`.

- **Parameters** – A map array of key-value pairs.

  Each key is a Key string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  Each value is a UTF-8 string, not more than 512000 bytes long.

  These key-value pairs define initialization parameters for the SerDe.

SkewedInfo structure

Specifies skewed values in a table. Skewed values are those that occur with very high frequency.

Fields

- **SkewedColumnNames** – An array of UTF-8 strings.

  A list of names of columns that contain skewed values.

- **SkewedColumnValues** – An array of UTF-8 strings.

  A list of values that appear so frequently as to be considered skewed.

- **SkewedColumnValueLocationMaps** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A mapping of skewed values to the columns that contain them.
Operations

- **CreatePartition action (Python: create_partition)**
- **BatchCreatePartition action (Python: batch_create_partition)**
- **UpdatePartition action (Python: update_partition)**
- **DeletePartition action (Python: delete_partition)**
- **BatchDeletePartition action (Python: batch_delete_partition)**
- **GetPartition action (Python: get_partition)**
- **GetPartitions action (Python: get_partitions)**
- **BatchGetPartition action (Python: batch_get_partition)**
- **BatchUpdatePartition action (Python: batch_update_partition)**
- **GetColumnStatisticsForPartition action (Python: get_column_statistics_for_partition)**
- **UpdateColumnStatisticsForPartition action (Python: update_column_statistics_for_partition)**
- **DeleteColumnStatisticsForPartition action (Python: delete_column_statistics_for_partition)**

**CreatePartition action (Python: create_partition)**

Creates a new partition.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The AWS account ID of the catalog in which the partition is to be created.
- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the metadata database in which the partition is to be created.
- **TableName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the metadata table in which the partition is to be created.
- **PartitionInput** – *Required*: A PartitionInput object.
  A PartitionInput structure defining the partition to be created.
Response

- No Response parameters.

Errors

- InvalidInputException
- AlreadyExistsException
- ResourceNumberLimitExceeded
- InternalServiceException
- EntityNotFoundException
- OperationTimeoutException
- GlueEncryptionException

BatchCreatePartition action (Python: batch_create_partition)

Creates one or more partitions in a batch operation.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the catalog in which the partition is to be created. Currently, this should be the AWS account ID.

- DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the metadata database in which the partition is to be created.

- TableName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the metadata table in which the partition is to be created.

- PartitionInputList – Required: An array of PartitionInput objects, not more than 100 structures.

  A list of PartitionInput structures that define the partitions to be created.
Response

- **Errors** – An array of `PartitionError` objects.

  The errors encountered when trying to create the requested partitions.

Errors

- `InvalidInputException`
- `AlreadyExistsException`
- `ResourceNumberLimitExceededExceptio`n
- `InternalServiceException`
- `EntityNotFoundException`
- `OperationTimeoutException`
- `GlueEncryptionException`

**UpdatePartition action (Python: update_partition)**

Updates a partition.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog where the partition to be updated resides. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the catalog database in which the table in question resides.

- **TableName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the table in which the partition to be updated is located.

- **PartitionValueList** – *Required*: An array of UTF-8 strings, not more than 100 strings.
List of partition key values that define the partition to update.


  The new partition object to update the partition to.

  The `Values` property can't be changed. If you want to change the partition key values for a partition, delete and recreate the partition.

**Response**

- *No Response parameters.*

**Errors**

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException

**DeletePartition action** *(Python: delete_partition)*

Deletes a specified partition.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog where the partition to be deleted resides. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).*

  The name of the catalog database in which the table in question resides.
• **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table that contains the partition to be deleted.

• **PartitionValues** – *Required:* An array of UTF-8 strings.

  The values that define the partition.

**Response**

• *No Response parameters.*

**Errors**

• EntityNotFoundException
• InvalidInputException
• InternalServiceException
• OperationTimeoutException

**BatchDeletePartition action (Python: batch_delete_partition)**

Deletes one or more partitions in a batch operation.

**Request**

• **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the partition to be deleted resides. If none is provided, the AWS account ID is used by default.

• **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database in which the table in question resides.

• **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table that contains the partitions to be deleted.
• **PartitionsToDelete** – *Required:* An array of `PartitionValueList` objects, not more than 25 structures.

  A list of `PartitionInput` structures that define the partitions to be deleted.

**Response**

• **Errors** – An array of `PartitionError` objects.

  The errors encountered when trying to delete the requested partitions.

**Errors**

• `InvalidInputException`
• `EntityNotFoundException`
• `InternalServiceException`
• `OperationTimeoutException`

**GetPartition action (Python: get_partition)**

Retrieves information about a specified partition.

**Request**

• **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the partition in question resides. If none is provided, the AWS account ID is used by default.

• **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database where the partition resides.

• **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the partition's table.

• **PartitionValues** – *Required:* An array of UTF-8 strings.
The values that define the partition.

Response

- Partition – A Partition object.

  The requested information, in the form of a Partition object.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException
- FederationSourceException
- FederationSourceRetryableException

GetPartitions action (Python: get_partitions)

Retrieves information about the partitions in a table.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the partitions in question reside. If none is provided, the AWS account ID is used by default.

- DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database where the partitions reside.

- TableName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The name of the partitions' table.

- **Expression** – Predicate string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

An expression that filters the partitions to be returned.

The expression uses SQL syntax similar to the SQL WHERE filter clause. The SQL statement parser [JSQLParser](#) parses the expression.

**Operators**: The following are the operators that you can use in the Expression API call:

- **=**
  
  Checks whether the values of the two operands are equal; if yes, then the condition becomes true.

  Example: Assume 'variable a' holds 10 and 'variable b' holds 20.

  \( (a = b) \) is not true.

- **<>**
  
  Checks whether the values of two operands are equal; if the values are not equal, then the condition becomes true.

  Example: \((a < > b)\) is true.

- **>**
  
  Checks whether the value of the left operand is greater than the value of the right operand; if yes, then the condition becomes true.

  Example: \((a > b)\) is not true.

- **<**
  
  Checks whether the value of the left operand is less than the value of the right operand; if yes, then the condition becomes true.

  Example: \((a < b)\) is true.
Checks whether the value of the left operand is greater than or equal to the value of the right operand; if yes, then the condition becomes true.

Example: \((a \geq b)\) is not true.

Checks whether the value of the left operand is less than or equal to the value of the right operand; if yes, then the condition becomes true.

Example: \((a \leq b)\) is true.

Logical operators.

Supported Partition Key Types: The following are the supported partition keys.

- string
- date
- timestamp
- int
- bigint
- long
- tinyint
- smallint
- decimal

If an type is encountered that is not valid, an exception is thrown.

The following list shows the valid operators on each type. When you define a crawler, the partitionKey type is created as a STRING, to be compatible with the catalog partitions.

Sample API Call:

Example

The table twitter_partition has three partitions:
Example

Get partition year equal to 2015

```bash
aws glue get-partitions --database-name dbname --table-name twitter_partition
   --expression "year*=*'2015'"
```

Example

Get partition year between 2016 and 2018 (exclusive)

```bash
aws glue get-partitions --database-name dbname --table-name twitter_partition
   --expression "year>'2016' AND year<'2018'"
```

Example

Get partition year between 2015 and 2018 (inclusive). The following API calls are equivalent to each other:

```bash
aws glue get-partitions --database-name dbname --table-name twitter_partition
   --expression "year>='2015' AND year=<='2018'"

aws glue get-partitions --database-name dbname --table-name twitter_partition
   --expression "year BETWEEN 2015 AND 2018"

aws glue get-partitions --database-name dbname --table-name twitter_partition
```

Example

A wildcard partition filter, where the following call output is partition year=2017. A regular expression is not supported in LIKE.
aws glue get-partitions --database-name dbname --table-name twitter_partition --expression "year LIKE '%7'"

- **NextToken** – UTF-8 string.

  A continuation token, if this is not the first call to retrieve these partitions.

- **Segment** – A **Segment** object.

  The segment of the table’s partitions to scan in this request.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum number of partitions to return in a single response.

- **ExcludeColumnSchema** – Boolean.

  When true, specifies not returning the partition column schema. Useful when you are interested only in other partition attributes such as partition values or location. This approach avoids the problem of a large response by not returning duplicate data.

- **TransactionId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Custom string pattern #11**.

  The transaction ID at which to read the partition contents.

- **QueryAsOfTime** – Timestamp.

  The time as of when to read the partition contents. If not set, the most recent transaction commit time will be used. Cannot be specified along with TransactionId.

**Response**

- **Partitions** – An array of **Partition** objects.

  A list of requested partitions.

- **NextToken** – UTF-8 string.

  A continuation token, if the returned list of partitions does not include the last one.
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- GlueEncryptionException
- InvalidStateException
- ResourceNotReadyException
- FederationSourceException
- FederationSourceRetryableException

BatchGetPartition action (Python: batch_get_partition)

Retrieves partitions in a batch request.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

- DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the catalog database where the partitions reside.

- TableName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the partitions' table.

- PartitionsToGet – Required: An array of PartitionValueList objects, not more than 1000 structures.

A list of partition values identifying the partitions to retrieve.
Response

- **Partitions** – An array of `Partition` objects.
  A list of the requested partitions.
- **UnprocessedKeys** – An array of `PartitionValueList` objects, not more than 1000 structures.
  A list of the partition values in the request for which partitions were not returned.

Errors

- `InvalidInputException`
- `EntityNotFoundException`
- `OperationTimeoutException`
- `InternalServiceException`
- `GlueEncryptionException`
- `InvalidStateException`
- `FederationSourceException`
- `FederationSourceRetryableException`

**BatchUpdatePartition action (Python: batch_update_partition)**

Updates one or more partitions in a batch operation.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The ID of the catalog in which the partition is to be updated. Currently, this should be the AWS account ID.
- **DatabaseName** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the metadata database in which the partition is to be updated.
- **TableName** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The name of the metadata table in which the partition is to be updated.

- **Entries** – Required: An array of `BatchUpdatePartitionRequestEntry` objects, not less than 1 or more than 100 structures.

  A list of up to 100 `BatchUpdatePartitionRequestEntry` objects to update.

**Response**

- **Errors** – An array of `BatchUpdatePartitionFailureEntry` objects.

  The errors encountered when trying to update the requested partitions. A list of `BatchUpdatePartitionFailureEntry` objects.

**Errors**

- `InvalidInputException`
- `EntityNotFoundException`
- `OperationTimeoutException`
- `InternalServiceException`
- `GlueEncryptionException`

**GetColumnStatisticsForPartition action (Python: get_column_statistics_for_partition)**

Retrieves partition statistics of columns.

The Identity and Access Management (IAM) permission required for this operation is `GetPartition`.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the `Single-line string pattern`.

  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.
• DatabaseName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The name of the catalog database where the partitions reside.

• TableName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The name of the partitions' table.

• PartitionValues – *Required:* An array of UTF-8 strings.

A list of partition values identifying the partition.

• ColumnNames – *Required:* An array of UTF-8 strings, not more than 100 strings.

A list of the column names.

**Response**

• ColumnStatisticsList – An array of [ColumnStatistics](#) objects.

List of ColumnStatistics that failed to be retrieved.

• Errors – An array of [ColumnError](#) objects.

Error occurred during retrieving column statistics data.

**Errors**

• EntityNotFoundException

• InvalidInputException

• InternalServiceException

• OperationTimeoutException

• GlueEncryptionException

**UpdateColumnStatisticsForPartition action (Python: update_column_statistics_for_partition)**

Creates or updates partition statistics of columns.
The Identity and Access Management (IAM) permission required for this operation is UpdatePartition.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database where the partitions reside.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the partitions' table.

- **PartitionValues** – *Required:* An array of UTF-8 strings.

  A list of partition values identifying the partition.

- **ColumnStatisticsList** – *Required:* An array of `ColumnStatistics` objects, not more than 25 structures.

  A list of the column statistics.

**Response**

- **Errors** – An array of `ColumnStatisticsError` objects.

  Error occurred during updating column statistics data.

**Errors**

- `EntityNotFoundException`
- `InvalidInputException`
- `InternalServiceException`
- `OperationTimeoutException`
• GlueEncryptionException

**DeleteColumnStatisticsForPartition action (Python: delete_column_statistics_for_partition)**

Delete the partition column statistics of a column.

The Identity and Access Management (IAM) permission required for this operation is DeletePartition.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog where the partitions in question reside. If none is supplied, the AWS account ID is used by default.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the catalog database where the partitions reside.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the partitions' table.

- **PartitionValues** – *Required:* An array of UTF-8 strings.

  A list of partition values identifying the partition.

- **ColumnName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Name of the column.

**Response**

- *No Response parameters.*
Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException

Connection API

The Connection API describes AWS Glue connection data types, and the API for creating, deleting, updating, and listing connections.

Data types

- Connection structure
- ConnectionInput structure
- PhysicalConnectionRequirements structure
- GetConnectionsFilter structure

Connection structure

Defines a connection to a data source.

Fields

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the connection definition.

- Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  The description of the connection.

- ConnectionType – UTF-8 string (valid values: JDBC | SFTP | MONGODB | KAFKA | NETWORK | MARKETPLACE | CUSTOM).
The type of the connection. Currently, SFTP is not supported.

- **MatchCriteria** – An array of UTF-8 strings, not more than 10 strings.

  A list of criteria that can be used in selecting this connection.

- **ConnectionProperties** – A map array of key-value pairs, not more than 100 pairs.

  Each key is a UTF-8 string (valid values: HOST | PORT | USERNAME="USER_NAME" | PASSWORD | ENCRYPTED_PASSWORD | JDBC_DRIVER_JAR_URI | JDBC_DRIVER_CLASS_NAME | JDBC_ENGINE | JDBC_ENGINE_VERSION | CONFIG_FILES | INSTANCE_ID | JDBC_CONNECTION_URL | JDBC_ENFORCE_SSL | CUSTOM_JDBC_CERT | SKIP_CUSTOM_JDBC_CERT_VALIDATION | CUSTOM_JDBC_CERT_STRING | CONNECTION_URL | KAFKA_BOOTSTRAP_SERVERS | KAFKA_SSL_ENABLED | KAFKA_CUSTOM_CERT | KAFKA_SKIP_CUSTOM_CERT_VALIDATION | KAFKA_CLIENT_KEYSTORE | KAFKA_CLIENT_KEYSTORE_PASSWORD | KAFKA_CLIENT_KEY_PASSWORD | ENCRYPTED_KAFKA_CLIENT_KEYSTORE_PASSWORD | ENCRYPTED_KAFKA_CLIENT_KEY_PASSWORD | SECRET_ID | CONNECTOR_URL | CONNECTOR_TYPE | CONNECTOR_CLASS_NAME | KAFKA_SASL_MECHANISM | KAFKA_SASL_SCRAM_USERNAME | KAFKA_SASL_SCRAM_PASSWORD | KAFKA_SASL_SCRAM_SECRET_ARNS | ENCRYPTED_KAFKA_SASL_SCRAM_PASSWORD | KAFKA_SASL_GSSAPI_KEYTAB | KAFKA_SASL_GSSAPI_KRB5_CONF | KAFKA_SASL_GSSAPI_SERVICE | KAFKA_SASL_GSSAPI_PRINCIPAL).

  Each value is a Value string, not more than 1024 bytes long.

  These key-value pairs define parameters for the connection:

  - **HOST** - The host URI: either the fully qualified domain name (FQDN) or the IPv4 address of the database host.
  
  - **PORT** - The port number, between 1024 and 65535, of the port on which the database host is listening for database connections.
  
  - **USER_NAME** - The name under which to log in to the database. The value string for USER_NAME is "USERNAME".
  
  - **PASSWORD** - A password, if one is used, for the user name.
  
  - **ENCRYPTED_PASSWORD** - When you enable connection password protection by setting ConnectionPasswordEncryption in the Data Catalog encryption settings, this field stores the encrypted password.
- **JDBC_DRIVER_JAR_URI** - The Amazon Simple Storage Service (Amazon S3) path of the JAR file that contains the JDBC driver to use.
- **JDBC_DRIVER_CLASS_NAME** - The class name of the JDBC driver to use.
- **JDBC_ENGINE** - The name of the JDBC engine to use.
- **JDBC_ENGINE_VERSION** - The version of the JDBC engine to use.
- **CONFIG_FILES** - (Reserved for future use.)
- **INSTANCE_ID** - The instance ID to use.
- **JDBC_CONNECTION_URL** - The URL for connecting to a JDBC data source.
- **JDBC_ENFORCE_SSL** - A Boolean string (true, false) specifying whether Secure Sockets Layer (SSL) with hostname matching is enforced for the JDBC connection on the client. The default is false.
- **CUSTOM_JDBC_CERT** - An Amazon S3 location specifying the customer's root certificate. AWS Glue uses this root certificate to validate the customer's certificate when connecting to the customer database. AWS Glue only handles X.509 certificates. The certificate provided must be DER-encoded and supplied in Base64 encoding PEM format.
- **SKIP_CUSTOM_JDBC_CERT_VALIDATION** - By default, this is false. AWS Glue validates the Signature algorithm and Subject Public Key Algorithm for the customer certificate. The only permitted algorithms for the Signature algorithm are SHA256withRSA, SHA384withRSA or SHA512withRSA. For the Subject Public Key Algorithm, the key length must be at least 2048. You can set the value of this property to true to skip AWS Glue's validation of the customer certificate.
- **CUSTOM_JDBC_CERT_STRING** - A custom JDBC certificate string which is used for domain match or distinguished name match to prevent a man-in-the-middle attack. In Oracle database, this is used as the SSL_SERVER_CERT_DN; in Microsoft SQL Server, this is used as the hostNameInCertificate.
- **CONNECTION_URL** - The URL for connecting to a general (non-JDBC) data source.
- **SECRET_ID** - The secret ID used for the secret manager of credentials.
- **CONNECTOR_URL** - The connector URL for a MARKETPLACE or CUSTOM connection.
- **CONNECTOR_TYPE** - The connector type for a MARKETPLACE or CUSTOM connection.
- **CONNECTOR_CLASS_NAME** - The connector class name for a MARKETPLACE or CUSTOM connection.
• KAFKA_BOOTSTRAP_SERVERS - A comma-separated list of host and port pairs that are the addresses of the Apache Kafka brokers in a Kafka cluster to which a Kafka client will connect to and bootstrap itself.

• KAFKA_SSL_ENABLED - Whether to enable or disable SSL on an Apache Kafka connection. Default value is "true".

• KAFKA_CUSTOM_CERT - The Amazon S3 URL for the private CA cert file (.pem format). The default is an empty string.

• KAFKA_SKIP_CUSTOM_CERT_VALIDATION - Whether to skip the validation of the CA cert file or not. AWS Glue validates for three algorithms: SHA256withRSA, SHA384withRSA and SHA512withRSA. Default value is "false".

• KAFKA_CLIENT_KEYSTORE - The Amazon S3 location of the client keystore file for Kafka client side authentication (Optional).

• KAFKA_CLIENT_KEYSTORE_PASSWORD - The password to access the provided keystore (Optional).

• KAFKA_CLIENT_KEY_PASSWORD - A keystore can consist of multiple keys, so this is the password to access the client key to be used with the Kafka server side key (Optional).

• ENCRYPTED_KAFKA_CLIENT_KEYSTORE_PASSWORD - The encrypted version of the Kafka client keystore password (if the user has the AWS Glue encrypt passwords setting selected).

• ENCRYPTED_KAFKA_CLIENT_KEY_PASSWORD - The encrypted version of the Kafka client key password (if the user has the AWS Glue encrypt passwords setting selected).

• KAFKA_SASL_MECHANISM - "SCRAM-SHA-512", "GSSAPI", or "AWS_MSK_IAM". These are the supported SASL Mechanisms.

• KAFKA_SASL_SCRAM_USERNAME - A plaintext username used to authenticate with the "SCRAM-SHA-512" mechanism.

• KAFKA_SASL_SCRAM_PASSWORD - A plaintext password used to authenticate with the "SCRAM-SHA-512" mechanism.

• ENCRYPTED_KAFKA_SASL_SCRAM_PASSWORD - The encrypted version of the Kafka SASL SCRAM password (if the user has the AWS Glue encrypt passwords setting selected).

• KAFKA_SASL_SCRAM_SECRETS_ARN - The Amazon Resource Name of a secret in AWS Secrets Manager.

• KAFKA_SASL_GSSAPI_KEYTAB - The S3 location of a Kerberos keytab file. A keytab stores long-term keys for one or more principals. For more information, see MIT Kerberos Documentation: Keytab.
• **KAFKA_SASL_GSSAPI_KRB5_CONF** - The S3 location of a Kerberos krb5.conf file. A krb5.conf stores Kerberos configuration information, such as the location of the KDC server. For more information, see [MIT Kerberos Documentation: krb5.conf](https://www.mit.edu/~krb/docs/krb5.conf).

• **KAFKA_SASL_GSSAPI_SERVICE** - The Kerberos service name, as set with `sasl.kerberos.service.name` in your [Kafka Configuration](https).

• **KAFKA_SASL_GSSAPI_PRINCIPAL** - The name of the Kerberos principal used by AWS Glue. For more information, see [Kafka Documentation: Configuring Kafka Brokers](https).

• **PhysicalConnectionRequirements** – A [PhysicalConnectionRequirements](https) object.

  A map of physical connection requirements, such as virtual private cloud (VPC) and SecurityGroup, that are needed to make this connection successfully.

• **CreationTime** – Timestamp.

  The time that this connection definition was created.

• **LastUpdatedTime** – Timestamp.

  The last time that this connection definition was updated.

• **LastUpdatedBy** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https).

  The user, group, or role that last updated this connection definition.

### ConnectionInput structure

A structure that is used to specify a connection to create or update.

**Fields**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https).

  The name of the connection. Connection will not function as expected without a name.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](https).

  The description of the connection.
• **ConnectionType** – *Required:* UTF-8 string (valid values: JDBC | SFTP | MONGODB | KAFKA | NETWORK | MARKETPLACE | CUSTOM).

The type of the connection. Currently, these types are supported:

• **JDBC** - Designates a connection to a database through Java Database Connectivity (JDBC).

  JDBC Connections use the following ConnectionParameters.
  
  • **Required:** All of (HOST, PORT, JDBC_ENGINE) or JDBC_CONNECTION_URL.
  
  • **Required:** All of (USERNAME, PASSWORD) or SECRET_ID.
  
  • **Optional:** JDBC_ENFORCE_SSL, CUSTOM_JDBC_CERT, CUSTOM_JDBC_CERT_STRING, SKIP_CUSTOM_JDBC_CERT_VALIDATION. These parameters are used to configure SSL with JDBC.

• **KAFKA** - Designates a connection to an Apache Kafka streaming platform.

  KAFKA Connections use the following ConnectionParameters.
  
  • **Required:** KAFKA_BOOTSTRAPSERVERS.
  
  • **Optional:** KAFKA_SSL_ENABLED, KAFKA_CUSTOM_CERT, KAFKA_SKIP_CUSTOM_CERT_VALIDATION. These parameters are used to configure SSL with KAFKA.

  • **Optional:** KAFKA_CLIENT_KEYSTORE, KAFKA_CLIENT_KEYSTORE_PASSWORD, KAFKA_CLIENT_KEY_PASSWORD, ENCRYPTED_KAFKA_CLIENT_KEYSTORE_PASSWORD, ENCRYPTED_KAFKA_CLIENT_KEY_PASSWORD. These parameters are used to configure TLS client configuration with SSL in KAFKA.

  • **Optional:** KAFKA_SASL_MECHANISM. Can be specified as SCRAM-SHA-512, GSSAPI, or AWS_MSK_IAM.

  • **Optional:** KAFKA_SASL_SCRAM_USERNAME, KAFKA_SASL_SCRAM_PASSWORD, ENCRYPTED_KAFKA_SASL_SCRAM_PASSWORD. These parameters are used to configure SASL/SCRAM-SHA-512 authentication with KAFKA.

  • **Optional:** KAFKA_SASL_GSSAPI_KEYTAB, KAFKA_SASL_GSSAPI_KRB5_CONF, KAFKA_SASL_GSSAPI_SERVICE, KAFKA_SASL_GSSAPI_PRINCIPAL. These parameters are used to configure SASL/GSSAPI authentication with KAFKA.

• **MONGODB** - Designates a connection to a MongoDB document database.

  MONGODB Connections use the following ConnectionParameters.

  • **Required:** CONNECTION_URL.
• Required: All of (USERNAME, PASSWORD) or SECRET_ID.

• NETWORK - Designates a network connection to a data source within an Amazon Virtual Private Cloud environment (Amazon VPC).

NETWORK Connections do not require ConnectionParameters. Instead, provide a PhysicalConnectionRequirements.

• MARKETPLACE - Uses configuration settings contained in a connector purchased from AWS Marketplace to read from and write to data stores that are not natively supported by AWS Glue.

MARKETPLACE Connections use the following ConnectionParameters.

• Required: CONNECTOR_TYPE, CONNECTOR_URL, CONNECTOR_CLASS_NAME, CONNECTION_URL.

• Required for JDBC CONNECTOR_TYPE connections: All of (USERNAME, PASSWORD) or SECRET_ID.

• CUSTOM - Uses configuration settings contained in a custom connector to read from and write to data stores that are not natively supported by AWS Glue.

SFTP is not supported.

For more information about how optional ConnectionProperties are used to configure features in AWS Glue, consult AWS Glue connection properties.

For more information about how optional ConnectionProperties are used to configure features in AWS Glue Studio, consult Using connectors and connections.

• MatchCriteria – An array of UTF-8 strings, not more than 10 strings.

A list of criteria that can be used in selecting this connection.

• ConnectionProperties – Required: A map array of key-value pairs, not more than 100 pairs.

Each key is a UTF-8 string (valid values: HOST | PORT | USERNAME="USER_NAME" | PASSWORD | ENCRYPTED_PASSWORD | JDBC_DRIVER_JAR_URI | JDBC_DRIVER_CLASS_NAME | JDBC_ENGINE | JDBC_ENGINE_VERSION | CONFIG_FILES | INSTANCE_ID | JDBC_CONNECTION_URL | JDBC_ENFORCE_SSL | CUSTOM_JDBC_CERT | SKIP_CUSTOM_JDBC_CERT_VALIDATION | CUSTOM_JDBC_CERT_STRING | CONNECTION_URL | KAFKA_BOOTSTRAP_SERVERS | KAFKA_SSL_ENABLED | KAFKA_CUSTOM_CERT | KAFKA_SKIP_CUSTOM_CERT_VALIDATION |
Each value is a Value string, not more than 1024 bytes long.

These key-value pairs define parameters for the connection.

- **PhysicalConnectionRequirements** – A [PhysicalConnectionRequirements](#) object.

A map of physical connection requirements, such as virtual private cloud (VPC) and SecurityGroup, that are needed to successfully make this connection.

### PhysicalConnectionRequirements structure

Specifies the physical requirements for a connection.

#### Fields

- **SubnetId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The subnet ID used by the connection.

- **SecurityGroupIdList** – An array of UTF-8 strings, not more than 50 strings.

  The security group ID list used by the connection.

- **AvailabilityZone** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The connection's Availability Zone. This field is redundant because the specified subnet implies the Availability Zone to be used. Currently the field must be populated, but it will be deprecated in the future.
GetConnectionsFilter structure

Filters the connection definitions that are returned by the GetConnections API operation.

Fields

• MatchCriteria – An array of UTF-8 strings, not more than 10 strings.
  
  A criteria string that must match the criteria recorded in the connection definition for that connection definition to be returned.

• ConnectionType – UTF-8 string (valid values: JDBC | SFTP | MONGODB | KAFKA | NETWORK | MARKETPLACE | CUSTOM).
  
  The type of connections to return. Currently, SFTP is not supported.

Operations

• CreateConnection action (Python: create_connection)
  
  DeleteConnection action (Python: delete_connection)

• GetConnection action (Python: get_connection)

• GetConnections action (Python: get_connections)

• UpdateConnection action (Python: update_connection)

• BatchDeleteConnection action (Python: batch_delete_connection)

CreateConnection action (Python: create_connection)

Creates a connection definition in the Data Catalog.

Request

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog in which to create the connection. If none is provided, the AWS account ID is used by default.

• ConnectionInput – Required: A ConnectionInput object.
  
  A ConnectionInput object defining the connection to create.
• Tags – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags you assign to the connection.

Response

• No Response parameters.

Errors

• AlreadyExistsException
• InvalidInputException
• OperationTimeoutException
• ResourceNumberLimitExceededException
• GlueEncryptionException

**DeleteConnection action (Python: delete_connection)**

Deletes a connection from the Data Catalog.

**Request**

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog in which the connection resides. If none is provided, the AWS account ID is used by default.

• ConnectionName – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the connection to delete.
Response

- No Response parameters.

Errors

- EntityNotFoundException
- OperationTimeoutException

GetConnection action (Python: get_connection)

Retrieves a connection definition from the Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which the connection resides. If none is provided, the AWS account ID is used by default.

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the connection definition to retrieve.

- HidePassword – Boolean.

  Allows you to retrieve the connection metadata without returning the password. For instance, the AWS Glue console uses this flag to retrieve the connection, and does not display the password. Set this parameter when the caller might not have permission to use the AWS KMS key to decrypt the password, but it does have permission to access the rest of the connection properties.

Response

- Connection – A Connection object.

  The requested connection definition.
Errors

- EntityNotFoundException
- OperationTimeoutException
- InvalidInputException
- GlueEncryptionException

GetConnections action (Python: get_connections)

Retrieves a list of connection definitions from the Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The ID of the Data Catalog in which the connections reside. If none is provided, the AWS account ID is used by default.
- Filter – A GetConnectionsFilter object.
  A filter that controls which connections are returned.
- HidePassword – Boolean.
  Allows you to retrieve the connection metadata without returning the password. For instance, the AWS Glue console uses this flag to retrieve the connection, and does not display the password. Set this parameter when the caller might not have permission to use the AWS KMS key to decrypt the password, but it does have permission to access the rest of the connection properties.
- NextToken – UTF-8 string.
  A continuation token, if this is a continuation call.
- MaxResults – Number (integer), not less than 1 or more than 1000.
  The maximum number of connections to return in one response.

Response

- ConnectionList – An array of Connection objects.
A list of requested connection definitions.

- NextToken – UTF-8 string.

A continuation token, if the list of connections returned does not include the last of the filtered connections.

Errors

- EntityNotFoundException
- OperationTimeoutException
- InvalidInputException
- GlueEncryptionException

UpdateConnection action (Python: update_connection)

Updates a connection definition in the Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which the connection resides. If none is provided, the AWS account ID is used by default.

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the connection definition to update.

- ConnectionInput – Required: A ConnectionInput object.

  A ConnectionInput object that redefines the connection in question.

Response

- No Response parameters.
Errors

- InvalidInputException
- EntityNotFoundException
- OperationTimeoutException
- InvalidInputException
- GlueEncryptionException

BatchDeleteConnection action (Python: batch_delete_connection)

Deletes a list of connection definitions from the Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which the connections reside. If none is provided, the AWS account ID is used by default.

- ConnectionNameList – Required: An array of UTF-8 strings, not more than 25 strings.

  A list of names of the connections to delete.

Response

- Succeeded – An array of UTF-8 strings.

  A list of names of the connection definitions that were successfully deleted.

- Errors – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a An ErrorDetail object.

  A map of the names of connections that were not successfully deleted to error details.
Errors

- InternalServiceException
- OperationTimeoutException

User-defined Function API

The User-defined Function API describes AWS Glue data types and operations used in working with functions.

Data types

- UserDefinedFunction structure
- UserDefinedFunctionInput structure

UserDefinedFunction structure

Represents the equivalent of a Hive user-defined function (UDF) definition.

Fields

- FunctionName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the function.
- DatabaseName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the catalog database that contains the function.
- ClassName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The Java class that contains the function code.
- OwnerName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The owner of the function.
- OwnerType – UTF-8 string (valid values: USER | ROLE | GROUP).
The owner type.

- **CreateTime** – Timestamp.
  
  The time at which the function was created.

- **ResourceUris** – An array of `ResourceUri` objects, not more than 1000 structures.
  
  The resource URIs for the function.

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog in which the function resides.

**UserDefinedFunctionInput structure**

A structure used to create or update a user-defined function.

**Fields**

- **FunctionName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the function.

- **ClassName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The Java class that contains the function code.

- **OwnerName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The owner of the function.

- **OwnerType** – UTF-8 string (valid values: USER | ROLE | GROUP).
  
  The owner type.

- **ResourceUris** – An array of `ResourceUri` objects, not more than 1000 structures.
  
  The resource URIs for the function.
Operations

- **CreateUserDefinedFunction action (Python: create_user_defined_function)**
- **UpdateUserDefinedFunction action (Python: update_user_defined_function)**
- **DeleteUserDefinedFunction action (Python: delete_user_defined_function)**
- **GetUserDefinedFunction action (Python: get_user_defined_function)**
- **GetUserDefinedFunctions action (Python: get_user_defined_functions)**

**CreateUserDefinedFunction action (Python: create_user_defined_function)**

Creates a new function definition in the Data Catalog.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog in which to create the function. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database in which to create the function.

- **FunctionInput** – **Required**: An UserDefinedFunctionInput object.

  A FunctionInput object that defines the function to create in the Data Catalog.

**Response**

- **No Response parameters.**

**Errors**

- AlreadyExistsException
- InvalidInputException
- InternalServiceException
• EntityNotFoundException
• OperationTimeoutException
• ResourceNumberLimitExceeded
• GlueEncryptionException

**UpdateUserDefinedFunction action (Python: update_user_definedFunction)**

Updates an existing function definition in the Data Catalog.

**Request**

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the Data Catalog where the function to be updated is located. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the catalog database where the function to be updated is located.

- **FunctionName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the function.

- **FunctionInput** – *Required:* An [UserDefinedFunctionInput](#) object.

  A FunctionInput object that redefines the function in the Data Catalog.

**Response**

- *No Response parameters.*

**Errors**

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
DELETEUSERDEFINEDFUNCTION action (Python: delete_user_defined_function)

Deletes an existing function definition from the Data Catalog.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the Data Catalog where the function to be deleted is located. If none is supplied, the AWS account ID is used by default.

- DatabaseName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the catalog database where the function is located.

- FunctionName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the function definition to be deleted.

Response

- No Response parameters.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException

GETUSERDEFINEDFUNCTION action (Python: get_user_defined_function)

Retrieves a specified function definition from the Data Catalog.
Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The ID of the Data Catalog where the function to be retrieved is located. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the catalog database where the function is located.

- **FunctionName** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the function.

Response

- **UserDefinedFunction** – An UserDefinedFunction object.
  
  The requested function definition.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- GlueEncryptionException

GetUserDefinedFunctions action (Python: get_user_defined_functions)

Retrieves multiple function definitions from the Data Catalog.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The ID of the Data Catalog where the functions to be retrieved are located. If none is provided, the AWS account ID is used by default.

- **DatabaseName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the catalog database where the functions are located. If none is provided, functions from all the databases across the catalog will be returned.

- **Pattern** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

An optional function-name pattern string that filters the function definitions returned.

- **NextToken** – UTF-8 string.

A continuation token, if this is a continuation call.

- **MaxResults** – Number (integer), not less than 1 or more than 100.

The maximum number of functions to return in one response.

**Response**

- **UserDefinedFunctions** – An array of UserDefinedFunction objects.

A list of requested function definitions.

- **NextToken** – UTF-8 string.

A continuation token, if the list of functions returned does not include the last requested function.

**Errors**

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- GlueEncryptionException
Importing an Athena catalog to AWS Glue

The Migration API describes AWS Glue data types and operations having to do with migrating an Athena Data catalog to AWS Glue.

Data types

- **CatalogImportStatus structure**

CatalogImportStatus structure

A structure containing migration status information.

Fields

- **ImportCompleted** – Boolean.
  
  True if the migration has completed, or False otherwise.

- **ImportTime** – Timestamp.
  
  The time that the migration was started.

- **ImportedBy** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the person who initiated the migration.

Operations

- **ImportCatalogToGlue action (Python: import_catalog_to_glue)**

- **GetCatalogImportStatus action (Python: get_catalog_import_status)**

ImportCatalogToGlue action (Python: import_catalog_to_glue)

Imports an existing Amazon Athena Data Catalog to AWS Glue.

Request

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The ID of the catalog to import. Currently, this should be the AWS account ID.

Response

- No Response parameters.

Errors

- InternalServiceException
- OperationTimeoutException

GetCatalogImportStatus action (Python: get_catalog_import_status)

Retrieves the status of a migration operation.

Request

- CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The ID of the catalog to migrate. Currently, this should be the AWS account ID.

Response

- ImportStatus – A CatalogImportStatus object.

The status of the specified catalog migration.

Errors

- InternalServiceException
- OperationTimeoutException
Table optimizer API

The table optimizer API describes the AWS Glue API for enabling compaction to improve read performance.

Data types

- **TableOptimizer structure**
- **TableOptimizerConfiguration structure**
- **TableOptimizerRun structure**
- **RunMetrics structure**
- **BatchGetTableOptimizerEntry structure**
- **BatchTableOptimizer structure**
- **BatchGetTableOptimizerError structure**

TableOptimizer structure

Contains details about an optimizer associated with a table.

**Fields**

- **type** – UTF-8 string (valid values: compaction="COMPACTION").
  
  The type of table optimizer. Currently, the only valid value is compaction.

- **configuration** – A **TableOptimizerConfiguration** object.
  
  A TableOptimizerConfiguration object that was specified when creating or updating a table optimizer.

- **lastRun** – A **TableOptimizerRun** object.
  
  A TableOptimizerRun object representing the last run of the table optimizer.

TableOptimizerConfiguration structure

Contains details on the configuration of a table optimizer. You pass this configuration when creating or updating a table optimizer.
Fields

- **roleArn** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Single-line string pattern.

  A role passed by the caller which gives the service permission to update the resources associated with the optimizer on the caller's behalf.

- **enabled** – Boolean.

  Whether table optimization is enabled.

**TableOptimizerRun structure**

Contains details for a table optimizer run.

**Fields**

- **eventType** – UTF-8 string (valid values: starting="STARTING" | completed="COMPLETED" | failed="FAILED" | in_progress="IN_PROGRESS").

  An event type representing the status of the table optimizer run.

- **startTimestamp** – Timestamp.

  Represents the epoch timestamp at which the compaction job was started within Lake Formation.

- **endTimestamp** – Timestamp.

  Represents the epoch timestamp at which the compaction job ended.

- **metrics** – A **RunMetrics** object.

  A RunMetrics object containing metrics for the optimizer run.

- **error** – UTF-8 string.

  An error that occurred during the optimizer run.

**RunMetrics structure**

Metrics for the optimizer run.
Fields

• NumberOfBytesCompacted – UTF-8 string.
  The number of bytes removed by the compaction job run.

• NumberOfFilesCompacted – UTF-8 string.
  The number of files removed by the compaction job run.

• NumberOfDpus – UTF-8 string.
  The number of DPU hours consumed by the job.

• JobDurationInHour – UTF-8 string.
  The duration of the job in hours.

BatchGetTableOptimizerEntry structure

Represents a table optimizer to retrieve in the BatchGetTableOptimizer operation.

Fields

• catalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The Catalog ID of the table.

• databaseName – UTF-8 string, at least 1 byte long.
  The name of the database in the catalog in which the table resides.

• tableName – UTF-8 string, at least 1 byte long.
  The name of the table.

• type – UTF-8 string (valid values: compaction="COMPACTION").
  The type of table optimizer.

BatchTableOptimizer structure

Contains details for one of the table optimizers returned by the BatchGetTableOptimizer operation.
Fields

- **catalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The Catalog ID of the table.

- **databaseName** – UTF-8 string, at least 1 byte long.

  The name of the database in the catalog in which the table resides.

- **tableName** – UTF-8 string, at least 1 byte long.

  The name of the table.

- **tableOptimizer** – A [TableOptimizer](#) object.

  A TableOptimizer object that contains details on the configuration and last run of a table optimizer.

**BatchGetTableOptimizerError structure**

Contains details on one of the errors in the error list returned by the BatchGetTableOptimizer operation.

Fields

- **error** – An [ErrorDetail](#) object.

  An ErrorDetail object containing code and message details about the error.

- **catalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The Catalog ID of the table.

- **databaseName** – UTF-8 string, at least 1 byte long.

  The name of the database in the catalog in which the table resides.

- **tableName** – UTF-8 string, at least 1 byte long.

  The name of the table.

- **type** – UTF-8 string (valid values: compaction="COMPACTION").
The type of table optimizer.

## Operations

- **GetTableOptimizer action (Python: get_table_optimizer)**
- **BatchGetTableOptimizer action (Python: batch_get_table_optimizer)**
- **ListTableOptimizerRuns action (Python: list_table_optimizer_runs)**
- **CreateTableOptimizer action (Python: create_table_optimizer)**
- **DeleteTableOptimizer action (Python: delete_table_optimizer)**
- **UpdateTableOptimizer action (Python: update_table_optimizer)**

### GetTableOptimizer action (Python: get_table_optimizer)

Returns the configuration of all optimizers associated with a specified table.

**Request**

- **CatalogId** – *Required:* Catalog id string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The Catalog ID of the table.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the database in the catalog in which the table resides.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the table.

- **Type** – *Required:* UTF-8 string (valid values: compaction="COMPACTION").

  The type of table optimizer.
Response

- **CatalogId** – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The Catalog ID of the table.
- **DatabaseName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the database in the catalog in which the table resides.
- **TableName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the table.
- **TableOptimizer** – A `TableOptimizer` object.
  
  The optimizer associated with the specified table.

Errors

- EntityNotFoundException
- InvalidInputException
- AccessDeniedException
- InternalServiceException

**BatchGetTableOptimizer action (Python: batch_get_table_optimizer)**

Returns the configuration for the specified table optimizers.

**Request**

- **Entries** – *Required:* An array of `BatchGetTableOptimizerEntry` objects.
  
  A list of BatchGetTableOptimizerEntry objects specifying the table optimizers to retrieve.

**Response**

- **TableOptimizers** – An array of `BatchTableOptimizer` objects.
A list of BatchTableOptimizer objects.

- Failures – An array of BatchGetTableOptimizerError objects.
  
  A list of errors from the operation.

Errors

- EntityNotFoundException
- InvalidInputException
- AccessDeniedException
- InternalServiceException

**ListTableOptimizerRuns action (Python: list_table_optimizer_runs)**

Lists the history of previous optimizer runs for a specific table.

**Request**

- CatalogId – *Required:* Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The Catalog ID of the table.
- DatabaseName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the database in the catalog in which the table resides.
- TableName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the table.
- Type – *Required:* UTF-8 string (valid values: compaction="COMPACTION").
  
  The type of table optimizer. Currently, the only valid value is compaction.
- MaxResults – Number (integer).
  
  The maximum number of optimizer runs to return on each call.
• NextToken – UTF-8 string.

  A continuation token, if this is a continuation call.

Response

• CatalogId – Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The Catalog ID of the table.

• DatabaseName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the database in the catalog in which the table resides.

• TableName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table.

• NextToken – UTF-8 string.

  A continuation token for paginating the returned list of optimizer runs, returned if the current segment of the list is not the last.

• TableOptimizerRuns – An array of TableOptimizerRun objects.

  A list of the optimizer runs associated with a table.

Errors

• EntityNotFoundException
• AccessDeniedException
• InvalidInputException
• ValidationException
• InternalServiceException
CreateTableOptimizer action (Python: create_table_optimizer)

Creates a new table optimizer for a specific function. compaction is the only currently supported optimizer type.

Request

- **CatalogId** – *Required:* Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The Catalog ID of the table.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the database in the catalog in which the table resides.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the table.

- **Type** – *Required:* UTF-8 string (valid values: compaction="COMPACTION").

  The type of table optimizer. Currently, the only valid value is compaction.

- **TableOptimizerConfiguration** – *Required:* A TableOptimizerConfiguration object.

  A TableOptimizerConfiguration object representing the configuration of a table optimizer.

Response

- **No Response parameters.**

Errors

- EntityNotFoundException
- ValidationException
- InvalidInputException
- AccessDeniedException
- AlreadyExistsException
• InternalServiceException

**DeleteTableOptimizer action (Python: delete_table_optimizer)**

Deletes an optimizer and all associated metadata for a table. The optimization will no longer be performed on the table.

**Request**

- **CatalogId** – *Required:* Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The Catalog ID of the table.

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the database in the catalog in which the table resides.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the table.

- **Type** – *Required:* UTF-8 string (valid values: compaction="COMPACTION").
  
  The type of table optimizer.

**Response**

- **No Response parameters.**

**Errors**

- EntityNotFoundException
- InvalidInputException
- AccessDeniedException
- InternalServiceException
UpdateTableOptimizer action (Python: update_table_optimizer)

Updates the configuration for an existing table optimizer.

Request

- **CatalogId** – *Required: Catalog id string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The Catalog ID of the table.

- **DatabaseName** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The name of the database in the catalog in which the table resides.

- **TableName** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The name of the table.

- **Type** – *Required: UTF-8 string (valid values: compaction="COMPACTION").*

  The type of table optimizer. Currently, the only valid value is compaction.

- **TableOptimizerConfiguration** – *Required: A TableOptimizerConfiguration object.*

  A TableOptimizerConfiguration object representing the configuration of a table optimizer.

Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- InvalidInputException
- AccessDeniedException
- ValidationException
- InternalServiceException
Crawlers and classifiers API

The Crawler and classifiers API describes the AWS Glue crawler and classifier data types, and includes the API for creating, deleting, updating, and listing crawlers or classifiers.

Topics

• Classifier API
• Crawler API
• Column statistics API
• Crawler scheduler API

Classifier API

The Classifier API describes AWS Glue classifier data types, and includes the API for creating, deleting, updating, and listing classifiers.

Data types

• Classifier structure
• GrokClassifier structure
• XMLClassifier structure
• JsonClassifier structure
• CsvClassifier structure
• CreateGrokClassifierRequest structure
• UpdateGrokClassifierRequest structure
• CreateXMLClassifierRequest structure
• UpdateXMLClassifierRequest structure
• CreateJsonClassifierRequest structure
• UpdateJsonClassifierRequest structure
• CreateCsvClassifierRequest structure
• UpdateCsvClassifierRequest structure
Classifier structure

Classifiers are triggered during a crawl task. A classifier checks whether a given file is in a format it can handle. If it is, the classifier creates a schema in the form of a StructType object that matches that data format.

You can use the standard classifiers that AWS Glue provides, or you can write your own classifiers to best categorize your data sources and specify the appropriate schemas to use for them. A classifier can be a grok classifier, an XML classifier, a JSON classifier, or a custom CSV classifier, as specified in one of the fields in the Classifier object.

Fields

- **GrokClassifier** – A [GrokClassifier](#) object.
  
  A classifier that uses grok.
- **XMLClassifier** – A [XMLClassifier](#) object.
  
  A classifier for XML content.
- **JsonClassifier** – A [JsonClassifier](#) object.
  
  A classifier for JSON content.
- **CsvClassifier** – A [CsvClassifier](#) object.
  
  A classifier for comma-separated values (CSV).

GrokClassifier structure

A classifier that uses grok patterns.

Fields

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the classifier.
- **Classification** – *Required*: UTF-8 string.
  
  An identifier of the data format that the classifier matches, such as Twitter, JSON, Omniture logs, and so on.
• **CreationTime** – Timestamp.
  The time that this classifier was registered.

• **LastUpdated** – Timestamp.
  The time that this classifier was last updated.

• **Version** – Number (long).
  The version of this classifier.

• **GrokPattern** – *Required:* UTF-8 string, not less than 1 or more than 2048 bytes long, matching the [A Logstash Grok string pattern](https://www.elastic.co/guide/en/logstash/current/grok.html).
  The grok pattern applied to a data store by this classifier. For more information, see built-in patterns in [Writing Custom Classifiers](https://docs.aws.amazon.com/glue/latest/dg/custom-classifier.html).

• **CustomPatterns** – UTF-8 string, not more than 16000 bytes long, matching the [URI address multi-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/custom-classifier.html). Optional custom grok patterns defined by this classifier. For more information, see custom patterns in [Writing Custom Classifiers](https://docs.aws.amazon.com/glue/latest/dg/custom-classifier.html).

**XMLClassifier structure**

A classifier for XML content.

**Fields**

• **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/custom-classifier.html).
  The name of the classifier.

• **Classification** – *Required:* UTF-8 string.
  An identifier of the data format that the classifier matches.

• **CreationTime** – Timestamp.
  The time that this classifier was registered.

• **LastUpdated** – Timestamp.
  The time that this classifier was last updated.
• **Version** – Number (long).

  The version of this classifier.

• **RowTag** – UTF-8 string.

  The XML tag designating the element that contains each record in an XML document being parsed. This can't identify a self-closing element (closed by `/>`). An empty row element that contains only attributes can be parsed as long as it ends with a closing tag (for example, `<row item_a="A" item_b="B"></row>` is okay, but `<row item_a="A" item_b="B" />` is not).

### JsonClassifier structure

A classifier for JSON content.

**Fields**

• **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the classifier.

• **CreationTime** – Timestamp.

  The time that this classifier was registered.

• **LastUpdated** – Timestamp.

  The time that this classifier was last updated.

• **Version** – Number (long).

  The version of this classifier.

• **JsonPath** – *Required*: UTF-8 string.

  A JsonPath string defining the JSON data for the classifier to classify. AWS Glue supports a subset of JsonPath, as described in Writing JsonPath Custom Classifiers.

### CsvClassifier structure

A classifier for custom CSV content.
Fields

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the classifier.

- **CreationTime** – Timestamp.

  The time that this classifier was registered.

- **LastUpdated** – Timestamp.

  The time that this classifier was last updated.

- **Version** – Number (long).

  The version of this classifier.

- **Delimiter** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the **Custom string pattern #10**.

  A custom symbol to denote what separates each column entry in the row.

- **QuoteSymbol** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the **Custom string pattern #10**.

  A custom symbol to denote what combines content into a single column value. It must be different from the column delimiter.

- **ContainsHeader** – UTF-8 string (valid values: UNKNOWN | PRESENT | ABSENT).

  Indicates whether the CSV file contains a header.

- **Header** – An array of UTF-8 strings.

  A list of strings representing column names.

- **DisableValueTrimming** – Boolean.

  Specifies not to trim values before identifying the type of column values. The default value is true.

- **AllowSingleColumn** – Boolean.

  Enables the processing of files that contain only one column.

- **CustomDatatypeConfigured** – Boolean.
Enables the custom datatype to be configured.

- **CustomDatatypes** – An array of UTF-8 strings.

  A list of custom datatypes including "BINARY", "BOOLEAN", "DATE", "DECIMAL", "DOUBLE", "FLOAT", "INT", "LONG", "SHORT", "STRING", "TIMESTAMP".

- **SerDe** – UTF-8 string (valid values: OpenCSVSerDe | LazySimpleSerDe | None).

  Sets the SerDe for processing CSV in the classifier, which will be applied in the Data Catalog. Valid values are OpenCSVSerDe, LazySimpleSerDe, and None. You can specify the None value when you want the crawler to do the detection.

### CreateGrokClassifierRequest structure

Specifies a grok classifier for CreateClassifier to create.

**Fields**

- **Classification** – *Required*: UTF-8 string.

  An identifier of the data format that the classifier matches, such as Twitter, JSON, Omniture logs, Amazon CloudWatch Logs, and so on.

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the new classifier.

- **GrokPattern** – *Required*: UTF-8 string, not less than 1 or more than 2048 bytes long, matching the A Logstash Grok string pattern.

  The grok pattern used by this classifier.

- **CustomPatterns** – UTF-8 string, not more than 16000 bytes long, matching the URI address multi-line string pattern.

  Optional custom grok patterns used by this classifier.

### UpdateGrokClassifierRequest structure

Specifies a grok classifier to update when passed to UpdateClassifier.
Fields

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the GrokClassifier.

- **Classification** – UTF-8 string.

  An identifier of the data format that the classifier matches, such as Twitter, JSON, Omniture logs, Amazon CloudWatch Logs, and so on.

- **GrokPattern** – UTF-8 string, not less than 1 or more than 2048 bytes long, matching the [Logstash Grok string pattern](#).

  The grok pattern used by this classifier.

- **CustomPatterns** – UTF-8 string, not more than 16000 bytes long, matching the [URI address multi-line string pattern](#).

  Optional custom grok patterns used by this classifier.

CreateXMLClassifierRequest structure

Specifies an XML classifier for CreateClassifier to create.

Fields

- **Classification** – *Required*: UTF-8 string.

  An identifier of the data format that the classifier matches.

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the classifier.

- **RowTag** – UTF-8 string.

  The XML tag designating the element that contains each record in an XML document being parsed. This can't identify a self-closing element (closed by `/>`). An empty row element that contains only attributes can be parsed as long as it ends with a closing tag (for example, `<row item_a="A" item_b="B"></row>` is okay, but `<row item_a="A" item_b="B" />` is not).
UpdateXMLClassifierRequest structure

Specifies an XML classifier to be updated.

Fields

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the classifier.

- **Classification** – UTF-8 string.

  An identifier of the data format that the classifier matches.

- **RowTag** – UTF-8 string.

  The XML tag designating the element that contains each record in an XML document being parsed. This cannot identify a self-closing element (closed by `/>`). An empty row element that contains only attributes can be parsed as long as it ends with a closing tag (for example, `<row item_a="A" item_b="B"></row>` is okay, but `<row item_a="A" item_b="B" />` is not).

CreateJsonClassifierRequest structure

Specifies a JSON classifier for CreateClassifier to create.

Fields

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the classifier.

- **JsonPath** – *Required:* UTF-8 string.

  A JsonPath string defining the JSON data for the classifier to classify. AWS Glue supports a subset of JsonPath, as described in Writing JsonPath Custom Classifiers.

UpdateJsonClassifierRequest structure

Specifies a JSON classifier to be updated.
**Fields**

- **Name** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the classifier.

- **JsonPath** – UTF-8 string.

  A JsonPath string defining the JSON data for the classifier to classify. AWS Glue supports a subset of JsonPath, as described in [Writing JsonPath Custom Classifiers](#).

**CreateCsvClassifierRequest structure**

Specifies a custom CSV classifier for `CreateClassifier` to create.

**Fields**

- **Name** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the classifier.

- **Delimiter** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the **Custom string pattern #10**.

  A custom symbol to denote what separates each column entry in the row.

- **QuoteSymbol** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the **Custom string pattern #10**.

  A custom symbol to denote what combines content into a single column value. Must be different from the column delimiter.

- **ContainsHeader** – UTF-8 string (valid values: UNKNOWN | PRESENT | ABSENT).

  Indicates whether the CSV file contains a header.

- **Header** – An array of UTF-8 strings.

  A list of strings representing column names.

- **DisableValueTrimming** – Boolean.
Specifies not to trim values before identifying the type of column values. The default value is true.

- **AllowSingleColumn** – Boolean.

   Enables the processing of files that contain only one column.

- **CustomDatatypeConfigured** – Boolean.

   Enables the configuration of custom datatypes.

- **CustomDatatypes** – An array of UTF-8 strings.

   Creates a list of supported custom datatypes.

- **Serde** – UTF-8 string (valid values: OpenCSVSerDe | LazySimpleSerDe | None).

   Sets the SerDe for processing CSV in the classifier, which will be applied in the Data Catalog. Valid values are OpenCSVSerDe, LazySimpleSerDe, and None. You can specify the None value when you want the crawler to do the detection.

**UpdateCsvClassifierRequest structure**

Specifies a custom CSV classifier to be updated.

**Fields**

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

   The name of the classifier.

- **Delimiter** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the Custom string pattern #10.

   A custom symbol to denote what separates each column entry in the row.

- **QuoteSymbol** – UTF-8 string, not less than 1 or more than 1 bytes long, matching the Custom string pattern #10.

   A custom symbol to denote what combines content into a single column value. It must be different from the column delimiter.

- **ContainsHeader** – UTF-8 string (valid values: UNKNOWN | PRESENT | ABSENT).
Indicates whether the CSV file contains a header.

- **Header** – An array of UTF-8 strings.

  A list of strings representing column names.

- **DisableValueTrimming** – Boolean.

  Specifies not to trim values before identifying the type of column values. The default value is true.

- **AllowSingleColumn** – Boolean.

  Enables the processing of files that contain only one column.

- **CustomDatatypeConfigured** – Boolean.

  Specifies the configuration of custom datatypes.

- **CustomDatatypes** – An array of UTF-8 strings.

  Specifies a list of supported custom datatypes.

- **SerDe** – UTF-8 string (valid values: OpenCSVSerDe | LazySimpleSerDe | None).

  Sets the SerDe for processing CSV in the classifier, which will be applied in the Data Catalog. Valid values are OpenCSVSerDe, LazySimpleSerDe, and None. You can specify the None value when you want the crawler to do the detection.

### Operations

- **CreateClassifier action (Python: create_classifier)**

- **DeleteClassifier action (Python: delete_classifier)**

- **GetClassifier action (Python: get_classifier)**

- **GetClassifiers action (Python: get_classifiers)**

- **UpdateClassifier action (Python: update_classifier)**

### CreateClassifier action (Python: create_classifier)

Creates a classifier in the user's account. This can be a GrokClassifier, an XMLClassifier, a JsonClassifier, or a CsvClassifier, depending on which field of the request is present.
Request

- **GrokClassifier** – A [CreateGrokClassifierRequest](#) object.
  
  A GrokClassifier object specifying the classifier to create.

- **XMLClassifier** – A [CreateXMLClassifierRequest](#) object.
  
  An XMLClassifier object specifying the classifier to create.

- **JsonClassifier** – A [CreateJsonClassifierRequest](#) object.
  
  A JsonClassifier object specifying the classifier to create.

- **CsvClassifier** – A [CreateCsvClassifierRequest](#) object.
  
  A CsvClassifier object specifying the classifier to create.

Response

- *No Response parameters.*

Errors

- **AlreadyExistsException**
- **InvalidInputException**
- **OperationTimeoutException**

**DeleteClassifier action (Python: delete_classifier)**

Removes a classifier from the Data Catalog.

Request

- **Name** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  Name of the classifier to remove.
Response

- No Response parameters.

Errors

- EntityNotFoundException
- OperationTimeoutException

GetClassifier action (Python: get_classifier)

Retrieve a classifier by name.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the classifier to retrieve.

Response

- Classifier – A Classifier object.

  The requested classifier.

Errors

- EntityNotFoundException
- OperationTimeoutException

GetClassifiers action (Python: get_classifiers)

Lists all classifier objects in the Data Catalog.

Request

- MaxResults – Number (integer), not less than 1 or more than 1000.
The size of the list to return (optional).

- **NextToken** – UTF-8 string.

  An optional continuation token.

**Response**

- **Classifiers** – An array of [Classifier](#) objects.

  The requested list of classifier objects.

- **NextToken** – UTF-8 string.

  A continuation token.

**Errors**

- **OperationTimeoutException**

**UpdateClassifier action (Python: update_classifier)**

Modifies an existing classifier (a GrokClassifier, an XMLClassifier, a JsonClassifier, or a CsvClassifier, depending on which field is present).

**Request**

- **GrokClassifier** – An [UpdateGrokClassifierRequest](#) object.

  A GrokClassifier object with updated fields.

- **XMLClassifier** – An [UpdateXMLClassifierRequest](#) object.

  An XMLClassifier object with updated fields.

- **JsonClassifier** – An [UpdateJsonClassifierRequest](#) object.

  A JsonClassifier object with updated fields.

- **CsvClassifier** – An [UpdateCsvClassifierRequest](#) object.

  A CsvClassifier object with updated fields.
Response

- No Response parameters.

Errors

- InvalidInputException
- VersionMismatchException
- EntityNotFoundException
- OperationTimeoutException

Crawler API

The Crawler API describes AWS Glue crawler data types, along with the API for creating, deleting, updating, and listing crawlers.

Data types

- Crawler structure
- Schedule structure
- CrawlerTargets structure
- S3Target structure
- S3DeltaCatalogTarget structure
- S3DeltaDirectTarget structure
- JdbcTarget structure
- MongoDBTarget structure
- DynamoDBTarget structure
- DeltaTarget structure
- IcebergTarget structure
- HudiTarget structure
- CatalogTarget structure
- CrawlerMetrics structure
- CrawlerHistory structure
• **CrawlsFilter structure**
• **SchemaChangePolicy structure**
• **LastCrawlInfo structure**
• **RecrawlPolicy structure**
• **LineageConfiguration structure**
• **LakeFormationConfiguration structure**

**Crawler structure**

Specifies a crawler program that examines a data source and uses classifiers to try to determine its schema. If successful, the crawler records metadata concerning the data source in the AWS Glue Data Catalog.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.
  
  The name of the crawler.

- **Role** – UTF-8 string.

  The Amazon Resource Name (ARN) of an IAM role that's used to access customer resources, such as Amazon Simple Storage Service (Amazon S3) data.

- **Targets** – A **CrawlerTargets** object.

  A collection of targets to crawl.

- **DatabaseName** – UTF-8 string.

  The name of the database in which the crawler's output is stored.

- **Description** – Description string, not more than 2048 bytes long, matching the *URI address multi-line string pattern*.

  A description of the crawler.

- **Classifiers** – An array of UTF-8 strings.

  A list of UTF-8 strings that specify the custom classifiers that are associated with the crawler.

- **RecrawlPolicy** – A **RecrawlPolicy** object.
A policy that specifies whether to crawl the entire dataset again, or to crawl only folders that were added since the last crawler run.

- **SchemaChangePolicy** – A [SchemaChangePolicy](#) object.

  The policy that specifies update and delete behaviors for the crawler.

- **LineageConfiguration** – A [LineageConfiguration](#) object.

  A configuration that specifies whether data lineage is enabled for the crawler.

- **State** – UTF-8 string (valid values: READY | RUNNING | STOPPING).

  Indicates whether the crawler is running, or whether a run is pending.

- **TablePrefix** – UTF-8 string, not more than 128 bytes long.

  The prefix added to the names of tables that are created.

- **Schedule** – A [Schedule](#) object.

  For scheduled crawlers, the schedule when the crawler runs.

- **CrawlElapsedTime** – Number (long).

  If the crawler is running, contains the total time elapsed since the last crawl began.

- **CreationTime** – Timestamp.

  The time that the crawler was created.

- **LastUpdated** – Timestamp.

  The time that the crawler was last updated.

- **LastCrawl** – A [LastCrawlInfo](#) object.

  The status of the last crawl, and potentially error information if an error occurred.

- **Version** – Number (long).

  The version of the crawler.

- **Configuration** – UTF-8 string.

  Crawler configuration information. This versioned JSON string allows users to specify aspects of a crawler's behavior. For more information, see [Setting crawler configuration options](#).

- **CrawlerSecurityConfiguration** – UTF-8 string, not more than 128 bytes long.
The name of the SecurityConfiguration structure to be used by this crawler.

- LakeFormationConfiguration – A LakeFormationConfiguration object.

  Specifies whether the crawler should use AWS Lake Formation credentials for the crawler instead of the IAM role credentials.

**Schedule structure**

A scheduling object using a cron statement to schedule an event.

**Fields**

- ScheduleExpression – UTF-8 string.

  A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: cron(15 12 * * ? *).

- State – UTF-8 string (valid values: SCHEDULED | NOT_SCHEDULED | TRANSITIONING).

  The state of the schedule.

**CrawlerTargets structure**

Specifies data stores to crawl.

**Fields**

- S3Targets – An array of S3Target objects.

  Specifies Amazon Simple Storage Service (Amazon S3) targets.

- JdbcTargets – An array of JdbcTarget objects.

  Specifies JDBC targets.

- MongoDBTargets – An array of MongoDBTarget objects.

  Specifies Amazon DocumentDB or MongoDB targets.

- DynamoDBTargets – An array of DynamoDBTarget objects.

  Specifies Amazon DynamoDB targets.
CatalogTargets – An array of CatalogTarget objects.

Specifies AWS Glue Data Catalog targets.

DeltaTargets – An array of DeltaTarget objects.

Specifies Delta data store targets.

IcebergTargets – An array of IcebergTarget objects.

Specifies Apache Iceberg data store targets.

HudiTargets – An array of HudiTarget objects.

Specifies Apache Hudi data store targets.

S3Target structure

Specifies a data store in Amazon Simple Storage Service (Amazon S3).

Fields

• Path – UTF-8 string.
  The path to the Amazon S3 target.

• Exclusions – An array of UTF-8 strings.
  A list of glob patterns used to exclude from the crawl. For more information, see Catalog Tables with a Crawler.

• ConnectionName – UTF-8 string.
  The name of a connection which allows a job or crawler to access data in Amazon S3 within an Amazon Virtual Private Cloud environment (Amazon VPC).

• SampleSize – Number (integer).
  Sets the number of files in each leaf folder to be crawled when crawling sample files in a dataset. If not set, all the files are crawled. A valid value is an integer between 1 and 249.

• EventQueueArn – UTF-8 string.
  A valid Amazon SQS ARN. For example, arn:aws:sqs:region:account:sqs.

• DlqEventQueueArn – UTF-8 string.
A valid Amazon dead-letter SQS ARN. For example, 

**S3DeltaCatalogTarget structure**

Specifies a target that writes to a Delta Lake data source in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.
  
  Specifies native partitioning using a sequence of keys.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the table in the database to write to.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to write to.

- **AdditionalOptions** – A map array of key-value pairs.
  
  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies additional connection options for the connector.

- **SchemaChangePolicy** – A `CatalogSchemaChangePolicy` object.
  
  A policy that specifies update behavior for the crawler.

**S3DeltaDirectTarget structure**

Specifies a target that writes to a Delta Lake data source in Amazon S3.
Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.
  Specifies native partitioning using a sequence of keys.

- **Path** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  The Amazon S3 path of your Delta Lake data source to write to.

- **Compression** – *Required:* UTF-8 string (valid values: uncompressed="UNCOMPRESSED" | snappy="SNAPPY").
  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip".

- **Format** – *Required:* UTF-8 string (valid values: json="JSON" | csv="CSV" | avro="AVRO" | orc="ORC" | parquet="PARQUET" | hudi="HUDI" | delta="DELTA").
  Specifies the data output format for the target.

- **AdditionalOptions** – A map array of key-value pairs.
  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).
  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).
  Specifies additional connection options for the connector.

- **SchemaChangePolicy** – A [DirectSchemaChangePolicy](#) object.
  A policy that specifies update behavior for the crawler.

**JdbcTarget structure**

Specifies a JDBC data store to crawl.
Fields

- **ConnectionName** – UTF-8 string.
  The name of the connection to use to connect to the JDBC target.

- **Path** – UTF-8 string.
  The path of the JDBC target.

- **Exclusions** – An array of UTF-8 strings.
  A list of glob patterns used to exclude from the crawl. For more information, see [Catalog Tables with a Crawler](#).

- **EnableAdditionalMetadata** – An array of UTF-8 strings.
  Specify a value of RAWTYPES or COMMENTS to enable additional metadata in table responses. RAWTYPES provides the native-level datatype. COMMENTS provides comments associated with a column or table in the database.

  If you do not need additional metadata, keep the field empty.

**MongoDBTarget structure**

Specifies an Amazon DocumentDB or MongoDB data store to crawl.

**Fields**

- **ConnectionName** – UTF-8 string.
  The name of the connection to use to connect to the Amazon DocumentDB or MongoDB target.

- **Path** – UTF-8 string.
  The path of the Amazon DocumentDB or MongoDB target (database/collection).

- **ScanAll** – Boolean.
  Indicates whether to scan all the records, or to sample rows from the table. Scanning all the records can take a long time when the table is not a high throughput table.

  A value of true means to scan all records, while a value of false means to sample the records. If no value is specified, the value defaults to true.
**DynamoDBTarget structure**

Specifies an Amazon DynamoDB table to crawl.

**Fields**

- **Path** – UTF-8 string.

  The name of the DynamoDB table to crawl.

- **scanAll** – Boolean.

  Indicates whether to scan all the records, or to sample rows from the table. Scanning all the records can take a long time when the table is not a high throughput table.

  A value of `true` means to scan all records, while a value of `false` means to sample the records. If no value is specified, the value defaults to `true`.

- **scanRate** – Number (double).

  The percentage of the configured read capacity units to use by the AWS Glue crawler. Read capacity units is a term defined by DynamoDB, and is a numeric value that acts as rate limiter for the number of reads that can be performed on that table per second.

  The valid values are null or a value between 0.1 to 1.5. A null value is used when user does not provide a value, and defaults to 0.5 of the configured Read Capacity Unit (for provisioned tables), or 0.25 of the max configured Read Capacity Unit (for tables using on-demand mode).

**DeltaTarget structure**

Specifies a Delta data store to crawl one or more Delta tables.

**Fields**

- **DeltaTables** – An array of UTF-8 strings.

  A list of the Amazon S3 paths to the Delta tables.

- **ConnectionName** – UTF-8 string.

  The name of the connection to use to connect to the Delta table target.

- **WriteManifest** – Boolean.
Specifies whether to write the manifest files to the Delta table path.

- **CreateNativeDeltaTable** – Boolean.

  Specifies whether the crawler will create native tables, to allow integration with query engines that support querying of the Delta transaction log directly.

**IcebergTarget structure**

Specifies an Apache Iceberg data source where Iceberg tables are stored in Amazon S3.

**Fields**

- **Paths** – An array of UTF-8 strings.

  One or more Amazon S3 paths that contains Iceberg metadata folders as `s3://bucket/prefix`.

- **ConnectionName** – UTF-8 string.

  The name of the connection to use to connect to the Iceberg target.

- **Exclusions** – An array of UTF-8 strings.

  A list of glob patterns used to exclude from the crawl. For more information, see [Catalog Tables with a Crawler](#).

- **MaximumTraversalDepth** – Number (integer).

  The maximum depth of Amazon S3 paths that the crawler can traverse to discover the Iceberg metadata folder in your Amazon S3 path. Used to limit the crawler run time.

**HudiTarget structure**

Specifies an Apache Hudi data source.

**Fields**

- **Paths** – An array of UTF-8 strings.
An array of Amazon S3 location strings for Hudi, each indicating the root folder with which the metadata files for a Hudi table resides. The Hudi folder may be located in a child folder of the root folder.

The crawler will scan all folders underneath a path for a Hudi folder.

- **ConnectionName** – UTF-8 string.
  
  The name of the connection to use to connect to the Hudi target. If your Hudi files are stored in buckets that require VPC authorization, you can set their connection properties here.

- **Exclusions** – An array of UTF-8 strings.
  
  A list of glob patterns used to exclude from the crawl. For more information, see [Catalog Tables with a Crawler](#).

- **MaximumTraversalDepth** – Number (integer).
  
  The maximum depth of Amazon S3 paths that the crawler can traverse to discover the Hudi metadata folder in your Amazon S3 path. Used to limit the crawler run time.

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**CatalogTarget structure**

Specifies an AWS Glue Data Catalog target.

**Fields**

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the database to be synchronized.

- **Tables** – *Required*: An array of UTF-8 strings, at least 1 string.
  
  A list of the tables to be synchronized.

- **ConnectionName** – UTF-8 string.
  
  The name of the connection for an Amazon S3-backed Data Catalog table to be a target of the crawl when using a Catalog connection type paired with a NETWORK Connection type.

- **EventQueueArn** – UTF-8 string.
  
  A valid Amazon SQS ARN. For example, `arn:aws:sqs:region:account:sqs`. 
• **DlqEventQueueArn** – UTF-8 string.

  A valid Amazon dead-letter SQS ARN. For example, `arn:aws:sqs:region:account:deadLetterQueue`.

**CrawlerMetrics structure**

Metrics for a specified crawler.

**Fields**

- **CrawlerName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/sqs/latest/APIReference/AmznSQS_20120210.html#AmznSQS_20120210.ListQueues). The name of the crawler.
- **TimeLeftSeconds** – Number (double), not more than None. The estimated time left to complete a running crawl.
- **StillEstimating** – Boolean. True if the crawler is still estimating how long it will take to complete this run.
- **LastRuntimeSeconds** – Number (double), not more than None. The duration of the crawler's most recent run, in seconds.
- **MedianRuntimeSeconds** – Number (double), not more than None. The median duration of this crawler's runs, in seconds.
- **TablesCreated** – Number (integer), not more than None. The number of tables created by this crawler.
- **TablesUpdated** – Number (integer), not more than None. The number of tables updated by this crawler.
- **TablesDeleted** – Number (integer), not more than None. The number of tables deleted by this crawler.
CrawlerHistory structure

Contains the information for a run of a crawler.

Fields

- **CrawlId** – UTF-8 string.
  
  A UUID identifier for each crawl.

- **State** – UTF-8 string (valid values: RUNNING | COMPLETED | FAILED | STOPPED).
  
  The state of the crawl.

- **StartTime** – Timestamp.
  
  The date and time on which the crawl started.

- **EndTime** – Timestamp.
  
  The date and time on which the crawl ended.

- **Summary** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  A run summary for the specific crawl in JSON. Contains the catalog tables and partitions that were added, updated, or deleted.

- **ErrorMessage** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  
  If an error occurred, the error message associated with the crawl.

- **LogGroup** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Log group string pattern.
  
  The log group associated with the crawl.

- **LogStream** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Log-stream string pattern.
  
  The log stream associated with the crawl.

- **MessagePrefix** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The prefix for a CloudWatch message about this crawl.
• **DPUHour** – Number (double), not more than None.

  The number of data processing units (DPU) used in hours for the crawl.

**CrawlsFilter structure**

A list of fields, comparators and value that you can use to filter the crawler runs for a specified crawler.

**Fields**

• **FieldName** – UTF-8 string (valid values: CRAWL_ID | STATE | START_TIME | END_TIME | DPU_HOUR).

  A key used to filter the crawler runs for a specified crawler. Valid values for each of the field names are:
  • CRAWL_ID: A string representing the UUID identifier for a crawl.
  • STATE: A string representing the state of the crawl.
  • START_TIME and END_TIME: The epoch timestamp in milliseconds.
  • DPU_HOUR: The number of data processing unit (DPU) hours used for the crawl.

• **FilterOperator** – UTF-8 string (valid values: GT | GE | LT | LE | EQ | NE).

  A defined comparator that operates on the value. The available operators are:
  • GT: Greater than.
  • GE: Greater than or equal to.
  • LT: Less than.
  • LE: Less than or equal to.
  • EQ: Equal to.
  • NE: Not equal to.

• **FieldValue** – UTF-8 string.

  The value provided for comparison on the crawl field.

**SchemaChangePolicy structure**

A policy that specifies update and deletion behaviors for the crawler.
Fields

• **UpdateBehavior** – UTF-8 string (valid values: LOG | UPDATE_IN_DATABASE).

  The update behavior when the crawler finds a changed schema.

• **DeleteBehavior** – UTF-8 string (valid values: LOG | DELETE_FROM_DATABASE | DEPRECATE_IN_DATABASE).

  The deletion behavior when the crawler finds a deleted object.

**LastCrawlInfo structure**

Status and error information about the most recent crawl.

Fields

• **Status** – UTF-8 string (valid values: SUCCEEDED | CANCELLED | FAILED).

  Status of the last crawl.

• **ErrorMessage** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  If an error occurred, the error information about the last crawl.

• **LogGroup** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Log group string pattern.

  The log group for the last crawl.

• **LogStream** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the Log-stream string pattern.

  The log stream for the last crawl.

• **MessagePrefix** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The prefix for a message about this crawl.

• **StartTime** – Timestamp.

  The time at which the crawl started.
RecrawlPolicy structure

When crawling an Amazon S3 data source after the first crawl is complete, specifies whether to crawl the entire dataset again or to crawl only folders that were added since the last crawler run. For more information, see Incremental Crawls in AWS Glue in the developer guide.

Fields

- **RecrawlBehavior** – UTF-8 string (valid values: CRAWL_EVERYTHING | CRAWL_NEW_FOLDERS_ONLY | CRAWL_EVENT_MODE).

  Specifies whether to crawl the entire dataset again or to crawl only folders that were added since the last crawler run.

  A value of CRAWL_EVERYTHING specifies crawling the entire dataset again.

  A value of CRAWL_NEW_FOLDERS_ONLY specifies crawling only folders that were added since the last crawler run.

  A value of CRAWL_EVENT_MODE specifies crawling only the changes identified by Amazon S3 events.

LineageConfiguration structure

Specifies data lineage configuration settings for the crawler.

Fields

- **CrawlerLineageSettings** – UTF-8 string (valid values: ENABLE | DISABLE).

  Specifies whether data lineage is enabled for the crawler. Valid values are:

  - ENABLE: enables data lineage for the crawler
  - DISABLE: disables data lineage for the crawler

LakeFormationConfiguration structure

Specifies AWS Lake Formation configuration settings for the crawler.
Fields

- **UseLakeFormationCredentials** – Boolean.
  
  Specifies whether to use AWS Lake Formation credentials for the crawler instead of the IAM role credentials.

- **AccountId** – UTF-8 string, not more than 12 bytes long.
  
  Required for cross account crawls. For same account crawls as the target data, this can be left as null.

Operations

- **CreateCrawler action (Python: create_crawler)**
- **DeleteCrawler action (Python: delete_crawler)**
- **GetCrawler action (Python: get_crawler)**
- **GetCrawlers action (Python: get_crawlers)**
- **GetCrawlerMetrics action (Python: get_crawler_metrics)**
- **UpdateCrawler action (Python: update_crawler)**
- **StartCrawler action (Python: start_crawler)**
- **StopCrawler action (Python: stop_crawler)**
- **BatchGetCrawlers action (Python: batch_get_crawlers)**
- **ListCrawlers action (Python: list_crawlers)**
- **ListCrawls action (Python: list_crawls)**

**CreateCrawler action (Python: create_crawler)**

Creates a new crawler with specified targets, role, configuration, and optional schedule. At least one crawl target must be specified, in the s3Targets field, the jdbcTargets field, or the DynamoDBTargets field.

Request

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
Name of the new crawler.

- **Role** – *Required*: UTF-8 string.

  The IAM role or Amazon Resource Name (ARN) of an IAM role used by the new crawler to access customer resources.

- **DatabaseName** – UTF-8 string.

  The AWS Glue database where results are written, such as: `arn:aws:daylight:us-east-1::database/sometable/*`.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the new crawler.

- **Targets** – *Required*: A `CrawlerTargets` object.

  A list of collection of targets to crawl.

- **Schedule** – UTF-8 string.

  A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

- **Classifiers** – An array of UTF-8 strings.

  A list of custom classifiers that the user has registered. By default, all built-in classifiers are included in a crawl, but these custom classifiers always override the default classifiers for a given classification.

- **TablePrefix** – UTF-8 string, not more than 128 bytes long.

  The table prefix used for catalog tables that are created.

- **SchemaChangePolicy** – A `SchemaChangePolicy` object.

  The policy for the crawler's update and deletion behavior.

- **RecrawlPolicy** – A `RecrawlPolicy` object.

  A policy that specifies whether to crawl the entire dataset again, or to crawl only folders that were added since the last crawler run.

- **LineageConfiguration** – A `LineageConfiguration` object.
Specifies data lineage configuration settings for the crawler.

- **LakeFormationConfiguration** – A [LakeFormationConfiguration](#) object.

  Specifies AWS Lake Formation configuration settings for the crawler.

- **Configuration** – UTF-8 string.

  Crawler configuration information. This versioned JSON string allows users to specify aspects of a crawler's behavior. For more information, see [Setting crawler configuration options](#).

- **CrawlerSecurityConfiguration** – UTF-8 string, not more than 128 bytes long.

  The name of the SecurityConfiguration structure to be used by this crawler.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags to use with this crawler request. You may use tags to limit access to the crawler. For more information about tags in AWS Glue, see [AWS Tags in AWS Glue](#) in the developer guide.

**Response**

- **No Response parameters.**

**Errors**

- **InvalidInputException**
- **AlreadyExistsException**
- **OperationTimeoutException**
- **ResourceNumberLimitExceeded**

**DeleteCrawler action (Python: delete_crawler)**

Removes a specified crawler from the AWS Glue Data Catalog, unless the crawler state is RUNNING.
Request

- Name – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The name of the crawler to remove.

Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- CrawlerRunningException
- SchedulerTransitioningException
- OperationTimeoutException

**GetCrawler action (Python: get_crawler)**

Retrieves metadata for a specified crawler.

Request

- Name – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The name of the crawler to retrieve metadata for.

Response

- Crawler – A [Crawler](#) object.

  The metadata for the specified crawler.

Errors

- EntityNotFoundException
• OperationTimeoutException

**GetCrawlers action (Python: get_crawlers)**

Retrieves metadata for all crawlers defined in the customer account.

**Request**

• MaxResults – Number (integer), not less than 1 or more than 1000.
  
The number of crawlers to return on each call.
• NextToken – UTF-8 string.
  
A continuation token, if this is a continuation request.

**Response**

• Crawlers – An array of **Crawler** objects.
  
A list of crawler metadata.
• NextToken – UTF-8 string.
  
A continuation token, if the returned list has not reached the end of those defined in this customer account.

**Errors**

• OperationTimeoutException

**GetCrawlerMetrics action (Python: get_crawler_metrics)**

Retrieves metrics about specified crawlers.

**Request**

• CrawlerNameList – An array of UTF-8 strings, not more than 100 strings.
  
A list of the names of crawlers about which to retrieve metrics.
• MaxResults – Number (integer), not less than 1 or more than 1000.
The maximum size of a list to return.

- **NextToken** – UTF-8 string.

  A continuation token, if this is a continuation call.

**Response**

- **CrawlerMetricsList** – An array of [CrawlerMetrics](#) objects.

  A list of metrics for the specified crawler.

- **NextToken** – UTF-8 string.

  A continuation token, if the returned list does not contain the last metric available.

**Errors**

- **OperationTimeoutException**

**UpdateCrawler action (Python: update_crawler)**

Updates a crawler. If a crawler is running, you must stop it using `StopCrawler` before updating it.

**Request**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Name of the new crawler.

- **Role** – UTF-8 string.

  The IAM role or Amazon Resource Name (ARN) of an IAM role that is used by the new crawler to access customer resources.

- **DatabaseName** – UTF-8 string.

  The AWS Glue database where results are stored, such as: `arn:aws:daylight:us-east-1::database/sometable/*`. 
• Description – UTF-8 string, not more than 2048 bytes long, matching the URI address multiline string pattern.

A description of the new crawler.

• Targets – A CrawlerTargets object.

A list of targets to crawl.

• Schedule – UTF-8 string.

A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers). For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

• Classifiers – An array of UTF-8 strings.

A list of custom classifiers that the user has registered. By default, all built-in classifiers are included in a crawl, but these custom classifiers always override the default classifiers for a given classification.

• TablePrefix – UTF-8 string, not more than 128 bytes long.

The table prefix used for catalog tables that are created.

• SchemaChangePolicy – A SchemaChangePolicy object.

The policy for the crawler's update and deletion behavior.

• RecrawlPolicy – A RecrawlPolicy object.

A policy that specifies whether to crawl the entire dataset again, or to crawl only folders that were added since the last crawler run.

• LineageConfiguration – A LineageConfiguration object.

Specifies data lineage configuration settings for the crawler.

• LakeFormationConfiguration – A LakeFormationConfiguration object.

Specifies AWS Lake Formation configuration settings for the crawler.

• Configuration – UTF-8 string.

Crawler configuration information. This versioned JSON string allows users to specify aspects of a crawler's behavior. For more information, see Setting crawler configuration options.

• CrawlerSecurityConfiguration – UTF-8 string, not more than 128 bytes long.
The name of the SecurityConfiguration structure to be used by this crawler.

Response

- No Response parameters.

Errors

- InvalidInputException
- VersionMismatchException
- EntityNotFoundException
- CrawlerRunningException
- OperationTimeoutException

StartCrawler action (Python: start_crawler)

Starts a crawl using the specified crawler, regardless of what is scheduled. If the crawler is already running, returns a CrawlerRunningException.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the crawler to start.

Response

- No Response parameters.

Errors

- EntityNotFoundException
- CrawlerRunningException
- OperationTimeoutException
StopCrawler action (Python: stop_crawler)

If the specified crawler is running, stops the crawl.

Request

- Name – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the crawler to stop.

Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- CrawlerNotRunningException
- CrawlerStoppingException
- OperationTimeoutException

BatchGetCrawlers action (Python: batch_get_crawlers)

Returns a list of resource metadata for a given list of crawler names. After calling the ListCrawlers operation, you can call this operation to access the data to which you have been granted permissions. This operation supports all IAM permissions, including permission conditions that uses tags.

Request

- CrawlerNames – *Required:* An array of UTF-8 strings, not more than 100 strings.

  A list of crawler names, which might be the names returned from the ListCrawlers operation.

Response

- Crawlers – An array of Crawler objects.
A list of crawler definitions.

- **CrawlersNotFound** – An array of UTF-8 strings, not more than 100 strings.

  A list of names of crawlers that were not found.

**Errors**

- **InvalidInputException**
- **OperationTimeoutException**

**ListCrawlers action (Python: list_crawlers)**

Retrieves the names of all crawler resources in this AWS account, or the resources with the specified tag. This operation allows you to see which resources are available in your account, and their names.

This operation takes the optional `Tags` field, which you can use as a filter on the response so that tagged resources can be retrieved as a group. If you choose to use tags filtering, only resources with the tag are retrieved.

**Request**

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum size of a list to return.

- **NextToken** – UTF-8 string.

  A continuation token, if this is a continuation request.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  Specifies to return only these tagged resources.
Response

- **CrawlerNames** – An array of UTF-8 strings, not more than 100 strings.
  
  The names of all crawlers in the account, or the crawlers with the specified tags.
- **NextToken** – UTF-8 string.
  
  A continuation token, if the returned list does not contain the last metric available.

Errors

- **OperationTimeoutException**

**ListCrawls action (Python: list_crawls)**

Returns all the crawls of a specified crawler. Returns only the crawls that have occurred since the launch date of the crawler history feature, and only retains up to 12 months of crawls. Older crawls will not be returned.

You may use this API to:

- Retrieve all the crawls of a specified crawler.
- Retrieve all the crawls of a specified crawler within a limited count.
- Retrieve all the crawls of a specified crawler in a specific time range.
- Retrieve all the crawls of a specified crawler with a particular state, crawl ID, or DPU hour value.

Request

- **CrawlerName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the crawler whose runs you want to retrieve.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum number of results to return. The default is 20, and maximum is 100.
- **Filters** – An array of CrawlsFilter objects.
  
  Filters the crawls by the criteria you specify in a list of CrawlsFilter objects.
• NextToken – UTF-8 string.

A continuation token, if this is a continuation call.

Response

• Crawls – An array of CrawlerHistory objects.

A list of CrawlerHistory objects representing the crawl runs that meet your criteria.

• NextToken – UTF-8 string.

A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.

Errors

• EntityNotFoundException

• OperationTimeoutException

• InvalidInputException

Column statistics API

The column statistics API describes AWS Glue APIs for returning statistics on columns in a table.

Data types

• ColumnStatisticsTaskRun structure

• ColumnStatisticsTaskRunningException structure

• ColumnStatisticsTaskNotRunningException structure

• ColumnStatisticsTaskStoppingException structure

ColumnStatisticsTaskRun structure

The object that shows the details of the column stats run.
Fields

- **CustomerId** – UTF-8 string, not more than 12 bytes long.
  The AWS account ID.
- **ColumnStatisticsTaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The identifier for the particular column statistics task run.
- **DatabaseName** – UTF-8 string.
  The database where the table resides.
- **TableName** – UTF-8 string.
  The name of the table for which column statistics is generated.
- **ColumnNameList** – An array of UTF-8 strings.
  A list of the column names. If none is supplied, all column names for the table will be used by default.
- **CatalogID** – Catalog id string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The ID of the Data Catalog where the table resides. If none is supplied, the AWS account ID is used by default.
- **Role** – UTF-8 string.
  The IAM role that the service assumes to generate statistics.
- **SampleSize** – Number (double), not more than 100.
  The percentage of rows used to generate statistics. If none is supplied, the entire table will be used to generate stats.
- **SecurityConfiguration** – UTF-8 string, not more than 128 bytes long.
  Name of the security configuration that is used to encrypt CloudWatch logs for the column stats task run.
- **NumberOfWorkers** – Number (integer), at least 1.
The number of workers used to generate column statistics. The job is preconfigured to autoscale up to 25 instances.

- **WorkerType** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The type of workers being used for generating stats. The default is g.1x.

- **Status** – UTF-8 string (valid values: STARTING | RUNNING | SUCCEEDED | FAILED | STOPPED).

  The status of the task run.

- **CreationTime** – Timestamp.

  The time that this task was created.

- **LastUpdated** – Timestamp.

  The last point in time when this task was modified.

- **StartTime** – Timestamp.

  The start time of the task.

- **EndTime** – Timestamp.

  The end time of the task.

- **ErrorMessage** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  The error message for the job.

- **DPUSeconds** – Number (double), not more than None.

  The calculated DPU usage in seconds for all autoscaled workers.

### ColumnStatisticsTaskRunningException structure

An exception thrown when you try to start another job while running a column stats generation job.

**Fields**

- **Message** – UTF-8 string.
A message describing the problem.

**ColumnStatisticsTaskNotRunningException structure**

An exception thrown when you try to stop a task run when there is no task running.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**ColumnStatisticsTaskStoppingException structure**

An exception thrown when you try to stop a task run.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**Operations**

- **StartColumnStatisticsTaskRun action (Python: start_column_statistics_task_run)**
- **GetColumnStatisticsTaskRun action (Python: get_column_statistics_task_run)**
- **GetColumnStatisticsTaskRuns action (Python: get_column_statistics_task_runs)**
- **ListColumnStatisticsTaskRuns action (Python: list_column_statistics_task_runs)**
- **StopColumnStatisticsTaskRun action (Python: stop_column_statistics_task_run)**

**StartColumnStatisticsTaskRun action (Python: start_column_statistics_task_run)**

Starts a column statistics task run, for a specified table and columns.

**Request**

- **DatabaseName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The name of the database where the table resides.

- **TableName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The name of the table to generate statistics.

- **ColumnNameList** – An array of UTF-8 strings.

A list of the column names to generate statistics. If none is supplied, all column names for the table will be used by default.

- **Role** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The IAM role that the service assumes to generate statistics.

- **SampleSize** – Number (double), not more than 100.

The percentage of rows used to generate statistics. If none is supplied, the entire table will be used to generate stats.

- **CatalogID** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The ID of the Data Catalog where the table reside. If none is supplied, the AWS account ID is used by default.

- **SecurityConfiguration** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

Name of the security configuration that is used to encrypt CloudWatch logs for the column stats task run.

**Response**

- **ColumnStatisticsTaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The identifier for the column statistics task run.
Errors

- AccessDeniedException
- EntityNotFoundException
- ColumnStatisticsTaskRunningException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- InvalidInputException

GetColumnStatisticsTaskRun action (Python: get_column_statistics_task_run)

Get the associated metadata/information for a task run, given a task run ID.

Request

- ColumnStatisticsTaskRunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The identifier for the particular column statistics task run.

Response


  A ColumnStatisticsTaskRun object representing the details of the column stats run.

Errors

- EntityNotFoundException
- OperationTimeoutException
- InvalidInputException

GetColumnStatisticsTaskRuns action (Python: get_column_statistics_task_runs)

Retrieves information about all runs associated with the specified table.
Request

- DatabaseName – *Required*: UTF-8 string.
  
  The name of the database where the table resides.
- TableName – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the table.
- MaxResults – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of the response.
- NextToken – UTF-8 string.
  
  A continuation token, if this is a continuation call.

Response

  
  A list of column statistics task runs.
- NextToken – UTF-8 string.
  
  A continuation token, if not all task runs have yet been returned.

Errors

- OperationTimeoutException

[ListColumnStatisticsTaskRuns action (Python: list_column_statistics_task_runs)](#)

List all task runs for a particular account.

Request

- MaxResults – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of the response.
- NextToken – UTF-8 string.
A continuation token, if this is a continuation call.

**Response**

- **ColumnStatisticsTaskRunIds** – An array of UTF-8 strings, not more than 100 strings.
  A list of column statistics task run IDs.
- **NextToken** – UTF-8 string.
  A continuation token, if not all task run IDs have yet been returned.

**Errors**

- **OperationTimeoutException**

**StopColumnStatisticsTaskRun action (Python: stop_column_statistics_task_run)**

Stops a task run for the specified table.

**Request**

- **DatabaseName** – *Required:* UTF-8 string.
  The name of the database where the table resides.
- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The name of the table.

**Response**

- *No Response parameters.*

**Errors**

- **EntityNotFoundException**
- **ColumnStatisticsTaskNotRunningException**
- ColumnStatisticsTaskStoppingException
- OperationTimeoutException

**Crawler scheduler API**

The Crawler scheduler API describes AWS Glue crawler data types, along with the API for creating, deleting, updating, and listing crawlers.

**Data types**

- [Schedule structure](#)

**Schedule structure**

A scheduling object using a `cron` statement to schedule an event.

**Fields**

- ScheduleExpression – UTF-8 string.
  
  A `cron` expression used to specify the schedule (see [Time-Based Schedules for Jobs and Crawlers](#)). For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

- State – UTF-8 string (valid values: SCHEDULED | NOT_SCHEDULED | TRANSITIONING).
  
  The state of the schedule.

**Operations**

- [UpdateCrawlerSchedule action](#) (Python: `update_crawler_schedule`)
- [StartCrawlerSchedule action](#) (Python: `start_crawler_schedule`)
- [StopCrawlerSchedule action](#) (Python: `stop_crawler_schedule`)

**UpdateCrawlerSchedule action (Python: `update_crawler_schedule`)**

Updates the schedule of a crawler using a `cron` expression.
Request

- **CrawlerName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the crawler whose schedule to update.

- **Schedule** – UTF-8 string.
  
  The updated cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- InvalidInputException
- VersionMismatchException
- SchedulerTransitioningException
- OperationTimeoutException

**StartCrawlerSchedule action (Python: start_crawler_schedule)**

Changes the schedule state of the specified crawler to SCHEDULED, unless the crawler is already running or the schedule state is already SCHEDULED.

Request

- **CrawlerName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Name of the crawler to schedule.
Response

• No Response parameters.

Errors

• EntityNotFoundException
• SchedulerRunningException
• SchedulerTransitioningException
• NoScheduleException
• OperationTimeoutException

StopCrawlerSchedule action (Python: stop_crawler_schedule)

Sets the schedule state of the specified crawler to NOT_SCHEDULED, but does not stop the crawler if it is already running.

Request

• CrawlerName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the crawler whose schedule state to set.

Response

• No Response parameters.

Errors

• EntityNotFoundException
• SchedulerNotRunningException
• SchedulerTransitioningException
• OperationTimeoutException
Autogenerating ETL Scripts API

The ETL script-generation API describes the datatypes and API for generating ETL scripts in AWS Glue.

Data types

- **CodeGenNode structure**
- **CodeGenNodeArg structure**
- **CodeGenEdge structure**
- **Location structure**
- **CatalogEntry structure**
- **MappingEntry structure**

**CodeGenNode structure**

Represents a node in a directed acyclic graph (DAG)

**Fields**

- **Id** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Identifier string pattern.

  A node identifier that is unique within the node's graph.

- **NodeType** – *Required*: UTF-8 string.

  The type of node that this is.

- **Args** – *Required*: An array of **CodeGenNodeArg** objects, not more than 50 structures.

  Properties of the node, in the form of name-value pairs.

- **LineNumber** – Number (integer).

  The line number of the node.

**CodeGenNodeArg structure**

An argument or property of a node.
Fields

- **Name** – *Required*: UTF-8 string.
  The name of the argument or property.
- **Value** – *Required*: UTF-8 string.
  The value of the argument or property.
- **Param** – Boolean.
  True if the value is used as a parameter.

**CodeGenEdge structure**

Represents a directional edge in a directed acyclic graph (DAG).

Fields

- **Source** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Identifier string pattern.
  The ID of the node at which the edge starts.
- **Target** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Identifier string pattern.
  The ID of the node at which the edge ends.
- **TargetParameter** – UTF-8 string.
  The target of the edge.

**Location structure**

The location of resources.

Fields

- **Jdbc** – An array of [CodeGenNodeArg](#) objects, not more than 50 structures.
  A JDBC location.
• S3 – An array of **CodeGenNodeArg** objects, not more than 50 structures.

  An Amazon Simple Storage Service (Amazon S3) location.

• DynamoDB – An array of **CodeGenNodeArg** objects, not more than 50 structures.

  An Amazon DynamoDB table location.

**CatalogEntry structure**

Specifies a table definition in the AWS Glue Data Catalog.

**Fields**

• **DatabaseName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The database in which the table metadata resides.

• **TableName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the table in question.

**MappingEntry structure**

Defines a mapping.

**Fields**

• **SourceTable** – UTF-8 string.

  The name of the source table.

• **SourcePath** – UTF-8 string.

  The source path.

• **SourceType** – UTF-8 string.

  The source type.

• **TargetTable** – UTF-8 string.
The target table.

- **TargetPath** – UTF-8 string.
  
  The target path.

- **TargetType** – UTF-8 string.
  
  The target type.

**Operations**

- [CreateScript action (Python: create_script)](#)
- [GetDataflowGraph action (Python: get_dataflow_graph)](#)
- [GetMapping action (Python: get_mapping)](#)
- [GetPlan action (Python: get_plan)](#)

**CreateScript action (Python: create_script)**

Transforms a directed acyclic graph (DAG) into code.

**Request**

- **DagNodes** – An array of [CodeGenNode](#) objects.
  
  A list of the nodes in the DAG.

- **DagEdges** – An array of [CodeGenEdge](#) objects.
  
  A list of the edges in the DAG.

- **Language** – UTF-8 string (valid values: PYTHON | SCALA).
  
  The programming language of the resulting code from the DAG.

**Response**

- **PythonScript** – UTF-8 string.
  
  The Python script generated from the DAG.
ScalaCode – UTF-8 string.

The Scala code generated from the DAG.

Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException

GetDataflowGraph action (Python: get_dataflow_graph)

Transforms a Python script into a directed acyclic graph (DAG).

Request

- PythonScript – UTF-8 string.

  The Python script to transform.

Response

- DagNodes – An array of CodeGenNode objects.

  A list of the nodes in the resulting DAG.
- DagEdges – An array of CodeGenEdge objects.

  A list of the edges in the resulting DAG.

Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException
GetMapping action (Python: get_mapping)

Creates mappings.

Request

• Source – Required: A CatalogEntry object.
  Specifies the source table.

• Sinks – An array of CatalogEntry objects.
  A list of target tables.

• Location – A Location object.
  Parameters for the mapping.

Response

• Mapping – Required: An array of MappingEntry objects.
  A list of mappings to the specified targets.

Errors

• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• EntityNotFoundException

GetPlan action (Python: get_plan)

Gets code to perform a specified mapping.

Request

• Mapping – Required: An array of MappingEntry objects.
  The list of mappings from a source table to target tables.
• **Source** – *Required:* A [CatalogEntry](#) object.

  The source table.

• **Sinks** – An array of [CatalogEntry](#) objects.

  The target tables.

• **Location** – A [Location](#) object.

  The parameters for the mapping.

• **Language** – UTF-8 string (valid values: PYTHON | SCALA).

  The programming language of the code to perform the mapping.

• **AdditionalPlanOptionsMap** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A map to hold additional optional key-value parameters.

Currently, these key-value pairs are supported:

- **inferSchema** — Specifies whether to set `inferSchema` to true or false for the default script generated by an AWS Glue job. For example, to set `inferSchema` to true, pass the following key value pair:

  ```
  --additional-plan-options-map '{"inferSchema":"true"}'
  ```

**Response**

• **PythonScript** – UTF-8 string.

  A Python script to perform the mapping.

• **ScalaCode** – UTF-8 string.

  The Scala code to perform the mapping.

**Errors**

• **InvalidInputException**
Visual job API

The Visual job API allows you to create data integration jobs by using the AWS Glue API from a JSON object that represents a visual configuration of an AWS Glue job.

A list of CodeGenConfigurationNodes are provided to a create or update job API to register a DAG in AWS Glue Studio for the created job and generate the associated code.

Data types

- CodeGenConfigurationNode structure
- JDBCConnectorOptions structure
- StreamingDataPreviewOptions structure
- AthenaConnectorSource structure
- JDBCConnectorSource structure
- SparkConnectorSource structure
- CatalogSource structure
- MySQLCatalogSource structure
- PostgreSQLCatalogSource structure
- OracleSQLCatalogSource structure
- MicrosoftSQLServerCatalogSource structure
- CatalogKinesisSource structure
- DirectKinesisSource structure
- KinesisStreamingSourceOptions structure
- CatalogKafkaSource structure
- DirectKafkaSource structure
- KafkaStreamingSourceOptions structure
- RedshiftSource structure
- AmazonRedshiftSource structure
• AmazonRedshiftNodeData structure
• AmazonRedshiftAdvancedOption structure
• Option structure
• S3CatalogSource structure
• S3SourceAdditionalOptions structure
• S3CsvSource structure
• DirectJDBCSource structure
• S3DirectSourceAdditionalOptions structure
• S3JsonSource structure
• S3ParquetSource structure
• S3DeltaSource structure
• S3CatalogDeltaSource structure
• CatalogDeltaSource structure
• S3HudiSource structure
• S3CatalogHudiSource structure
• CatalogHudiSource structure
• DynamoDBCatalogSource structure
• RelationalCatalogSource structure
• JDBCConnectorTarget structure
• SparkConnectorTarget structure
• BasicCatalogTarget structure
• MySQLCatalogTarget structure
• PostgreSQLCatalogTarget structure
• OracleSQLCatalogTarget structure
• MicrosoftSQLServerCatalogTarget structure
• RedshiftTarget structure
• AmazonRedshiftTarget structure
• UpsertRedshiftTargetOptions structure
• S3CatalogTarget structure
- S3GlueParquetTarget structure
- CatalogSchemaChangePolicy structure
- S3DirectTarget structure
- S3HudiCatalogTarget structure
- S3HudiDirectTarget structure
- S3DeltaCatalogTarget structure
- S3DeltaDirectTarget structure
- DirectSchemaChangePolicy structure
- ApplyMapping structure
- Mapping structure
- SelectFields structure
- DropFields structure
- RenameField structure
- Spigot structure
- Join structure
- JoinColumn structure
- SplitFields structure
- SelectFromCollection structure
- FillMissingValues structure
- Filter structure
- FilterExpression structure
- FilterValue structure
- CustomCode structure
- SparkSQL structure
- SqlAlias structure
- DropNullFields structure
- NullCheckBoxList structure
- NullValueField structure
- Datatype structure
- Merge structure
CodeGenConfigurationNode structure

CodeGenConfigurationNode enumerates all valid Node types. One and only one of its member variables can be populated.

**Fields**

- **AthenaConnectorSource** – An `AthenaConnectorSource` object.
• JDBCConnectorSource – A `JDBCConnectorSource` object.
   Specifies a connector to a JDBC data source.
• SparkConnectorSource – A `SparkConnectorSource` object.
   Specifies a connector to an Apache Spark data source.
• CatalogSource – A `CatalogSource` object.
   Specifies a data store in the AWS Glue Data Catalog.
• RedshiftSource – A `RedshiftSource` object.
   Specifies an Amazon Redshift data store.
• S3CatalogSource – A `S3CatalogSource` object.
   Specifies an Amazon S3 data store in the AWS Glue Data Catalog.
• S3CsvSource – A `S3CsvSource` object.
   Specifies a command-separated value (CSV) data store stored in Amazon S3.
• S3JsonSource – A `S3JsonSource` object.
   Specifies a JSON data store stored in Amazon S3.
• S3ParquetSource – A `S3ParquetSource` object.
   Specifies an Apache Parquet data store stored in Amazon S3.
• RelationalCatalogSource – A `RelationalCatalogSource` object.
   Specifies a relational catalog data store in the AWS Glue Data Catalog.
• DynamoDBCatalogSource – A `DynamoDBCatalogSource` object.
   Specifies a DynamoDBC Catalog data store in the AWS Glue Data Catalog.
• JDBCConnectorTarget – A `JDBCConnectorTarget` object.
   Specifies a data target that writes to Amazon S3 in Apache Parquet columnar storage.
• SparkConnectorTarget – A `SparkConnectorTarget` object.
   Specifies a target that uses an Apache Spark connector.
• **CatalogTarget** – A `BasicCatalogTarget` object.

  Specifies a target that uses a AWS Glue Data Catalog table.

• **RedshiftTarget** – A `RedshiftTarget` object.

  Specifies a target that uses Amazon Redshift.

• **S3CatalogTarget** – A `S3CatalogTarget` object.

  Specifies a data target that writes to Amazon S3 using the AWS Glue Data Catalog.

• **S3GlueParquetTarget** – A `S3GlueParquetTarget` object.

  Specifies a data target that writes to Amazon S3 in Apache Parquet columnar storage.

• **S3DirectTarget** – A `S3DirectTarget` object.

  Specifies a data target that writes to Amazon S3.

• **ApplyMapping** – An `ApplyMapping` object.

  Specifies a transform that maps data property keys in the data source to data property keys in the data target. You can rename keys, modify the data types for keys, and choose which keys to drop from the dataset.

• **SelectFields** – A `SelectFields` object.

  Specifies a transform that chooses the data property keys that you want to keep.

• **DropFields** – A `DropFields` object.

  Specifies a transform that chooses the data property keys that you want to drop.

• **RenameField** – A `RenameField` object.

  Specifies a transform that renames a single data property key.

• **Spigot** – A `Spigot` object.

  Specifies a transform that writes samples of the data to an Amazon S3 bucket.

• **Join** – A `Join` object.

  Specifies a transform that joins two datasets into one dataset using a comparison phrase on the specified data property keys. You can use inner, outer, left, right, left semi, and left anti joins.

• **SplitFields** – A `SplitFields` object.
Specifies a transform that splits data property keys into two DynamicFrames. The output is a collection of DynamicFrames: one with selected data property keys, and one with the remaining data property keys.

• **SelectFromCollection** – A **SelectFromCollection** object.

  Specifies a transform that chooses one DynamicFrame from a collection of DynamicFrames. The output is the selected DynamicFrame

• **FillMissingValues** – A **FillMissingValues** object.

  Specifies a transform that locates records in the dataset that have missing values and adds a new field with a value determined by imputation. The input data set is used to train the machine learning model that determines what the missing value should be.

• **Filter** – A **Filter** object.

  Specifies a transform that splits a dataset into two, based on a filter condition.

• **CustomCode** – A **CustomCode** object.

  Specifies a transform that uses custom code you provide to perform the data transformation. The output is a collection of DynamicFrames.

• **SparkSQL** – A **SparkSQL** object.

  Specifies a transform where you enter a SQL query using Spark SQL syntax to transform the data. The output is a single DynamicFrame.

• **DirectKinesisSource** – A **DirectKinesisSource** object.

  Specifies a direct Amazon Kinesis data source.

• **DirectKafkaSource** – A **DirectKafkaSource** object.

  Specifies an Apache Kafka data store.

• **CatalogKinesisSource** – A **CatalogKinesisSource** object.

  Specifies a Kinesis data source in the AWS Glue Data Catalog.

• **CatalogKafkaSource** – A **CatalogKafkaSource** object.

  Specifies an Apache Kafka data store in the Data Catalog.

• **DropNullFields** – A **DropNullFields** object.
Specifies a transform that removes columns from the dataset if all values in the column are 'null'. By default, AWS Glue Studio will recognize null objects, but some values such as empty strings, strings that are "null", -1 integers or other placeholders such as zeros, are not automatically recognized as nulls.

• **Merge** – A [Merge](#) object.

  Specifies a transform that merges a DynamicFrame with a staging DynamicFrame based on the specified primary keys to identify records. Duplicate records (records with the same primary keys) are not de-duplicated.

• **Union** – An [Union](#) object.

  Specifies a transform that combines the rows from two or more datasets into a single result.

• **PIIDetection** – A [PIIDetection](#) object.

  Specifies a transform that identifies, removes or masks PII data.

• **Aggregate** – An [Aggregate](#) object.

  Specifies a transform that groups rows by chosen fields and computes the aggregated value by specified function.

• **DropDuplicates** – A [DropDuplicates](#) object.

  Specifies a transform that removes rows of repeating data from a data set.

• **GovernedCatalogTarget** – A [GovernedCatalogTarget](#) object.

  Specifies a data target that writes to a governed catalog.

• **GovernedCatalogSource** – A [GovernedCatalogSource](#) object.

  Specifies a data source in a governed Data Catalog.

• **MicrosoftSQLServerCatalogSource** – A [MicrosoftSQLServerCatalogSource](#) object.

  Specifies a Microsoft SQL server data source in the AWS Glue Data Catalog.

• **MySQLCatalogSource** – A [MySQLCatalogSource](#) object.

  Specifies a MySQL data source in the AWS Glue Data Catalog.

• **OracleSQLCatalogSource** – An [OracleSQLCatalogSource](#) object.

  Specifies an Oracle data source in the AWS Glue Data Catalog.
- **PostgreSQLCatalogSource** – A [PostgreSQLCatalogSource](#) object.
  
  Specifies a PostgreSQL data source in the AWS Glue Data Catalog.
- **MicrosoftSQLServerCatalogTarget** – A [MicrosoftSQLServerCatalogTarget](#) object.
  
  Specifies a target that uses Microsoft SQL.
- **MySQLCatalogTarget** – A [MySQLCatalogTarget](#) object.
  
  Specifies a target that uses MySQL.
- **OracleSQLCatalogTarget** – An [OracleSQLCatalogTarget](#) object.
  
  Specifies a target that uses Oracle SQL.
- **PostgreSQLCatalogTarget** – A [PostgreSQLCatalogTarget](#) object.
  
  Specifies a target that uses Postgres SQL.
- **DynamicTransform** – A [DynamicTransform](#) object.
  
  Specifies a custom visual transform created by a user.
- **EvaluateDataQuality** – An [EvaluateDataQuality](#) object.
  
  Specifies your data quality evaluation criteria.
- **S3CatalogHudiSource** – A [S3CatalogHudiSource](#) object.
  
  Specifies a Hudi data source that is registered in the AWS Glue Data Catalog. The data source must be stored in Amazon S3.
- **CatalogHudiSource** – A [CatalogHudiSource](#) object.
  
  Specifies a Hudi data source that is registered in the AWS Glue Data Catalog.
- **S3HudiSource** – A [S3HudiSource](#) object.
  
  Specifies a Hudi data source stored in Amazon S3.
- **S3HudiCatalogTarget** – A [S3HudiCatalogTarget](#) object.
  
  Specifies a target that writes to a Hudi data source in the AWS Glue Data Catalog.
- **S3HudiDirectTarget** – A [S3HudiDirectTarget](#) object.
  
  Specifies a target that writes to a Hudi data source in Amazon S3.
- **S3CatalogDeltaSource** – A [S3CatalogDeltaSource](#) object.
Specifies a Delta Lake data source that is registered in the AWS Glue Data Catalog. The data source must be stored in Amazon S3.

- **CatalogDeltaSource** – A [CatalogDeltaSource](#) object.

  Specifies a Delta Lake data source that is registered in the AWS Glue Data Catalog.

- **S3DeltaSource** – A [S3DeltaSource](#) object.

  Specifies a Delta Lake data source stored in Amazon S3.

- **S3DeltaCatalogTarget** – A [S3DeltaCatalogTarget](#) object.

  Specifies a target that writes to a Delta Lake data source in the AWS Glue Data Catalog.

- **S3DeltaDirectTarget** – A [S3DeltaDirectTarget](#) object.

  Specifies a target that writes to a Delta Lake data source in Amazon S3.

- **AmazonRedshiftSource** – An [AmazonRedshiftSource](#) object.

  Specifies a target that writes to a data source in Amazon Redshift.

- **AmazonRedshiftTarget** – An [AmazonRedshiftTarget](#) object.

  Specifies a target that writes to a data target in Amazon Redshift.

- **EvaluateDataQualityMultiFrame** – An [EvaluateDataQualityMultiFrame](#) object.

  Specifies your data quality evaluation criteria. Allows multiple input data and returns a collection of Dynamic Frames.

- **Recipe** – A [Recipe](#) object.

  Specifies an AWS Glue DataBrew recipe node.

- **SnowflakeSource** – A [SnowflakeSource](#) object.

  Specifies a Snowflake data source.

- **SnowflakeTarget** – A [SnowflakeTarget](#) object.

  Specifies a target that writes to a Snowflake data source.

- **ConnectorDataSource** – A [ConnectorDataSource](#) object.

  Specifies a source generated with standard connection options.

- **ConnectorDataTarget** – A [ConnectorDataTarget](#) object.
Specifies a target generated with standard connection options.

JDBCConnectorOptions structure

Additional connection options for the connector.

Fields

- FilterPredicate – UTF-8 string, matching the Custom string pattern #32.
  Extra condition clause to filter data from source. For example:
  
  `BillingCity='Mountain View'`

  When using a query instead of a table name, you should validate that the query works with the specified filterPredicate.

- PartitionColumn – UTF-8 string, matching the Custom string pattern #32.
  
  The name of an integer column that is used for partitioning. This option works only when it's included with lowerBound, upperBound, and numPartitions. This option works the same way as in the Spark SQL JDBC reader.

- LowerBound – Number (long), not more than None.
  
  The minimum value of partitionColumn that is used to decide partition stride.

- UpperBound – Number (long), not more than None.
  
  The maximum value of partitionColumn that is used to decide partition stride.

- NumPartitions – Number (long), not more than None.
  
  The number of partitions. This value, along with lowerBound (inclusive) and upperBound (exclusive), form partition strides for generated WHERE clause expressions that are used to split the partitionColumn.

- JobBookmarkKeys – An array of UTF-8 strings.
  
  The name of the job bookmark keys on which to sort.

- JobBookmarkKeysSortOrder – UTF-8 string, matching the Custom string pattern #32.
  
  Specifies an ascending or descending sort order.
• **DataTypeMapping** – A map array of key-value pairs.

Each key is a UTF-8 string (valid values: ARRAY | BIGINT | BINARY | BIT | BLOB | BOOLEAN | CHAR | CLOB | DATALINK | DATE | DECIMAL | DISTINCT | DOUBLE | FLOAT | INTEGER | JAVA_OBJECT | LONGNVARCHAR | LONGVARBINARY | LONGVARCHAR | NCHAR | NCLOB | NULL | NUMERIC | NVARCHAR | OTHER | REAL | REF | REF_CURSOR | ROWID | SMALLINT | SQLXML | STRUCT | TIME | TIME_WITH_TIMEZONE | TIMESTAMP | TIMESTAMP_WITH_TIMEZONE | TINYINT | VARBINARY | VARCHAR).

Each value is a UTF-8 string (valid values: DATE | STRING | TIMESTAMP | INT | FLOAT | LONG | BIGDECIMAL | BYTE | SHORT | DOUBLE).

Custom data type mapping that builds a mapping from a JDBC data type to an AWS Glue data type. For example, the option "dataTypeMapping":{"FLOAT":"STRING"} maps data fields of JDBC type FLOAT into the Java String type by calling the ResultSet.getString() method of the driver, and uses it to build the AWS Glue record. The ResultSet object is implemented by each driver, so the behavior is specific to the driver you use. Refer to the documentation for your JDBC driver to understand how the driver performs the conversions.

**StreamingDataPreviewOptions structure**

Specifies options related to data preview for viewing a sample of your data.

**Fields**

• **PollingTime** – Number (long), at least 10.

  The polling time in milliseconds.

• **RecordPollingLimit** – Number (long), at least 1.

  The limit to the number of records polled.

**AthenaConnectorSource structure**

Specifies a connector to an Amazon Athena data source.

**Fields**

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
The name of the data source.

- **ConnectionName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of the connection that is associated with the connector.

- **ConnectorName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of a connector that assists with accessing the data store in AWS Glue Studio.

- **ConnectionType** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The type of connection, such as marketplace.athena or custom.athena, designating a connection to an Amazon Athena data store.

- **ConnectionTable** – UTF-8 string, matching the Custom string pattern #33.

  The name of the table in the data source.

- **SchemaName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of the Cloudwatch log group to read from. For example, /aws-glue/jobs/output.

- **OutputSchemas** – An array of GlueSchema objects.

  Specifies the data schema for the custom Athena source.

### JDBCConnectorSource structure

Specifies a connector to a JDBC data source.

#### Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.

  The name of the data source.

- **ConnectionName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of the connection that is associated with the connector.

- **ConnectorName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of a connector that assists with accessing the data store in AWS Glue Studio.

- **ConnectionType** – *Required:* UTF-8 string, matching the Custom string pattern #32.
The type of connection, such as marketplace.jdbc or custom.jdbc, designating a connection to a JDBC data store.

- **AdditionalOptions** – A [JDBCConnectorOptions](#) object.

  Additional connection options for the connector.

- **ConnectionTable** – UTF-8 string, matching the [Custom string pattern #33](#).

  The name of the table in the data source.

- **Query** – UTF-8 string, matching the [Custom string pattern #34](#).

  The table or SQL query to get the data from. You can specify either `ConnectionTable` or `query`, but not both.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the custom JDBC source.

### SparkConnectorSource structure

Specifies a connector to an Apache Spark data source.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the data source.

- **ConnectionName** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the connection that is associated with the connector.

- **ConnectorName** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of a connector that assists with accessing the data store in AWS Glue Studio.

- **ConnectionType** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The type of connection, such as marketplace.spark or custom.spark, designating a connection to an Apache Spark data store.

- **AdditionalOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).
Each value is a UTF-8 string, matching the Custom string pattern #32.

Additional connection options for the connector.

- **OutputSchemas** – An array of GlueSchema objects.

  Specifies data schema for the custom spark source.

---

**CatalogSource structure**

Specifies a data store in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the data store.

- **Database** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the database to read from.

- **Table** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the table in the database to read from.

**MySQLCatalogSource structure**

Specifies a MySQL data source in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the data source.

- **Database** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the database to read from.

- **Table** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the table in the database to read from.
PostgreSQLCatalogSource structure

Specifies a PostgreSQL data source in the AWS Glue Data Catalog.

Fields

- Name – Required: UTF-8 string, matching the Custom string pattern #35.
  The name of the data source.
- Database – Required: UTF-8 string, matching the Custom string pattern #32.
  The name of the database to read from.
- Table – Required: UTF-8 string, matching the Custom string pattern #32.
  The name of the table in the database to read from.

OracleSQLCatalogSource structure

Specifies an Oracle data source in the AWS Glue Data Catalog.

Fields

- Name – Required: UTF-8 string, matching the Custom string pattern #35.
  The name of the data source.
- Database – Required: UTF-8 string, matching the Custom string pattern #32.
  The name of the database to read from.
- Table – Required: UTF-8 string, matching the Custom string pattern #32.
  The name of the table in the database to read from.

MicrosoftSQLServerCatalogSource structure

Specifies a Microsoft SQL server data source in the AWS Glue Data Catalog.

Fields

- Name – Required: UTF-8 string, matching the Custom string pattern #35.
The name of the data source.

- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to read from.

- **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the table in the database to read from.

### CatalogKinesisSource structure

Specifies a Kinesis data source in the AWS Glue Data Catalog.

#### Fields

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data source.

- **WindowSize** – Number (integer), not more than None.
  
  The amount of time to spend processing each micro batch.

- **DetectSchema** – Boolean.
  
  Whether to automatically determine the schema from the incoming data.

- **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the table in the database to read from.

- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to read from.

- **StreamingOptions** – A [KinesisStreamingSourceOptions](#) object.
  
  Additional options for the Kinesis streaming data source.

- **DataPreviewOptions** – A [StreamingDataPreviewOptions](#) object.
  
  Additional options for data preview.
DirectKinesisSource structure

Specifies a direct Amazon Kinesis data source.

Fields

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.
  
  The name of the data source.

- **WindowSize** – Number (integer), not more than None.
  
  The amount of time to spend processing each micro batch.

- **DetectSchema** – Boolean.
  
  Whether to automatically determine the schema from the incoming data.

- **StreamingOptions** – A KinesisStreamingSourceOptions object.
  
  Additional options for the Kinesis streaming data source.

- **DataPreviewOptions** – A StreamingDataPreviewOptions object.
  
  Additional options for data preview.

KinesisStreamingSourceOptions structure

Additional options for the Amazon Kinesis streaming data source.

Fields

- **EndpointUrl** – UTF-8 string, matching the Custom string pattern #32.
  
  The URL of the Kinesis endpoint.

- **StreamName** – UTF-8 string, matching the Custom string pattern #32.
  
  The name of the Kinesis data stream.

- **Classification** – UTF-8 string, matching the Custom string pattern #32.
  
  An optional classification.

- **Delimiter** – UTF-8 string, matching the Custom string pattern #32.
Specifies the delimiter character.

- StartingPosition – UTF-8 string (valid values: latest="LATEST" | trim_horizon="TRIM_HORIZON" | earliest="EARLIEST" | timestamp="TIMESTAMP").

  The starting position in the Kinesis data stream to read data from. The possible values are "latest", "trim_horizon", "earliest", or a timestamp string in UTC format in the pattern yyyy-mm-ddTHH:MM:SSZ (where Z represents a UTC timezone offset with a +/-). For example: "2023-04-04T08:00:00-04:00"). The default value is "latest".

  Note: Using a value that is a timestamp string in UTC format for "startingPosition" is supported only for AWS Glue version 4.0 or later.

- MaxFetchTimeInMs – Number (long), not more than None.

  The maximum time spent in the job executor to fetch a record from the Kinesis data stream per shard, specified in milliseconds (ms). The default value is 1000.

- MaxFetchRecordsPerShard – Number (long), not more than None.

  The maximum number of records to fetch per shard in the Kinesis data stream. The default value is 100000.

- MaxRecordPerRead – Number (long), not more than None.

  The maximum number of records to fetch from the Kinesis data stream in each getRecords operation. The default value is 10000.

- AddIdleTimeBetweenReads – Boolean.

  Adds a time delay between two consecutive getRecords operations. The default value is "False". This option is only configurable for Glue version 2.0 and above.

- IdleTimeBetweenReadsInMs – Number (long), not more than None.

  The minimum time delay between two consecutive getRecords operations, specified in ms. The default value is 1000. This option is only configurable for Glue version 2.0 and above.

- DescribeShardInterval – Number (long), not more than None.

  The minimum time interval between two ListShards API calls for your script to consider resharding. The default value is 1s.

- NumRetries – Number (integer), not more than None.
The maximum number of retries for Kinesis Data Streams API requests. The default value is 3.

- **RetryIntervalMs** – Number (long), not more than None.

  The cool-off time period (specified in ms) before retrying the Kinesis Data Streams API call. The default value is 1000.

- **MaxRetryIntervalMs** – Number (long), not more than None.

  The maximum cool-off time period (specified in ms) between two retries of a Kinesis Data Streams API call. The default value is 10000.

- **AvoidEmptyBatches** – Boolean.

  Avoids creating an empty microbatch job by checking for unread data in the Kinesis data stream before the batch is started. The default value is "False".

- **StreamArn** – UTF-8 string, matching the [Custom string pattern #32](#).

  The Amazon Resource Name (ARN) of the Kinesis data stream.

- **RoleArn** – UTF-8 string, matching the [Custom string pattern #32](#).

  The Amazon Resource Name (ARN) of the role to assume using AWS Security Token Service (AWS STS). This role must have permissions for describe or read record operations for the Kinesis data stream. You must use this parameter when accessing a data stream in a different account. Used in conjunction with "awsSTSSessionName".

- **RoleSessionName** – UTF-8 string, matching the [Custom string pattern #32](#).

  An identifier for the session assuming the role using AWS STS. You must use this parameter when accessing a data stream in a different account. Used in conjunction with "awsSTSSRoleARN".

- **AddRecordTimestamp** – UTF-8 string, matching the [Custom string pattern #32](#).

  When this option is set to 'true', the data output will contain an additional column named "__src_timestamp" that indicates the time when the corresponding record received by the stream. The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

- **EmitConsumerLagMetrics** – UTF-8 string, matching the [Custom string pattern #32](#).

  When this option is set to 'true', for each batch, it will emit the metrics for the duration between the oldest record received by the stream and the time it arrives in AWS Glue to CloudWatch. The
metric's name is "glue.driver.streaming.maxConsumerLagInMs". The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

• **StartingTimestamp** – UTF-8 string.

  The timestamp of the record in the Kinesis data stream to start reading data from. The possible values are a timestamp string in UTC format of the pattern `yyyy-mm-ddTHH:MM:SSZ` (where `Z` represents a UTC timezone offset with a +/-). For example: "2023-04-04T08:00:00+08:00").

**CatalogKafkaSource structure**

Specifies an Apache Kafka data store in the Data Catalog.

**Fields**

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the data store.

• **WindowSize** – Number (integer), not more than None.

  The amount of time to spend processing each micro batch.

• **DetectSchema** – Boolean.

  Whether to automatically determine the schema from the incoming data.

• **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the table in the database to read from.

• **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the database to read from.

• **StreamingOptions** – A [KafkaStreamingSourceOptions](#) object.

  Specifies the streaming options.

• **DataPreviewOptions** – A [StreamingDataPreviewOptions](#) object.

  Specifies options related to data preview for viewing a sample of your data.
DirectKafkaSource structure

Specifies an Apache Kafka data store.

Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data store.

- **StreamingOptions** – A [KafkaStreamingSourceOptions](#) object.
  
  Specifies the streaming options.

- **WindowSize** – Number (integer), not more than None.
  
  The amount of time to spend processing each micro batch.

- **DetectSchema** – Boolean.
  
  Whether to automatically determine the schema from the incoming data.

- **DataPreviewOptions** – A [StreamingDataPreviewOptions](#) object.
  
  Specifies options related to data preview for viewing a sample of your data.

KafkaStreamingSourceOptions structure

Additional options for streaming.

Fields

- **BootstrapServers** – UTF-8 string, matching the [Custom string pattern #32](#).
  
  A list of bootstrap server URLs, for example, as `b-1.vpc-test-2.o4q88o.c6.kafka.us-east-1.amazonaws.com:9094`. This option must be specified in the API call or defined in the table metadata in the Data Catalog.

- **SecurityProtocol** – UTF-8 string, matching the [Custom string pattern #32](#).
  
  The protocol used to communicate with brokers. The possible values are "SSL" or "PLAINTEXT".

- **ConnectionName** – UTF-8 string, matching the [Custom string pattern #32](#).
The name of the connection.

- **TopicName** – UTF-8 string, matching the Custom string pattern #32.
  
  The topic name as specified in Apache Kafka. You must specify at least one of "topicName", "assign" or "subscribePattern".

- **Assign** – UTF-8 string, matching the Custom string pattern #32.
  
  The specific TopicPartitions to consume. You must specify at least one of "topicName", "assign" or "subscribePattern".

- **SubscribePattern** – UTF-8 string, matching the Custom string pattern #32.
  
  A Java regex string that identifies the topic list to subscribe to. You must specify at least one of "topicName", "assign" or "subscribePattern".

- **Classification** – UTF-8 string, matching the Custom string pattern #32.
  
  An optional classification.

- **Delimiter** – UTF-8 string, matching the Custom string pattern #32.
  
  Specifies the delimiter character.

- **StartingOffsets** – UTF-8 string, matching the Custom string pattern #32.
  
  The starting position in the Kafka topic to read data from. The possible values are "earliest" or "latest". The default value is "latest".

- **EndingOffsets** – UTF-8 string, matching the Custom string pattern #32.
  
  The end point when a batch query is ended. Possible values are either "latest" or a JSON string that specifies an ending offset for each TopicPartition.

- **PollTimeoutMs** – Number (long), not more than None.
  
  The timeout in milliseconds to poll data from Kafka in Spark job executors. The default value is 512.

- **NumRetries** – Number (integer), not more than None.
  
  The number of times to retry before failing to fetch Kafka offsets. The default value is 3.

- **RetryIntervalMs** – Number (long), not more than None.
  
  The time in milliseconds to wait before retrying to fetch Kafka offsets. The default value is 10.
• **MaxOffsetsPerTrigger** – Number (long), not more than None.

  The rate limit on the maximum number of offsets that are processed per trigger interval. The specified total number of offsets is proportionally split across topicPartitions of different volumes. The default value is null, which means that the consumer reads all offsets until the known latest offset.

• **MinPartitions** – Number (integer), not more than None.

  The desired minimum number of partitions to read from Kafka. The default value is null, which means that the number of spark partitions is equal to the number of Kafka partitions.

• **IncludeHeaders** – Boolean.

  Whether to include the Kafka headers. When the option is set to "true", the data output will contain an additional column named "glue_streaming_kafka_headers" with type Array[Struct(key: String, value: String)]. The default value is "false". This option is available in AWS Glue version 3.0 or later only.

• **AddRecordTimestamp** – UTF-8 string, matching the Custom string pattern #32.

  When this option is set to 'true', the data output will contain an additional column named "__src_timestamp" that indicates the time when the corresponding record received by the topic. The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

• **EmitConsumerLagMetrics** – UTF-8 string, matching the Custom string pattern #32.

  When this option is set to 'true', for each batch, it will emit the metrics for the duration between the oldest record received by the topic and the time it arrives in AWS Glue to CloudWatch. The metric's name is "glue.driver.streaming.maxConsumerLagInMs". The default value is 'false'. This option is supported in AWS Glue version 4.0 or later.

• **StartingTimestamp** – UTF-8 string.

  The timestamp of the record in the Kafka topic to start reading data from. The possible values are a timestamp string in UTC format of the pattern yyyy-mm-ddTHH:MM:SSZ (where Z represents a UTC timezone offset with a +/-). For example: "2023-04-04T08:00:00+08:00".

  Only one of StartingTimestamp or StartingOffsets must be set.
RedshiftSource structure

Specifies an Amazon Redshift data store.

Fields

- Name – *Required*: UTF-8 string, matching the [Custom string pattern #35](#). The name of the Amazon Redshift data store.
- Database – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The database to read from.
- Table – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The database table to read from.
- RedshiftTmpDir – UTF-8 string, matching the [Custom string pattern #32](#). The Amazon S3 path where temporary data can be staged when copying out of the database.
- TmpDirIAMRole – UTF-8 string, matching the [Custom string pattern #32](#). The IAM role with permissions.

AmazonRedshiftSource structure

Specifies an Amazon Redshift source.

Fields

- Name – UTF-8 string, matching the [Custom string pattern #35](#). The name of the Amazon Redshift source.
- Data – An [AmazonRedshiftNodeData](#) object. Specifies the data of the Amazon Redshift source node.

AmazonRedshiftNodeData structure

Specifies an Amazon Redshift node.
Fields

- **AccessType** – UTF-8 string, matching the [Custom string pattern #31](#). The access type for the Redshift connection. Can be a direct connection or catalog connections.

- **SourceType** – UTF-8 string, matching the [Custom string pattern #31](#). The source type to specify whether a specific table is the source or a custom query.

- **Connection** – An [Option](#) object. The AWS Glue connection to the Redshift cluster.

- **Schema** – An [Option](#) object. The Redshift schema name when working with a direct connection.

- **Table** – An [Option](#) object. The Redshift table name when working with a direct connection.

- **CatalogDatabase** – An [Option](#) object. The name of the AWS Glue Data Catalog database when working with a data catalog.

- **CatalogTable** – An [Option](#) object. The AWS Glue Data Catalog table name when working with a data catalog.

- **CatalogRedshiftSchema** – UTF-8 string. The Redshift schema name when working with a data catalog.

- **CatalogRedshiftTable** – UTF-8 string. The database table to read from.

- **TempDir** – UTF-8 string, matching the [Custom string pattern #32](#). The Amazon S3 path where temporary data can be staged when copying out of the database.

- **IamRole** – An [Option](#) object. Optional. The role name use when connection to S3. The IAM role ill default to the role on the job when left blank.

- **AdvancedOptions** – An array of [AmazonRedshiftAdvancedOption](#) objects.
Optional values when connecting to the Redshift cluster.

- **SampleQuery** – UTF-8 string.
  
  The SQL used to fetch the data from a Redshift sources when the SourceType is 'query'.

- **PreAction** – UTF-8 string.
  
  The SQL used before a MERGE or APPEND with upsert is run.

- **PostAction** – UTF-8 string.
  
  The SQL used before a MERGE or APPEND with upsert is run.

- **Action** – UTF-8 string.
  
  Specifies how writing to a Redshift cluster will occur.

- **TablePrefix** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  Specifies the prefix to a table.

- **Upsert** – Boolean.
  
  The action used on Redshift sinks when doing an APPEND.

- **MergeAction** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  The action used when to determine how a MERGE in a Redshift sink will be handled.

- **MergeWhenMatched** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  The action used when to determine how a MERGE in a Redshift sink will be handled when an existing record matches a new record.

- **MergeWhenNotMatched** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  The action used when to determine how a MERGE in a Redshift sink will be handled when an existing record doesn't match a new record.

- **MergeClause** – UTF-8 string.
  
  The SQL used in a custom merge to deal with matching records.

- **CrawlerConnection** – UTF-8 string.
  
  Specifies the name of the connection that is associated with the catalog table used.

- **TableSchema** – An array of [Option](#) objects.
The array of schema output for a given node.

- **StagingTable** – UTF-8 string.
  
  The name of the temporary staging table that is used when doing a MERGE or APPEND with upsert.

- **SelectedColumns** – An array of Option objects.
  
  The list of column names used to determine a matching record when doing a MERGE or APPEND with upsert.

**AmazonRedshiftAdvancedOption structure**

Specifies an optional value when connecting to the Redshift cluster.

**Fields**

- **Key** – UTF-8 string.
  
  The key for the additional connection option.

- **Value** – UTF-8 string.
  
  The value for the additional connection option.

**Option structure**

Specifies an option value.

**Fields**

- **Value** – UTF-8 string, matching the Custom string pattern #32.
  
  Specifies the value of the option.

- **Label** – UTF-8 string, matching the Custom string pattern #32.
  
  Specifies the label of the option.

- **Description** – UTF-8 string, matching the Custom string pattern #32.
  
  Specifies the description of the option.
S3CatalogSource structure

Specifies an Amazon S3 data store in the AWS Glue Data Catalog.

Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.
  
  The name of the data store.

- **Database** – *Required:* UTF-8 string, matching the Custom string pattern #32.
  
  The database to read from.

- **Table** – *Required:* UTF-8 string, matching the Custom string pattern #32.
  
  The database table to read from.

- **PartitionPredicate** – UTF-8 string, matching the Custom string pattern #32.
  
  Partitions satisfying this predicate are deleted. Files within the retention period in these partitions are not deleted. Set to "" – empty by default.

- **AdditionalOptions** – A S3SourceAdditionalOptions object.
  
  Specifies additional connection options.

S3SourceAdditionalOptions structure

Specifies additional connection options for the Amazon S3 data store.

Fields

- **BoundedSize** – Number (long).
  
  Sets the upper limit for the target size of the dataset in bytes that will be processed.

- **BoundedFiles** – Number (long).
  
  Sets the upper limit for the target number of files that will be processed.

S3CsvSource structure

Specifies a command-separated value (CSV) data store stored in Amazon S3.
Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data store.

- **Paths** – *Required:* An array of UTF-8 strings.
  
  A list of the Amazon S3 paths to read from.

- **CompressionType** – UTF-8 string (valid values: gzip="GZIP" | bzip2="BZIP2").
  
  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip").

- **Exclusions** – An array of UTF-8 strings.
  
  A string containing a JSON list of Unix-style glob patterns to exclude. For example, ":["**.pdf"]" excludes all PDF files.

- **GroupSize** – UTF-8 string, matching the [Custom string pattern #32](#).
  
  The target group size in bytes. The default is computed based on the input data size and the size of your cluster. When there are fewer than 50,000 input files, "groupFiles" must be set to "inPartition" for this to take effect.

- **GroupFiles** – UTF-8 string, matching the [Custom string pattern #32](#).
  
  Grouping files is turned on by default when the input contains more than 50,000 files. To turn on grouping with fewer than 50,000 files, set this parameter to "inPartition". To disable grouping when there are more than 50,000 files, set this parameter to "none".

- **Recurse** – Boolean.
  
  If set to true, recursively reads files in all subdirectories under the specified paths.

- **MaxBand** – Number (integer), not more than None.
  
  This option controls the duration in milliseconds after which the s3 listing is likely to be consistent. Files with modification timestamps falling within the last maxBand milliseconds are tracked specially when using JobBookmarks to account for Amazon S3 eventual consistency. Most users don't need to set this option. The default is 900000 milliseconds, or 15 minutes.

- **MaxFilesInBand** – Number (integer), not more than None.
This option specifies the maximum number of files to save from the last maxBand seconds. If this number is exceeded, extra files are skipped and only processed in the next job run.

* AdditionalOptions – A [S3DirectSourceAdditionalOptions](#) object.

Specifies additional connection options.

* Separator – **Required**: UTF-8 string (valid values: comma="COMMA" | crtrl="CTRLA" | pipe="PIPE" | semicolon="SEMICOLON" | tab="TAB").

Specifies the delimiter character. The default is a comma: ",", but any other character can be specified.

* Escaper – UTF-8 string, matching the [Custom string pattern #33](#).

Specifies a character to use for escaping. This option is used only when reading CSV files. The default value is none. If enabled, the character which immediately follows is used as-is, except for a small set of well-known escapes (\n, \t, \t, and \).

* QuoteChar – **Required**: UTF-8 string (valid values: quote="QUOTE" | quillemet="QUILLEMET" | single_quote="SINGLE_QUOTE" | disabled="DISABLED").

Specifies the character to use for quoting. The default is a double quote: '"'. Set this to -1 to turn off quoting entirely.

* Multiline – Boolean.

A Boolean value that specifies whether a single record can span multiple lines. This can occur when a field contains a quoted new-line character. You must set this option to True if any record spans multiple lines. The default value is False, which allows for more aggressive file-splitting during parsing.

* WithHeader – Boolean.

A Boolean value that specifies whether to treat the first line as a header. The default value is False.

* WriteHeader – Boolean.

A Boolean value that specifies whether to write the header to output. The default value is True.

* SkipFirst – Boolean.

A Boolean value that specifies whether to skip the first data line. The default value is False.
• **OptimizePerformance** – Boolean.

  A Boolean value that specifies whether to use the advanced SIMD CSV reader along with Apache Arrow based columnar memory formats. Only available in AWS Glue version 3.0.

• **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the S3 CSV source.

**DirectJDBCSource structure**

Specifies the direct JDBC source connection.

**Fields**

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the JDBC source connection.

• **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The database of the JDBC source connection.

• **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The table of the JDBC source connection.

• **ConnectionName** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The connection name of the JDBC source.

• **ConnectionType** – *Required*: UTF-8 string (valid values: sqlserver | mysql | oracle | postgresql | redshift).

  The connection type of the JDBC source.

• **RedshiftTmpDir** – UTF-8 string, matching the [Custom string pattern #32](#).

  The temp directory of the JDBC Redshift source.

**S3DirectSourceAdditionalOptions structure**

Specifies additional connection options for the Amazon S3 data store.
Fields

- **BoundedSize** – Number (long).
  
  Sets the upper limit for the target size of the dataset in bytes that will be processed.

- **BoundedFiles** – Number (long).
  
  Sets the upper limit for the target number of files that will be processed.

- **EnableSamplePath** – Boolean.
  
  Sets option to enable a sample path.

- **SamplePath** – UTF-8 string, matching the Custom string pattern #32.
  
  If enabled, specifies the sample path.

**S3JsonSource structure**

Specifies a JSON data store stored in Amazon S3.

Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.
  
  The name of the data store.

- **Paths** – *Required:* An array of UTF-8 strings.
  
  A list of the Amazon S3 paths to read from.

- **CompressionType** – UTF-8 string (valid values: gzip="GZIP" | bzip2="BZIP2").
  
  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip").

- **Exclusions** – An array of UTF-8 strings.
  
  A string containing a JSON list of Unix-style glob patterns to exclude. For example, "["**.pdf"]" excludes all PDF files.

- **GroupSize** – UTF-8 string, matching the Custom string pattern #32.
The target group size in bytes. The default is computed based on the input data size and the size of your cluster. When there are fewer than 50,000 input files, "groupFiles" must be set to "inPartition" for this to take effect.

- **GroupFiles** – UTF-8 string, matching the [Custom string pattern #32](#).

  Grouping files is turned on by default when the input contains more than 50,000 files. To turn on grouping with fewer than 50,000 files, set this parameter to "inPartition". To disable grouping when there are more than 50,000 files, set this parameter to "none".

- **Recurse** – Boolean.

  If set to true, recursively reads files in all subdirectories under the specified paths.

- **MaxBand** – Number (integer), not more than None.

  This option controls the duration in milliseconds after which the s3 listing is likely to be consistent. Files with modification timestamps falling within the last maxBand milliseconds are tracked specially when using JobBookmarks to account for Amazon S3 eventual consistency. Most users don't need to set this option. The default is 900000 milliseconds, or 15 minutes.

- **MaxFilesInBand** – Number (integer), not more than None.

  This option specifies the maximum number of files to save from the last maxBand seconds. If this number is exceeded, extra files are skipped and only processed in the next job run.

- **AdditionalOptions** – A [S3DirectSourceAdditionalOptions](#) object.

  Specifies additional connection options.

- **JsonPath** – UTF-8 string, matching the [Custom string pattern #32](#).

  A JsonPath string defining the JSON data.

- **Multiline** – Boolean.

  A Boolean value that specifies whether a single record can span multiple lines. This can occur when a field contains a quoted new-line character. You must set this option to True if any record spans multiple lines. The default value is False, which allows for more aggressive file-splitting during parsing.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the S3 JSON source.
S3ParquetSource structure

Specifies an Apache Parquet data store stored in Amazon S3.

Fields

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.
  The name of the data store.
- **Paths** – *Required*: An array of UTF-8 strings.
  A list of the Amazon S3 paths to read from.
- **CompressionType** – UTF-8 string (valid values: snappy="SNAPPY" | lzo="LZO" | gzip="GZIP" | uncompressed="UNCOMPRESSED" | none="NONE").
  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip".
- **Exclusions** – An array of UTF-8 strings.
  A string containing a JSON list of Unix-style glob patterns to exclude. For example, "["**.pdf"]" excludes all PDF files.
- **GroupSize** – UTF-8 string, matching the Custom string pattern #32.
  The target group size in bytes. The default is computed based on the input data size and the size of your cluster. When there are fewer than 50,000 input files, "groupFiles" must be set to "inPartition" for this to take effect.
- **GroupFiles** – UTF-8 string, matching the Custom string pattern #32.
  Grouping files is turned on by default when the input contains more than 50,000 files. To turn on grouping with fewer than 50,000 files, set this parameter to "inPartition". To disable grouping when there are more than 50,000 files, set this parameter to "none".
- **Recurse** – Boolean.
  If set to true, recursively reads files in all subdirectories under the specified paths.
- **MaxBand** – Number (integer), not more than None.
  This option controls the duration in milliseconds after which the s3 listing is likely to be consistent. Files with modification timestamps falling within the last maxBand milliseconds are
tracked specially when using JobBookmarks to account for Amazon S3 eventual consistency. Most users don't need to set this option. The default is 900000 milliseconds, or 15 minutes.

- **MaxFilesInBand** – Number (integer), not more than None.

  This option specifies the maximum number of files to save from the last maxBand seconds. If this number is exceeded, extra files are skipped and only processed in the next job run.

- **AdditionalOptions** – A `S3DirectSourceAdditionalOptions` object.

  Specifies additional connection options.

- **OutputSchemas** – An array of `GlueSchema` objects.

  Specifies the data schema for the S3 Parquet source.

### S3DeltaSource structure

Specifies a Delta Lake data source stored in Amazon S3.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the Delta Lake source.

- **Paths** – *Required*: An array of UTF-8 strings.

  A list of the Amazon S3 paths to read from.

- **AdditionalDeltaOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the Custom string pattern #32.

  Each value is a UTF-8 string, matching the Custom string pattern #32.

  Specifies additional connection options.

- **AdditionalOptions** – A `S3DirectSourceAdditionalOptions` object.

  Specifies additional options for the connector.

- **OutputSchemas** – An array of `GlueSchema` objects.

  Specifies the data schema for the Delta Lake source.
**S3CatalogDeltaSource structure**

Specifies a Delta Lake data source that is registered in the AWS Glue Data Catalog. The data source must be stored in Amazon S3.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the Delta Lake data source.

- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to read from.

- **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the table in the database to read from.

- **AdditionalDeltaOptions** – A map array of key-value pairs.
  
  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).
  
  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies additional connection options.

- **OutputSchemas** – An array of GlueSchema objects.
  
  Specifies the data schema for the Delta Lake source.

**CatalogDeltaSource structure**

Specifies a Delta Lake data source that is registered in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the Delta Lake data source.

- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to read from.
• **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the table in the database to read from.

• **AdditionalDeltaOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies additional connection options.

• **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the Delta Lake source.

### S3HudiSource structure

Specifies a Hudi data source stored in Amazon S3.

#### Fields

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the Hudi source.

• **Paths** – *Required*: An array of UTF-8 strings.

  A list of the Amazon S3 paths to read from.

• **AdditionalHudiOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies additional connection options.

• **AdditionalOptions** – A [S3DirectSourceAdditionalOptions](#) object.

  Specifies additional options for the connector.

• **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the Hudi source.
S3CatalogHudiSource structure

Specifies a Hudi data source that is registered in the AWS Glue Data Catalog. The Hudi data source must be stored in Amazon S3.

Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  - The name of the Hudi data source.
- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  - The name of the database to read from.
- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  - The name of the table in the database to read from.
- **AdditionalHudiOptions** – A map array of key-value pairs.
  - Each key is a UTF-8 string, matching the [Custom string pattern #32](#).
  - Each value is a UTF-8 string, matching the [Custom string pattern #32](#).
  - Specifies additional connection options.
- **OutputSchemas** – An array of [GlueSchema](#) objects.
  - Specifies the data schema for the Hudi source.

CatalogHudiSource structure

Specifies a Hudi data source that is registered in the AWS Glue Data Catalog.

Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  - The name of the Hudi data source.
- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  - The name of the database to read from.
- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
The name of the table in the database to read from.

- AdditionalHudiOptions – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the Custom string pattern #32.

  Each value is a UTF-8 string, matching the Custom string pattern #32.

  Specifies additional connection options.

- OutputSchemas – An array of GlueSchema objects.

  Specifies the data schema for the Hudi source.

**DynamoDBCatalogSource structure**

Specifies a DynamoDB data source in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the data source.

- **Database** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the database to read from.

- **Table** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The name of the table in the database to read from.

**RelationalCatalogSource structure**

Specifies a Relational database data source in the AWS Glue Data Catalog.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the data source.

- **Database** – *Required*: UTF-8 string, matching the Custom string pattern #32.
The name of the database to read from.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the table in the database to read from.

### JDBCConnectorTarget structure

Specifies a data target that writes to Amazon S3 in Apache Parquet columnar storage.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

- **ConnectionName** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the connection that is associated with the connector.

- **ConnectionTable** – *Required:* UTF-8 string, matching the [Custom string pattern #33](#).

  The name of the table in the data target.

- **ConnectorName** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of a connector that will be used.

- **ConnectionType** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The type of connection, such as marketplace.jdbc or custom.jdbc, designating a connection to a JDBC data target.

- **AdditionalOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Additional connection options for the connector.

- **OutputSchemas** – An array of [GlueSchema](#) objects.
Specifies the data schema for the JDBC target.

**SparkConnectorTarget structure**

Specifies a target that uses an Apache Spark connector.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data target.

- **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the data target.

- **ConnectionName** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of a connection for an Apache Spark connector.

- **ConnectorName** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of an Apache Spark connector.

- **ConnectionType** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The type of connection, such as marketplace.spark or custom.spark, designating a connection to an Apache Spark data store.

- **AdditionalOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Additional connection options for the connector.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the custom spark target.

**BasicCatalogTarget structure**

Specifies a target that uses an AWS Glue Data Catalog table.
Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#). The name of your data target.
- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.
- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The database that contains the table you want to use as the target. This database must already exist in the Data Catalog.
- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The table that defines the schema of your output data. This table must already exist in the Data Catalog.

**MySQLCatalogTarget structure**

Specifies a target that uses MySQL.

Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.
- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.
- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the database to write to.
- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the table in the database to write to.

**PostgreSQLCatalogTarget structure**

Specifies a target that uses Postgres SQL.
Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the database to write to.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the table in the database to write to.

### OracleSQLCatalogTarget structure

Specifies a target that uses Oracle SQL.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the database to write to.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#). The name of the table in the database to write to.

### MicrosoftSQLServerCatalogTarget structure

Specifies a target that uses Microsoft SQL.
Fields

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.
- **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.
- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The name of the database to write to.
- **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The name of the table in the database to write to.

**RedshiftTarget structure**

Specifies a target that uses Amazon Redshift.

Fields

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.
- **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.
- **Database** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The name of the database to write to.
- **Table** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The name of the table in the database to write to.
- **RedshiftTmpDir** – UTF-8 string, matching the [Custom string pattern #32](#). The Amazon S3 path where temporary data can be staged when copying out of the database.
- **TmpDirIAMRole** – UTF-8 string, matching the [Custom string pattern #32](#). The IAM role with permissions.
• UpsertRedshiftOptions – An `UpsertRedshiftTargetOptions` object.

  The set of options to configure an upsert operation when writing to a Redshift target.

**AmazonRedshiftTarget structure**

Specifies an Amazon Redshift target.

**Fields**

• Name – UTF-8 string, matching the `Custom string pattern #35`.

  The name of the Amazon Redshift target.

• Data – An `AmazonRedshiftNodeData` object.

  Specifies the data of the Amazon Redshift target node.

• Inputs – An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

**UpsertRedshiftTargetOptions structure**

The options to configure an upsert operation when writing to a Redshift target.

**Fields**

• TableLocation – UTF-8 string, matching the `Custom string pattern #32`.

  The physical location of the Redshift table.

• ConnectionName – UTF-8 string, matching the `Custom string pattern #32`.

  The name of the connection to use to write to Redshift.

• UpsertKeys – An array of UTF-8 strings.

  The keys used to determine whether to perform an update or insert.

**S3CatalogTarget structure**

Specifies a data target that writes to Amazon S3 using the AWS Glue Data Catalog.
**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.
  
  Specifies native partitioning using a sequence of keys.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the table in the database to write to.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  The name of the database to write to.

- **SchemaChangePolicy** – A [CatalogSchemaChangePolicy](#) object.
  
  A policy that specifies update behavior for the crawler.

**S3GlueParquetTarget structure**

Specifies a data target that writes to Amazon S3 in Apache Parquet columnar storage.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.
  
  Specifies native partitioning using a sequence of keys.

- **Path** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  A single Amazon S3 path to write to.
• Compression – UTF-8 string (valid values: snappy="SNAPPY" | lzo="LZO" | gzip="GZIP" | uncompressed="UNCOMPRESSED" | none="NONE").

  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip").

• SchemaChangePolicy – A DirectSchemaChangePolicy object.

  A policy that specifies update behavior for the crawler.

**CatalogSchemaChangePolicy structure**

A policy that specifies update behavior for the crawler.

**Fields**

• EnableUpdateCatalog – Boolean.

  Whether to use the specified update behavior when the crawler finds a changed schema.

• UpdateBehavior – UTF-8 string (valid values: UPDATE_IN_DATABASE | LOG).

  The update behavior when the crawler finds a changed schema.

**S3DirectTarget structure**

Specifies a data target that writes to Amazon S3.

**Fields**

• Name – **Required**: UTF-8 string, matching the Custom string pattern #35.

  The name of the data target.

• Inputs – **Required**: An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

• PartitionKeys – An array of UTF-8 strings.

  Specifies native partitioning using a sequence of keys.

• Path – **Required**: UTF-8 string, matching the Custom string pattern #32.
A single Amazon S3 path to write to.

- **Compression** – UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip".

- **Format** – *Required:* UTF-8 string (valid values: json="JSON" | csv="CSV" | avro="AVRO" | orc="ORC" | parquet="PARQUET" | hudi="HUDI" | delta="DELTA").

  Specifies the data output format for the target.

- **SchemaChangePolicy** – A [DirectSchemaChangePolicy](#) object.

  A policy that specifies update behavior for the crawler.

---

## S3HudiCatalogTarget structure

Specifies a target that writes to a Hudi data source in the AWS Glue Data Catalog.

### Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.

  Specifies native partitioning using a sequence of keys.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the table in the database to write to.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the database to write to.

- **AdditionalOptions** – *Required:* A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).
Each value is a UTF-8 string, matching the Custom string pattern #32.

Specifies additional connection options for the connector.

• **SchemaChangePolicy** – A [CatalogSchemaChangePolicy](#) object.

  A policy that specifies update behavior for the crawler.

### S3HudiDirectTarget structure

Specifies a target that writes to a Hudi data source in Amazon S3.

#### Fields

• **Name** – *Required*: UTF-8 string, matching the Custom string pattern #35.

  The name of the data target.

• **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

• **Path** – *Required*: UTF-8 string, matching the Custom string pattern #32.

  The Amazon S3 path of your Hudi data source to write to.

• **Compression** – *Required*: UTF-8 string (valid values: gzip="GZIP" | lzo="LZO" | uncompressed="UNCOMPRESSED" | snappy="SNAPPY").

  Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip").

• **PartitionKeys** – An array of UTF-8 strings.

  Specifies native partitioning using a sequence of keys.

• **Format** – *Required*: UTF-8 string (valid values: json="JSON" | csv="CSV" | avro="AVRO" | orc="ORC" | parquet="PARQUET" | hudi="HUDI" | delta="DELTA").

  Specifies the data output format for the target.

• **AdditionalOptions** – *Required*: A map array of key-value pairs.

  Each key is a UTF-8 string, matching the Custom string pattern #32.
Each value is a UTF-8 string, matching the Custom string pattern #32.

Specifies additional connection options for the connector.

- **SchemaChangePolicy** – A DirectSchemaChangePolicy object.

  A policy that specifies update behavior for the crawler.

### S3DeltaCatalogTarget structure

Specifies a target that writes to a Delta Lake data source in the AWS Glue Data Catalog.

#### Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.

  The name of the data target.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings.

  Specifies native partitioning using a sequence of keys.

- **Table** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of the table in the database to write to.

- **Database** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The name of the database to write to.

- **AdditionalOptions** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the Custom string pattern #32.

  Each value is a UTF-8 string, matching the Custom string pattern #32.

  Specifies additional connection options for the connector.

- **SchemaChangePolicy** – A CatalogSchemaChangePolicy object.

  A policy that specifies update behavior for the crawler.
S3DeltaDirectTarget structure

Specifies a target that writes to a Delta Lake data source in Amazon S3.

Fields

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#). The name of the data target.

- **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings. The nodes that are inputs to the data target.

- **PartitionKeys** – An array of UTF-8 strings. Specifies native partitioning using a sequence of keys.

- **Path** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#). The Amazon S3 path of your Delta Lake data source to write to.

- **Compression** – *Required*: UTF-8 string (valid values: uncompressed="UNCOMPRESSED" | snappy="SNAPPY"). Specifies how the data is compressed. This is generally not necessary if the data has a standard file extension. Possible values are "gzip" and "bzip").

- **Format** – *Required*: UTF-8 string (valid values: json="JSON" | csv="CSV" | avro="AVRO" | orc="ORC" | parquet="PARQUET" | hudi="HUDI" | delta="DELTA"). Specifies the data output format for the target.

- **AdditionalOptions** – A map array of key-value pairs. Each key is a UTF-8 string, matching the [Custom string pattern #32](#). Each value is a UTF-8 string, matching the [Custom string pattern #32](#). Specifies additional connection options for the connector.

DirectSchemaChangePolicy structure

A policy that specifies update behavior for the crawler.

Fields

• EnableUpdateCatalog – Boolean.
  Whether to use the specified update behavior when the crawler finds a changed schema.

• UpdateBehavior – UTF-8 string (valid values: UPDATE_IN_DATABASE | LOG).
  The update behavior when the crawler finds a changed schema.

• Table – UTF-8 string, matching the Custom string pattern #32.
  Specifies the table in the database that the schema change policy applies to.

• Database – UTF-8 string, matching the Custom string pattern #32.
  Specifies the database that the schema change policy applies to.

ApplyMapping structure

Specifies a transform that maps data property keys in the data source to data property keys in the data target. You can rename keys, modify the data types for keys, and choose which keys to drop from the dataset.

Fields

• Name – Required: UTF-8 string, matching the Custom string pattern #35.
  The name of the transform node.

• Inputs – Required: An array of UTF-8 strings, not less than 1 or more than 1 strings.
  The data inputs identified by their node names.

• Mapping – Required: An array of Mapping objects.
  Specifies the mapping of data property keys in the data source to data property keys in the data target.
Mapping structure

Specifies the mapping of data property keys.

Fields

• **ToKey** – UTF-8 string, matching the [Custom string pattern #32](#).

  After the apply mapping, what the name of the column should be. Can be the same as FromPath.

• **FromPath** – An array of UTF-8 strings.

  The table or column to be modified.

• **FromType** – UTF-8 string, matching the [Custom string pattern #32](#).

  The type of the data to be modified.

• **ToType** – UTF-8 string, matching the [Custom string pattern #32](#).

  The data type that the data is to be modified to.

• **Dropped** – Boolean.

  If true, then the column is removed.

• **Children** – An array of Mapping objects.

  Only applicable to nested data structures. If you want to change the parent structure, but also one of its children, you can fill out this data structure. It is also Mapping, but its FromPath will be the parent's FromPath plus the FromPath from this structure.

For the children part, suppose you have the structure:

```json
{
  "FromPath": "OuterStructure", "ToKey": "OuterStructure", "ToType": "Struct", "Dropped": false, "Children": [{
    "FromPath": "inner", "ToKey": "inner", "ToType": "Double", "Dropped": false,
  }]
}
```

You can specify a Mapping that looks like:

```json
{
  "FromPath": "OuterStructure", "ToKey": "OuterStructure", "ToType": "Struct", "Dropped": false, "Children": [{
    "FromPath": "inner", "ToKey": "inner", "ToType": "Double", "Dropped": false,
  }]
}
```
SelectFields structure

Specifies a transform that chooses the data property keys that you want to keep.

Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.
  
The name of the transform node.
- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
The data inputs identified by their node names.
- **Paths** – *Required:* An array of UTF-8 strings.
  
A JSON path to a variable in the data structure.

DropFields structure

Specifies a transform that chooses the data property keys that you want to drop.

Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.
  
The name of the transform node.
- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
The data inputs identified by their node names.
- **Paths** – *Required:* An array of UTF-8 strings.
  
A JSON path to a variable in the data structure.

RenameField structure

Specifies a transform that renames a single data property key.

Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.

SelectFields

1964
The name of the transform node.

• Inputs – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The data inputs identified by their node names.

• SourcePath – *Required:* An array of UTF-8 strings.

  A JSON path to a variable in the data structure for the source data.

• TargetPath – *Required:* An array of UTF-8 strings.

  A JSON path to a variable in the data structure for the target data.

**Spigot structure**

Specifies a transform that writes samples of the data to an Amazon S3 bucket.

**Fields**

• Name – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.

• Inputs – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The data inputs identified by their node names.

• Path – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  A path in Amazon S3 where the transform will write a subset of records from the dataset to a JSON file in an Amazon S3 bucket.

• Topk – Number (integer), not more than 100.

  Specifies a number of records to write starting from the beginning of the dataset.

• Prob – Number (double), not more than 1.

  The probability (a decimal value with a maximum value of 1) of picking any given record. A value of 1 indicates that each row read from the dataset should be included in the sample output.
Join structure

Specifies a transform that joins two datasets into one dataset using a comparison phrase on the specified data property keys. You can use inner, outer, left, right, left semi, and left anti joins.

Fields

- Name – Required: UTF-8 string, matching the Custom string pattern #35.
  
  The name of the transform node.

- Inputs – Required: An array of UTF-8 strings, not less than 2 or more than 2 strings.
  
  The data inputs identified by their node names.

- JoinType – Required: UTF-8 string (valid values: equijoin="EQUIJOIN" | left="LEFT" | right="RIGHT" | outer="OUTER" | leftsemi="LEFT_SEMI" | leftanti="LEFT_ANTI").
  
  Specifies the type of join to be performed on the datasets.

- Columns – Required: An array of JoinColumn objects, not less than 2 or more than 2 structures.
  
  A list of the two columns to be joined.

JoinColumn structure

Specifies a column to be joined.

Fields

- From – Required: UTF-8 string, matching the Custom string pattern #32.
  
  The column to be joined.

- Keys – Required: An array of UTF-8 strings.
  
  The key of the column to be joined.

SplitFields structure

Specifies a transform that splits data property keys into two DynamicFrames. The output is a collection of DynamicFrames: one with selected data property keys, and one with the remaining data property keys.
Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The data inputs identified by their node names.

- **Paths** – *Required:* An array of UTF-8 strings.
  
  A JSON path to a variable in the data structure.

### SelectFromCollection structure

Specifies a transform that chooses one DynamicFrame from a collection of DynamicFrames. The output is the selected DynamicFrame

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The data inputs identified by their node names.

- **Index** – *Required:* Number (integer), not more than None.
  
  The index for the DynamicFrame to be selected.

### FillMissingValues structure

Specifies a transform that locates records in the dataset that have missing values and adds a new field with a value determined by imputation. The input data set is used to train the machine learning model that determines what the missing value should be.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The data inputs identified by their node names.

- **ImputedPath** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  A JSON path to a variable in the data structure for the dataset that is imputed.

- **FilledPath** – UTF-8 string, matching the Custom string pattern #32.

  A JSON path to a variable in the data structure for the dataset that is filled.

## Filter structure

Specifies a transform that splits a dataset into two, based on a filter condition.

### Fields

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #35.

  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The data inputs identified by their node names.

- **LogicalOperator** – *Required:* UTF-8 string (valid values: AND | OR).

  The operator used to filter rows by comparing the key value to a specified value.

- **Filters** – *Required:* An array of FilterExpression objects.

  Specifies a filter expression.

## FilterExpression structure

Specifies a filter expression.

### Fields

- **Operation** – *Required:* UTF-8 string (valid values: EQ | LT | GT | LTE | GTE | REGEX | ISNULL).
The type of operation to perform in the expression.

- Negated – Boolean.

Whether the expression is to be negated.

- Values – Required: An array of `FilterValue` objects.

A list of filter values.

**FilterValue structure**

Represents a single entry in the list of values for a `FilterExpression`.

**Fields**

- **Type** – Required: UTF-8 string (valid values: COLUMNEXTRACTED | CONSTANT).
  
  The type of filter value.

- **Value** – Required: An array of UTF-8 strings.
  
  The value to be associated.

**CustomCode structure**

Specifies a transform that uses custom code you provide to perform the data transformation. The output is a collection of DynamicFrames.

**Fields**

- **Name** – Required: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the transform node.

- **Inputs** – Required: An array of UTF-8 strings, at least 1 string.
  
  The data inputs identified by their node names.

- **Code** – Required: UTF-8 string, matching the [Custom string pattern #27](#).
  
  The custom code that is used to perform the data transformation.

- **ClassName** – Required: UTF-8 string, matching the [Custom string pattern #32](#).
The name defined for the custom code node class.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the custom code transform.

### SparkSQL structure

Specifies a transform where you enter a SQL query using Spark SQL syntax to transform the data. The output is a single DynamicFrame.

#### Fields

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, at least 1 string.

  The data inputs identified by their node names. You can associate a table name with each input node to use in the SQL query. The name you choose must meet the Spark SQL naming restrictions.

- **SqlQuery** – *Required:* UTF-8 string, matching the [Custom string pattern #34](#).

  A SQL query that must use Spark SQL syntax and return a single data set.

- **SqlAliases** – *Required:* An array of [SqlAlias](#) objects.

  A list of aliases. An alias allows you to specify what name to use in the SQL for a given input. For example, you have a datasource named "MyDataSource". If you specify From as MyDataSource, and Alias as SqlName, then in your SQL you can do:

  ```sql
  select * from SqlName
  ```

  and that gets data from MyDataSource.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies the data schema for the SparkSQL transform.
SqlAlias structure

Represents a single entry in the list of values for SqlAliases.

Fields

- **From** – *Required*: UTF-8 string, matching the [Custom string pattern #31](#). A table, or a column in a table.

- **Alias** – *Required*: UTF-8 string, matching the [Custom string pattern #33](#). A temporary name given to a table, or a column in a table.

DropNullFields structure

Specifies a transform that removes columns from the dataset if all values in the column are 'null'. By default, AWS Glue Studio will recognize null objects, but some values such as empty strings, strings that are "null", -1 integers or other placeholders such as zeros, are not automatically recognized as nulls.

Fields

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#). The name of the transform node.

- **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings. The data inputs identified by their node names.

- **NullCheckBoxList** – A [NullCheckBoxList](#) object. A structure that represents whether certain values are recognized as null values for removal.

- **NullTextList** – An array of [NullValueField](#) objects, not more than 50 structures. A structure that specifies a list of NullValueField structures that represent a custom null value such as zero or other value being used as a null placeholder unique to the dataset.

The DropNullFields transform removes custom null values only if both the value of the null placeholder and the datatype match the data.
NullCheckBoxList structure

Represents whether certain values are recognized as null values for removal.

**Fields**

- **IsEmpty** – Boolean.
  
  Specifies that an empty string is considered as a null value.

- **IsNullString** – Boolean.
  
  Specifies that a value spelling out the word 'null' is considered as a null value.

- **IsNegOne** – Boolean.
  
  Specifies that an integer value of -1 is considered as a null value.

NullValueField structure

Represents a custom null value such as a zeros or other value being used as a null placeholder unique to the dataset.

**Fields**

- **Value** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  The value of the null placeholder.

- **Datatype** – *Required:* A Datatype object.

  The datatype of the value.

Datatype structure

A structure representing the datatype of the value.

**Fields**

- **Id** – *Required:* UTF-8 string, matching the Custom string pattern #31.

  The datatype of the value.
• **Label** – *Required:* UTF-8 string, matching the [Custom string pattern #31](#).

  A label assigned to the datatype.

**Merge structure**

Specifies a transform that merges a `DynamicFrame` with a staging `DynamicFrame` based on the specified primary keys to identify records. Duplicate records (records with the same primary keys) are not de-duplicated.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 2 or more than 2 strings.

  The data inputs identified by their node names.

- **Source** – *Required:* UTF-8 string, matching the [Custom string pattern #31](#).

  The source `DynamicFrame` that will be merged with a staging `DynamicFrame`.

- **PrimaryKeys** – *Required:* An array of UTF-8 strings.

  The list of primary key fields to match records from the source and staging dynamic frames.

**Union structure**

Specifies a transform that combines the rows from two or more datasets into a single result.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 2 or more than 2 strings.

  The node ID inputs to the transform.

- **UnionType** – *Required:* UTF-8 string (valid values: ALL | DISTINCT).
Indicates the type of Union transform.

Specify ALL to join all rows from data sources to the resulting DynamicFrame. The resulting union does not remove duplicate rows.

Specify DISTINCT to remove duplicate rows in the resulting DynamicFrame.

**PIIDetection structure**

Specifies a transform that identifies, removes or masks PII data.

**Fields**

- **Name** – *Required: UTF-8 string, matching the Custom string pattern #35.*
  
  The name of the transform node.

- **Inputs** – *Required: An array of UTF-8 strings, not less than 1 or more than 1 strings.*
  
  The node ID inputs to the transform.

- **PiiType** – *Required: UTF-8 string (valid values: RowAudit | RowMasking | ColumnAudit | ColumnMasking).*
  
  Indicates the type of PIIDetection transform.

- **EntityTypesToDetect** – *Required: An array of UTF-8 strings.*
  
  Indicates the types of entities the PIIDetection transform will identify as PII data.

  PII type entities include: PERSON_NAME, DATE, USA_SNN, EMAIL, USA_ITIN, USA_PASSPORT_NUMBER, PHONE_NUMBER, BANK_ACCOUNT, IP_ADDRESS, MAC_ADDRESS, USA_CPT_CODE, USA_HPCPCS_CODE, USA_NATIONAL_DRUG_CODE, USA_MEDICARE_BENEFICIARY_IDENTIFIER, USA_HEALTH_INSURANCE_CLAIM_NUMBER, CREDIT_CARD, USA_NATIONAL_PROVIDER_IDENTIFIER, USA_DEA_NUMBER, USA_DRIVING_LICENSE...

- **OutputColumnName** – UTF-8 string, matching the Custom string pattern #32.
  
  Indicates the output column name that will contain any entity type detected in that row.

- **SampleFraction** – Number (double), not more than 1.
  
  Indicates the fraction of the data to sample when scanning for PII entities.
• **ThresholdFraction** – Number (double), not more than 1.

  Indicates the fraction of the data that must be met in order for a column to be identified as PII data.

• **MaskValue** – UTF-8 string, not more than 256 bytes long, matching the [Custom string pattern #29](#).

  Indicates the value that will replace the detected entity.

### Aggregate structure

Specifies a transform that groups rows by chosen fields and computes the aggregated value by specified function.

**Fields**

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.

• **Inputs** – *Required*: An array of UTF-8 strings, not less than 1 or more than 1 strings.

  Specifies the fields and rows to use as inputs for the aggregate transform.

• **Groups** – *Required*: An array of UTF-8 strings.

  Specifies the fields to group by.

• **Aggs** – *Required*: An array of `AggregateOperation` objects, not less than 1 or more than 30 structures.

  Specifies the aggregate functions to be performed on specified fields.

### DropDuplicates structure

Specifies a transform that removes rows of repeating data from a data set.

**Fields**

• **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the transform node.
• Inputs – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The data inputs identified by their node names.
• Columns – An array of UTF-8 strings.

  The name of the columns to be merged or removed if repeating.

**GovernedCatalogTarget structure**

Specifies a data target that writes to Amazon S3 using the AWS Glue Data Catalog.

**Fields**

• Name – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the data target.
• Inputs – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.
• PartitionKeys – An array of UTF-8 strings.

  Specifies native partitioning using a sequence of keys.
• Table – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the table in the database to write to.
• Database – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The name of the database to write to.

  A policy that specifies update behavior for the governed catalog.

**GovernedCatalogSource structure**

Specifies the data store in the governed AWS Glue Data Catalog.

**Fields**

• Name – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
The name of the data store.

- **Database** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The database to read from.

- **Table** – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).

  The database table to read from.

- **PartitionPredicate** – UTF-8 string, matching the [Custom string pattern #32](#).

  Partitions satisfying this predicate are deleted. Files within the retention period in these partitions are not deleted. Set to "" – empty by default.

- **AdditionalOptions** – A [S3SourceAdditionalOptions](#) object.

  Specifies additional connection options.

## AggregateOperation structure

Specifies the set of parameters needed to perform aggregation in the aggregate transform.

### Fields

- **Column** – *Required:* An array of UTF-8 strings.

  Specifies the column on the data set on which the aggregation function will be applied.

- **AggFunc** – *Required:* UTF-8 string (valid values: avg | countDistinct | count | first | last | kurtosis | max | min | skewness | stddev_samp | stddev_pop | sum | sumDistinct | var_samp | var_pop).

  Specifies the aggregation function to apply.

  Possible aggregation functions include: avg countDistinct, count, first, last, kurtosis, max, min, skewness, stddev_samp, stddev_pop, sum, sumDistinct, var_samp, var_pop

## GlueSchema structure

Specifies a user-defined schema when a schema cannot be determined by AWS Glue.
Fields

- Columns – An array of `GlueStudioSchemaColumn` objects.

  Specifies the column definitions that make up a AWS Glue schema.

**GlueStudioSchemaColumn structure**

Specifies a single column in a AWS Glue schema definition.

**Fields**

- Name – *Required*: UTF-8 string, not more than 1024 bytes long, matching the [Single-line string pattern](#).

  The name of the column in the AWS Glue Studio schema.

- Type – UTF-8 string, not more than 131072 bytes long, matching the [Single-line string pattern](#).

  The hive type for this column in the AWS Glue Studio schema.

**GlueStudioColumn structure**

Specifies a single column in AWS GlueStudio.

**Fields**

- Key – *Required*: UTF-8 string, matching the [Custom string pattern #33](#).

  The key of the column in AWS Glue Studio.

- FullPath – *Required*: An array of UTF-8 strings.

  The full URL of the column in AWS Glue Studio.

- Type – *Required*: UTF-8 string (valid values: array="ARRAY" | bigint="BIGINT" | bigint array="BIGINT_ARRAY" | binary="BINARY" | binary array="BINARY_ARRAY" | boolean="BOOLEAN" | boolean array="BOOLEAN_ARRAY" | byte="BYTE" | byte array="BYTE_ARRAY" | char="CHAR" | char array="CHAR_ARRAY" | choice="CHOICE" | choice array="CHOICE_ARRAY" | date="DATE" | date array="DATE_ARRAY" | decimal="DECIMAL" | decimal array="DECIMAL_ARRAY" | double="DOUBLE" | double array="DOUBLE_ARRAY" | enum="ENUM" | enum array="ENUM_ARRAY" |
The type of the column in AWS Glue Studio.

- Children – An array of structures.

The children of the parent column in AWS Glue Studio.

**DynamicTransform structure**

Specifies the set of parameters needed to perform the dynamic transform.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  Specifies the name of the dynamic transform.

- **TransformName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  Specifies the name of the dynamic transform as it appears in the AWS Glue Studio visual editor.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.

  Specifies the inputs for the dynamic transform that are required.

- **Parameters** – An array of TransformConfigParameter objects.

  Specifies the parameters of the dynamic transform.

- **FunctionName** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  Specifies the name of the function of the dynamic transform.

- **Path** – *Required:* UTF-8 string, matching the Custom string pattern #32.

  Specifies the path of the dynamic transform source and config files.
• Version – UTF-8 string, matching the Custom string pattern #32.

  This field is not used and will be deprecated in future release.

• OutputSchemas – An array of GlueSchema objects.

  Specifies the data schema for the dynamic transform.

**TransformConfigParameter structure**

Specifies the parameters in the config file of the dynamic transform.

**Fields**

• Name – Required: UTF-8 string, matching the Custom string pattern #32.

  Specifies the name of the parameter in the config file of the dynamic transform.

• Type – Required: UTF-8 string (valid values: str="STR" | int="INT" | float="FLOAT" | complex="COMPLEX" | bool="BOOL" | list="LIST" | null="NULL").

  Specifies the parameter type in the config file of the dynamic transform.

• ValidationRule – UTF-8 string, matching the Custom string pattern #32.

  Specifies the validation rule in the config file of the dynamic transform.

• ValidationMessage – UTF-8 string, matching the Custom string pattern #32.

  Specifies the validation message in the config file of the dynamic transform.

• Value – An array of UTF-8 strings.

  Specifies the value of the parameter in the config file of the dynamic transform.

• ListType – UTF-8 string (valid values: str="STR" | int="INT" | float="FLOAT" | complex="COMPLEX" | bool="BOOL" | list="LIST" | null="NULL").

  Specifies the list type of the parameter in the config file of the dynamic transform.

• IsOptional – Boolean.

  Specifies whether the parameter is optional or not in the config file of the dynamic transform.
**EvaluateDataQuality structure**

Specifies your data quality evaluation criteria.

**Fields**

- **Name** – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the data quality evaluation.

- **Inputs** – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The inputs of your data quality evaluation.

- **Ruleset** – *Required:* UTF-8 string, not less than 1 or more than 65536 bytes long, matching the [Custom string pattern #30](#).
  
  The ruleset for your data quality evaluation.

- **Output** – UTF-8 string (valid values: PrimaryInput | EvaluationResults).
  
  The output of your data quality evaluation.

- **PublishingOptions** – A [DQResultsPublishingOptions](#) object.
  
  Options to configure how your results are published.

- **StopJobOnFailureOptions** – A [DQStopJobOnFailureOptions](#) object.
  
  Options to configure how your job will stop if your data quality evaluation fails.

**DQResultsPublishingOptions structure**

Options to configure how your data quality evaluation results are published.

**Fields**

- **EvaluationContext** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  The context of the evaluation.

- **ResultsS3Prefix** – UTF-8 string, matching the [Custom string pattern #32](#).
  
  The Amazon S3 prefix prepended to the results.

- **CloudWatchMetricsEnabled** – Boolean.
Enable metrics for your data quality results.

- ResultsPublishingEnabled – Boolean.

Enable publishing for your data quality results.

**DQStopJobOnFailureOptions structure**

Options to configure how your job will stop if your data quality evaluation fails.

**Fields**

- StopJobOnFailureTiming – UTF-8 string (valid values: Immediate | AfterDataLoad).
  
  When to stop job if your data quality evaluation fails. Options are Immediate or AfterDataLoad.

**EvaluateDataQualityMultiFrame structure**

Specifies your data quality evaluation criteria.

**Fields**

- Name – *Required:* UTF-8 string, matching the Custom string pattern #35.
  
  The name of the data quality evaluation.

- Inputs – *Required:* An array of UTF-8 strings, at least 1 string.
  
  The inputs of your data quality evaluation. The first input in this list is the primary data source.

- AdditionalDataSources – A map array of key-value pairs.
  
  Each key is a UTF-8 string, matching the Custom string pattern #35.

  Each value is a UTF-8 string, matching the Custom string pattern #32.

  The aliases of all data sources except primary.

- Ruleset – *Required:* UTF-8 string, not less than 1 or more than 65536 bytes long, matching the Custom string pattern #30.
  
  The ruleset for your data quality evaluation.
• PublishingOptions – A `DQResultsPublishingOptions` object.
  
  Options to configure how your results are published.
• AdditionalOptions – A map array of key-value pairs.
  
  Each key is a UTF-8 string (valid values: `performanceTuning.caching="CacheOption"` | `observations.scope="ObservationsOption"`).

  Each value is a UTF-8 string.

  Options to configure runtime behavior of the transform.
• StopJobOnFailureOptions – A `DQStopJobOnFailureOptions` object.

  Options to configure how your job will stop if your data quality evaluation fails.

**Recipe structure**

A AWS Glue Studio node that uses a AWS Glue DataBrew recipe in AWS Glue jobs.

**Fields**

• Name – *Required:* UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of the AWS Glue Studio node.
• Inputs – *Required:* An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the recipe node, identified by id.
• RecipeReference – *Required:* A `RecipeReference` object.
  
  A reference to the DataBrew recipe used by the node.

**RecipeReference structure**

A reference to a AWS Glue DataBrew recipe.

**Fields**

• RecipeArn – *Required:* UTF-8 string, matching the [Custom string pattern #32](#).
  
  The ARN of the DataBrew recipe.
• RecipeVersion – *Required:* UTF-8 string, not less than 1 or more than 16 bytes long.

  The RecipeVersion of the DataBrew recipe.

**SnowflakeNodeData structure**

Specifies configuration for Snowflake nodes in AWS Glue Studio.

**Fields**

• SourceType – UTF-8 string, matching the [Custom string pattern #31](#).

  Specifies how retrieved data is specified. Valid values: "table", "query".

• Connection – An [Option](#) object.

  Specifies a AWS Glue Data Catalog Connection to a Snowflake endpoint.

• Schema – UTF-8 string.

  Specifies a Snowflake database schema for your node to use.

• Table – UTF-8 string.

  Specifies a Snowflake table for your node to use.

• Database – UTF-8 string.

  Specifies a Snowflake database for your node to use.

• TempDir – UTF-8 string, matching the [Custom string pattern #32](#).

  Not currently used.

• IamRole – An [Option](#) object.

  Not currently used.

• AdditionalOptions – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #32](#).

  Each value is a UTF-8 string, matching the [Custom string pattern #32](#).

  Specifies additional options passed to the Snowflake connector. If options are specified elsewhere in this node, this will take precedence.
- **SampleQuery** – UTF-8 string.
  
  A SQL string used to retrieve data with the query `sourcetype`.

- **PreAction** – UTF-8 string.
  
  A SQL string run before the Snowflake connector performs its standard actions.

- **PostAction** – UTF-8 string.
  
  A SQL string run after the Snowflake connector performs its standard actions.

- **Action** – UTF-8 string.
  
  Specifies what action to take when writing to a table with preexisting data. Valid values: `append`, `merge`, `truncate`, `drop`.

- **Upsert** – Boolean.
  
  Used when Action is `append`. Specifies the resolution behavior when a row already exists. If true, preexisting rows will be updated. If false, those rows will be inserted.

- **MergeAction** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  Specifies a merge action. Valid values: `simple`, `custom`. If simple, merge behavior is defined by `MergeWhenMatched` and `MergeWhenNotMatched`. If custom, defined by `MergeClause`.

- **MergeWhenMatched** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  Specifies how to resolve records that match preexisting data when merging. Valid values: `update`, `delete`.

- **MergeWhenNotMatched** – UTF-8 string, matching the [Custom string pattern #31](#).
  
  Specifies how to process records that do not match preexisting data when merging. Valid values: `insert`, `none`.

- **MergeClause** – UTF-8 string.
  
  A SQL statement that specifies a custom merge behavior.

- **StagingTable** – UTF-8 string.
  
  The name of a staging table used when performing `merge` or `upsert` `append` actions. Data is written to this table, then moved to table by a generated postaction.

- **SelectedColumns** – An array of [Option](#) objects.
Specifies the columns combined to identify a record when detecting matches for merges and upserts. A list of structures with value, label and description keys. Each structure describes a column.

- AutoPushdown – Boolean.

  Specifies whether automatic query pushdown is enabled. If pushdown is enabled, then when a query is run on Spark, if part of the query can be "pushed down" to the Snowflake server, it is pushed down. This improves performance of some queries.

- TableSchema – An array of Option objects.

  Manually defines the target schema for the node. A list of structures with value, label and description keys. Each structure defines a column.

**SnowflakeSource structure**

Specifies a Snowflake data source.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#35).

  The name of the Snowflake data source.

- **Data** – *Required*: A [SnowflakeNodeData](#) object.

  Configuration for the Snowflake data source.

- **OutputSchemas** – An array of [GlueSchema](#) objects.

  Specifies user-defined schemas for your output data.

**SnowflakeTarget structure**

Specifies a Snowflake target.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).

  The name of the Snowflake target.
• Data – Required: A `SnowflakeNodeData` object.

  Specifies the data of the Snowflake target node.

• Inputs – An array of UTF-8 strings, not less than 1 or more than 1 strings.

  The nodes that are inputs to the data target.

### ConnectorDataSource structure

Specifies a source generated with standard connection options.

**Fields**

• Name – Required: UTF-8 string, matching the Custom string pattern #35.

  The name of this source node.

• ConnectionType – Required: UTF-8 string, matching the Custom string pattern #32.

  The `connectionType`, as provided to the underlying AWS Glue library. This node type supports the following connection types:

  • opensearch
  • azuresql
  • azurecosmos
  • bigquery
  • saphana
  • teradata
  • vertica

• Data – Required: A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A map specifying connection options for the node. You can find standard connection options for the corresponding connection type in the [Connection parameters](#) section of the AWS Glue documentation.

• OutputSchemas – An array of `GlueSchema` objects.
Specifies the data schema for this source.

**ConnectorDataTarget structure**

Specifies a target generated with standard connection options.

**Fields**

- **Name** – *Required*: UTF-8 string, matching the [Custom string pattern #35](#).
  
  The name of this target node.

- **ConnectionType** – *Required*: UTF-8 string, matching the [Custom string pattern #32](#).
  
  The `connectionType`, as provided to the underlying AWS Glue library. This node type supports the following connection types:
  
  - opensearch
  - azuresql
  - azurecosmos
  - bigquery
  - saphana
  - teradata
  - vertica

- **Data** – *Required*: A map array of key-value pairs.
  
  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A map specifying connection options for the node. You can find standard connection options for the corresponding connection type in the [Connection parameters](#) section of the AWS Glue documentation.

- **Inputs** – An array of UTF-8 strings, not less than 1 or more than 1 strings.
  
  The nodes that are inputs to the data target.
Jobs API

The Jobs API describes jobs data types and contains APIs for working with jobs, job runs, and triggers in AWS Glue.

Topics

- Jobs
- Job runs
- Triggers

Jobs

The Jobs API describes the data types and API related to creating, updating, deleting, or viewing jobs in AWS Glue.

Data types

- Job structure
- ExecutionProperty structure
- NotificationProperty structure
- JobCommand structure
- ConnectionsList structure
- JobUpdate structure
- SourceControlDetails structure

Job structure

Specifies a job definition.

Fields

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name you assign to this job definition.
• **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  A description of the job.

• **LogUri** – UTF-8 string.

  This field is reserved for future use.

• **Role** – UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role associated with this job.

• **CreatedOn** – Timestamp.

  The time and date that this job definition was created.

• **LastModifiedOn** – Timestamp.

  The last point in time when this job definition was modified.

• **ExecutionProperty** – An [ExecutionProperty](#) object.

  An ExecutionProperty specifying the maximum number of concurrent runs allowed for this job.

• **Command** – A [JobCommand](#) object.

  The JobCommand that runs this job.

• **DefaultArguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  The default arguments for every run of this job, specified as name-value pairs.

  You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.

  Job arguments may be logged. Do not pass plaintext secrets as arguments. Retrieve secrets from a AWS Glue Connection, AWS Secrets Manager or other secret management mechanism if you intend to keep them within the Job.
For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

For information about the arguments you can provide to this field when configuring Spark jobs, see the Special Parameters Used by AWS Glue topic in the developer guide.

For information about the arguments you can provide to this field when configuring Ray jobs, see Using job parameters in Ray jobs in the developer guide.

- NonOverridableArguments – A map array of key-value pairs.
  Each key is a UTF-8 string.
  Each value is a UTF-8 string.
  Arguments for this job that are not overridden when providing job arguments in a job run, specified as name-value pairs.

- Connections – A ConnectionsList object.
  The connections used for this job.

- MaxRetries – Number (integer).
  The maximum number of times to retry this job after a JobRun fails.

- AllocatedCapacity – Number (integer).
  This field is deprecated. Use MaxCapacity instead.
  The number of AWS Glue data processing units (DPUs) allocated to runs of this job. You can allocate a minimum of 2 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

- Timeout – Number (integer), at least 1.
  The job timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

- MaxCapacity – Number (double).
  For Glue version 1.0 or earlier jobs, using the standard worker type, the number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative
measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

For Glue version 2.0 or later jobs, you cannot specify a Maximum capacity. Instead, you should specify a Worker type and the Number of workers.

Do not set MaxCapacity if using WorkerType and NumberOfWorkers.

The value that can be allocated for MaxCapacity depends on whether you are running a Python shell job, an Apache Spark ETL job, or an Apache Spark streaming ETL job:

- When you specify a Python shell job (JobCommand.Name="pythonshell"), you can allocate either 0.0625 or 1 DPU. The default is 0.0625 DPU.

- When you specify an Apache Spark ETL job (JobCommand.Name="glueetl") or Apache Spark streaming ETL job (JobCommand.Name="gluestreaming"), you can allocate from 2 to 100 DPUs. The default is 10 DPUs. This job type cannot have a fractional DPU allocation.

- WorkerType – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, G.8X or G.025X for Spark jobs. Accepts the value Z.2X for Ray jobs.

- For the G.1X worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the G.2X worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the G.4X worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).
• For the G.8X worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the G.4X worker type.

• For the G.025X worker type, each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

• For the Z.2X worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

• NumberOfWorkers – Number (integer).

   The number of workers of a defined workerType that are allocated when a job runs.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

   The name of the SecurityConfiguration structure to be used with this job.

• NotificationProperty – A NotificationProperty object.

   Specifies configuration properties of a job notification.

• Running – Boolean.

   This field is reserved for future use.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.

   In Spark jobs, GlueVersion determines the versions of Apache Spark and Python that AWS Glue available in a job. The Python version indicates the version supported for jobs of type Spark.

   Ray jobs should set GlueVersion to 4.0 or greater. However, the versions of Ray, Python and additional libraries available in your Ray job are determined by the Runtime parameter of the Job command.

   For more information about the available AWS Glue versions and corresponding Spark and Python versions, see Glue version in the developer guide.
Jobs that are created without specifying a Glue version default to Glue 0.9.

- **CodeGenConfigurationNodes** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #31](#).

  Each value is a `CodeGenConfigurationNode` object.

  The representation of a directed acyclic graph on which both the Glue Studio visual component and Glue Studio code generation is based.

- **ExecutionClass** – UTF-8 string, not more than 16 bytes long (valid values: FLEX="" | STANDARD="").

  Indicates whether the job is run with a standard or flexible execution class. The standard execution class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

  The flexible execution class is appropriate for time-insensitive jobs whose start and completion times may vary.

  Only jobs with AWS Glue version 3.0 and above and command type `glueetl` will be allowed to set `ExecutionClass` to FLEX. The flexible execution class is available for Spark jobs.

- **SourceControlDetails** – A `SourceControlDetails` object.

  The details for a source control configuration for a job, allowing synchronization of job artifacts to or from a remote repository.

### ExecutionProperty structure

An execution property of a job.

**Fields**

- **MaxConcurrentRuns** – Number (integer).

  The maximum number of concurrent runs allowed for the job. The default is 1. An error is returned when this threshold is reached. The maximum value you can specify is controlled by a service limit.
NotificationProperty structure

Specifies configuration properties of a notification.

Fields

• NotifyDelayAfter – Number (integer), at least 1.

After a job run starts, the number of minutes to wait before sending a job run delay notification.

JobCommand structure

Specifies code that runs when a job is run.

Fields

• Name – UTF-8 string.

  The name of the job command. For an Apache Spark ETL job, this must be glueetl. For a Python shell job, it must be pythonshell. For an Apache Spark streaming ETL job, this must be gluestreaming. For a Ray job, this must be glueray.

• ScriptLocation – UTF-8 string, not more than 400000 bytes long.

  Specifies the Amazon Simple Storage Service (Amazon S3) path to a script that runs a job.

• PythonVersion – UTF-8 string, matching the Custom string pattern #16.

  The Python version being used to run a Python shell job. Allowed values are 2 or 3.

• Runtime – UTF-8 string, not more than 64 bytes long, matching the Custom string pattern #23.

  In Ray jobs, Runtime is used to specify the versions of Ray, Python and additional libraries available in your environment. This field is not used in other job types. For supported runtime environment values, see Working with Ray jobs in the AWS Glue Developer Guide.

ConnectionsList structure

Specifies the connections used by a job.

Fields

• Connections – An array of UTF-8 strings.
A list of connections used by the job.

**JobUpdate structure**

Specifies information used to update an existing job definition. The previous job definition is completely overwritten by this information.

**Fields**

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  
  Description of the job being defined.

- **LogUri** – UTF-8 string.

  This field is reserved for future use.

- **Role** – UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role associated with this job (required).

- **ExecutionProperty** – An ExecutionProperty object.

  An ExecutionProperty specifying the maximum number of concurrent runs allowed for this job.

- **Command** – A JobCommand object.

  The JobCommand that runs this job (required).

- **DefaultArguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  The default arguments for every run of this job, specified as name-value pairs.

  You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.
Job arguments may be logged. Do not pass plaintext secrets as arguments. Retrieve secrets from a AWS Glue Connection, AWS Secrets Manager or other secret management mechanism if you intend to keep them within the Job.

For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

For information about the arguments you can provide to this field when configuring Spark jobs, see the Special Parameters Used by AWS Glue topic in the developer guide.

For information about the arguments you can provide to this field when configuring Ray jobs, see Using job parameters in Ray jobs in the developer guide.

- **NonOverridableArguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  Arguments for this job that are not overridden when providing job arguments in a job run, specified as name-value pairs.

- **Connections** – A ConnectionsList object.

  The connections used for this job.

- **MaxRetries** – Number (integer).

  The maximum number of times to retry this job if it fails.

- **AllocatedCapacity** – Number (integer).

  This field is deprecated. Use MaxCapacity instead.

  The number of AWS Glue data processing units (DPUs) to allocate to this job. You can allocate a minimum of 2 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

- **Timeout** – Number (integer), at least 1.

  The job timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).
- **MaxCapacity** – Number (double).

For Glue version 1.0 or earlier jobs, using the standard worker type, the number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the [AWS Glue pricing page](#).

For Glue version 2.0+ jobs, you cannot specify a **Maximum capacity**. Instead, you should specify a **Worker type** and the **Number of workers**.

Do not set **MaxCapacity** if using **WorkerType** and **NumberOfWorkers**.

The value that can be allocated for **MaxCapacity** depends on whether you are running a Python shell job, an Apache Spark ETL job, or an Apache Spark streaming ETL job:

- When you specify a Python shell job (JobCommand.Name="pythonshell"), you can allocate either 0.0625 or 1 DPU. The default is 0.0625 DPU.

- When you specify an Apache Spark ETL job (JobCommand.Name="glueetl") or Apache Spark streaming ETL job (JobCommand.Name="gluestreaming"), you can allocate from 2 to 100 DPUs. The default is 10 DPUs. This job type cannot have a fractional DPU allocation.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, G.8X or G.025X for Spark jobs. Accepts the value Z.2X for Ray jobs.

- For the G.1X worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the G.2X worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the G.4X worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia),..
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US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).

• For the G.8X worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the G.4X worker type.

• For the G.025X worker type, each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

• For the Z.2X worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

• NumberOfWorkers – Number (integer).

  The number of workers of a defined workerType that are allocated when a job runs.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the SecurityConfiguration structure to be used with this job.

• NotificationProperty – A NotificationProperty object.

  Specifies the configuration properties of a job notification.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.

  In Spark jobs, GlueVersion determines the versions of Apache Spark and Python that AWS Glue available in a job. The Python version indicates the version supported for jobs of type Spark.

  Ray jobs should set GlueVersion to 4.0 or greater. However, the versions of Ray, Python and additional libraries available in your Ray job are determined by the Runtime parameter of the Job command.

  For more information about the available AWS Glue versions and corresponding Spark and Python versions, see Glue version in the developer guide.
Jobs that are created without specifying a Glue version default to Glue 0.9.

- **CodeGenConfigurationNodes** – A map array of key-value pairs.

  Each key is a UTF-8 string, matching the [Custom string pattern #31](#).

  Each value is a [CodeGenConfigurationNode](#) object.

  The representation of a directed acyclic graph on which both the Glue Studio visual component and Glue Studio code generation is based.

- **ExecutionClass** – UTF-8 string, not more than 16 bytes long (valid values: FLEX="" | STANDARD="").

  Indicates whether the job is run with a standard or flexible execution class. The standard execution-class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

  The flexible execution class is appropriate for time-insensitive jobs whose start and completion times may vary.

  Only jobs with AWS Glue version 3.0 and above and command type glueetl will be allowed to set ExecutionClass to FLEX. The flexible execution class is available for Spark jobs.

- **SourceControlDetails** – A [SourceControlDetails](#) object.

  The details for a source control configuration for a job, allowing synchronization of job artifacts to or from a remote repository.

**SourceControlDetails structure**

The details for a source control configuration for a job, allowing synchronization of job artifacts to or from a remote repository.

**Fields**

- **Provider** – UTF-8 string.

  The provider for the remote repository.

- **Repository** – UTF-8 string, not less than 1 or more than 512 bytes long.

  The name of the remote repository that contains the job artifacts.
• Owner – UTF-8 string, not less than 1 or more than 512 bytes long.

   The owner of the remote repository that contains the job artifacts.

• Branch – UTF-8 string, not less than 1 or more than 512 bytes long.

   An optional branch in the remote repository.

• Folder – UTF-8 string, not less than 1 or more than 512 bytes long.

   An optional folder in the remote repository.

• LastCommitId – UTF-8 string, not less than 1 or more than 512 bytes long.

   The last commit ID for a commit in the remote repository.

• LastSyncTimestamp – UTF-8 string, not less than 1 or more than 512 bytes long.

   The date and time that the last job synchronization was performed.

• AuthStrategy – UTF-8 string.

   The type of authentication, which can be an authentication token stored in AWS Secrets Manager, or a personal access token.

• AuthToken – UTF-8 string, not less than 1 or more than 512 bytes long.

   The value of an authorization token.

**Operations**

• [CreateJob action](http://example.com) ([Python: create_job])

• [UpdateJob action](http://example.com) ([Python: update_job])

• [GetJob action](http://example.com) ([Python: get_job])

• [GetJobs action](http://example.com) ([Python: get_jobs])

• [DeleteJob action](http://example.com) ([Python: delete_job])

• [ListJobs action](http://example.com) ([Python: list_jobs])

• [BatchGetJobs action](http://example.com) ([Python: batch_get_jobs])

• [UpdateSourceControlFromJob action](http://example.com) ([Python: update_source_control_from_job])

• [UpdateJobFromSourceControl action](http://example.com) ([Python: update_job_from_source_control])
CreateJob action (Python: create_job)

Creates a new job definition.

Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name you assign to this job definition. It must be unique in your account.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  Description of the job being defined.

- **LogUri** – UTF-8 string.

  This field is reserved for future use.

- **Role** – *Required:* UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role associated with this job.

- **ExecutionProperty** – An ExecutionProperty object.

  An ExecutionProperty specifying the maximum number of concurrent runs allowed for this job.

- **Command** – *Required:* A JobCommand object.

  The JobCommand that runs this job.

- **DefaultValueArguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  The default arguments for every run of this job, specified as name-value pairs.

  You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.
Job arguments may be logged. Do not pass plaintext secrets as arguments. Retrieve secrets from a AWS Glue Connection, AWS Secrets Manager or other secret management mechanism if you intend to keep them within the Job.

For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

For information about the arguments you can provide to this field when configuring Spark jobs, see the Special Parameters Used by AWS Glue topic in the developer guide.

For information about the arguments you can provide to this field when configuring Ray jobs, see Using job parameters in Ray jobs in the developer guide.

- **NonOverridableArguments** – A map array of key-value pairs.
  
  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  Arguments for this job that are not overridden when providing job arguments in a job run, specified as name-value pairs.

- **Connections** – A ConnectionsList object.
  
  The connections used for this job.

- **MaxRetries** – Number (integer).
  
  The maximum number of times to retry this job if it fails.

- **AllocatedCapacity** – Number (integer).
  
  This parameter is deprecated. Use MaxCapacity instead.

  The number of AWS Glue data processing units (DPUs) to allocate to this Job. You can allocate a minimum of 2 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

- **Timeout** – Number (integer), at least 1.
  
  The job timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).
• MaxCapacity – Number (double).

For Glue version 1.0 or earlier jobs, using the standard worker type, the number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

For Glue version 2.0+ jobs, you cannot specify a Maximum capacity. Instead, you should specify a Worker type and the Number of workers.

Do not set MaxCapacity if using WorkerType and NumberOfWorkers.

The value that can be allocated for MaxCapacity depends on whether you are running a Python shell job, an Apache Spark ETL job, or an Apache Spark streaming ETL job:

• When you specify a Python shell job (JobCommand.Name="pythonshell"), you can allocate either 0.0625 or 1 DPU. The default is 0.0625 DPU.

• When you specify an Apache Spark ETL job (JobCommand.Name="glueetl") or Apache Spark streaming ETL job (JobCommand.Name="gluestreaming"), you can allocate from 2 to 100 DPUs. The default is 10 DPUs. This job type cannot have a fractional DPU allocation.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the SecurityConfiguration structure to be used with this job.

• Tags – A map array of key-value pairs, not more than 50 pairs.

Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

Each value is a UTF-8 string, not more than 256 bytes long.

The tags to use with this job. You may use tags to limit access to the job. For more information about tags in AWS Glue, see AWS Tags in AWS Glue in the developer guide.

• NotificationProperty – A NotificationProperty object.

Specifies configuration properties of a job notification.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.
In Spark jobs, GlueVersion determines the versions of Apache Spark and Python that AWS Glue available in a job. The Python version indicates the version supported for jobs of type Spark.

Ray jobs should set GlueVersion to 4.0 or greater. However, the versions of Ray, Python and additional libraries available in your Ray job are determined by the Runtime parameter of the Job command.

For more information about the available AWS Glue versions and corresponding Spark and Python versions, see Glue version in the developer guide.

Jobs that are created without specifying a Glue version default to Glue 0.9.

- **NumberOfWorkers** – Number (integer).
  The number of workers of a defined workerType that are allocated when a job runs.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").
  The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, G.8X or G.025X for Spark jobs. Accepts the value Z.2X for Ray jobs.

  - For the G.1X worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

  - For the G.2X worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

  - For the G.4X worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).
• For the G.8X worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the G.4X worker type.

• For the G.025X worker type, each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

• For the Z.2X worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

• CodeGenConfigurationNodes – A map array of key-value pairs.

Each key is a UTF-8 string, matching the Custom string pattern #31.

Each value is a A CodeGenConfigurationNode object.

The representation of a directed acyclic graph on which both the Glue Studio visual component and Glue Studio code generation is based.

• ExecutionClass – UTF-8 string, not more than 16 bytes long (valid values: FLEX="" | STANDARD="").

 Indicates whether the job is run with a standard or flexible execution class. The standard execution-class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

The flexible execution class is appropriate for time-insensitive jobs whose start and completion times may vary.

Only jobs with AWS Glue version 3.0 and above and command type glueetl will be allowed to set ExecutionClass to FLEX. The flexible execution class is available for Spark jobs.

• SourceControlDetails – A SourceControlDetails object.

The details for a source control configuration for a job, allowing synchronization of job artifacts to or from a remote repository.
Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique name that was provided for this job definition.

Errors

- InvalidInputException
- IdempotentParameterMismatchException
- AlreadyExistsException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentModificationException

UpdateJob action (Python: update_job)

Updates an existing job definition. The previous job definition is completely overwritten by this information.

Request

- JobName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition to update.

  Specifies the values with which to update the job definition. Unspecified configuration is removed or reset to default values.

Response

- JobName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
Returns the name of the updated job definition.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- ConcurrentModificationException

GetJob action (Python: get_job)

Retrieves an existing job definition.

Request

- JobName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition to retrieve.

Response

- Job – A Job object.

  The requested job definition.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
GetJobs action (Python: get_jobs)

Retrieves all current job definitions.

Request

- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation call.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of the response.

Response

- **Jobs** – An array of **Job** objects.
  
  A list of job definitions.

- **NextToken** – UTF-8 string.
  
  A continuation token, if not all job definitions have yet been returned.

Errors

- **InvalidInputException**
- **EntityNotFoundException**
- **InternalServiceException**
- **OperationTimeoutException**

DeleteJob action (Python: delete_job)

Deletes a specified job definition. If the job definition is not found, no exception is thrown.

Request

- **JobName** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition to delete.
Response

- JobName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition that was deleted.

Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException

ListJobs action (Python: list_jobs)

Retrieves the names of all job resources in this AWS account, or the resources with the specified tag. This operation allows you to see which resources are available in your account, and their names.

This operation takes the optional Tags field, which you can use as a filter on the response so that tagged resources can be retrieved as a group. If you choose to use tags filtering, only resources with the tag are retrieved.

Request

- NextToken – UTF-8 string.

  A continuation token, if this is a continuation request.

- MaxResults – Number (integer), not less than 1 or more than 1000.

  The maximum size of a list to return.

- Tags – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  Specifies to return only these tagged resources.
Response

- **JobNames** – An array of UTF-8 strings.
  
  The names of all jobs in the account, or the jobs with the specified tags.
- **NextToken** – UTF-8 string.
  
  A continuation token, if the returned list does not contain the last metric available.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException

**BatchGetJobs action (Python: batch_get_jobs)**

Returns a list of resource metadata for a given list of job names. After calling the ListJobs operation, you can call this operation to access the data to which you have been granted permissions. This operation supports all IAM permissions, including permission conditions that uses tags.

Request

- **JobNames** – *Required: An array of UTF-8 strings.*
  
  A list of job names, which might be the names returned from the ListJobs operation.

Response

- **Jobs** – An array of Job objects.
  
  A list of job definitions.
- **JobsNotFound** – An array of UTF-8 strings.
  
  A list of names of jobs not found.
Errors

- InternalServiceException
- OperationTimeoutException
- InvalidInputException

**UpdateSourceControlFromJob action (Python: update_source_control_from_job)**

Synchronizes a job to the source control repository. This operation takes the job artifacts from the AWS Glue internal stores and makes a commit to the remote repository that is configured on the job.

This API supports optional parameters which take in the repository information.

**Request**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the AWS Glue job to be synchronized to or from the remote repository.

- **Provider** – UTF-8 string.
  
  The provider for the remote repository. Possible values: GITHUB, AWS_CODE_COMMIT, GITLAB, BITBUCKET.

- **RepositoryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the remote repository that contains the job artifacts. For BitBucket providers, `RepositoryName` should include `WorkspaceName`. Use the format `<WorkspaceName>/<RepositoryName>`.

- **RepositoryOwner** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The owner of the remote repository that contains the job artifacts.

- **BranchName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  An optional branch in the remote repository.
- Folder – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

An optional folder in the remote repository.

- CommitId – UTF-8 string, not less than 1 or more than 40 bytes long, matching the Single-line string pattern.

A commit ID for a commit in the remote repository.

- AuthStrategy – UTF-8 string.

  The type of authentication, which can be an authentication token stored in AWS Secrets Manager, or a personal access token.

- AuthToken – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The value of the authorization token.

**Response**

- JobName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the AWS Glue job.

**Errors**

- AccessDeniedException
- AlreadyExistsException
- InvalidInputException
- ValidationException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
UpdateJobFromSourceControl action (Python: update_job_from_source_control)

Synchronizes a job from the source control repository. This operation takes the job artifacts that are located in the remote repository and updates the AWS Glue internal stores with these artifacts.

This API supports optional parameters which take in the repository information.

**Request**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the AWS Glue job to be synchronized to or from the remote repository.

- **Provider** – UTF-8 string.

  The provider for the remote repository. Possible values: GITHUB, AWS_CODE_COMMIT, GITLAB, BITBUCKET.

- **RepositoryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the remote repository that contains the job artifacts. For BitBucket providers, RepositoryName should include WorkspaceName. Use the format `<WorkspaceName>/<RepositoryName>`.

- **RepositoryOwner** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The owner of the remote repository that contains the job artifacts.

- **BranchName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  An optional branch in the remote repository.

- **Folder** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  An optional folder in the remote repository.

- **CommitId** – UTF-8 string, not less than 1 or more than 40 bytes long, matching the Single-line string pattern.

  A commit ID for a commit in the remote repository.
• **AuthStrategy** – UTF-8 string.

  The type of authentication, which can be an authentication token stored in AWS Secrets Manager, or a personal access token.

• **AuthToken** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the `Single-line string pattern`.

  The value of the authorization token.

### Response

• **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the `Single-line string pattern`.

  The name of the AWS Glue job.

### Errors

• **AccessDeniedException**

• **AlreadyExistsException**

• **InvalidInputException**

• **ValidationException**

• **EntityNotFoundException**

• **InternalServiceException**

• **OperationTimeoutException**

### Job runs

The Jobs Runs API describes the data types and API related to starting, stopping, or viewing job runs, and resetting job bookmarks, in AWS Glue.

### Data types

• **JobRun structure**

• **Predecessor structure**

• **JobBookmarkEntry structure**
• **BatchStopJobRunSuccessfulSubmission** structure
• **BatchStopJobRunError** structure

**JobRun structure**

Contains information about a job run.

**Fields**

- **Id** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The ID of this job run.

- **Attempt** – Number (integer).

  The number of the attempt to run this job.

- **PreviousRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The ID of the previous run of this job. For example, the JobRunId specified in the StartJobRun action.

- **TriggerName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The name of the trigger that started this job run.

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The name of the job definition being used in this run.

- **StartedOn** – Timestamp.

  The date and time at which this job run was started.

- **LastModifiedOn** – Timestamp.

  The last time that this job run was modified.

- **CompletedOn** – Timestamp.

  The date and time that this job run completed.
• JobRunState – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT | ERROR | WAITING).

The current state of the job run. For more information about the statuses of jobs that have terminated abnormally, see AWS Glue Job Run Statuses.

• Arguments – A map array of key-value pairs.

Each key is a UTF-8 string.

Each value is a UTF-8 string.

The job arguments associated with this run. For this job run, they replace the default arguments set in the job definition itself.

You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.

Job arguments may be logged. Do not pass plaintext secrets as arguments. Retrieve secrets from a AWS Glue Connection, AWS Secrets Manager or other secret management mechanism if you intend to keep them within the Job.

For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

For information about the arguments you can provide to this field when configuring Spark jobs, see the Special Parameters Used by AWS Glue topic in the developer guide.

For information about the arguments you can provide to this field when configuring Ray jobs, see Using job parameters in Ray jobs in the developer guide.

• ErrorMessage – UTF-8 string.

An error message associated with this job run.

• PredecessorRuns – An array of Predecessor objects.

A list of predecessors to this job run.

• AllocatedCapacity – Number (integer).

This field is deprecated. Use MaxCapacity instead.
The number of AWS Glue data processing units (DPUs) allocated to this JobRun. From 2 to 100 DPUs can be allocated; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

- **ExecutionTime** – Number (integer).

  The amount of time (in seconds) that the job run consumed resources.

- **Timeout** – Number (integer), at least 1.

  The JobRun timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. This value overrides the timeout value set in the parent job.

  Streaming jobs do not have a timeout. The default for non-streaming jobs is 2,880 minutes (48 hours).

- **MaxCapacity** – Number (double).

  For Glue version 1.0 or earlier jobs, using the standard worker type, the number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

  For Glue version 2.0+ jobs, you cannot specify a Maximum capacity. Instead, you should specify a Worker type and the Number of workers.

  Do not set MaxCapacity if using WorkerType and NumberOfWorkers.

  The value that can be allocated for MaxCapacity depends on whether you are running a Python shell job, an Apache Spark ETL job, or an Apache Spark streaming ETL job:

  - When you specify a Python shell job (JobCommand.Name="pythonshell"), you can allocate either 0.0625 or 1 DPU. The default is 0.0625 DPU.

  - When you specify an Apache Spark ETL job (JobCommand.Name="glueetl") or Apache Spark streaming ETL job (JobCommand.Name="gluestreaming"), you can allocate from 2 to 100 DPUs. The default is 10 DPUs. This job type cannot have a fractional DPU allocation.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").
The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, G.8X or G.025X for Spark jobs. Accepts the value Z.2X for Ray jobs.

- For the **G.1X** worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the **G.2X** worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.

- For the **G.4X** worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).

- For the **G.8X** worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the **G.4X** worker type.

- For the **G.025X** worker type, each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

- For the **Z.2X** worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

- **NumberOfWorkers** – Number (integer).
  
  The number of workers of a defined **workerType** that are allocated when a job runs.

- **SecurityConfiguration** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the SecurityConfiguration structure to be used with this job run.
• **LogGroupName** – UTF-8 string.

    The name of the log group for secure logging that can be server-side encrypted in Amazon CloudWatch using AWS KMS. This name can be /aws-glue/jobs/, in which case the default encryption is NONE. If you add a role name and SecurityConfiguration name (in other words, /aws-glue/jobs-yourRoleName-yourSecurityConfigurationName/), then that security configuration is used to encrypt the log group.

• **NotificationProperty** – A [NotificationProperty](#) object.

    Specifies configuration properties of a job run notification.

• **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).

    In Spark jobs, GlueVersion determines the versions of Apache Spark and Python that AWS Glue available in a job. The Python version indicates the version supported for jobs of type Spark.

    Ray jobs should set GlueVersion to 4.0 or greater. However, the versions of Ray, Python and additional libraries available in your Ray job are determined by the Runtime parameter of the Job command.

    For more information about the available AWS Glue versions and corresponding Spark and Python versions, see [Glue version](#) in the developer guide.

    Jobs that are created without specifying a Glue version default to Glue 0.9.

• **DPUSeconds** – Number (double).

    This field populates only for Auto Scaling job runs, and represents the total time each executor ran during the lifecycle of a job run in seconds, multiplied by a DPU factor (1 for G.1X, 2 for G.2X, or 0.25 for G.025X workers). This value may be different than the executionEngineRuntime * MaxCapacity as in the case of Auto Scaling jobs, as the number of executors running at a given time may be less than the MaxCapacity. Therefore, it is possible that the value of DPUSeconds is less than executionEngineRuntime * MaxCapacity.

• **ExecutionClass** – UTF-8 string, not more than 16 bytes long (valid values: FLEX="" | STANDARD="").
Indicates whether the job is run with a standard or flexible execution class. The standard execution-class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

The flexible execution class is appropriate for time-insensitive jobs whose start and completion times may vary.

Only jobs with AWS Glue version 3.0 and above and command type `glueetl` will be allowed to set `ExecutionClass` to `FLEX`. The flexible execution class is available for Spark jobs.

**Predecessor structure**

A job run that was used in the predicate of a conditional trigger that triggered this job run.

**Fields**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The name of the job definition used by the predecessor job run.

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The job-run ID of the predecessor job run.

**JobBookmarkEntry structure**

Defines a point that a job can resume processing.

**Fields**

- **JobName** – UTF-8 string.
  
  The name of the job in question.

- **Version** – Number (integer).
  
  The version of the job.

- **Run** – Number (integer).
The run ID number.

- **Attempt** – Number (integer).

  The attempt ID number.

- **PreviousRunId** – UTF-8 string.

  The unique run identifier associated with the previous job run.

- **RunId** – UTF-8 string.

  The run ID number.

- **JobBookmark** – UTF-8 string.

  The bookmark itself.

### BatchStopJobRunSuccessfulSubmission structure

Records a successful request to stop a specified JobRun.

**Fields**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the job definition used in the job run that was stopped.

- **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The JobRunId of the job run that was stopped.

### BatchStopJobRunError structure

Records an error that occurred when attempting to stop a specified job run.

**Fields**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the job definition that is used in the job run in question.
• **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The JobRunId of the job run in question.

• **ErrorDetail** – An ErrorDetail object.

  Specifies details about the error that was encountered.

**Operations**

• **StartJobRun action (Python: start_job_run)**

• **BatchStopJobRun action (Python: batch_stop_job_run)**

• **GetJobRun action (Python: get_job_run)**

• **GetJobRuns action (Python: get_job_runs)**

• **GetJobBookmark action (Python: get_job_bookmark)**

• **GetJobBookmarks action (Python: get_job_bookmarks)**

• **ResetJobBookmark action (Python: reset_job_bookmark)**

**StartJobRun action (Python: start_job_run)**

Starts a job run using a job definition.

**Request**

• **JobName** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition to use.

• **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of a previous JobRun to retry.

• **Arguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.
The job arguments associated with this run. For this job run, they replace the default arguments set in the job definition itself.

You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.

Job arguments may be logged. Do not pass plaintext secrets as arguments. Retrieve secrets from a AWS Glue Connection, AWS Secrets Manager or other secret management mechanism if you intend to keep them within the Job.

For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

For information about the arguments you can provide to this field when configuring Spark jobs, see the Special Parameters Used by AWS Glue topic in the developer guide.

For information about the arguments you can provide to this field when configuring Ray jobs, see Using job parameters in Ray jobs in the developer guide.

- **AllocatedCapacity** – Number (integer).

  This field is deprecated. Use **MaxCapacity** instead.

  The number of AWS Glue data processing units (DPUs) to allocate to this JobRun. You can allocate a minimum of 2 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the [AWS Glue pricing page](https://aws.amazon.com/glue/pricing/).

- **Timeout** – Number (integer), at least 1.

  The JobRun timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. This value overrides the timeout value set in the parent job.

  Streaming jobs do not have a timeout. The default for non-streaming jobs is 2,880 minutes (48 hours).

- **MaxCapacity** – Number (double).

  For Glue version 1.0 or earlier jobs, using the standard worker type, the number of AWS Glue data processing units (DPUs) that can be allocated when this job runs. A DPU is a relative
measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

For Glue version 2.0+ jobs, you cannot specify a Maximum capacity. Instead, you should specify a Worker type and the Number of workers.

Do not set MaxCapacity if using WorkerType and NumberOfWorkers.

The value that can be allocated for MaxCapacity depends on whether you are running a Python shell job, an Apache Spark ETL job, or an Apache Spark streaming ETL job:

- When you specify a Python shell job (JobCommand.Name="pythonshell"), you can allocate either 0.0625 or 1 DPU. The default is 0.0625 DPU.
- When you specify an Apache Spark ETL job (JobCommand.Name="glueetl") or Apache Spark streaming ETL job (JobCommand.Name="gluestreaming"), you can allocate from 2 to 100 DPUs. The default is 10 DPUs. This job type cannot have a fractional DPU allocation.
- SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the SecurityConfiguration structure to be used with this job run.

- NotificationProperty – A NotificationProperty object.

Specifies configuration properties of a job run notification.

- WorkerType – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, G.8X or G.025X for Spark jobs. Accepts the value Z.2X for Ray jobs.

- For the G.1X worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.
- For the G.2X worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offers a scalable and cost effective way to run most jobs.
- For the G.4X worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend
this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).

- For the G.8X worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the G.4X worker type.

- For the G.025X worker type, each worker maps to 0.25 DPU (2 vCPUs, 4 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for low volume streaming jobs. This worker type is only available for AWS Glue version 3.0 streaming jobs.

- For the Z.2X worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

- **NumberOfWorkers** – Number (integer).

  The number of workers of a defined workerType that are allocated when a job runs.

- **ExecutionClass** – UTF-8 string, not more than 16 bytes long (valid values: FLEX="" | STANDARD="").

  Indicates whether the job is run with a standard or flexible execution class. The standard execution-class is ideal for time-sensitive workloads that require fast job startup and dedicated resources.

  The flexible execution class is appropriate for time-insensitive jobs whose start and completion times may vary.

  Only jobs with AWS Glue version 3.0 and above and command type glueetl will be allowed to set ExecutionClass to FLEX. The flexible execution class is available for Spark jobs.

**Response**

- **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The ID assigned to this job run.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentRunsExceededException

BatchStopJobRun action (Python: batch_stop_job_run)

Stops one or more job runs for a specified job definition.

Request

- JobName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job definition for which to stop job runs.

- JobRunIds – Required: An array of UTF-8 strings, not less than 1 or more than 25 strings.

  A list of the JobRunIds that should be stopped for that job definition.

Response

- SuccessfulSubmissions – An array of BatchStopJobRunSuccessfulSubmission objects.

  A list of the JobRuns that were successfully submitted for stopping.

- Errors – An array of BatchStopJobRunError objects.

  A list of the errors that were encountered in trying to stop JobRuns, including the JobRunId for which each error was encountered and details about the error.
Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException

GetJobRun action (Python: get_job_run)

Retrieves the metadata for a given job run.

Request

- JobName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the job definition being run.

- RunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the job run.

- PredecessorsIncluded – Boolean.

  True if a list of predecessor runs should be returned.

Response

- JobRun – A JobRun object.

  The requested job-run metadata.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
GetJobRuns action (Python: get_job_runs)

Retrieves metadata for all runs of a given job definition.

Request

- **JobName** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the job definition for which to retrieve all job runs.

- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation call.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of the response.

Response

- **JobRuns** – An array of JobRun objects.
  
  A list of job-run metadata objects.

- **NextToken** – UTF-8 string.
  
  A continuation token, if not all requested job runs have been returned.

Errors

- **InvalidInputException**
- **EntityNotFoundException**
- **InternalServiceException**
- **OperationTimeoutException**

GetJobBookmark action (Python: get_job_bookmark)

Returns information on a job bookmark entry.

For more information about enabling and using job bookmarks, see:
• Tracking processed data using job bookmarks
• Job parameters used by AWS Glue
• Job structure

Request

• JobName – Required: UTF-8 string.
  The name of the job in question.
• Version – Number (integer).
  The version of the job.
• RunId – UTF-8 string.
  The unique run identifier associated with this job run.

Response

• JobBookmarkEntry – A JobBookmarkEntry object.
  A structure that defines a point that a job can resume processing.

Errors

• EntityNotFoundException
• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• ValidationException

GetJobBookmarks action (Python: get_job_bookmarks)

Returns information on the job bookmark entries. The list is ordered on decreasing version numbers.

For more information about enabling and using job bookmarks, see:
Tracking processed data using job bookmarks

Job parameters used by AWS Glue

Job structure

Request

- JobName – *Required*: UTF-8 string.
  
  The name of the job in question.

- MaxResults – Number (integer).
  
  The maximum size of the response.

- NextToken – Number (integer).
  
  A continuation token, if this is a continuation call.

Response

- JobBookmarkEntries – An array of JobBookmarkEntry objects.
  
  A list of job bookmark entries that defines a point that a job can resume processing.

- NextToken – Number (integer).
  
  A continuation token, which has a value of 1 if all the entries are returned, or > 1 if not all requested job runs have been returned.

Errors

- InvalidInputException

- EntityNotFoundException

- InternalServiceException

- OperationTimeoutException

ResetJobBookmark action (Python: reset_job_bookmark)

Resets a bookmark entry.
For more information about enabling and using job bookmarks, see:

- Tracking processed data using job bookmarks
- Job parameters used by AWS Glue
- Job structure

**Request**

- **JobName** – *Required*: UTF-8 string.
  
  The name of the job in question.

- **RunId** – UTF-8 string.
  
  The unique run identifier associated with this job run.

**Response**

- **JobBookmarkEntry** – A JobBookmarkEntry object.
  
  The reset bookmark entry.

**Errors**

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException

**Triggers**

The Triggers API describes the data types and API related to creating, updating, or deleting, and starting and stopping job triggers in AWS Glue.

**Data types**

- Trigger structure
- TriggerUpdate structure
• Predicate structure
• Condition structure
• Action structure
• EventBatchingCondition structure

**Trigger structure**

Information about a specific trigger.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.
  
  The name of the trigger.

- **WorkflowName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.
  
  The name of the workflow associated with the trigger.

- **Id** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.
  
  Reserved for future use.

- **Type** – UTF-8 string (valid values: SCHEDULED | CONDITIONAL | ON_DEMAND | EVENT).
  
  The type of trigger that this is.

- **State** – UTF-8 string (valid values: CREATING | CREATED | ACTIVATING | ACTIVATED | DEACTIVATING | DEACTIVATED | DELETING | UPDATING).
  
  The current state of the trigger.

- **Description** – Description string, not more than 2048 bytes long, matching the *URL address multi-line string pattern*.
  
  A description of this trigger.

- **Schedule** – UTF-8 string.
A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

- **Actions** – An array of Action objects.

  The actions initiated by this trigger.

- **Predicate** – A Predicate object.

  The predicate of this trigger, which defines when it will fire.

- **EventBatchingCondition** – An EventBatchingCondition object.

  Batch condition that must be met (specified number of events received or batch time window expired) before EventBridge event trigger fires.

**TriggerUpdate structure**

A structure used to provide information used to update a trigger. This object updates the previous trigger definition by overwriting it completely.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Reserved for future use.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of this trigger.

- **Schedule** – UTF-8 string.

  A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

- **Actions** – An array of Action objects.

  The actions initiated by this trigger.
- **Predicate** – A [Predicate](#) object.

  The predicate of this trigger, which defines when it will fire.

- **EventBatchingCondition** – An [EventBatchingCondition](#) object.

  Batch condition that must be met (specified number of events received or batch time window expired) before EventBridge event trigger fires.

**Predicate structure**

Defines the predicate of the trigger, which determines when it fires.

**Fields**

- **Logical** – UTF-8 string (valid values: AND | ANY).

  An optional field if only one condition is listed. If multiple conditions are listed, then this field is required.

- **Conditions** – An array of [Condition](#) objects.

  A list of the conditions that determine when the trigger will fire.

**Condition structure**

Defines a condition under which a trigger fires.

**Fields**

- **LogicalOperator** – UTF-8 string (valid values: EQUALS).

  A logical operator.

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the job whose JobRuns this condition applies to, and on which this trigger waits.

- **State** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT | ERROR | WAITING).
The condition state. Currently, the only job states that a trigger can listen for are SUCCEEDED, STOPPED, FAILED, and TIMEOUT. The only crawler states that a trigger can listen for are SUCCEEDED, FAILED, and CANCELLED.

- **CrawlerName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the crawler to which this condition applies.

- **CrawlState** – UTF-8 string (valid values: RUNNING | CANCELLING | CANCELLED | SUCCEEDED | FAILED | ERROR).

  The state of the crawler to which this condition applies.

### Action structure

Defines an action to be initiated by a trigger.

**Fields**

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of a job to be run.

- **Arguments** – A map array of key-value pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  The job arguments used when this trigger fires. For this job run, they replace the default arguments set in the job definition itself.

  You can specify arguments here that your own job-execution script consumes, as well as arguments that AWS Glue itself consumes.

  For information about how to specify and consume your own Job arguments, see the Calling AWS Glue APIs in Python topic in the developer guide.

  For information about the key-value pairs that AWS Glue consumes to set up your job, see the Special Parameters Used by AWS Glue topic in the developer guide.
• Timeout – Number (integer), at least 1.

  The JobRun timeout in minutes. This is the maximum time that a job run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours). This overrides the timeout value set in the parent job.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the SecurityConfiguration structure to be used with this action.

• NotificationProperty – A NotificationProperty object.

  Specifies configuration properties of a job run notification.

• CrawlerName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the crawler to be used with this action.

**EventBatchingCondition structure**

Batch condition that must be met (specified number of events received or batch time window expired) before EventBridge event trigger fires.

**Fields**

• BatchSize – Required: Number (integer), not less than 1 or more than 100.

  Number of events that must be received from Amazon EventBridge before EventBridge event trigger fires.

• BatchWindow – Number (integer), not less than 1 or more than 900.

  Window of time in seconds after which EventBridge event trigger fires. Window starts when first event is received.

**Operations**

• [CreateTrigger action (Python: create_trigger)]

• [StartTrigger action (Python: start_trigger)]

• [GetTrigger action (Python: get_trigger)]
- **GetTriggers** action (Python: get_triggers)
- **UpdateTrigger** action (Python: update_trigger)
- **StopTrigger** action (Python: stop_trigger)
- **DeleteTrigger** action (Python: delete_trigger)
- **ListTriggers** action (Python: list_triggers)
- **BatchGetTriggers** action (Python: batch_get_triggers)

### CreateTrigger action (Python: create_trigger)

Creates a new trigger.

**Request**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the trigger.

- **WorkflowName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the workflow associated with the trigger.

- **Type** – *Required*: UTF-8 string (valid values: SCHEDULED | CONDITIONAL | ON_DEMAND | EVENT).

  The type of the new trigger.

- **Schedule** – UTF-8 string.

  A cron expression used to specify the schedule (see Time-Based Schedules for Jobs and Crawlers. For example, to run something every day at 12:15 UTC, you would specify: `cron(15 12 * * ? *)`.

  This field is required when the trigger type is SCHEDULED.

- **Predicate** – A Predicate object.

  A predicate to specify when the new trigger should fire.

  This field is required when the trigger type is CONDITIONAL.

- **Actions** – *Required*: An array of Action objects.
The actions initiated by this trigger when it fires.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the new trigger.

- **StartOnCreation** – Boolean.

  Set to true to start SCHEDULED and CONDITIONAL triggers when created. True is not supported for ON_DEMAND triggers.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags to use with this trigger. You may use tags to limit access to the trigger. For more information about tags in AWS Glue, see [AWS Tags in AWS Glue](#) in the developer guide.

- **EventBatchingCondition** – An EventBatchingCondition object.

  Batch condition that must be met (specified number of events received or batch time window expired) before EventBridge event trigger fires.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the trigger.

**Errors**

- AlreadyExistsException
- EntityNotFoundException
- InvalidInputException
- IdempotentParameterMismatchException
- InternalServiceException
• OperationTimeoutException
• ResourceNumberLimitExceededException
• ConcurrentModificationException

**StartTrigger action (Python: start_trigger)**

Starts an existing trigger. See [Triggering Jobs](#) for information about how different types of trigger are started.

**Request**

- **Name** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*
  
  The name of the trigger to start.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the trigger that was started.

**Errors**

- InvalidInputException
- InternalServiceException
- EntityNotFoundException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentRunsExceededExeception

**GetTrigger action (Python: get_trigger)**

Retrieves the definition of a trigger.
Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern.*

  The name of the trigger to retrieve.

Response

- **Trigger** – A [Trigger](#) object.

  The requested trigger definition.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException

**GetTriggers action (Python: get_triggers)**

Gets all the triggers associated with a job.

Request

- **NextToken** – UTF-8 string.

  A continuation token, if this is a continuation call.

- **DependentJobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern.*

  The name of the job to retrieve triggers for. The trigger that can start this job is returned, and if there is no such trigger, all triggers are returned.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum size of the response.
Response

- Triggers – An array of Trigger objects.
  A list of triggers for the specified job.
- NextToken – UTF-8 string.
  A continuation token, if not all the requested triggers have yet been returned.

Errors

- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException

UpdateTrigger action (Python: update_trigger)

Updates a trigger definition.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the trigger to update.
- TriggerUpdate – Required: A TriggerUpdate object.
  The new values with which to update the trigger.

Response

- Trigger – A Trigger object.
  The resulting trigger definition.
Errors

- InvalidInputException
- InternalServiceException
- EntityNotFoundException
- OperationTimeoutException
- ConcurrentModificationException

StopTrigger action (Python: stop_trigger)

Stops a specified trigger.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the trigger to stop.

Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the trigger that was stopped.

Errors

- InvalidInputException
- InternalServiceException
- EntityNotFoundException
- OperationTimeoutException
- ConcurrentModificationException
DeleteTrigger action (Python: delete_trigger)

Deletes a specified trigger. If the trigger is not found, no exception is thrown.

**Request**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the trigger to delete.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the trigger that was deleted.

**Errors**

- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ConcurrentModificationException

ListTriggers action (Python: list_triggers)

Retrieves the names of all trigger resources in this AWS account, or the resources with the specified tag. This operation allows you to see which resources are available in your account, and their names.

This operation takes the optional Tags field, which you can use as a filter on the response so that tagged resources can be retrieved as a group. If you choose to use tags filtering, only resources with the tag are retrieved.

**Request**

- **NextToken** – UTF-8 string.
A continuation token, if this is a continuation request.

- **DependentJobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the job for which to retrieve triggers. The trigger that can start this job is returned. If there is no such trigger, all triggers are returned.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum size of a list to return.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  Specifies to return only these tagged resources.

**Response**

- **TriggerNames** – An array of UTF-8 strings.

  The names of all triggers in the account, or the triggers with the specified tags.

- **NextToken** – UTF-8 string.

  A continuation token, if the returned list does not contain the last metric available.

**Errors**

- **EntityNotFoundException**
- **InvalidInputException**
- **InternalServiceException**
- **OperationTimeoutException**

**BatchGetTriggers action (Python: batch_get_triggers)**

Returns a list of resource metadata for a given list of trigger names. After calling the ListTriggers operation, you can call this operation to access the data to which you have been
granted permissions. This operation supports all IAM permissions, including permission conditions that uses tags.

Request

- **TriggerNames** – *Required: An array of UTF-8 strings.*

  A list of trigger names, which may be the names returned from the ListTriggers operation.

Response

- **Triggers** – An array of **Trigger** objects.

  A list of trigger definitions.
- **TriggersNotFound** – An array of UTF-8 strings.

  A list of names of triggers not found.

Errors

- **InternalServiceException**
- **OperationTimeoutException**
- **InvalidInputException**

Interactive sessions API

The interactive sessions API describes the AWS Glue API related to using AWS Glue interactive sessions to build and test extract, transform, and load (ETL) scripts for data integration.

Data types

- **Session structure**
- **SessionCommand structure**
- **Statement structure**
- **StatementOutput structure**
- **StatementOutputData structure**
Session structure

The period in which a remote Spark runtime environment is running.

Fields

- **Id** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*. The ID of the session.
- **CreatedOn** – Timestamp. The time and date when the session was created.
- **Status** – UTF-8 string (valid values: PROVISIONING | READY | FAILED | TIMEOUT | STOPPING | STOPPED). The session status.
- **ErrorMessage** – Description string, not more than 2048 bytes long, matching the *URI address multi-line string pattern*. The error message displayed during the session.
- **Description** – Description string, not more than 2048 bytes long, matching the *URI address multi-line string pattern*. The description of the session.
- **Role** – UTF-8 string, not less than 20 or more than 2048 bytes long, matching the *Custom string pattern #20*. The name or Amazon Resource Name (ARN) of the IAM role associated with the Session.
- **Command** – A *SessionCommand* object. The command object. See SessionCommand.
- **DefaultArguments** – A map array of key-value pairs, not more than 75 pairs. Each key is a UTF-8 string, not less than 1 or more than 128 bytes long, matching the *Custom string pattern #21*. Each value is a UTF-8 string, not more than 4096 bytes long, matching the *URI address multi-line string pattern*. 
A map array of key-value pairs. Max is 75 pairs.

- **Connections** – A [ConnectionsList](#) object.
  
  The number of connections used for the session.

- **Progress** – Number (double).
  
  The code execution progress of the session.

- **MaxCapacity** – Number (double).
  
  The number of AWS Glue data processing units (DPUs) that can be allocated when the job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB memory.

- **SecurityConfiguration** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the SecurityConfiguration structure to be used with the session.

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.
  
  The AWS Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The GlueVersion must be greater than 2.0.

- **DataAccessId** – UTF-8 string, not less than 1 or more than 36 bytes long.
  
  The data access ID of the session.

- **PartitionId** – UTF-8 string, not less than 1 or more than 36 bytes long.
  
  The partition ID of the session.

- **NumberOfWorkers** – Number (integer).
  
  The number of workers of a defined WorkerType to use for the session.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").
  
  The type of predefined worker that is allocated when a session runs. Accepts a value of G.1X, G.2X, G.4X, or G.8X for Spark sessions. Accepts the value Z.2X for Ray sessions.

- **CompletedOn** – Timestamp.
The date and time that this session is completed.

- **ExecutionTime** – Number (double).

  The total time the session ran for.

- **DPUS Seconds** – Number (double).

  The DPUs consumed by the session (formula: ExecutionTime * MaxCapacity).

- **IdleTimeout** – Number (integer).

  The number of minutes when idle before the session times out.

**SessionCommand structure**

The sessionCommand that runs the job.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Specifies the name of the SessionCommand. Can be 'glueetl' or 'gluestreaming'.

- **PythonVersion** – UTF-8 string, matching the [Custom string pattern #16](#).

  Specifies the Python version. The Python version indicates the version supported for jobs of type Spark.

**Statement structure**

The statement or request for a particular action to occur in a session.

**Fields**

- **Id** – Number (integer).

  The ID of the statement.

- **Code** – UTF-8 string.

  The execution code of the statement.
- **State** – UTF-8 string (valid values: WAITING | RUNNING | AVAILABLE | CANCELLING | CANCELLED | ERROR).

  The state while request is actioned.

- **Output** – A **StatementOutput** object.

  The output in JSON.

- **Progress** – Number (double).

  The code execution progress.

- **StartedOn** – Number (long).

  The unix time and date that the job definition was started.

- **CompletedOn** – Number (long).

  The unix time and date that the job definition was completed.

**StatementOutput structure**

The code execution output in JSON format.

**Fields**

- **Data** – A **StatementOutputData** object.

  The code execution output.

- **ExecutionCount** – Number (integer).

  The execution count of the output.

- **Status** – UTF-8 string (valid values: WAITING | RUNNING | AVAILABLE | CANCELLING | CANCELLED | ERROR).

  The status of the code execution output.

- **ErrorName** – UTF-8 string.

  The name of the error in the output.

- **ErrorValue** – UTF-8 string.

  The error value of the output.
• Traceback – An array of UTF-8 strings.

The traceback of the output.

StatementOutputData structure

The code execution output in JSON format.

Fields

• TextPlain – UTF-8 string.

The code execution output in text format.

Operations

• CreateSession action (Python: create_session)
• StopSession action (Python: stop_session)
• DeleteSession action (Python: delete_session)
• GetSession action (Python: get_session)
• ListSessions action (Python: list_sessions)
• RunStatement action (Python: run_statement)
• CancelStatement action (Python: cancel_statement)
• GetStatement action (Python: get_statement)
• ListStatements action (Python: list_statements)

CreateSession action (Python: create_session)

Creates a new session.

Request

Request to create a new session.

• Id – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The ID of the session request.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  The description of the session.

- **Role** – *Required:* UTF-8 string, not less than 20 or more than 2048 bytes long, matching the Custom string pattern #20.

  The IAM Role ARN

- **Command** – *Required:* A SessionCommand object.

  The SessionCommand that runs the job.

- **Timeout** – Number (integer), at least 1.

  The number of minutes before session times out. Default for Spark ETL jobs is 48 hours (2880 minutes), the maximum session lifetime for this job type. Consult the documentation for other job types.

- **IdleTimeout** – Number (integer), at least 1.

  The number of minutes when idle before session times out. Default for Spark ETL jobs is value of Timeout. Consult the documentation for other job types.

- **DefaultArguments** – A map array of key-value pairs, not more than 75 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.

  Each value is a UTF-8 string, not more than 4096 bytes long, matching the URI address multi-line string pattern.

  A map array of key-value pairs. Max is 75 pairs.

- **Connections** – A ConnectionsList object.

  The number of connections to use for the session.

- **MaxCapacity** – Number (double).
The number of AWS Glue data processing units (DPUs) that can be allocated when the job runs. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB memory.

- **NumberOfWorkers** – Number (integer).

  The number of workers of a defined **WorkerType** to use for the session.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

  The type of predefined worker that is allocated when a job runs. Accepts a value of G.1X, G.2X, G.4X, or G.8X for Spark jobs. Accepts the value Z.2X for Ray notebooks.

  - For the **G.1X** worker type, each worker maps to 1 DPU (4 vCPUs, 16 GB of memory) with 84GB disk (approximately 34GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offer a scalable and cost effective way to run most jobs.

  - For the **G.2X** worker type, each worker maps to 2 DPU (8 vCPUs, 32 GB of memory) with 128GB disk (approximately 77GB free), and provides 1 executor per worker. We recommend this worker type for workloads such as data transforms, joins, and queries, to offer a scalable and cost effective way to run most jobs.

  - For the **G.4X** worker type, each worker maps to 4 DPU (16 vCPUs, 64 GB of memory) with 256GB disk (approximately 235GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs in the following AWS Regions: US East (Ohio), US East (N. Virginia), US West (Oregon), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Tokyo), Canada (Central), Europe (Frankfurt), Europe (Ireland), and Europe (Stockholm).

  - For the **G.8X** worker type, each worker maps to 8 DPU (32 vCPUs, 128 GB of memory) with 512GB disk (approximately 487GB free), and provides 1 executor per worker. We recommend this worker type for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. This worker type is available only for AWS Glue version 3.0 or later Spark ETL jobs, in the same AWS Regions as supported for the **G.4X** worker type.

  - For the **Z.2X** worker type, each worker maps to 2 M-DPU (8vCPUs, 64 GB of memory) with 128 GB disk (approximately 120GB free), and provides up to 8 Ray workers based on the autoscaler.

- **SecurityConfiguration** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/security-configuration.html).
The name of the SecurityConfiguration structure to be used with the session

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).

  The AWS Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The GlueVersion must be greater than 2.0.

- **DataAccessId** – UTF-8 string, not less than 1 or more than 36 bytes long.

  The data access ID of the session.

- **PartitionId** – UTF-8 string, not less than 1 or more than 36 bytes long.

  The partition ID of the session.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The map of key value pairs (tags) belonging to the session.

- **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The origin of the request.

**Response**

- **Session** – A [Session](session) object.

  Returns the session object in the response.

**Errors**

- AccessDeniedException
- IdempotentParameterMismatchException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException
• ValidationException
• AlreadyExistsException
• ResourceNumberLimitExceeded

**StopSession action (Python: stop_session)**

Stops the session.

**Request**

- **Id** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the `Single-line string pattern`.

  The ID of the session to be stopped.

- **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the `Custom string pattern #21`.

  The origin of the request.

**Response**

- **Id** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the `Single-line string pattern`.

  Returns the Id of the stopped session.

**Errors**

- AccessDeniedException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException
- IllegalSessionStateException
- ConcurrentModificationException
DeleteSession action (Python: delete_session)

Deletes the session.

Request

- **Id** – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the session to be deleted.

- **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The name of the origin of the delete session request.

Response

- **Id** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Returns the ID of the deleted session.

Errors

- AccessDeniedException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException
- IllegalSessionStateException
- ConcurrentModificationException

GetSession action (Python: get_session)

Retrieves the session.
Request

- **Id** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
The ID of the session.

- **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).
  
The origin of the request.

Response

- **Session** – A [Session](#) object.
  
The session object is returned in the response.

Errors

- AccessDeniedException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException

ListSessions action (Python: list_sessions)

Retrieve a list of sessions.

Request

- **NextToken** – UTF-8 string, not more than 400000 bytes long.
  
The token for the next set of results, or null if there are no more result.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
The maximum number of results.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.
Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

Each value is a UTF-8 string, not more than 256 bytes long.

Tags belonging to the session.
• **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.

The origin of the request.

**Response**

• **Ids** – An array of UTF-8 strings.

  Returns the ID of the session.

• **Sessions** – An array of Session objects.

  Returns the session object.

• **NextToken** – UTF-8 string, not more than 400000 bytes long.

  The token for the next set of results, or null if there are no more result.

**Errors**

• AccessDeniedException
• InvalidInputException
• InternalServiceException
• OperationTimeoutException

**RunStatement action (Python: run_statement)**

Executes the statement.

**Request**

• **SessionId** – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The Session Id of the statement to be run.

- **Code** – *Required:* UTF-8 string, not more than 68000 bytes long.
  
  The statement code to be run.

- **RequestOrigin** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The origin of the request.

**Response**

- **Id** – Number (integer).

  Returns the Id of the statement that was run.

**Errors**

- **EntityNotFoundException**
- **AccessDeniedException**
- **InternalServiceException**
- **OperationTimeoutException**
- **InvalidInputException**
- **ValidationException**
- **ResourceNumberLimitExceededException**
- **IllegalSessionStateException**

**CancelStatement action (Python: cancel_statement)**

Cancels the statement.

**Request**

- **SessionId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The Session ID of the statement to be cancelled.
• Id – **Required**: Number (integer).

  The ID of the statement to be cancelled.

• RequestOrigin – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The origin of the request to cancel the statement.

**Response**

• *No Response parameters.*

**Errors**

• AccessDeniedException
• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException
• InvalidInputException
• IllegalSessionStateException

**GetStatement action (Python: get_statement)**

Retrieves the statement.

**Request**

• SessionId – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The Session ID of the statement.

• Id – **Required**: Number (integer).

  The Id of the statement.

• RequestOrigin – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).
The origin of the request.

Response

• Statement – A Statement object.

   Returns the statement.

Errors

• AccessDeniedException
• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException
• InvalidInputException
• IllegalSessionStateException

ListStatements action (Python: list_statements)

Lists statements for the session.

Request

• SessionId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

   The Session ID of the statements.

• RequestOrigin – UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.

   The origin of the request to list statements.

• NextToken – UTF-8 string, not more than 400000 bytes long.

   A continuation token, if this is a continuation call.
Response

- **Statements** – An array of `Statement` objects.
  
  Returns the list of statements.

- **NextToken** – UTF-8 string, not more than 400000 bytes long.
  
  A continuation token, if not all statements have yet been returned.

Errors

- **AccessDeniedException**
- **EntityNotFoundException**
- **InternalServiceException**
- **OperationTimeoutException**
- **InvalidInputException**
- **IllegalSessionStateException**

Development endpoints API

The Development endpoints API describes the AWS Glue API related to testing using a custom DevEndpoint.

Data types

- [DevEndpoint structure](#)
- [DevEndpointCustomLibraries structure](#)

DevEndpoint structure

A development endpoint where a developer can remotely debug extract, transform, and load (ETL) scripts.

Fields

- **EndpointName** – UTF-8 string.
The name of the DevEndpoint.


  The Amazon Resource Name (ARN) of the IAM role used in this DevEndpoint.

- **SecurityGroupIds** – An array of UTF-8 strings.

  A list of security group identifiers used in this DevEndpoint.

- **SubnetId** – UTF-8 string.

  The subnet ID for this DevEndpoint.

- **YarnEndpointAddress** – UTF-8 string.

  The YARN endpoint address used by this DevEndpoint.

- **PrivateAddress** – UTF-8 string.

  A private IP address to access the DevEndpoint within a VPC if the DevEndpoint is created within one. The PrivateAddress field is present only when you create the DevEndpoint within your VPC.

- **ZeppelinRemoteSparkInterpreterPort** – Number (integer).

  The Apache Zeppelin port for the remote Apache Spark interpreter.

- **PublicAddress** – UTF-8 string.

  The public IP address used by this DevEndpoint. The PublicAddress field is present only when you create a non-virtual private cloud (VPC) DevEndpoint.

- **Status** – UTF-8 string.

  The current status of this DevEndpoint.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

  The type of predefined worker that is allocated to the development endpoint. Accepts a value of Standard, G.1X, or G.2X.

  - For the Standard worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
For the G.1X worker type, each worker maps to 1 DPU (4 vCPU, 16 GB of memory, 64 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs.

For the G.2X worker type, each worker maps to 2 DPU (8 vCPU, 32 GB of memory, 128 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs.

Known issue: when a development endpoint is created with the G.2X WorkerType configuration, the Spark drivers for the development endpoint will run on 4 vCPU, 16 GB of memory, and a 64 GB disk.

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).

Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The Python version indicates the version supported for running your ETL scripts on development endpoints.

For more information about the available AWS Glue versions and corresponding Spark and Python versions, see [Glue version](#) in the developer guide.

Development endpoints that are created without specifying a Glue version default to Glue 0.9.

You can specify a version of Python support for development endpoints by using the `Arguments` parameter in the `CreateDevEndpoint` or `UpdateDevEndpoint` APIs. If no arguments are provided, the version defaults to Python 2.

- **NumberOfWorkers** – Number (integer).

  The number of workers of a defined `workerType` that are allocated to the development endpoint.

  The maximum number of workers you can define are 299 for G.1X, and 149 for G.2X.

- **NumberOfNodes** – Number (integer).

  The number of AWS Glue Data Processing Units (DPUs) allocated to this DevEndpoint.

- **AvailabilityZone** – UTF-8 string.

  The AWS Availability Zone where this DevEndpoint is located.

- **VpcId** – UTF-8 string.
The ID of the virtual private cloud (VPC) used by this DevEndpoint.

- **ExtraPythonLibsS3Path** – UTF-8 string.
  
The paths to one or more Python libraries in an Amazon S3 bucket that should be loaded in your DevEndpoint. Multiple values must be complete paths separated by a comma.

  ![Note]

  You can only use pure Python libraries with a DevEndpoint. Libraries that rely on C extensions, such as the pandas Python data analysis library, are not currently supported.

- **ExtraJarsS3Path** – UTF-8 string.
  
The path to one or more Java .jar files in an S3 bucket that should be loaded in your DevEndpoint.

  ![Note]

  You can only use pure Java/Scala libraries with a DevEndpoint.

- **FailureReason** – UTF-8 string.
  
The reason for a current failure in this DevEndpoint.

- **LastUpdateStatus** – UTF-8 string.
  
The status of the last update.

- **CreatedTimestamp** – Timestamp.
  
The point in time at which this DevEndpoint was created.

- **LastModifiedTimestamp** – Timestamp.
  
The point in time at which this DevEndpoint was last modified.

- **PublicKey** – UTF-8 string.
  
The public key to be used by this DevEndpoint for authentication. This attribute is provided for backward compatibility because the recommended attribute to use is public keys.

- **PublicKeys** – An array of UTF-8 strings, not more than 5 strings.
A list of public keys to be used by the DevEndpoints for authentication. Using this attribute is preferred over a single public key because the public keys allow you to have a different private key per client.

**Note**

If you previously created an endpoint with a public key, you must remove that key to be able to set a list of public keys. Call the UpdateDevEndpoint API operation with the public key content in the deletePublicKeys attribute, and the list of new keys in the addPublicKeys attribute.

- **SecurityConfiguration** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the SecurityConfiguration structure to be used with this DevEndpoint.

- **Arguments** – A map array of key-value pairs, not more than 100 pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A map of arguments used to configure the DevEndpoint.

  Valid arguments are:

  - "--enable-glue-datacatalog": ""

    You can specify a version of Python support for development endpoints by using the Arguments parameter in the CreateDevEndpoint or UpdateDevEndpoint APIs. If no arguments are provided, the version defaults to Python 2.

**DevEndpointCustomLibraries structure**

Custom libraries to be loaded into a development endpoint.

**Fields**

- **ExtraPythonLibsS3Path** – UTF-8 string.
The paths to one or more Python libraries in an Amazon Simple Storage Service (Amazon S3) bucket that should be loaded in your DevEndpoint. Multiple values must be complete paths separated by a comma.

ℹ️ **Note**

You can only use pure Python libraries with a DevEndpoint. Libraries that rely on C extensions, such as the pandas Python data analysis library, are not currently supported.

- ExtraJarsS3Path – UTF-8 string.

The path to one or more Java .jar files in an S3 bucket that should be loaded in your DevEndpoint.

ℹ️ **Note**

You can only use pure Java/Scala libraries with a DevEndpoint.

### Operations

- [CreateDevEndpoint action](Python: create_dev_endpoint)
- [UpdateDevEndpoint action](Python: update_dev_endpoint)
- [DeleteDevEndpoint action](Python: delete_dev_endpoint)
- [GetDevEndpoint action](Python: get_dev_endpoint)
- [GetDevEndpoints action](Python: get_dev_endpoints)
- [BatchGetDevEndpoints action](Python: batch_get_dev_endpoints)
- [ListDevEndpoints action](Python: list_dev_endpoints)

### CreateDevEndpoint action (Python: create_dev_endpoint)

Creates a new development endpoint.

**Request**

- EndpointName – **Required**: UTF-8 string.
The name to be assigned to the new DevEndpoint.

  
  The IAM role for the DevEndpoint.

- **SecurityGroupIds** – An array of UTF-8 strings.
  
  Security group IDs for the security groups to be used by the new DevEndpoint.

- **SubnetId** – UTF-8 string.
  
  The subnet ID for the new DevEndpoint to use.

- **PublicKey** – UTF-8 string.
  
  The public key to be used by this DevEndpoint for authentication. This attribute is provided for backward compatibility because the recommended attribute to use is public keys.

- **PublicKeys** – An array of UTF-8 strings, not more than 5 strings.
  
  A list of public keys to be used by the development endpoints for authentication. The use of this attribute is preferred over a single public key because the public keys allow you to have a different private key per client.

  **Note**
  
  If you previously created an endpoint with a public key, you must remove that key to be able to set a list of public keys. Call the UpdateDevEndpoint API with the public key content in the `deletePublicKeys` attribute, and the list of new keys in the `addPublicKeys` attribute.

- **NumberOfNodes** – Number (integer).
  
  The number of AWS Glue Data Processing Units (DPUs) to allocate to this DevEndpoint.

- **WorkerType** – UTF-8 string (valid values: `Standard` | `G.1X` | `G.2X` | `G.025X` | `G.4X` | `G.8X` | `Z.2X`).
  
  The type of predefined worker that is allocated to the development endpoint. Accepts a value of `Standard`, `G.1X`, or `G.2X`.

  - For the `Standard` worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
• For the G.1X worker type, each worker maps to 1 DPU (4 vCPU, 16 GB of memory, 64 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs.

• For the G.2X worker type, each worker maps to 2 DPU (8 vCPU, 32 GB of memory, 128 GB disk), and provides 1 executor per worker. We recommend this worker type for memory-intensive jobs.

Known issue: when a development endpoint is created with the G.2X WorkerType configuration, the Spark drivers for the development endpoint will run on 4 vCPU, 16 GB of memory, and a 64 GB disk.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.

Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The Python version indicates the version supported for running your ETL scripts on development endpoints.

For more information about the available AWS Glue versions and corresponding Spark and Python versions, see Glue version in the developer guide.

Development endpoints that are created without specifying a Glue version default to Glue 0.9.

You can specify a version of Python support for development endpoints by using the Arguments parameter in the CreateDevEndpoint or UpdateDevEndpoint APIs. If no arguments are provided, the version defaults to Python 2.

• NumberOfWorkers – Number (integer).

The number of workers of a defined workerType that are allocated to the development endpoint.

The maximum number of workers you can define are 299 for G.1X, and 149 for G.2X.

• ExtraPythonLibsS3Path – UTF-8 string.

The paths to one or more Python libraries in an Amazon S3 bucket that should be loaded in your DevEndpoint. Multiple values must be complete paths separated by a comma.
Note

You can only use pure Python libraries with a DevEndpoint. Libraries that rely on C extensions, such as the pandas Python data analysis library, are not yet supported.

• ExtraJarsS3Path – UTF-8 string.

  The path to one or more Java .jar files in an S3 bucket that should be loaded in your DevEndpoint.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the SecurityConfiguration structure to be used with this DevEndpoint.

• Tags – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags to use with this DevEndpoint. You may use tags to limit access to the DevEndpoint. For more information about tags in AWS Glue, see AWS Tags in AWS Glue in the developer guide.

• Arguments – A map array of key-value pairs, not more than 100 pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  A map of arguments used to configure the DevEndpoint.

Response

• EndpointName – UTF-8 string.

  The name assigned to the new DevEndpoint.

• Status – UTF-8 string.

  The current status of the new DevEndpoint.

• SecurityGroupIds – An array of UTF-8 strings.
The security groups assigned to the new DevEndpoint.

- **SubnetId** – UTF-8 string.
  
  The subnet ID assigned to the new DevEndpoint.

- **RoleArn** – UTF-8 string, matching the [AWS IAM ARN string pattern](https://docs.aws.amazon.com/IAM/latest/userguide/arns.html).
  
  The Amazon Resource Name (ARN) of the role assigned to the new DevEndpoint.

- **YarnEndpointAddress** – UTF-8 string.
  
  The address of the YARN endpoint used by this DevEndpoint.

- **ZeppelinRemoteSparkInterpreterPort** – Number (integer).
  
  The Apache Zeppelin port for the remote Apache Spark interpreter.

- **NumberOfNodes** – Number (integer).
  
  The number of AWS Glue Data Processing Units (DPUs) allocated to this DevEndpoint.

- **WorkerType** – UTF-8 string (valid values: Standard=", G.1X=", G.2X=", G.025X=", G.4X=", G.8X=", Z.2X=").
  
  The type of predefined worker that is allocated to the development endpoint. May be a value of Standard, G.1X, or G.2X.

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](https://docs.aws.amazon.com/glue/latest/dg/etl-params.html).
  
  Glue version determines the versions of Apache Spark and Python that AWS Glue supports. The Python version indicates the version supported for running your ETL scripts on development endpoints.

  For more information about the available AWS Glue versions and corresponding Spark and Python versions, see [Glue version](https://docs.aws.amazon.com/glue/latest/dg/etl-params.html) in the developer guide.

- **NumberOfWorkers** – Number (integer).
  
  The number of workers of a defined workerType that are allocated to the development endpoint.

- **AvailabilityZone** – UTF-8 string.
  
  The AWS Availability Zone where this DevEndpoint is located.
• VpcId – UTF-8 string.

  The ID of the virtual private cloud (VPC) used by this DevEndpoint.

• ExtraPythonLibsS3Path – UTF-8 string.

  The paths to one or more Python libraries in an S3 bucket that will be loaded in your DevEndpoint.

• ExtraJarsS3Path – UTF-8 string.

  Path to one or more Java .jar files in an S3 bucket that will be loaded in your DevEndpoint.

• FailureReason – UTF-8 string.

  The reason for a current failure in this DevEndpoint.

• SecurityConfiguration – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the SecurityConfiguration structure being used with this DevEndpoint.

• CreatedTimestamp – Timestamp.

  The point in time at which this DevEndpoint was created.

• Arguments – A map array of key-value pairs, not more than 100 pairs.

  Each key is a UTF-8 string.

  Each value is a UTF-8 string.

  The map of arguments used to configure this DevEndpoint.

Valid arguments are:

• "--enable-glue-datacatalog": ""

You can specify a version of Python support for development endpoints by using the Arguments parameter in the CreateDevEndpoint or UpdateDevEndpoint APIs. If no arguments are provided, the version defaults to Python 2.

Errors

• AccessDeniedException
• AlreadyExistsException
• IdempotentParameterMismatchException
• InternalServiceException
• OperationTimeoutException
• InvalidInputException
• ValidationException
• ResourceNumberLimitExceededException

**UpdateDevEndpoint action (Python: update_dev_endpoint)**

Updates a specified development endpoint.

**Request**

• **EndpointName** – *Required*: UTF-8 string.
  
  The name of the DevEndpoint to be updated.

• **PublicKey** – UTF-8 string.
  
  The public key for the DevEndpoint to use.

• **AddPublicKeys** – An array of UTF-8 strings, not more than 5 strings.
  
  The list of public keys for the DevEndpoint to use.

• **DeletePublicKeys** – An array of UTF-8 strings, not more than 5 strings.
  
  The list of public keys to be deleted from the DevEndpoint.

• **CustomLibraries** – A [DevEndpointCustomLibraries](#) object.
  
  Custom Python or Java libraries to be loaded in the DevEndpoint.

• **UpdateEtlLibraries** – Boolean.
  
  True if the list of custom libraries to be loaded in the development endpoint needs to be updated, or False if otherwise.

• **DeleteArguments** – An array of UTF-8 strings.
  
  The list of argument keys to be deleted from the map of arguments used to configure the DevEndpoint.
• AddArguments – A map array of key-value pairs, not more than 100 pairs.

Each key is a UTF-8 string.

Each value is a UTF-8 string.

The map of arguments to add the map of arguments used to configure the DevEndpoint.

Valid arguments are:
• "--enable-glue-datacatalog": ""

You can specify a version of Python support for development endpoints by using the Arguments parameter in the CreateDevEndpoint or UpdateDevEndpoint APIs. If no arguments are provided, the version defaults to Python 2.

Response

• No Response parameters.

Errors

• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException
• InvalidInputException
• ValidationException

DeleteDevEndpoint action (Python: delete_dev_endpoint)

Deletes a specified development endpoint.

Request

• EndpointName – Required: UTF-8 string.

The name of the DevEndpoint.
Response

- *No Response parameters.*

Errors

- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException

**GetDevEndpoint action (Python: get_dev_endpoint)**

Retrieves information about a specified development endpoint.

**Note**

When you create a development endpoint in a virtual private cloud (VPC), AWS Glue returns only a private IP address, and the public IP address field is not populated. When you create a non-VPC development endpoint, AWS Glue returns only a public IP address.

Request

- EndpointName – *Required:* UTF-8 string.

  Name of the DevEndpoint to retrieve information for.

Response


  A DevEndpoint definition.

Errors

- EntityNotFoundException
AWS Glue

- InternalServiceException
- OperationTimeoutException
- InvalidInputException

**GetDevEndpoints action (Python: get_dev_endpoints)**

Retrieves all the development endpoints in this AWS account.

**Note**

When you create a development endpoint in a virtual private cloud (VPC), AWS Glue returns only a private IP address and the public IP address field is not populated. When you create a non-VPC development endpoint, AWS Glue returns only a public IP address.

**Request**

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum size of information to return.

- **NextToken** – UTF-8 string.

  A continuation token, if this is a continuation call.

**Response**

- **DevEndpoints** – An array of DevEndpoint objects.

  A list of DevEndpoint definitions.

- **NextToken** – UTF-8 string.

  A continuation token, if not all DevEndpoint definitions have yet been returned.

**Errors**

- EntityNotFoundException
- InternalServiceException
• OperationTimeoutException

• InvalidInputException

**BatchGetDevEndpoints action (Python: batch_get_dev_endpoints)**

Returns a list of resource metadata for a given list of development endpoint names. After calling the ListDevEndpoints operation, you can call this operation to access the data to which you have been granted permissions. This operation supports all IAM permissions, including permission conditions that uses tags.

**Request**

• `customerAccountId` – UTF-8 string.

  The AWS account ID.

• `DevEndpointNames` – *Required:* An array of UTF-8 strings, not less than 1 or more than 25 strings.

  The list of DevEndpoint names, which might be the names returned from the ListDevEndpoint operation.

**Response**

• `DevEndpoints` – An array of `DevEndpoint` objects.

  A list of DevEndpoint definitions.

• `DevEndpointsNotFound` – An array of UTF-8 strings, not less than 1 or more than 25 strings.

  A list of DevEndpoints not found.

**Errors**

• AccessDeniedException

• InternalServiceException

• OperationTimeoutException

• InvalidInputException
ListDevEndpoints action (Python: list_dev_endpoints)

Retrieves the names of all DevEndpoint resources in this AWS account, or the resources with the specified tag. This operation allows you to see which resources are available in your account, and their names.

This operation takes the optional Tags field, which you can use as a filter on the response so that tagged resources can be retrieved as a group. If you choose to use tags filtering, only resources with the tag are retrieved.

Request

- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation request.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of a list to return.
- **Tags** – A map array of key-value pairs, not more than 50 pairs.
  
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  
  Each value is a UTF-8 string, not more than 256 bytes long.
  
  Specifies to return only these tagged resources.

Response

- **DevEndpointNames** – An array of UTF-8 strings.
  
  The names of all the DevEndpoints in the account, or the DevEndpoints with the specified tags.
- **NextToken** – UTF-8 string.
  
  A continuation token, if the returned list does not contain the last metric available.

Errors

- **InvalidInputException**
• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException

Schema registry

The Schema registry API describes the data types and API related to working with schemas in AWS Glue.

Data types

• RegistryId structure
• RegistryListItem structure
• MetadataInfo structure
• OtherMetadataValueListItem structure
• SchemaListItem structure
• SchemaVersionListItem structure
• MetadataKeyValuePair structure
• SchemaVersionErrorItem structure
• ErrorDetails structure
• SchemaVersionNumber structure
• SchemaId structure

RegistryId structure

A wrapper structure that may contain the registry name and Amazon Resource Name (ARN).

Fields

• RegistryName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  Name of the registry. Used only for lookup. One of RegistryArn or RegistryName has to be provided.
• **RegistryArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  Arn of the registry to be updated. One of RegistryArn or RegistryName has to be provided.

**RegistryListItem structure**

A structure containing the details for a registry.

**Fields**

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).

  The name of the registry.

- **RegistryArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the registry.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  A description of the registry.

- **Status** – UTF-8 string (valid values: AVAILABLE | DELETING).

  The status of the registry.

- **CreatedTime** – UTF-8 string.

  The data the registry was created.

- **UpdatedTime** – UTF-8 string.

  The date the registry was updated.

**MetadataInfo structure**

A structure containing metadata information for a schema version.
Fields

- **MetadataValue** – UTF-8 string, not less than 1 or more than 256 bytes long, matching the [Custom string pattern #25](#).
  
  The metadata key's corresponding value.

- **CreatedTime** – UTF-8 string.
  
  The time at which the entry was created.

- **OtherMetadataValueList** – An array of [OtherMetadataValueListItem](#) objects.
  
  Other metadata belonging to the same metadata key.

**OtherMetadataValueListItem structure**

A structure containing other metadata for a schema version belonging to the same metadata key.

**Fields**

- **MetadataValue** – UTF-8 string, not less than 1 or more than 256 bytes long, matching the [Custom string pattern #25](#).
  
  The metadata key's corresponding value for the other metadata belonging to the same metadata key.

- **CreatedTime** – UTF-8 string.
  
  The time at which the entry was created.

**SchemaListItem structure**

An object that contains minimal details for a schema.

**Fields**

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).
  
  the name of the registry where the schema resides.
• **SchemaName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name of the schema.

• **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

  The Amazon Resource Name (ARN) for the schema.

• **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description for the schema.

• **SchemaStatus** – UTF-8 string (valid values: AVAILABLE | PENDING | DELETING).

  The status of the schema.

• **CreatedTime** – UTF-8 string.

  The date and time that a schema was created.

• **UpdatedTime** – UTF-8 string.

  The date and time that a schema was updated.

**SchemaVersionListItem structure**

An object containing the details about a schema version.

**Fields**

• **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

  The Amazon Resource Name (ARN) of the schema.

• **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

  The unique identifier of the schema version.

• **VersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.
• Status – UTF-8 string (valid values: AVAILABLE | PENDING | FAILURE | DELETING).

  The status of the schema version.
• CreatedTime – UTF-8 string.

  The date and time the schema version was created.

**MetadataKeyValuePair structure**

A structure containing a key value pair for metadata.

**Fields**

• MetadataKey – UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #25.

  A metadata key.
• MetadataValue – UTF-8 string, not less than 1 or more than 256 bytes long, matching the Custom string pattern #25.

  A metadata key's corresponding value.

**SchemaVersionErrorItem structure**

An object that contains the error details for an operation on a schema version.

**Fields**

• VersionNumber – Number (long), not less than 1 or more than 100000.

  The version number of the schema.
• ErrorDetails – An ErrorDetails object.

  The details of the error for the schema version.

**ErrorDetails structure**

An object containing error details.
Fields

- ErrorCode – UTF-8 string.
  The error code for an error.
- ErrorMessage – UTF-8 string.
  The error message for an error.

SchemaVersionNumber structure

A structure containing the schema version information.

Fields

  The latest version available for the schema.
- VersionNumber – Number (long), not less than 1 or more than 100000.
  The version number of the schema.

SchemaId structure

The unique ID of the schema in the AWS Glue schema registry.

Fields

- SchemaArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.
  The Amazon Resource Name (ARN) of the schema. One of SchemaArn or SchemaName has to be provided.
- SchemaName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.
  The name of the schema. One of SchemaArn or SchemaName has to be provided.
- RegistryName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.
The name of the schema registry that contains the schema.

**Operations**

- CreateRegistry action (Python: create_registry)
- CreateSchema action (Python: create_schema)
- GetSchema action (Python: get_schema)
- ListSchemaVersions action (Python: list_schema_versions)
- GetSchemaVersion action (Python: get_schema_version)
- GetSchemaVersionsDiff action (Python: get_schema_versions_diff)
- ListRegistries action (Python: list_registries)
- ListSchemas action (Python: list_schemas)
- RegisterSchemaVersion action (Python: register_schema_version)
- UpdateSchema action (Python: update_schema)
- CheckSchemaVersionValidity action (Python: check_schema_version_validity)
- UpdateRegistry action (Python: update_registry)
- GetSchemaByDefinition action (Python: get_schema_by_definition)
- GetRegistry action (Python: get_registry)
- PutSchemaVersionMetadata action (Python: put_schema_version_metadata)
- QuerySchemaVersionMetadata action (Python: query_schema_version_metadata)
- RemoveSchemaVersionMetadata action (Python: remove_schema_version_metadata)
- DeleteRegistry action (Python: delete_registry)
- DeleteSchema action (Python: delete_schema)
- DeleteSchemaVersions action (Python: delete_schema_versions)

**CreateRegistry action (Python: create_registry)**

Creates a new registry which may be used to hold a collection of schemas.
Request

- **RegistryName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).

  Name of the registry to be created of max length of 255, and may only contain letters, numbers, hyphen, underscore, dollar sign, or hash mark. No whitespace.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  A description of the registry. If description is not provided, there will not be any default value for this.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  AWS tags that contain a key value pair and may be searched by console, command line, or API.

Response

- **RegistryArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the newly created registry.

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).

  The name of the registry.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  A description of the registry.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.
The tags for the registry.

Errors

- InvalidInputException
- AccessDeniedException
- AlreadyExistsException
- ResourceNumberLimitExceededException
- ConcurrentModificationException
- InternalServiceException

CreateSchema action (Python: create_schema)

Creates a new schema set and registers the schema definition. Returns an error if the schema set already exists without actually registering the version.

When the schema set is created, a version checkpoint will be set to the first version. Compatibility mode "DISABLED" restricts any additional schema versions from being added after the first schema version. For all other compatibility modes, validation of compatibility settings will be applied only from the second version onwards when the RegisterSchemaVersion API is used.

When this API is called without a RegistryId, this will create an entry for a "default-registry" in the registry database tables, if it is not already present.

Request

- RegistryId – A RegistryId object.

  This is a wrapper shape to contain the registry identity fields. If this is not provided, the default registry will be used. The ARN format for the same will be: arn:aws:glue:us-east-2:<customer id>:registry/default-registry:random-5-letter-id.

- SchemaName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  Name of the schema to be created of max length of 255, and may only contain letters, numbers, hyphen, underscore, dollar sign, or hash mark. No whitespace.
• **DataFormat** – *Required: UTF-8 string (valid values: AVRO | JSON | PROTOBUF).*

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

• **Compatibility** – UTF-8 string (valid values: NONE | DISABLED | BACKWARD | BACKWARD_ALL | FORWARD | FORWARD_ALL | FULL | FULL_ALL).

  The compatibility mode of the schema. The possible values are:

  • **NONE**: No compatibility mode applies. You can use this choice in development scenarios or if you do not know the compatibility mode that you want to apply to schemas. Any new version added will be accepted without undergoing a compatibility check.

  • **DISABLED**: This compatibility choice prevents versioning for a particular schema. You can use this choice to prevent future versioning of a schema.

  • **BACKWARD**: This compatibility choice is recommended as it allows data receivers to read both the current and one previous schema version. This means that for instance, a new schema version cannot drop data fields or change the type of these fields, so they can't be read by readers using the previous version.

  • **BACKWARD_ALL**: This compatibility choice allows data receivers to read both the current and all previous schema versions. You can use this choice when you need to delete fields or add optional fields, and check compatibility against all previous schema versions.

  • **FORWARD**: This compatibility choice allows data receivers to read both the current and one next schema version, but not necessarily later versions. You can use this choice when you need to add fields or delete optional fields, but only check compatibility against the last schema version.

  • **FORWARD_ALL**: This compatibility choice allows data receivers to read written by producers of any new registered schema. You can use this choice when you need to add fields or delete optional fields, and check compatibility against all previous schema versions.

  • **FULL**: This compatibility choice allows data receivers to read data written by producers using the previous or next version of the schema, but not necessarily earlier or later versions. You can use this choice when you need to add or remove optional fields, but only check compatibility against the last schema version.

  • **FULL_ALL**: This compatibility choice allows data receivers to read data written by producers using all previous schema versions. You can use this choice when you need to add or remove optional fields, and check compatibility against all previous schema versions.

• **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
An optional description of the schema. If description is not provided, there will not be any automatic default value for this.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  AWS tags that contain a key value pair and may be searched by console, command line, or API. If specified, follows the AWS tags-on-create pattern.

- **SchemaDefinition** – UTF-8 string, not less than 1 or more than 170000 bytes long, matching the [Custom string pattern #24](https://aws.amazon.com/).

  The schema definition using the `DataFormat` setting for `SchemaName`.

**Response**

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](https://aws.amazon.com/).

  The name of the registry.

- **RegistryArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](https://aws.amazon.com/).

  The Amazon Resource Name (ARN) of the registry.

- **SchemaName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](https://aws.amazon.com/).

  The name of the schema.

- **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](https://aws.amazon.com/).

  The Amazon Resource Name (ARN) of the schema.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](https://aws.amazon.com/).

  A description of the schema if specified when created.
• **DataFormat** – UTF-8 string (valid values: AVRO | JSON | PROTOBUF).

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

• **Compatibility** – UTF-8 string (valid values: NONE | DISABLED | BACKWARD | BACKWARD_ALL | FORWARD | FORWARD_ALL | FULL | FULL_ALL).

  The schema compatibility mode.

• **SchemaCheckpoint** – Number (long), not less than 1 or more than 100000.

  The version number of the checkpoint (the last time the compatibility mode was changed).

• **LatestSchemaVersion** – Number (long), not less than 1 or more than 100000.

  The latest version of the schema associated with the returned schema definition.

• **NextSchemaVersion** – Number (long), not less than 1 or more than 100000.

  The next version of the schema associated with the returned schema definition.

• **SchemaStatus** – UTF-8 string (valid values: AVAILABLE | PENDING | DELETING).

  The status of the schema.

• **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags for the schema.

• **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the [Custom string pattern #12](#).

  The unique identifier of the first schema version.

• **SchemaVersionStatus** – UTF-8 string (valid values: AVAILABLE | PENDING | FAILURE | DELETING).

  The status of the first schema version created.

**Errors**

• **InvalidInputException**
GetSchema action (Python: get_schema)

Describes the specified schema in detail.

Request

- SchemaId – *Required:* A `SchemaId` object.

  This is a wrapper structure to contain schema identity fields. The structure contains:
  - `SchemaId$SchemaArn`: The Amazon Resource Name (ARN) of the schema. Either `SchemaArn` or `SchemaName` and `RegistryName` has to be provided.
  - `SchemaId$SchemaName`: The name of the schema. Either `SchemaArn` or `SchemaName` and `RegistryName` has to be provided.

Response

- `RegistryName` – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#). The name of the registry.
- `RegistryArn` – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#). The Amazon Resource Name (ARN) of the registry.
- `SchemaName` – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#). The name of the schema.
• **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](https://docs.aws.amazon.com/glue/latest/dg/custom-patterns.html).

  The Amazon Resource Name (ARN) of the schema.

• **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/custom-patterns.html).

  A description of schema if specified when created

• **DataFormat** – UTF-8 string (valid values: AVRO | JSON | PROTOBUF).

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

• **Compatibility** – UTF-8 string (valid values: NONE | DISABLED | BACKWARD | BACKWARD_ALL | FORWARD | FORWARD_ALL | FULL | FULL_ALL).

  The compatibility mode of the schema.

• **SchemaCheckpoint** – Number (long), not less than 1 or more than 100000.

  The version number of the checkpoint (the last time the compatibility mode was changed).

• **LatestSchemaVersion** – Number (long), not less than 1 or more than 100000.

  The latest version of the schema associated with the returned schema definition.

• **NextSchemaVersion** – Number (long), not less than 1 or more than 100000.

  The next version of the schema associated with the returned schema definition.

• **SchemaStatus** – UTF-8 string (valid values: AVAILABLE | PENDING | DELETING).

  The status of the schema.

• **CreatedTime** – UTF-8 string.

  The date and time the schema was created.

• **UpdatedTime** – UTF-8 string.

  The date and time the schema was updated.

**Errors**

• **InvalidInputException**

• **AccessDeniedException**
• EntityNotFoundException
• InternalServiceException

ListSchemaVersions action (Python: list_schema_versions)

Returns a list of schema versions that you have created, with minimal information. Schema versions in Deleted status will not be included in the results. Empty results will be returned if there are no schema versions available.

Request

• SchemaId – Required: A Schemald object.

This is a wrapper structure to contain schema identity fields. The structure contains:

• Schemald$SchemaArn: The Amazon Resource Name (ARN) of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.

• Schemald$SchemaName: The name of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.

• MaxResults – Number (integer), not less than 1 or more than 100.

Maximum number of results required per page. If the value is not supplied, this will be defaulted to 25 per page.

• NextToken – UTF-8 string.

A continuation token, if this is a continuation call.

Response

• Schemas – An array of SchemaVersionListItem objects.

An array of SchemaVersionList objects containing details of each schema version.

• NextToken – UTF-8 string.

A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.
Errors

- InvalidInputException
- AccessDeniedException
- EntityNotFoundException
- InternalServiceException

GetSchemaVersion action (Python: get_schema_version)

Get the specified schema by its unique ID assigned when a version of the schema is created or registered. Schema versions in Deleted status will not be included in the results.

Request

- SchemaId – A SchemaId object.

  This is a wrapper structure to contain schema identity fields. The structure contains:
  - SchemaId$SchemaArn: The Amazon Resource Name (ARN) of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.
  - SchemaId$SchemaName: The name of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.
  - SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

    The SchemaVersionId of the schema version. This field is required for fetching by schema ID. Either this or the SchemaId wrapper has to be provided.

    The version number of the schema.

Response

- SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

    The SchemaVersionId of the schema version.
• **SchemaDefinition** – UTF-8 string, not less than 1 or more than 170000 bytes long, matching the [Custom string pattern #24](#).

  The schema definition for the schema ID.

• **DataFormat** – UTF-8 string (valid values: AVRO | JSON | PROTOBUF).

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

• **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the schema.

• **VersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.

• **Status** – UTF-8 string (valid values: AVAILABLE | PENDING | FAILURE | DELETING).

  The status of the schema version.

• **CreatedTime** – UTF-8 string.

  The date and time the schema version was created.

### Errors

- **InvalidInputException**
- **AccessDeniedException**
- **EntityNotFoundException**
- **InternalServiceException**

### GetSchemaVersionsDiff action (Python: get_schema_versions_diff)

Fetches the schema version difference in the specified difference type between two stored schema versions in the Schema Registry.

This API allows you to compare two schema versions between two schema definitions under the same schema.
**Request**

- **SchemaId** – *Required:* A [SchemaId](#) object.

  This is a wrapper structure to contain schema identity fields. The structure contains:
  - **SchemaId$SchemaArn:** The Amazon Resource Name (ARN) of the schema. One of SchemaArn or SchemaName has to be provided.
  - **SchemaId$SchemaName:** The name of the schema. One of SchemaArn or SchemaName has to be provided.

  The first of the two schema versions to be compared.

  The second of the two schema versions to be compared.
- **SchemaDiffType** – *Required:* UTF-8 string (valid values: SYNTAX_DIFF).

  Refers to SYNTAX_DIFF, which is the currently supported diff type.

**Response**

- **Diff** – UTF-8 string, not less than 1 or more than 340000 bytes long, matching the [Custom string pattern #24](#).

  The difference between schemas as a string in JsonPatch format.

**Errors**

- InvalidInputException
- EntityNotFoundException
- AccessDeniedException
- InternalServiceException
ListRegistries action (Python: list_registries)

Returns a list of registries that you have created, with minimal registry information. Registries in the Deleting status will not be included in the results. Empty results will be returned if there are no registries available.

Request

- MaxResults – Number (integer), not less than 1 or more than 100.
  
  Maximum number of results required per page. If the value is not supplied, this will be defaulted to 25 per page.
- NextToken – UTF-8 string.

  A continuation token, if this is a continuation call.

Response

- Registries – An array of RegistryListItem objects.
  
  An array of RegistryDetailedListItem objects containing minimal details of each registry.
- NextToken – UTF-8 string.

  A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.

Errors

- InvalidInputException
- AccessDeniedException
- InternalServiceException

ListSchemas action (Python: list_schemas)

Returns a list of schemas with minimal details. Schemas in Deleting status will not be included in the results. Empty results will be returned if there are no schemas available.
When the RegistryId is not provided, all the schemas across registries will be part of the API response.

**Request**

- **RegistryId** – A `RegistryId` object.
  
  A wrapper structure that may contain the registry name and Amazon Resource Name (ARN).
  
- **MaxResults** – Number (integer), not less than 1 or more than 100.
  
  Maximum number of results required per page. If the value is not supplied, this will be defaulted to 25 per page.
  
- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation call.

**Response**

- **Schemas** – An array of `SchemaListItem` objects.
  
  An array of `SchemaListItem` objects containing details of each schema.
  
- **NextToken** – UTF-8 string.
  
  A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.

**Errors**

- `InvalidInputException`
- `AccessDeniedException`
- `EntityNotFoundException`
- `InternalServiceException`
RegisterSchemaVersion action (Python: register_schema_version)

Add a new version to the existing schema. Returns an error if new version of schema does not meet the compatibility requirements of the schema set. This API will not create a new schema set and will return a 404 error if the schema set is not already present in the Schema Registry.

If this is the first schema definition to be registered in the Schema Registry, this API will store the schema version and return immediately. Otherwise, this call has the potential to run longer than other operations due to compatibility modes. You can call the GetSchemaVersion API with the SchemaVersionId to check compatibility modes.

If the same schema definition is already stored in Schema Registry as a version, the schema ID of the existing schema is returned to the caller.

Request

- SchemaId – Required: A Schemald object.

  This is a wrapper structure to contain schema identity fields. The structure contains:
  - Schemald$SchemaArn: The Amazon Resource Name (ARN) of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.
  - Schemald$SchemaName: The name of the schema. Either SchemaArn or SchemaName and RegistryName has to be provided.
  - SchemaDefinition – Required: UTF-8 string, not less than 1 or more than 170000 bytes long, matching the Custom string pattern #24.

    The schema definition using the DataFormat setting for the SchemaName.

Response

- SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

    The unique ID that represents the version of this schema.

- VersionNumber – Number (long), not less than 1 or more than 100000.

    The version of this schema (for sync flow only, in case this is the first version).

- Status – UTF-8 string (valid values: AVAILABLE | PENDING | FAILURE | DELETING).
The status of the schema version.

Errors

- InvalidInputException
- AccessDeniedException
- EntityNotFoundException
- ResourceNumberLimitExceededException
- ConcurrentModificationException
- InternalServiceException

**UpdateSchema action (Python: update_schema)**

Updates the description, compatibility setting, or version checkpoint for a schema set.

For updating the compatibility setting, the call will not validate compatibility for the entire set of schema versions with the new compatibility setting. If the value for Compatibility is provided, the VersionNumber (a checkpoint) is also required. The API will validate the checkpoint version number for consistency.

If the value for the VersionNumber (checkpoint) is provided, Compatibility is optional and this can be used to set/reset a checkpoint for the schema.

This update will happen only if the schema is in the AVAILABLE state.

**Request**


  This is a wrapper structure to contain schema identity fields. The structure contains:

  - SchemaId$SchemaArn: The Amazon Resource Name (ARN) of the schema. One of SchemaArn or SchemaName has to be provided.
  - SchemaId$SchemaName: The name of the schema. One of SchemaArn or SchemaName has to be provided.
Version number required for checkpointing. One of VersionNumber or Compatibility has to be provided.

- Compatibility – UTF-8 string (valid values: NONE | DISABLED | BACKWARD | BACKWARD_ALL | FORWARD | FORWARD_ALL | FULL | FULL_ALL).

  The new compatibility setting for the schema.

- Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  The new description for the schema.

**Response**

- SchemaArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

  The Amazon Resource Name (ARN) of the schema.

- SchemaName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name of the schema.

- RegistryName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name of the registry that contains the schema.

**Errors**

- InvalidInputException
- AccessDeniedException
- EntityNotFoundException
- ConcurrentModificationException
- InternalServiceException
CheckSchemaVersionValidity action (Python: check_schema_version_validity)

Validates the supplied schema. This call has no side effects, it simply validates using the supplied schema using DataFormat as the format. Since it does not take a schema set name, no compatibility checks are performed.

Request

- **DataFormat** – *Required: UTF-8 string (valid values: AVRO | JSON | PROTOBUF)*.

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

- **SchemaDefinition** – *Required: UTF-8 string, not less than 1 or more than 170000 bytes long, matching the Custom string pattern #24*.

  The definition of the schema that has to be validated.

Response

- **Valid** – Boolean.

  Return true, if the schema is valid and false otherwise.

- **Error** – UTF-8 string, not less than 1 or more than 5000 bytes long.

  A validation failure error message.

Errors

- **InvalidInputException**
- **AccessDeniedException**
- **InternalServiceException**

UpdateRegistry action (Python: update_registry)

Updates an existing registry which is used to hold a collection of schemas. The updated properties relate to the registry, and do not modify any of the schemas within the registry.
Request

- **RegistryId** – *Required:* A RegistryId object.

  This is a wrapper structure that may contain the registry name and Amazon Resource Name (ARN).

- **Description** – *Required:* Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the registry. If description is not provided, this field will not be updated.

Response

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name of the updated registry.

- **RegistryArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

  The Amazon Resource name (ARN) of the updated registry.

Errors

- InvalidInputException
- AccessDeniedException
- EntityNotFoundException
- ConcurrentModificationException
- InternalServiceException

**GetSchemaByDefinition action (Python: get_schema_by_definition)**

Retrieves a schema by the SchemaDefinition. The schema definition is sent to the Schema Registry, canonicalized, and hashed. If the hash is matched within the scope of the SchemaName or ARN (or the default registry, if none is supplied), that schema's metadata is returned. Otherwise, a 404 or NotFound error is returned. Schema versions in Deleted statuses will not be included in the results.
Request

- **SchemaId** – *Required*: A [SchemaId](#) object.

  This is a wrapper structure to contain schema identity fields. The structure contains:

  - SchemaId$SchemaArn: The Amazon Resource Name (ARN) of the schema. One of SchemaArn or SchemaName has to be provided.
  
  - SchemaId$SchemaName: The name of the schema. One of SchemaArn or SchemaName has to be provided.

- **SchemaDefinition** – *Required*: UTF-8 string, not less than 1 or more than 170000 bytes long, matching the [Custom string pattern #24](#).

  The definition of the schema for which schema details are required.

Response

- **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the [Custom string pattern #12](#).

  The schema ID of the schema version.

- **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the schema.

- **DataFormat** – UTF-8 string (valid values: AVRO | JSON | PROTOBUF).

  The data format of the schema definition. Currently AVRO, JSON and PROTOBUF are supported.

- **Status** – UTF-8 string (valid values: AVAILABLE | PENDING | FAILURE | DELETING).

  The status of the schema version.

- **CreatedTime** – UTF-8 string.

  The date and time the schema was created.

Errors

- **InvalidInputException**
• AccessDeniedException
• EntityNotFoundException
• InternalServiceException

GetRegistry action (Python: get_registry)

Describes the specified registry in detail.

Request

• RegistryId – Required: A RegistryId object.

   This is a wrapper structure that may contain the registry name and Amazon Resource Name (ARN).

Response

• RegistryName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

   The name of the registry.

• RegistryArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

   The Amazon Resource Name (ARN) of the registry.

• Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

   A description of the registry.

• Status – UTF-8 string (valid values: AVAILABLE | DELETING).

   The status of the registry.

• CreatedTime – UTF-8 string.

   The date and time the registry was created.

• UpdatedTime – UTF-8 string.

   The date and time the registry was updated.
Errors

- InvalidInputException
- AccessDeniedException
- EntityNotFoundException
- InternalServiceException

PutSchemaVersionMetadata action (Python: put_schema_version_metadata)

Puts the metadata key value pair for a specified schema version ID. A maximum of 10 key value pairs will be allowed per schema version. They can be added over one or more calls.

Request

- SchemaId – A Schemald object.
  The unique ID for the schema.
  The version number of the schema.
- SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.
  The unique version ID of the schema version.
- MetadataKeyValue – Required: A MetadataKeyValuePair object.
  The metadata key's corresponding value.

Response

- SchemaArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.
  The Amazon Resource Name (ARN) for the schema.
- SchemaName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.
The name for the schema.

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name for the registry.

- **LatestVersion** – Boolean.

  The latest version of the schema.

- **VersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.

- **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

  The unique version ID of the schema version.

- **MetadataKey** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #25.

  The metadata key.

- **MetadataValue** – UTF-8 string, not less than 1 or more than 256 bytes long, matching the Custom string pattern #25.

  The value of the metadata key.

**Errors**

- **InvalidInputException**
- **AccessDeniedException**
- **AlreadyExistsException**
- **EntityNotFoundException**
- **ResourceNumberLimitExceeded**
QuerySchemaVersionMetadata action (Python: query_schema_version_metadata)

Queries for the schema version metadata information.

Request

- SchemaId – A SchemaId object.
  
  A wrapper structure that may contain the schema name and Amazon Resource Name (ARN).
  
  The version number of the schema.
- SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.
  
  The unique version ID of the schema version.
- MetadataList – An array of MetadataKeyValuePair objects.
  
  Search key-value pairs for metadata, if they are not provided all the metadata information will be fetched.
- MaxResults – Number (integer), not less than 1 or more than 50.
  
  Maximum number of results required per page. If the value is not supplied, this will be defaulted to 25 per page.
- NextToken – UTF-8 string.
  
  A continuation token, if this is a continuation call.

Response

- MetadataInfoMap – A map array of key-value pairs.
  
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #25.
  
  Each value is a A MetadataInfo object.
  
  A map of a metadata key and associated values.
• SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

The unique version ID of the schema version.

• NextToken – UTF-8 string.

A continuation token for paginating the returned list of tokens, returned if the current segment of the list is not the last.

Errors

• InvalidInputException
• AccessDeniedException
• EntityNotFoundException

RemoveSchemaVersionMetadata action (Python: remove_schema_version_metadata)

Removes a key value pair from the schema version metadata for the specified schema version ID.

Request

• SchemaId – A Schemald object.

A wrapper structure that may contain the schema name and Amazon Resource Name (ARN).

• SchemaVersionNumber – A SchemaVersionNumber object.

The version number of the schema.

• SchemaVersionId – UTF-8 string, not less than 36 or more than 36 bytes long, matching the Custom string pattern #12.

The unique version ID of the schema version.

• MetadataKeyValue – Required: A MetadataKeyValuePair object.

The value of the metadata key.
**Response**

- **SchemaArn** – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the schema.

- **SchemaName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).

  The name of the schema.

- **RegistryName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #13](#).

  The name of the registry.

- **LatestVersion** – Boolean.

  The latest version of the schema.

- **VersionNumber** – Number (long), not less than 1 or more than 100000.

  The version number of the schema.

- **SchemaVersionId** – UTF-8 string, not less than 36 or more than 36 bytes long, matching the [Custom string pattern #12](#).

  The version ID for the schema version.

- **MetadataKey** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #25](#).

  The metadata key.

- **MetadataValue** – UTF-8 string, not less than 1 or more than 256 bytes long, matching the [Custom string pattern #25](#).

  The value of the metadata key.

**Errors**

- **InvalidInputException**
- **AccessDeniedException**
- **EntityNotFoundException**
DeleteRegistry action (Python: delete_registry)

Delete the entire registry including schema and all of its versions. To get the status of the delete operation, you can call the GetRegistry API after the asynchronous call. Deleting a registry will deactivate all online operations for the registry such as the UpdateRegistry, CreateSchema, UpdateSchema, and RegisterSchemaVersion APIs.

Request

- RegistryId – *Required*: A RegistryId object.

  This is a wrapper structure that may contain the registry name and Amazon Resource Name (ARN).

Response

- RegistryName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.

  The name of the registry being deleted.
- RegistryArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.

  The Amazon Resource Name (ARN) of the registry being deleted.
- Status – UTF-8 string (valid values: AVAILABLE | DELETING).

  The status of the registry. A successful operation will return the Deleting status.

Errors

- InvalidInputException
- EntityNotFoundException
- AccessDeniedException
- ConcurrentModificationException
DeleteSchema action (Python: delete_schema)

Deletes the entire schema set, including the schema set and all of its versions. To get the status of the delete operation, you can call GetSchema API after the asynchronous call. Deleting a registry will deactivate all online operations for the schema, such as the GetSchemaByDefinition, and RegisterSchemaVersion APIs.

Request

- SchemaId – Required: A Schemald object.
  
  This is a wrapper structure that may contain the schema name and Amazon Resource Name (ARN).

Response

- SchemaArn – UTF-8 string, not less than 1 or more than 10240 bytes long, matching the Custom string pattern #17.
  
  The Amazon Resource Name (ARN) of the schema being deleted.
- SchemaName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #13.
  
  The name of the schema being deleted.
- Status – UTF-8 string (valid values: AVAILABLE | PENDING | DELETING).
  
  The status of the schema.

Errors

- InvalidInputException
- EntityNotFoundException
- AccessDeniedException
- ConcurrentModificationException
DeleteSchemaVersions action (Python: delete_schema_versions)

Remove versions from the specified schema. A version number or range may be supplied. If the compatibility mode forbids deleting of a version that is necessary, such as BACKWARDS_FULL, an error is returned. Calling the GetSchemaVersions API after this call will list the status of the deleted versions.

When the range of version numbers contain check pointed version, the API will return a 409 conflict and will not proceed with the deletion. You have to remove the checkpoint first using the DeleteSchemaCheckpoint API before using this API.

You cannot use the DeleteSchemaVersions API to delete the first schema version in the schema set. The first schema version can only be deleted by the DeleteSchema API. This operation will also delete the attached SchemaVersionMetadata under the schema versions. Hard deletes will be enforced on the database.

If the compatibility mode forbids deleting of a version that is necessary, such as BACKWARDS_FULL, an error is returned.

Request

- SchemaId – *Required:* A SchemaId object.
  
  This is a wrapper structure that may contain the schema name and Amazon Resource Name (ARN).

- Versions – *Required:* UTF-8 string, not less than 1 or more than 100000 bytes long, matching the Custom string pattern #26.
  
  A version range may be supplied which may be of the format:
  
  - a single version number, 5
  - a range, 5-8 : deletes versions 5, 6, 7, 8

Response

  
  A list of SchemaVersionErrorItem objects, each containing an error and schema version.
Errors

- InvalidInputException
- EntityNotFoundException
- AccessDeniedException
- ConcurrentModificationException

Workflows

The Workflows API describes the data types and API related to creating, updating, or viewing workflows in AWS Glue.

Data types

- JobNodeDetails structure
- CrawlerNodeDetails structure
- TriggerNodeDetails structure
- Crawl structure
- Node structure
- Edge structure
- Workflow structure
- WorkflowGraph structure
- WorkflowRun structure
- WorkflowRunStatistics structure
- StartingEventBatchCondition structure
- Blueprint structure
- BlueprintDetails structure
- LastActiveDefinition structure
- BlueprintRun structure

JobNodeDetails structure

The details of a Job node present in the workflow.
Fields

- **JobRuns** – An array of **JobRun** objects.
  The information for the job runs represented by the job node.

**CrawlerNodeDetails structure**

The details of a Crawler node present in the workflow.

**Fields**

- **Crawls** – An array of **Crawl** objects.
  A list of crawls represented by the crawl node.

**TriggerNodeDetails structure**

The details of a Trigger node present in the workflow.

**Fields**

- **Trigger** – A **Trigger** object.
  The information of the trigger represented by the trigger node.

**Crawl structure**

The details of a crawl in the workflow.

**Fields**

- **State** – UTF-8 string (valid values: RUNNING | CANCELLING | CANCELLED | SUCCEEDED | FAILED | ERROR).
  The state of the crawler.
- **StartedOn** – Timestamp.
  The date and time on which the crawl started.
- **CompletedOn** – Timestamp.
The date and time on which the crawl completed.

- **ErrorMessage** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).

  The error message associated with the crawl.

- **LogGroup** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the [Log group string pattern](#).

  The log group associated with the crawl.

- **LogStream** – UTF-8 string, not less than 1 or more than 512 bytes long, matching the [Log-stream string pattern](#).

  The log stream associated with the crawl.

## Node structure

A node represents an AWS Glue component (trigger, crawler, or job) on a workflow graph.

### Fields

- **Type** – UTF-8 string (valid values: CRAWLER | JOB | TRIGGER).

  The type of AWS Glue component represented by the node.

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of the AWS Glue component represented by the node.

- **UniqueId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The unique Id assigned to the node within the workflow.

- **TriggerDetails** – A [TriggerNodeDetails](#) object.

  Details of the Trigger when the node represents a Trigger.

- **JobDetails** – A [JobNodeDetails](#) object.

  Details of the Job when the node represents a Job.
• CrawlerDetails – A `CrawlerNodeDetails` object.

  Details of the crawler when the node represents a crawler.

**Edge structure**

An edge represents a directed connection between two AWS Glue components that are part of the workflow the edge belongs to.

**Fields**

• `SourceId` – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique of the node within the workflow where the edge starts.

• `DestinationId` – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique of the node within the workflow where the edge ends.

**Workflow structure**

A workflow is a collection of multiple dependent AWS Glue jobs and crawlers that are run to complete a complex ETL task. A workflow manages the execution and monitoring of all its jobs and crawlers.

**Fields**

• `Name` – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the workflow.

• `Description` – UTF-8 string.

  A description of the workflow.

• `DefaultRunProperties` – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
Each value is a UTF-8 string.

A collection of properties to be used as part of each execution of the workflow. The run properties are made available to each job in the workflow. A job can modify the properties for the next jobs in the flow.

- **CreatedOn** – Timestamp.
  
The date and time when the workflow was created.

- **LastModifiedOn** – Timestamp.
  
The date and time when the workflow was last modified.

- **LastRun** – A [WorkflowRun](#) object.
  
The information about the last execution of the workflow.

- **Graph** – A [WorkflowGraph](#) object.
  
The graph representing all the AWS Glue components that belong to the workflow as nodes and directed connections between them as edges.

- **CreationStatus** – UTF-8 string (valid values: CREATING | CREATED | CREATION_FAILED).
  
The creation status of the workflow.

- **MaxConcurrentRuns** – Number (integer).
  
You can use this parameter to prevent unwanted multiple updates to data, to control costs, or in some cases, to prevent exceeding the maximum number of concurrent runs of any of the component jobs. If you leave this parameter blank, there is no limit to the number of concurrent workflow runs.

- **BlueprintDetails** – A [BlueprintDetails](#) object.
  
This structure indicates the details of the blueprint that this particular workflow is created from.

### WorkflowGraph structure

A workflow graph represents the complete workflow containing all the AWS Glue components present in the workflow and all the directed connections between them.
Fields

- **Nodes** – An array of [Node](#) objects.

  A list of the the AWS Glue components belong to the workflow represented as nodes.

- **Edges** – An array of [Edge](#) objects.

  A list of all the directed connections between the nodes belonging to the workflow.

**WorkflowRun structure**

A workflow run is an execution of a workflow providing all the runtime information.

Fields

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Name of the workflow that was run.

- **WorkflowRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of this workflow run.

- **PreviousRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The ID of the previous workflow run.

- **WorkflowRunProperties** – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  Each value is a UTF-8 string.

  The workflow run properties which were set during the run.

- **StartedOn** – Timestamp.

  The date and time when the workflow run was started.

- **CompletedOn** – Timestamp.
The date and time when the workflow run completed.

- **Status** – UTF-8 string (valid values: RUNNING | COMPLETED | STOPPING | STOPPED | ERROR).
  
  The status of the workflow run.

- **ErrorMessage** – UTF-8 string.
  
  This error message describes any error that may have occurred in starting the workflow run. Currently the only error message is "Concurrent runs exceeded for workflow: foo."

- **Statistics** – A `WorkflowRunStatistics` object.
  
  The statistics of the run.

- **Graph** – A `WorkflowGraph` object.
  
  The graph representing all the AWS Glue components that belong to the workflow as nodes and directed connections between them as edges.

- **StartingEventBatchCondition** – A `StartingEventBatchCondition` object.
  
  The batch condition that started the workflow run.

**WorkflowRunStatistics structure**

Workflow run statistics provides statistics about the workflow run.

**Fields**

- **TotalActions** – Number (integer).
  
  Total number of Actions in the workflow run.

- **TimeoutActions** – Number (integer).
  
  Total number of Actions that timed out.

- **FailedActions** – Number (integer).
  
  Total number of Actions that have failed.

- **StoppedActions** – Number (integer).
  
  Total number of Actions that have stopped.
• **SucceededActions** – Number (integer).

  Total number of Actions that have succeeded.

• **RunningActions** – Number (integer).

  Total number Actions in running state.

• **ErroredActions** – Number (integer).

  Indicates the count of job runs in the ERROR state in the workflow run.

• **WaitingActions** – Number (integer).

  Indicates the count of job runs in WAITING state in the workflow run.

### StartingEventBatchCondition structure

The batch condition that started the workflow run. Either the number of events in the batch size arrived, in which case the BatchSize member is non-zero, or the batch window expired, in which case the BatchWindow member is non-zero.

**Fields**

• **BatchSize** – Number (integer).

  Number of events in the batch.

• **BatchWindow** – Number (integer).

  Duration of the batch window in seconds.

### Blueprint structure

The details of a blueprint.

**Fields**

• **Name** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.

  The name of the blueprint.

• **Description** – UTF-8 string, not less than 1 or more than 512 bytes long.
The description of the blueprint.

- **CreatedOn** – Timestamp.
  
  The date and time the blueprint was registered.

- **LastModifiedOn** – Timestamp.
  
  The date and time the blueprint was last modified.

- **ParameterSpec** – UTF-8 string, not less than 1 or more than 131072 bytes long.
  
  A JSON string that indicates the list of parameter specifications for the blueprint.

- **BlueprintLocation** – UTF-8 string.
  
  Specifies the path in Amazon S3 where the blueprint is published.

- **BlueprintServiceLocation** – UTF-8 string.
  
  Specifies a path in Amazon S3 where the blueprint is copied when you call CreateBlueprint/UpdateBlueprint to register the blueprint in AWS Glue.

- **Status** – UTF-8 string (valid values: CREATING | ACTIVE | UPDATING | FAILED).
  
  The status of the blueprint registration.

  - Creating — The blueprint registration is in progress.
  
  - Active — The blueprint has been successfully registered.
  
  - Updating — An update to the blueprint registration is in progress.
  
  - Failed — The blueprint registration failed.

- **ErrorMessage** – UTF-8 string.
  
  An error message.

- **LastActiveDefinition** – A [LastActiveDefinition](#) object.
  
  When there are multiple versions of a blueprint and the latest version has some errors, this attribute indicates the last successful blueprint definition that is available with the service.

**BlueprintDetails structure**

The details of a blueprint.
Fields

- **BlueprintName** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#). The name of the blueprint.
- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#). The run ID for this blueprint.

**LastActiveDefinition structure**

When there are multiple versions of a blueprint and the latest version has some errors, this attribute indicates the last successful blueprint definition that is available with the service.

**Fields**

- **Description** – UTF-8 string, not less than 1 or more than 512 bytes long. The description of the blueprint.
- **LastModifiedOn** – Timestamp. The date and time the blueprint was last modified.
- **ParameterSpec** – UTF-8 string, not less than 1 or more than 131072 bytes long. A JSON string specifying the parameters for the blueprint.
- **BlueprintLocation** – UTF-8 string. Specifies a path in Amazon S3 where the blueprint is published by the AWS Glue developer.
- **BlueprintServiceLocation** – UTF-8 string. Specifies a path in Amazon S3 where the blueprint is copied when you create or update the blueprint.

**BlueprintRun structure**

The details of a blueprint run.
Fields

- **BlueprintName** – UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The name of the blueprint.

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The run ID for this blueprint run.

- **WorkflowName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The name of a workflow that is created as a result of a successful blueprint run. If a blueprint run has an error, there will not be a workflow created.

- **State** – UTF-8 string (valid values: RUNNING | SUCCEEDED | FAILED | ROLLING_BACK).

  The state of the blueprint run. Possible values are:
  - Running — The blueprint run is in progress.
  - Succeeded — The blueprint run completed successfully.
  - Failed — The blueprint run failed and rollback is complete.
  - Rolling Back — The blueprint run failed and rollback is in progress.

- **StartedOn** – Timestamp.

  The date and time that the blueprint run started.

- **CompletedOn** – Timestamp.

  The date and time that the blueprint run completed.

- **ErrorMessage** – UTF-8 string.

  Indicates any errors that are seen while running the blueprint.

- **RollbackErrorMessage** – UTF-8 string.

  If there are any errors while creating the entities of a workflow, we try to roll back the created entities until that point and delete them. This attribute indicates the errors seen while trying to delete the entities that are created.

- **Parameters** – UTF-8 string, not less than 1 or more than 131072 bytes long.
The blueprint parameters as a string. You will have to provide a value for each key that is required from the parameter spec that is defined in the Blueprint$ParameterSpec.

- **RoleArn** – UTF-8 string, not less than 1 or more than 1024 bytes long, matching the Custom string pattern #20.

The role ARN. This role will be assumed by the AWS Glue service and will be used to create the workflow and other entities of a workflow.

**Operations**

- [CreateWorkflow action](#): (Python: create_workflow)
- [UpdateWorkflow action](#): (Python: update_workflow)
- [DeleteWorkflow action](#): (Python: delete_workflow)
- [GetWorkflow action](#): (Python: get_workflow)
- [ListWorkflows action](#): (Python: list_workflows)
- [BatchGetWorkflows action](#): (Python: batch_get_workflows)
- [GetWorkflowRun action](#): (Python: get_workflow_run)
- [GetWorkflowRuns action](#): (Python: get_workflow_runs)
- [GetWorkflowRunProperties action](#): (Python: get_workflow_run_properties)
- [PutWorkflowRunProperties action](#): (Python: put_workflow_run_properties)
- [CreateBlueprint action](#): (Python: create_blueprint)
- [UpdateBlueprint action](#): (Python: update_blueprint)
- [DeleteBlueprint action](#): (Python: delete_blueprint)
- [ListBlueprints action](#): (Python: list_blueprints)
- [BatchGetBlueprints action](#): (Python: batch_get_blueprints)
- [StartBlueprintRun action](#): (Python: start_blueprint_run)
- [GetBlueprintRun action](#): (Python: get_blueprint_run)
- [GetBlueprintRuns action](#): (Python: get_blueprint_runs)
- [StartWorkflowRun action](#): (Python: start_workflow_run)
- [StopWorkflowRun action](#): (Python: stop_workflow_run)
- [ResumeWorkflowRun action](#): (Python: resume_workflow_run)
CreateWorkflow action (Python: create_workflow)

Creates a new workflow.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name to be assigned to the workflow. It should be unique within your account.

- Description – UTF-8 string.

  A description of the workflow.

- DefaultRunProperties – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string.

  A collection of properties to be used as part of each execution of the workflow.

- Tags – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags to be used with this workflow.

- MaxConcurrentRuns – Number (integer).

  You can use this parameter to prevent unwanted multiple updates to data, to control costs, or in some cases, to prevent exceeding the maximum number of concurrent runs of any of the component jobs. If you leave this parameter blank, there is no limit to the number of concurrent workflow runs.

Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The name of the workflow which was provided as part of the request.

Errors

- AlreadyExistsException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentModificationException

UpdateWorkflow action (Python: update_workflow)

Updates an existing workflow.

Request

- Name – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the workflow to be updated.

- Description – UTF-8 string.

  The description of the workflow.

- DefaultRunProperties – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string.

  A collection of properties to be used as part of each execution of the workflow.

- MaxConcurrentRuns – Number (integer).

  You can use this parameter to prevent unwanted multiple updates to data, to control costs, or in some cases, to prevent exceeding the maximum number of concurrent runs of any of the
component jobs. If you leave this parameter blank, there is no limit to the number of concurrent workflow runs.

Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name of the workflow which was specified in input.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- ConcurrentModificationException

DeleteWorkflow action (Python: delete_workflow)

Deletes a workflow.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Name of the workflow to be deleted.

Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Name of the workflow specified in input.
Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ConcurrentModificationException

**GetWorkflow action (Python: get_workflow)**
Retrieves resource metadata for a workflow.

**Request**

- **Name** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*
  
  The name of the workflow to retrieve.

- **IncludeGraph** – Boolean.
  
  Specifies whether to include a graph when returning the workflow resource metadata.

**Response**

  
  The resource metadata for the workflow.

**Errors**

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException

**ListWorkflows action (Python: list_workflows)**
Lists names of workflows created in the account.
Request

- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation request.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of a list to return.

Response

- **Workflows** – An array of UTF-8 strings, not less than 1 or more than 25 strings.
  
  List of names of workflows in the account.
- **NextToken** – UTF-8 string.
  
  A continuation token, if not all workflow names have been returned.

Errors

- **InvalidInputException**
- **InternalServiceException**
- **OperationTimeoutException**

BatchGetWorkflows action (Python: batch_get_workflows)

Returns a list of resource metadata for a given list of workflow names. After calling the ListWorkflows operation, you can call this operation to access the data to which you have been granted permissions. This operation supports all IAM permissions, including permission conditions that uses tags.

Request

- **Names** – *Required:* An array of UTF-8 strings, not less than 1 or more than 25 strings.
  
  A list of workflow names, which may be the names returned from the ListWorkflows operation.
- **IncludeGraph** – Boolean.
Specifies whether to include a graph when returning the workflow resource metadata.

Response

- **Workflows** – An array of [Workflow](#) objects, not less than 1 or more than 25 structures.
  
  A list of workflow resource metadata.

- **MissingWorkflows** – An array of UTF-8 strings, not less than 1 or more than 25 strings.
  
  A list of names of workflows not found.

Errors

- InternalServiceException
- OperationTimeoutException
- InvalidInputException

**GetWorkflowRun action (Python: get_workflow_run)**

Retrieves the metadata for a given workflow run.

Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  Name of the workflow being run.

- **RunId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  The ID of the workflow run.

- **IncludeGraph** – Boolean.
  
  Specifies whether to include the workflow graph in response or not.
Response

- Run – A WorkflowRun object.
  The requested workflow run metadata.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException

GetWorkflowRuns action (Python: get_workflow_runs)

Retrieves metadata for all runs of a given workflow.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  Name of the workflow whose metadata of runs should be returned.
- IncludeGraph – Boolean.
  Specifies whether to include the workflow graph in response or not.
- NextToken – UTF-8 string.
  The maximum size of the response.
- MaxResults – Number (integer), not less than 1 or more than 1000.
  The maximum number of workflow runs to be included in the response.

Response

- Runs – An array of WorkflowRun objects, not less than 1 or more than 1000 structures.
  A list of workflow run metadata objects.
• NextToken – UTF-8 string.

  A continuation token, if not all requested workflow runs have been returned.

Errors

• InvalidInputException
• EntityNotFoundException
• InternalServiceException
• OperationTimeoutException

GetWorkflowRunProperties action (Python: get_workflow_run_properties)

Retrieves the workflow run properties which were set during the run.

Request

• Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Name of the workflow which was run.

• RunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the workflow run whose run properties should be returned.

Response

• RunProperties – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a UTF-8 string.

  The workflow run properties which were set during the specified run.
Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException

PutWorkflowRunProperties action (Python: put_workflow_run_properties)

Puts the specified workflow run properties for the given workflow run. If a property already exists for the specified run, then it overrides the value otherwise adds the property to existing properties.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  Name of the workflow which was run.
- RunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The ID of the workflow run for which the run properties should be updated.
- RunProperties – Required: A map array of key-value pairs.
  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  Each value is a UTF-8 string.
  The properties to put for the specified run.

Response

- No Response parameters.
Errors

- AlreadyExistsException
- EntityNotFoundException
- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentModificationException

CreateBlueprint action (Python: create_blueprint)

Registers a blueprint with AWS Glue.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.
  The name of the blueprint.
- Description – UTF-8 string, not less than 1 or more than 512 bytes long.
  A description of the blueprint.
- BlueprintLocation – Required: UTF-8 string, not less than 1 or more than 8192 bytes long, matching the Custom string pattern #22.
  Specifies a path in Amazon S3 where the blueprint is published.
- Tags – A map array of key-value pairs, not more than 50 pairs.
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  Each value is a UTF-8 string, not more than 256 bytes long.
  The tags to be applied to this blueprint.
Response

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Returns the name of the blueprint that was registered.

Errors

- AlreadyExistsException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- ResourceNumberLimitExceededException

**UpdateBlueprint action (Python: update_blueprint)**

Updates a registered blueprint.

**Request**

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 128 bytes long, matching the Custom string pattern #21.

  The name of the blueprint.

- **Description** – UTF-8 string, not less than 1 or more than 512 bytes long.

  A description of the blueprint.

- **BlueprintLocation** – *Required:* UTF-8 string, not less than 1 or more than 8192 bytes long, matching the Custom string pattern #22.

  Specifies a path in Amazon S3 where the blueprint is published.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
Returns the name of the blueprint that was updated.

Errors

- EntityNotFoundException
- ConcurrentModificationException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- IllegalBlueprintStateException

**DeleteBlueprint action (Python: delete_blueprint)**

Deletes an existing blueprint.

**Request**

- Name – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the blueprint to delete.

**Response**

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Returns the name of the blueprint that was deleted.

**Errors**

- InvalidInputException
- OperationTimeoutException
- InternalServiceException
ListBlueprints action (Python: list_blueprints)

Lists all the blueprint names in an account.

Request

- **NextToken** – UTF-8 string.
  
  A continuation token, if this is a continuation request.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum size of a list to return.
- **Tags** – A map array of key-value pairs, not more than 50 pairs.
  
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  
  Each value is a UTF-8 string, not more than 256 bytes long.
  
  Filters the list by an AWS resource tag.

Response

- **Blueprints** – An array of UTF-8 strings.
  
  List of names of blueprints in the account.
- **NextToken** – UTF-8 string.
  
  A continuation token, if not all blueprint names have been returned.

Errors

- **InvalidInputException**
- **InternalServiceException**
- **OperationTimeoutException**

BatchGetBlueprints action (Python: batch_get_blueprints)

Retrieves information about a list of blueprints.
Request

- **Names** – *Required:* An array of UTF-8 strings, not less than 1 or more than 25 strings.
  
  A list of blueprint names.
- **IncludeBlueprint** – Boolean.

  Specifies whether or not to include the blueprint in the response.
- **IncludeParameterSpec** – Boolean.

  Specifies whether or not to include the parameters, as a JSON string, for the blueprint in the response.

Response

- **Blueprints** – An array of *Blueprint* objects.

  Returns a list of blueprint as a Blueprints object.
- **MissingBlueprints** – An array of UTF-8 strings.

  Returns a list of BlueprintNames that were not found.

Errors

- InternalServiceException
- OperationTimeoutException
- InvalidInputException

**StartBlueprintRun action (Python: start_blueprint_run)**

Starts a new run of the specified blueprint.

Request

- **BlueprintName** – *Required:* UTF-8 string, not less than 1 or more than 128 bytes long, matching the *Custom string pattern #21.*

  The name of the blueprint.
- **Parameters** – UTF-8 string, not less than 1 or more than 131072 bytes long.

  Specifies the parameters as a BlueprintParameters object.

- **RoleArn** – *Required*: UTF-8 string, not less than 1 or more than 1024 bytes long, matching the [Custom string pattern #20](#).

  Specifies the IAM role used to create the workflow.

**Response**

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The run ID for this blueprint run.

**Errors**

- **InvalidInputException**
- **OperationTimeoutException**
- **InternalServiceException**
- **ResourceNumberLimitExceededException**
- **EntityNotFoundException**
- **IllegalBlueprintStateException**

**GetBlueprintRun action (Python: get_blueprint_run)**

Retrieves the details of a blueprint run.

**Request**

- **BlueprintName** – *Required*: UTF-8 string, not less than 1 or more than 128 bytes long, matching the [Custom string pattern #21](#).

  The name of the blueprint.

- **RunId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The run ID for the blueprint run you want to retrieve.

Response

- BlueprintRun – A BlueprintRun object.

  Returns a BlueprintRun object.

Errors

- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException

GetBlueprintRuns action (Python: get_blueprint_runs)

Retrieves the details of blueprint runs for a specified blueprint.

Request

- BlueprintName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the blueprint.
- NextToken – UTF-8 string.

  A continuation token, if this is a continuation request.
- MaxResults – Number (integer), not less than 1 or more than 1000.

  The maximum size of a list to return.

Response

- BlueprintRuns – An array of BlueprintRun objects.

  Returns a list of BlueprintRun objects.
- NextToken – UTF-8 string.
A continuation token, if not all blueprint runs have been returned.

Errors

- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- InvalidInputException

StartWorkflowRun action (Python: start_workflow_run)

Starts a new run of the specified workflow.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the workflow to start.
- RunProperties – A map array of key-value pairs.
  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  Each value is a UTF-8 string.
  The workflow run properties for the new workflow run.

Response

- RunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  An Id for the new run.
Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- ResourceNumberLimitExceededException
- ConcurrentRunsExceededExeception

StopWorkflowRun action (Python: stop_workflow_run)

Stops the execution of the specified workflow run.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the workflow to stop.

- RunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the workflow run to stop.

Response

- No Response parameters.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
- IllegalWorkflowStateException
ResumeWorkflowRun action (Python: resume_workflow_run)

Restarts selected nodes of a previous partially completed workflow run and resumes the workflow run. The selected nodes and all nodes that are downstream from the selected nodes are run.

Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the workflow to resume.

- **RunId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the workflow run to resume.

- **NodeIds** – *Required:* An array of UTF-8 strings.

  A list of the node IDs for the nodes you want to restart. The nodes that are to be restarted must have a run attempt in the original run.

Response

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The new ID assigned to the resumed workflow run. Each resume of a workflow run will have a new run ID.

- **NodeIds** – An array of UTF-8 strings.

  A list of the node IDs for the nodes that were actually restarted.

Errors

- InvalidInputException
- EntityNotFoundException
- InternalServiceException
- OperationTimeoutException
• ConcurrentRunsExceededException
• IllegalWorkflowStateException

Machine learning API

The Machine learning API describes the machine learning data types, and includes the API for creating, deleting, or updating a transform, or starting a machine learning task run.

Data types

• TransformParameters structure
• EvaluationMetrics structure
• MLTransform structure
• FindMatchesParameters structure
• FindMatchesMetrics structure
• ConfusionMatrix structure
• GlueTable structure
• TaskRun structure
• TransformFilterCriteria structure
• TransformSortCriteria structure
• TaskRunFilterCriteria structure
• TaskRunSortCriteria structure
• TaskRunProperties structure
• FindMatchesTaskRunProperties structure
• ImportLabelsTaskRunProperties structure
• ExportLabelsTaskRunProperties structure
• LabelingSetGenerationTaskRunProperties structure
• SchemaColumn structure
• TransformEncryption structure
• MLUserDataEncryption structure
• **ColumnImportance structure**

**TransformParameters structure**

The algorithm-specific parameters that are associated with the machine learning transform.

**Fields**

- **TransformType** – *Required: UTF-8 string (valid values: FIND.MATCHES).*
  
  The type of machine learning transform.
  
  For information about the types of machine learning transforms, see [Creating Machine Learning Transforms](#).

- **FindMatchesParameters** – A [FindMatchesParameters](#) object.
  
  The parameters for the find matches algorithm.

**EvaluationMetrics structure**

Evaluation metrics provide an estimate of the quality of your machine learning transform.

**Fields**

- **TransformType** – *Required: UTF-8 string (valid values: FIND.MATCHES).*
  
  The type of machine learning transform.

- **FindMatchesMetrics** – A [FindMatchesMetrics](#) object.
  
  The evaluation metrics for the find matches algorithm.

**MLTransform structure**

A structure for a machine learning transform.

**Fields**

- **TransformId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
The unique transform ID that is generated for the machine learning transform. The ID is guaranteed to be unique and does not change.

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A user-defined name for the machine learning transform. Names are not guaranteed unique and can be changed at any time.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A user-defined, long-form description text for the machine learning transform. Descriptions are not guaranteed to be unique and can be changed at any time.

- **Status** – UTF-8 string (valid values: NOT_READY | READY | DELETING).

  The current status of the machine learning transform.

- **CreatedOn** – Timestamp.

  A timestamp. The time and date that this machine learning transform was created.

- **LastModifiedOn** – Timestamp.

  A timestamp. The last point in time when this machine learning transform was modified.

- **InputRecordTables** – An array of GlueTable objects, not more than 10 structures.

  A list of AWS Glue table definitions used by the transform.

- **Parameters** – A TransformParameters object.

  A TransformParameters object. You can use parameters to tune (customize) the behavior of the machine learning transform by specifying what data it learns from and your preference on various tradeoffs (such as precious vs. recall, or accuracy vs. cost).

- **EvaluationMetrics** – An EvaluationMetrics object.

  An EvaluationMetrics object. Evaluation metrics provide an estimate of the quality of your machine learning transform.

- **LabelCount** – Number (integer).

  A count identifier for the labeling files generated by AWS Glue for this transform. As you create a better transform, you can iteratively download, label, and upload the labeling file.
• Schema – An array of `SchemaColumn` objects, not more than 100 structures.

  A map of key-value pairs representing the columns and data types that this transform can run against. Has an upper bound of 100 columns.

• Role – UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role with the required permissions. The required permissions include both AWS Glue service role permissions to AWS Glue resources, and Amazon S3 permissions required by the transform.

  • This role needs AWS Glue service role permissions to allow access to resources in AWS Glue. See [Attach a Policy to IAM Users That Access AWS Glue](#).

  • This role needs permission to your Amazon Simple Storage Service (Amazon S3) sources, targets, temporary directory, scripts, and any libraries used by the task run for this transform.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).

  This value determines which version of AWS Glue this machine learning transform is compatible with. Glue 1.0 is recommended for most customers. If the value is not set, the Glue compatibility defaults to Glue 0.9. For more information, see [AWS Glue Versions](#) in the developer guide.

• MaxCapacity – Number (double).

  The number of AWS Glue data processing units (DPUs) that are allocated to task runs for this transform. You can allocate from 2 to 100 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the [AWS Glue pricing page](#).

  MaxCapacity is a mutually exclusive option with `NumberOfWorkers` and `WorkerType`.

  • If either `NumberOfWorkers` or `WorkerType` is set, then `MaxCapacity` cannot be set.

  • If `MaxCapacity` is set then neither `NumberOfWorkers` or `WorkerType` can be set.

  • If `WorkerType` is set, then `NumberOfWorkers` is required (and vice versa).

  • `MaxCapacity` and `NumberOfWorkers` must both be at least 1.

  When the `WorkerType` field is set to a value other than Standard, the `MaxCapacity` field is set automatically and becomes read-only.

• WorkerType – UTF-8 string (valid values: `Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").
The type of predefined worker that is allocated when a task of this transform runs. Accepts a value of Standard, G.1X, or G.2X.

- For the Standard worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
- For the G.1X worker type, each worker provides 4 vCPU, 16 GB of memory and a 64GB disk, and 1 executor per worker.
- For the G.2X worker type, each worker provides 8 vCPU, 32 GB of memory and a 128GB disk, and 1 executor per worker.

MaxCapacity is a mutually exclusive option with NumberOfWorkers and WorkerType.

- If either NumberOfWorkers or WorkerType is set, then MaxCapacity cannot be set.
- If MaxCapacity is set then neither NumberOfWorkers or WorkerType can be set.
- If WorkerType is set, then NumberOfWorkers is required (and vice versa).
- MaxCapacity and NumberOfWorkers must both be at least 1.

- NumberOfWorkers – Number (integer).

  The number of workers of a defined workerType that are allocated when a task of the transform runs.

  If WorkerType is set, then NumberOfWorkers is required (and vice versa).

- Timeout – Number (integer), at least 1.

  The timeout in minutes of the machine learning transform.

- MaxRetries – Number (integer).

  The maximum number of times to retry after an MLTaskRun of the machine learning transform fails.

- TransformEncryption – A TransformEncryption object.

  The encryption-at-rest settings of the transform that apply to accessing user data. Machine learning transforms can access user data encrypted in Amazon S3 using KMS.

**FindMatchesParameters structure**

The parameters to configure the find matches transform.
Fields

- **PrimaryKeyColumnName** – UTF-8 string, not less than 1 or more than 1024 bytes long, matching the Single-line string pattern.

  The name of a column that uniquely identifies rows in the source table. Used to help identify matching records.

- **PrecisionRecallTradeoff** – Number (double), not more than 1.0.

  The value selected when tuning your transform for a balance between precision and recall. A value of 0.5 means no preference; a value of 1.0 means a bias purely for precision, and a value of 0.0 means a bias for recall. Because this is a tradeoff, choosing values close to 1.0 means very low recall, and choosing values close to 0.0 results in very low precision.

  The precision metric indicates how often your model is correct when it predicts a match.

  The recall metric indicates that for an actual match, how often your model predicts the match.

- **AccuracyCostTradeoff** – Number (double), not more than 1.0.

  The value that is selected when tuning your transform for a balance between accuracy and cost. A value of 0.5 means that the system balances accuracy and cost concerns. A value of 1.0 means a bias purely for accuracy, which typically results in a higher cost, sometimes substantially higher. A value of 0.0 means a bias purely for cost, which results in a less accurate FindMatches transform, sometimes with unacceptable accuracy.

  Accuracy measures how well the transform finds true positives and true negatives. Increasing accuracy requires more machine resources and cost. But it also results in increased recall.

  Cost measures how many compute resources, and thus money, are consumed to run the transform.

- **EnforceProvidedLabels** – Boolean.

  The value to switch on or off to force the output to match the provided labels from users. If the value is True, the find matches transform forces the output to match the provided labels. The results override the normal conflation results. If the value is False, the find matches transform does not ensure all the labels provided are respected, and the results rely on the trained model.

  Note that setting this value to true may increase the conflation execution time.
FindMatchesMetrics structure

The evaluation metrics for the find matches algorithm. The quality of your machine learning transform is measured by getting your transform to predict some matches and comparing the results to known matches from the same dataset. The quality metrics are based on a subset of your data, so they are not precise.

Fields

- **AreaUnderPRCurve** – Number (double), not more than 1.0.

  The area under the precision/recall curve (AUPRC) is a single number measuring the overall quality of the transform, that is independent of the choice made for precision vs. recall. Higher values indicate that you have a more attractive precision vs. recall tradeoff.

  For more information, see [Precision and recall](https://en.wikipedia.org/wiki/Precision_and_recall) in Wikipedia.

- **Precision** – Number (double), not more than 1.0.

  The precision metric indicates when often your transform is correct when it predicts a match. Specifically, it measures how well the transform finds true positives from the total true positives possible.

  For more information, see [Precision and recall](https://en.wikipedia.org/wiki/Precision_and_recall) in Wikipedia.

- **Recall** – Number (double), not more than 1.0.

  The recall metric indicates that for an actual match, how often your transform predicts the match. Specifically, it measures how well the transform finds true positives from the total records in the source data.

  For more information, see [Precision and recall](https://en.wikipedia.org/wiki/Precision_and_recall) in Wikipedia.

- **F1** – Number (double), not more than 1.0.

  The maximum F1 metric indicates the transform's accuracy between 0 and 1, where 1 is the best accuracy.

  For more information, see [F1 score](https://en.wikipedia.org/wiki/F1_score) in Wikipedia.

- **ConfusionMatrix** – A ConfusionMatrix object.

  The confusion matrix shows you what your transform is predicting accurately and what types of errors it is making.
For more information, see [Confusion matrix](https://en.wikipedia.org/wiki/Confusion_matrix) in Wikipedia.

- **ColumnImportances** – An array of [ColumnImportance](https://docs.aws.amazon.com/glue/latest/dg/transform-columns-importance.html) objects, not more than 100 structures.

  A list of ColumnImportance structures containing column importance metrics, sorted in order of descending importance.

### ConfusionMatrix structure

The confusion matrix shows you what your transform is predicting accurately and what types of errors it is making.

For more information, see [Confusion matrix](https://en.wikipedia.org/wiki/Confusion_matrix) in Wikipedia.

**Fields**

- **NumTruePositives** – Number (long).

  The number of matches in the data that the transform correctly found, in the confusion matrix for your transform.

- **NumFalsePositives** – Number (long).

  The number of nonmatches in the data that the transform incorrectly classified as a match, in the confusion matrix for your transform.

- **NumTrueNegatives** – Number (long).

  The number of nonmatches in the data that the transform correctly rejected, in the confusion matrix for your transform.

- **NumFalseNegatives** – Number (long).

  The number of matches in the data that the transform didn't find, in the confusion matrix for your transform.

### GlueTable structure

The database and table in the AWS Glue Data Catalog that is used for input or output data.
Fields

- **DatabaseName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A database name in the AWS Glue Data Catalog.

- **TableName** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A table name in the AWS Glue Data Catalog.

- **CatalogId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A unique identifier for the AWS Glue Data Catalog.

- **ConnectionName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the connection to the AWS Glue Data Catalog.

- **AdditionalOptions** – A map array of key-value pairs, not less than 1 or more than 10 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  Additional options for the table. Currently there are two keys supported:

  - **pushDownPredicate:** to filter on partitions without having to list and read all the files in your dataset.
  - **catalogPartitionPredicate:** to use server-side partition pruning using partition indexes in the AWS Glue Data Catalog.

**TaskRun structure**

The sampling parameters that are associated with the machine learning transform.
**Fields**

- **TransformId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier for the transform.

- **TaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier for this task run.

- **Status** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The current status of the requested task run.

- **LogGroupName** – UTF-8 string.

  The names of the log group for secure logging, associated with this task run.

- **Properties** – A TaskRunProperties object.

  Specifies configuration properties associated with this task run.

- **ErrorString** – UTF-8 string.

  The list of error strings associated with this task run.

- **StartedOn** – Timestamp.

  The date and time that this task run started.

- **LastModifiedOn** – Timestamp.

  The last point in time that the requested task run was updated.

- **CompletedOn** – Timestamp.

  The last point in time that the requested task run was completed.

- **ExecutionTime** – Number (integer).

  The amount of time (in seconds) that the task run consumed resources.
TransformFilterCriteria structure

The criteria used to filter the machine learning transforms.

Fields

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  A unique transform name that is used to filter the machine learning transforms.

- **TransformType** – UTF-8 string (valid values: FIND_MATCHES).
  
  The type of machine learning transform that is used to filter the machine learning transforms.

- **Status** – UTF-8 string (valid values: NOT_READY | READY | DELETING).
  
  Filters the list of machine learning transforms by the last known status of the transforms (to indicate whether a transform can be used or not). One of "NOT_READY", "READY", or "DELETING".

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).
  
  This value determines which version of AWS Glue this machine learning transform is compatible with. Glue 1.0 is recommended for most customers. If the value is not set, the Glue compatibility defaults to Glue 0.9. For more information, see [AWS Glue Versions](#) in the developer guide.

- **CreatedBefore** – Timestamp.
  
  The time and date before which the transforms were created.

- **CreatedAfter** – Timestamp.
  
  The time and date after which the transforms were created.

- **LastModifiedBefore** – Timestamp.
  
  Filter on transforms last modified before this date.

- **LastModifiedAfter** – Timestamp.
  
  Filter on transforms last modified after this date.

- **Schema** – An array of [SchemaColumn](#) objects, not more than 100 structures.
  
  Filters on datasets with a specific schema. The Map<Column, Type> object is an array of key-value pairs representing the schema this transform accepts, where Column is the name of a
column, and Type is the type of the data such as an integer or string. Has an upper bound of 100 columns.

**TransformSortCriteria structure**

The sorting criteria that are associated with the machine learning transform.

**Fields**

- **Column** – *Required*: UTF-8 string (valid values: NAME | TRANSFORM_TYPE | STATUS | CREATED | LAST_MODIFIED).
  
  The column to be used in the sorting criteria that are associated with the machine learning transform.

- **SortDirection** – *Required*: UTF-8 string (valid values: DESCENDING | ASCENDING).

  The sort direction to be used in the sorting criteria that are associated with the machine learning transform.

**TaskRunFilterCriteria structure**

The criteria that are used to filter the task runs for the machine learning transform.

**Fields**

- **TaskRunType** – UTF-8 string (valid values: EVALUATION | LABELING_SET_GENERATION | IMPORT_LABELS | EXPORT_LABELS | FIND_MATCHES).

  The type of task run.

- **Status** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The current status of the task run.

- **StartedBefore** – Timestamp.

  Filter on task runs started before this date.

- **StartedAfter** – Timestamp.

  Filter on task runs started after this date.
TaskRunSortCriteria structure

The sorting criteria that are used to sort the list of task runs for the machine learning transform.

Fields

• Column – Required: UTF-8 string (valid values: TASK_RUN_TYPE | STATUS | STARTED).
  The column to be used to sort the list of task runs for the machine learning transform.

• SortDirection – Required: UTF-8 string (valid values: DESCENDING | ASCENDING).
  The sort direction to be used to sort the list of task runs for the machine learning transform.

TaskRunProperties structure

The configuration properties for the task run.

Fields

• TaskType – UTF-8 string (valid values: EVALUATION | LABELING_SET_GENERATION | IMPORT_LABELS | EXPORT_LABELS | FIND_MATCHES).
  The type of task run.

• ImportLabelsTaskRunProperties – An ImportLabelsTaskRunProperties object.
  The configuration properties for an importing labels task run.

• ExportLabelsTaskRunProperties – An ExportLabelsTaskRunProperties object.
  The configuration properties for an exporting labels task run.

• LabelingSetGenerationTaskRunProperties – A LabelingSetGenerationTaskRunProperties object.
  The configuration properties for a labeling set generation task run.

• FindMatchesTaskRunProperties – A FindMatchesTaskRunProperties object.
  The configuration properties for a find matches task run.
FindMatchesTaskRunProperties structure

Specifies configuration properties for a Find Matches task run.

Fields

• JobId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The job ID for the Find Matches task run.

• JobName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The name assigned to the job for the Find Matches task run.

• JobRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The job run ID for the Find Matches task run.

ImportLabelsTaskRunProperties structure

Specifies configuration properties for an importing labels task run.

Fields

• InputS3Path – UTF-8 string.

The Amazon Simple Storage Service (Amazon S3) path from where you will import the labels.

• Replace – Boolean.

Indicates whether to overwrite your existing labels.

ExportLabelsTaskRunProperties structure

Specifies configuration properties for an exporting labels task run.

Fields

• OutputS3Path – UTF-8 string.
The Amazon Simple Storage Service (Amazon S3) path where you will export the labels.

**LabelingSetGenerationTaskRunProperties structure**

Specifies configuration properties for a labeling set generation task run.

**Fields**

- `OutputS3Path` – UTF-8 string.
  
The Amazon Simple Storage Service (Amazon S3) path where you will generate the labeling set.

**SchemaColumn structure**

A key-value pair representing a column and data type that this transform can run against. The `Schema` parameter of the `MLTransform` may contain up to 100 of these structures.

**Fields**

- `Name` – UTF-8 string, not less than 1 or more than 1024 bytes long, matching the `Single-line string pattern`.
  
The name of the column.
- `DataType` – UTF-8 string, not more than 131072 bytes long, matching the `Single-line string pattern`.
  
The type of data in the column.

**TransformEncryption structure**

The encryption-at-rest settings of the transform that apply to accessing user data. Machine learning transforms can access user data encrypted in Amazon S3 using KMS.

Additionally, imported labels and trained transforms can now be encrypted using a customer provided KMS key.

**Fields**

- `MLUserDataEncryption` – A `MLUserDataEncryption` object.
An MLUserDataEncryption object containing the encryption mode and customer-provided KMS key ID.

- TaskRunSecurityConfigurationName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the security configuration.

**MLUserDataEncryption structure**

The encryption-at-rest settings of the transform that apply to accessing user data.

**Fields**

- **MLUserDataEncryptionMode** – Required: UTF-8 string (valid values: DISABLED | SSE-KMS="SSEKMS").

  The encryption mode applied to user data. Valid values are:

  - DISABLED: encryption is disabled
  - SSEKMS: use of server-side encryption with AWS Key Management Service (SSE-KMS) for user data stored in Amazon S3.

- **KmsKeyId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID for the customer-provided KMS key.

**ColumnImportance structure**

A structure containing the column name and column importance score for a column.

Column importance helps you understand how columns contribute to your model, by identifying which columns in your records are more important than others.

**Fields**

- **ColumnName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of a column.
• Importance – Number (double), not more than 1.0.

The column importance score for the column, as a decimal.

Operations

- CreateMLTransform action (Python: create_ml_transform)
- UpdateMLTransform action (Python: update_ml_transform)
- DeleteMLTransform action (Python: delete_ml_transform)
- GetMLTransform action (Python: get_ml_transform)
- GetMLTransforms action (Python: get_ml_transforms)
- ListMLTransforms action (Python: list_ml_transforms)
- StartMLEvaluationTaskRun action (Python: start_ml_evaluation_task_run)
- StartMLLabelingSetGenerationTaskRun action (Python: start_ml_labeling_set_generation_task_run)
- GetMLTaskRun action (Python: get_ml_task_run)
- GetMLTaskRuns action (Python: get_ml_task_runs)
- CancelMLTaskRun action (Python: cancel_ml_task_run)
- StartExportLabelsTaskRun action (Python: start_export_labels_task_run)
- StartImportLabelsTaskRun action (Python: start_import_labels_task_run)

CreateMLTransform action (Python: create_ml_transform)

Creates an AWS Glue machine learning transform. This operation creates the transform and all the necessary parameters to train it.

Call this operation as the first step in the process of using a machine learning transform (such as the FindMatches transform) for deduplicating data. You can provide an optional Description, in addition to the parameters that you want to use for your algorithm.

You must also specify certain parameters for the tasks that AWS Glue runs on your behalf as part of learning from your data and creating a high-quality machine learning transform. These parameters include Role, and optionally, AllocatedCapacity, Timeout, and MaxRetries. For more information, see Jobs.
Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern.**

  The unique name that you give the transform when you create it.

- **Description** – Description string, not more than 2048 bytes long, matching the **URI address multi-line string pattern.**

  A description of the machine learning transform that is being defined. The default is an empty string.

- **InputRecordTables** – *Required:* An array of **GlueTable** objects, not more than 10 structures.

  A list of AWS Glue table definitions used by the transform.

- **Parameters** – *Required:* A **TransformParameters** object.

  The algorithmic parameters that are specific to the transform type used. Conditionally dependent on the transform type.

- **Role** – *Required:* UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role with the required permissions. The required permissions include both AWS Glue service role permissions to AWS Glue resources, and Amazon S3 permissions required by the transform.

  - This role needs AWS Glue service role permissions to allow access to resources in AWS Glue. See **Attach a Policy to IAM Users That Access AWS Glue.**
  
  - This role needs permission to your Amazon Simple Storage Service (Amazon S3) sources, targets, temporary directory, scripts, and any libraries used by the task run for this transform.

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Custom string pattern #15.**

  This value determines which version of AWS Glue this machine learning transform is compatible with. Glue 1.0 is recommended for most customers. If the value is not set, the Glue compatibility defaults to Glue 0.9. For more information, see **AWS Glue Versions** in the developer guide.

- **MaxCapacity** – Number (double).

  The number of AWS Glue data processing units (DPUs) that are allocated to task runs for this transform. You can allocate from 2 to 100 DPUs; the default is 10. A DPU is a relative measure of
processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the AWS Glue pricing page.

MaxCapacity is a mutually exclusive option with NumberOfWorkers and WorkerType.

- If either NumberOfWorkers or WorkerType is set, then MaxCapacity cannot be set.
- If MaxCapacity is set then neither NumberOfWorkers or WorkerType can be set.
- If WorkerType is set, then NumberOfWorkers is required (and vice versa).
- MaxCapacity and NumberOfWorkers must both be at least 1.

When the WorkerType field is set to a value other than Standard, the MaxCapacity field is set automatically and becomes read-only.

When the WorkerType field is set to a value other than Standard, the MaxCapacity field is set automatically and becomes read-only.

- WorkerType – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when this task runs. Accepts a value of Standard, G.1X, or G.2X.

- For the Standard worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
- For the G.1X worker type, each worker provides 4 vCPU, 16 GB of memory and a 64GB disk, and 1 executor per worker.
- For the G.2X worker type, each worker provides 8 vCPU, 32 GB of memory and a 128GB disk, and 1 executor per worker.

MaxCapacity is a mutually exclusive option with NumberOfWorkers and WorkerType.

- If either NumberOfWorkers or WorkerType is set, then MaxCapacity cannot be set.
- If MaxCapacity is set then neither NumberOfWorkers or WorkerType can be set.
- If WorkerType is set, then NumberOfWorkers is required (and vice versa).
- MaxCapacity and NumberOfWorkers must both be at least 1.

- NumberOfWorkers – Number (integer).

The number of workers of a defined workerType that are allocated when this task runs.

- If WorkerType is set, then NumberOfWorkers is required (and vice versa).
- **Timeout** – Number (integer), at least 1.

  The timeout of the task run for this transform in minutes. This is the maximum time that a task run for this transform can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

- **MaxRetries** – Number (integer).

  The maximum number of times to retry a task for this transform after a task run fails.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  The tags to use with this machine learning transform. You may use tags to limit access to the machine learning transform. For more information about tags in AWS Glue, see [AWS Tags in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-tags.html) in the developer guide.

- **TransformEncryption** – A `TransformEncryption` object.

  The encryption-at-rest settings of the transform that apply to accessing user data. Machine learning transforms can access user data encrypted in Amazon S3 using KMS.

**Response**

- **TransformId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/glueregulatory/2020-03-01/guia.html#single-line-string-pattern).

  A unique identifier that is generated for the transform.

**Errors**

- `AlreadyExistsException`
- `InvalidInputException`
- `OperationTimeoutException`
- `InternalServiceException`
- `AccessDeniedException`
- `ResourceNumberLimitExceeded Exception`
• IdempotentParameterMismatchException

UpdateMLTransform action (Python: update_ml_transform)

Updates an existing machine learning transform. Call this operation to tune the algorithm parameters to achieve better results.

After calling this operation, you can call the StartMLEvaluationTaskRun operation to assess how well your new parameters achieved your goals (such as improving the quality of your machine learning transform, or making it more cost-effective).

Request

• TransformId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A unique identifier that was generated when the transform was created.

• Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique name that you gave the transform when you created it.

• Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the transform. The default is an empty string.

• Parameters – A TransformParameters object.

  The configuration parameters that are specific to the transform type (algorithm) used. Conditionally dependent on the transform type.

• Role – UTF-8 string.

  The name or Amazon Resource Name (ARN) of the IAM role with the required permissions.

• GlueVersion – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Custom string pattern #15.

  This value determines which version of AWS Glue this machine learning transform is compatible with. Glue 1.0 is recommended for most customers. If the value is not set, the Glue compatibility defaults to Glue 0.9. For more information, see AWS Glue Versions in the developer guide.
• MaxCapacity – Number (double).

The number of AWS Glue data processing units (DPUs) that are allocated to task runs for this transform. You can allocate from 2 to 100 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the [AWS Glue pricing page](https://aws.amazon.com/glue/pricing/).

When the WorkerType field is set to a value other than Standard, the MaxCapacity field is set automatically and becomes read-only.

• WorkerType – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when this task runs. Accepts a value of Standard, G.1X, or G.2X.

• For the Standard worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
• For the G.1X worker type, each worker provides 4 vCPU, 16 GB of memory and a 64GB disk, and 1 executor per worker.
• For the G.2X worker type, each worker provides 8 vCPU, 32 GB of memory and a 128GB disk, and 1 executor per worker.

• NumberOfWorkers – Number (integer).

The number of workers of a defined workerType that are allocated when this task runs.

• Timeout – Number (integer), at least 1.

The timeout for a task run for this transform in minutes. This is the maximum time that a task run for this transform can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

• MaxRetries – Number (integer).

The maximum number of times to retry a task for this transform after a task run fails.

**Response**

• TransformId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The unique identifier for the transform that was updated.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- AccessDeniedException

DeleteMLTransform action (Python: delete_ml_transform)

Deletes an AWS Glue machine learning transform. Machine learning transforms are a special type of transform that use machine learning to learn the details of the transformation to be performed by learning from examples provided by humans. These transformations are then saved by AWS Glue. If you no longer need a transform, you can delete it by calling DeleteMLTransforms. However, any AWS Glue jobs that still reference the deleted transform will no longer succeed.

Request

- TransformId – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the transform to delete.

Response

- TransformId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the transform that was deleted.

Errors

- EntityNotFoundException
- InvalidInputException
• OperationTimeoutException
• InternalServiceException

GetMLTransform action (Python: get_ml_transform)

Gets an AWS Glue machine learning transform artifact and all its corresponding metadata. Machine learning transforms are a special type of transform that use machine learning to learn the details of the transformation to be performed by learning from examples provided by humans. These transformations are then saved by AWS Glue. You can retrieve their metadata by calling GetMLTransform.

Request

• TransformId – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the transform, generated at the time that the transform was created.

Response

• TransformId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the transform, generated at the time that the transform was created.

• Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique name given to the transform when it was created.

• Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the transform.

• Status – UTF-8 string (valid values: NOT_READY | READY | DELETING).

  The last known status of the transform (to indicate whether it can be used or not). One of "NOT_READY", "READY", or "DELETING".

• CreatedOn – Timestamp.
The date and time when the transform was created.

- **LastModifiedOn** – Timestamp.

The date and time when the transform was last modified.

- **InputRecordTables** – An array of [GlueTable](#) objects, not more than 10 structures.

A list of AWS Glue table definitions used by the transform.

- **Parameters** – A [TransformParameters](#) object.

The configuration parameters that are specific to the algorithm used.

- **EvaluationMetrics** – An [EvaluationMetrics](#) object.

The latest evaluation metrics.

- **LabelCount** – Number (integer).

The number of labels available for this transform.

- **Schema** – An array of [SchemaColumn](#) objects, not more than 100 structures.

The `Map<Column, Type>` object that represents the schema that this transform accepts. Has an upper bound of 100 columns.

- **Role** – UTF-8 string.

The name or Amazon Resource Name (ARN) of the IAM role with the required permissions.

- **GlueVersion** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Custom string pattern #15](#).

This value determines which version of AWS Glue this machine learning transform is compatible with. Glue 1.0 is recommended for most customers. If the value is not set, the Glue compatibility defaults to Glue 0.9. For more information, see [AWS Glue Versions](#) in the developer guide.

- **MaxCapacity** – Number (double).

The number of AWS Glue data processing units (DPUs) that are allocated to task runs for this transform. You can allocate from 2 to 100 DPUs; the default is 10. A DPU is a relative measure of processing power that consists of 4 vCPUs of compute capacity and 16 GB of memory. For more information, see the [AWS Glue pricing page](#).
When the WorkerType field is set to a value other than Standard, the MaxCapacity field is set automatically and becomes read-only.

- **WorkerType** – UTF-8 string (valid values: Standard="" | G.1X="" | G.2X="" | G.025X="" | G.4X="" | G.8X="" | Z.2X="").

The type of predefined worker that is allocated when this task runs. Accepts a value of Standard, G.1X, or G.2X.

- For the Standard worker type, each worker provides 4 vCPU, 16 GB of memory and a 50GB disk, and 2 executors per worker.
- For the G.1X worker type, each worker provides 4 vCPU, 16 GB of memory and a 64GB disk, and 1 executor per worker.
- For the G.2X worker type, each worker provides 8 vCPU, 32 GB of memory and a 128GB disk, and 1 executor per worker.

- **NumberOfWorkers** – Number (integer).

   The number of workers of a defined workerType that are allocated when this task runs.

- **Timeout** – Number (integer), at least 1.

   The timeout for a task run for this transform in minutes. This is the maximum time that a task run for this transform can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

- **MaxRetries** – Number (integer).

   The maximum number of times to retry a task for this transform after a task run fails.

- **TransformEncryption** – A TransformEncryption object.

   The encryption-at-rest settings of the transform that apply to accessing user data. Machine learning transforms can access user data encrypted in Amazon S3 using KMS.

### Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
GetMLTransforms action (Python: get_ml_transforms)

Gets a sortable, filterable list of existing AWS Glue machine learning transforms. Machine learning transforms are a special type of transform that use machine learning to learn the details of the transformation to be performed by learning from examples provided by humans. These transformations are then saved by AWS Glue, and you can retrieve their metadata by calling GetMLTransforms.

Request

- **NextToken** – UTF-8 string.
  
  A paginated token to offset the results.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum number of results to return.

- **Filter** – A `TransformFilterCriteria` object.
  
  The filter transformation criteria.

- **Sort** – A `TransformSortCriteria` object.
  
  The sorting criteria.

Response

- **Transforms** – *Required:* An array of `MLTransform` objects.
  
  A list of machine learning transforms.

- **NextToken** – UTF-8 string.
  
  A pagination token, if more results are available.

Errors

- **EntityNotFoundException**
- **InvalidInputException**
- **OperationException**
- **InternalServiceException**
ListMLTransforms action (Python: list_ml_transforms)

Retrieves a sortable, filterable list of existing AWS Glue machine learning transforms in this AWS account, or the resources with the specified tag. This operation takes the optional Tags field, which you can use as a filter of the responses so that tagged resources can be retrieved as a group. If you choose to use tag filtering, only resources with the tags are retrieved.

Request

• NextToken – UTF-8 string.
  A continuation token, if this is a continuation request.

• MaxResults – Number (integer), not less than 1 or more than 1000.
  The maximum size of a list to return.

• Filter – A TransformFilterCriteria object.
  A TransformFilterCriteria used to filter the machine learning transforms.

• Sort – A TransformSortCriteria object.
  A TransformSortCriteria used to sort the machine learning transforms.

• Tags – A map array of key-value pairs, not more than 50 pairs.
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  Each value is a UTF-8 string, not more than 256 bytes long.
  Specifies to return only these tagged resources.

Response

• TransformIds – Required: An array of UTF-8 strings.
  The identifiers of all the machine learning transforms in the account, or the machine learning transforms with the specified tags.

• NextToken – UTF-8 string.
  A continuation token, if the returned list does not contain the last metric available.
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException

StartMLEvaluationTaskRun action (Python: start_ml_evaluation_task_run)

Starts a task to estimate the quality of the transform.

When you provide label sets as examples of truth, AWS Glue machine learning uses some of those examples to learn from them. The rest of the labels are used as a test to estimate quality.

Returns a unique identifier for the run. You can call GetMLTaskRun to get more information about the stats of the EvaluationTaskRun.

Request

- TransformId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the machine learning transform.

Response

- TaskRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier associated with this run.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- ConcurrentRunsExceededException
- MLTransformNotReadyException

**StartMLLabelingSetGenerationTaskRun action (Python: `start_ml_labeling_set_generation_task_run`)**

Starts the active learning workflow for your machine learning transform to improve the transform's quality by generating label sets and adding labels.

When the `StartMLLabelingSetGenerationTaskRun` finishes, AWS Glue will have generated a "labeling set" or a set of questions for humans to answer.

In the case of the `FindMatches` transform, these questions are of the form, "What is the correct way to group these rows together into groups composed entirely of matching records?"

After the labeling process is finished, you can upload your labels with a call to `StartImportLabelsTaskRun`. After `StartImportLabelsTaskRun` finishes, all future runs of the machine learning transform will use the new and improved labels and perform a higher-quality transformation.

**Request**

- **TransformId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The unique identifier of the machine learning transform.

- **OutputS3Path** – *Required*: UTF-8 string.

  The Amazon Simple Storage Service (Amazon S3) path where you generate the labeling set.

**Response**

- **TaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

  The unique run identifier that is associated with this task run.
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- ConcurrentRunsExceeded Exception

GetMLTaskRun action (Python: get_ml_task_run)

Gets details for a specific task run on a machine learning transform. Machine learning task runs are asynchronous tasks that AWS Glue runs on your behalf as part of various machine learning workflows. You can check the stats of any task run by calling GetMLTaskRun with the TaskRunID and its parent transform's TransformID.

Request

- TransformId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the machine learning transform.

- TaskRunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the task run.

Response

- TransformId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the task run.

- TaskRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique run identifier associated with this run.
• Status – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).
  The status for this task run.
• LogGroupName – UTF-8 string.
  The names of the log groups that are associated with the task run.
• Properties – A TaskRunProperties object.
  The list of properties that are associated with the task run.
• ErrorString – UTF-8 string.
  The error strings that are associated with the task run.
• StartedOn – Timestamp.
  The date and time when this task run started.
• LastModifiedOn – Timestamp.
  The date and time when this task run was last modified.
• CompletedOn – Timestamp.
  The date and time when this task run was completed.
• ExecutionTime – Number (integer).
  The amount of time (in seconds) that the task run consumed resources.

Errors

• EntityNotFoundException
• InvalidInputException
• OperationTimeoutException
• InternalServiceException

GetMLTaskRuns action (Python: get_ml_task_runs)

Gets a list of runs for a machine learning transform. Machine learning task runs are asynchronous tasks that AWS Glue runs on your behalf as part of various machine learning workflows. You can
get a sortable, filterable list of machine learning task runs by calling GetMLTaskRuns with their parent transform's TransformID and other optional parameters as documented in this section.

This operation returns a list of historic runs and must be paginated.

**Request**

- **TransformId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The unique identifier of the machine learning transform.

- **NextToken** – UTF-8 string.
  
  A token for pagination of the results. The default is empty.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum number of results to return.

- **Filter** – A TaskRunFilterCriteria object.
  
  The filter criteria, in the TaskRunFilterCriteria structure, for the task run.

- **Sort** – A TaskRunSortCriteria object.
  
  The sorting criteria, in the TaskRunSortCriteria structure, for the task run.

**Response**

- **TaskRuns** – An array of TaskRun objects.
  
  A list of task runs that are associated with the transform.

- **NextToken** – UTF-8 string.
  
  A pagination token, if more results are available.

**Errors**

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException

GetMLTaskRuns (get_ml_task_runs)
CancelMLTaskRun action (Python: cancel_ml_task_run)

Cancels (stops) a task run. Machine learning task runs are asynchronous tasks that AWS Glue runs on your behalf as part of various machine learning workflows. You can cancel a machine learning task run at any time by calling CancelMLTaskRun with a task run's parent transform's TransformID and the task run's TaskRunId.

Request

- **TransformId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the machine learning transform.

- **TaskRunId** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A unique identifier for the task run.

Response

- **TransformId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier of the machine learning transform.

- **TaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier for the task run.

- **Status** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The status for this run.

Errors

- **EntityNotFoundException**
StartExportLabelsTaskRun action (Python: start_export_labels_task_run)

Begins an asynchronous task to export all labeled data for a particular transform. This task is the only label-related API call that is not part of the typical active learning workflow. You typically use StartExportLabelsTaskRun when you want to work with all of your existing labels at the same time, such as when you want to remove or change labels that were previously submitted as truth. This API operation accepts the `TransformId` whose labels you want to export and an Amazon Simple Storage Service (Amazon S3) path to export the labels to. The operation returns a `TaskRunId`. You can check on the status of your task run by calling the GetMLTaskRun API.

Request

- **RequestId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The unique identifier of the machine learning transform.

- **OutputS3Path** – *Required*: UTF-8 string.
  
  The Amazon S3 path where you export the labels.

Response

- **TaskRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The unique identifier for the task run.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
StartImportLabelsTaskRun action (Python: start_import_labels_task_run)

Enables you to provide additional labels (examples of truth) to be used to teach the machine learning transform and improve its quality. This API operation is generally used as part of the active learning workflow that starts with the StartMLLabelingSetGenerationTaskRun call and that ultimately results in improving the quality of your machine learning transform.

After the StartMLLabelingSetGenerationTaskRun finishes, AWS Glue machine learning will have generated a series of questions for humans to answer. (Answering these questions is often called 'labeling' in the machine learning workflows). In the case of the FindMatches transform, these questions are of the form, "What is the correct way to group these rows together into groups composed entirely of matching records?" After the labeling process is finished, users upload their answers/labels with a call to StartImportLabelsTaskRun. After StartImportLabelsTaskRun finishes, all future runs of the machine learning transform use the new and improved labels and perform a higher-quality transformation.

By default, StartMLLabelingSetGenerationTaskRun continually learns from and combines all labels that you upload unless you set Replace to true. If you set Replace to true, StartImportLabelsTaskRun deletes and forgets all previously uploaded labels and learns only from the exact set that you upload. Replacing labels can be helpful if you realize that you previously uploaded incorrect labels, and you believe that they are having a negative effect on your transform quality.

You can check on the status of your task run by calling the GetMLTaskRun operation.

Request

- **TransformId** – *Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.*

  The unique identifier of the machine learning transform.

- **InputS3Path** – *Required: UTF-8 string.*

  The Amazon Simple Storage Service (Amazon S3) path from where you import the labels.

- **ReplaceAllLabels** – Boolean.

  StartImportLabelsTaskRun (start_import_labels_task_run)
Indicates whether to overwrite your existing labels.

Response

- TaskRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique identifier for the task run.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- ResourceNumberLimitExceeded Exception
- InternalServiceException

Data Quality API

The Data Quality API describes the data quality data types, and includes the API for creating, deleting, or updating data quality rulesets, runs and evaluations.

Data types

- [DataSource structure](#)
- [DataQualityRulesetListDetails structure](#)
- [DataQualityTargetTable structure](#)
- [DataQualityRulesetEvaluationRunDescription structure](#)
- [DataQualityRulesetEvaluationRunFilter structure](#)
- [DataQualityEvaluationRunAdditionalRunOptions structure](#)
- [DataQualityRuleRecommendationRunDescription structure](#)
- [DataQualityRuleRecommendationRunFilter structure](#)
- [DataQualityResult structure](#)
• DataQualityRuleResult structure
• DataQualityResultDescription structure
• DataQualityResultFilterCriteria structure
• DataQualityRulesetFilterCriteria structure

DataSource structure

A data source (an AWS Glue table) for which you want data quality results.

Fields

• GlueTable – Required: A GlueTable object.
  An AWS Glue table.

DataQualityRulesetListDetails structure

Describes a data quality ruleset returned by GetDataQualityRuleset.

Fields

• Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  The name of the data quality ruleset.
• Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  A description of the data quality ruleset.
• CreatedOn – Timestamp.
  The date and time the data quality ruleset was created.
• LastModifiedOn – Timestamp.
  The date and time the data quality ruleset was last modified.
• TargetTable – A DataQualityTargetTable object.
  An object representing an AWS Glue table.
• RecommendationRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

When a ruleset was created from a recommendation run, this run ID is generated to link the two together.

• RuleCount – Number (integer).

The number of rules in the ruleset.

**DataQualityTargetTable structure**

An object representing an AWS Glue table.

**Fields**

• TableName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The name of the AWS Glue table.

• DatabaseName – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The name of the database where the AWS Glue table exists.

• CatalogId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The catalog id where the AWS Glue table exists.

**DataQualityRulesetEvaluationRunDescription structure**

Describes the result of a data quality ruleset evaluation run.

**Fields**

• RunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).

The unique run identifier associated with this run.
• Status – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The status for this run.

• StartedOn – Timestamp.

  The date and time when the run started.

• DataSource – A DataQualityRulesetEvaluationRunFilter structure

  The data source (an AWS Glue table) associated with the run.

DataQualityRulesetEvaluationRunFilter structure

The filter criteria.

Fields

• DataSource – Required: A DataSource object.

  Filter based on a data source (an AWS Glue table) associated with the run.

• StartedBefore – Timestamp.

  Filter results by runs that started before this time.

• StartedAfter – Timestamp.

  Filter results by runs that started after this time.

DataQualityEvaluationRunAdditionalRunOptions structure

Additional run options you can specify for an evaluation run.

Fields

• CloudWatchMetricsEnabled – Boolean.

  Whether or not to enable CloudWatch metrics.

• ResultsS3Prefix – UTF-8 string.

  Prefix for Amazon S3 to store results.
DataQualityRuleRecommendationRunDescription structure

Describes the result of a data quality rule recommendation run.

Fields

- RunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The unique run identifier associated with this run.

- Status – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).
  
  The status for this run.

- StartedOn – Timestamp.
  
  The date and time when this run started.

- DataSource – A DataSource object.
  
  The data source (AWS Glue table) associated with the recommendation run.

DataQualityRuleRecommendationRunFilter structure

A filter for listing data quality recommendation runs.

Fields

- DataSource – Required: A DataSource object.
  
  Filter based on a specified data source (AWS Glue table).

- StartedBefore – Timestamp.
  
  Filter based on time for results started before provided time.

- StartedAfter – Timestamp.
  
  Filter based on time for results started after provided time.
DataQualityResult structure

Describes a data quality result.

Fields

- **ResultId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  A unique result ID for the data quality result.

- **Score** – Number (double), not more than 1.0.
  
  An aggregate data quality score. Represents the ratio of rules that passed to the total number of rules.

- **DataSource** – A DataSource object.
  
  The table associated with the data quality result, if any.

- **RulesetName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the ruleset associated with the data quality result.

- **EvaluationContext** – UTF-8 string.
  
  In the context of a job in AWS Glue Studio, each node in the canvas is typically assigned some sort of name and data quality nodes will have names. In the case of multiple nodes, the evaluationContext can differentiate the nodes.

- **StartedOn** – Timestamp.
  
  The date and time when this data quality run started.

- **CompletedOn** – Timestamp.
  
  The date and time when this data quality run completed.

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The job name associated with the data quality result, if any.

- **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
The job run ID associated with the data quality result, if any.

- **RulesetEvaluationRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The unique run ID for the ruleset evaluation for this data quality result.

- **RuleResults** – An array of DataQualityRuleResult objects, not more than 2000 structures.

  A list of DataQualityRuleResult objects representing the results for each rule.

- **AnalyzerResults** – An array of DataQualityAnalyzerResult objects, not more than 2000 structures.

  A list of DataQualityAnalyzerResult objects representing the results for each analyzer.

- **Observations** – An array of DataQualityObservation objects, not more than 50 structures.

  A list of DataQualityObservation objects representing the observations generated after evaluating the rules and analyzers.

### DataQualityRuleResult structure

Describes the result of the evaluation of a data quality rule.

**Fields**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the data quality rule.

- **Description** – UTF-8 string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the data quality rule.

- **EvaluationMessage** – UTF-8 string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  An evaluation message.

- **Result** – UTF-8 string (valid values: PASS | FAIL | ERROR).

  A pass or fail status for the rule.
• EvaluatedMetrics – A map array of key-value pairs.

Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

Each value is a Number (double).

A map of metrics associated with the evaluation of the rule.

**DataQualityResultDescription structure**

Describes a data quality result.

**Fields**

• ResultId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The unique result ID for this data quality result.

• DataSource – A **DataSource** object.

The table name associated with the data quality result.

• JobName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The job name associated with the data quality result.

• JobRunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The job run ID associated with the data quality result.

• StartedOn – Timestamp.

The time that the run started for this data quality result.

**DataQualityResultFilterCriteria structure**

Criteria used to return data quality results.
Fields

- **DataSource** – A `DataSource` object.
  
  Filter results by the specified data source. For example, retrieving all results for an AWS Glue table.

- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Filter results by the specified job name.

- **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Filter results by the specified job run ID.

- **StartedAfter** – Timestamp.
  
  Filter results by runs that started after this time.

- **StartedBefore** – Timestamp.
  
  Filter results by runs that started before this time.

**DataQualityRulesetFilterCriteria structure**

The criteria used to filter data quality rule sets.

Fields

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the ruleset filter criteria.

- **Description** – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  
  The description of the ruleset filter criteria.

- **CreatedBefore** – Timestamp.
  
  Filter on rule sets created before this date.

- **CreatedAfter** – Timestamp.
Filter on rulesets created after this date.

- **LastModifiedBefore** – Timestamp.

Filter on rulesets last modified before this date.

- **LastModifiedAfter** – Timestamp.

Filter on rulesets last modified after this date.

- **TargetTable** – A [DataQualityTargetTable](#) object.

The name and database name of the target table.

**Operations**

- **StartDataQualityRulesetEvaluationRun** action (Python: start_data_quality_ruleset_evaluation_run)
- **CancelDataQualityRulesetEvaluationRun** action (Python: cancel_data_quality_ruleset_evaluation_run)
- **GetDataQualityRulesetEvaluationRun** action (Python: get_data_quality_ruleset_evaluation_run)
- **ListDataQualityRulesetEvaluationRuns** action (Python: list_data_quality_ruleset_evaluation_runs)
- **StartDataQualityRuleRecommendationRun** action (Python: start_data_quality_rule_recommendation_run)
- **CancelDataQualityRuleRecommendationRun** action (Python: cancel_data_quality_rule_recommendation_run)
- **GetDataQualityRuleRecommendationRun** action (Python: get_data_quality_rule_recommendation_run)
- **ListDataQualityRuleRecommendationRuns** action (Python: list_data_quality_rule_recommendation_runs)
- **GetDataQualityResult** action (Python: get_data_quality_result)
- **BatchGetDataQualityResult** action (Python: batch_get_data_quality_result)
- **ListDataQualityResults** action (Python: list_data_quality_results)
- **CreateDataQualityRuleset** action (Python: create_data_quality_ruleset)
- **DeleteDataQualityRuleset** action (Python: delete_data_quality_ruleset)
- **GetDataQualityRuleset** action (Python: get_data_quality_ruleset)
StartDataQualityRulesetEvaluationRun action (Python: start_data_quality_ruleset_evaluation_run)

Once you have a ruleset definition (either recommended or your own), you call this operation to evaluate the ruleset against a data source (AWS Glue table). The evaluation computes results which you can retrieve with the GetDataQualityResult API.

Request

- **DataSource** – *Required:* A `DataSource` object.
  
  The data source (AWS Glue table) associated with this run.

- **Role** – *Required:* UTF-8 string.
  
  An IAM role supplied to encrypt the results of the run.

- **NumberOfWorkers** – Number (integer).
  
  The number of G.1X workers to be used in the run. The default is 5.

- **Timeout** – Number (integer), at least 1.
  
  The timeout for a run in minutes. This is the maximum time that a run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

- **ClientToken** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  Used for idempotency and is recommended to be set to a random ID (such as a UUID) to avoid creating or starting multiple instances of the same resource.

- **AdditionalRunOptions** – A `DataQualityEvaluationRunAdditionalRunOptions` object.
  
  Additional run options you can specify for an evaluation run.

- **RulesetNames** – *Required:* An array of UTF-8 strings, not less than 1 or more than 10 strings.
  
  A list of ruleset names. At this time, only one ruleset name is taken.

- **AdditionalDataSources** – A map array of key-value pairs.
Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

Each value is a *DataSource* object.

A map of reference strings to additional data sources you can specify for an evaluation run.

**Response**

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The unique run identifier associated with this run.

**Errors**

- InvalidInputException
- EntityNotFoundException
- OperationTimeoutException
- InternalServiceException
- ConflictException

**CancelDataQualityRulesetEvaluationRun action (Python: cancel_data_quality_ruleset_evaluation_run)**

Cancels a run where a ruleset is being evaluated against a data source.

**Request**

- **RunId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the *Single-line string pattern*.

  The unique run identifier associated with this run.

**Response**

- *No Response parameters.*
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException

**GetDataQualityRulesetEvaluationRun action (Python: get_data_quality_ruleset_evaluation_run)**

Retrieves a specific run where a ruleset is evaluated against a data source.

**Request**

- RunId – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The unique run identifier associated with this run.

**Response**

- RunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The unique run identifier associated with this run.
- DataSource – A **DataSource** object.

  The data source (an AWS Glue table) associated with this evaluation run.
- Role – UTF-8 string.

  An IAM role supplied to encrypt the results of the run.
- NumberOfWorkers – Number (integer).

  The number of G.1X workers to be used in the run. The default is 5.
- Timeout – Number (integer), at least 1.

  The timeout for a run in minutes. This is the maximum time that a run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).
• AdditionalRunOptions – A `DataQualityEvaluationRunAdditionalRunOptions` object.

  Additional run options you can specify for an evaluation run.

• Status – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The status for this run.

• ErrorString – UTF-8 string.

  The error strings that are associated with the run.

• StartedOn – Timestamp.

  The date and time when this run started.

• LastModifiedOn – Timestamp.

  A timestamp. The last point in time when this data quality rule recommendation run was modified.

• CompletedOn – Timestamp.

  The date and time when this run was completed.

• ExecutionTime – Number (integer).

  The amount of time (in seconds) that the run consumed resources.

• RulesetNames – An array of UTF-8 strings, not less than 1 or more than 10 strings.

  A list of ruleset names for the run. Currently, this parameter takes only one Ruleset name.

• ResultIds – An array of UTF-8 strings, not less than 1 or more than 10 strings.

  A list of result IDs for the data quality results for the run.

• AdditionalDataSources – A map array of key-value pairs.

  Each key is a UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  Each value is a A `DataSource` object.

  A map of reference strings to additional data sources you can specify for an evaluation run.
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException

**ListDataQualityRulesetEvaluationRuns action (Python: list_data_quality_ruleset_evaluation_runs)**

Lists all the runs meeting the filter criteria, where a ruleset is evaluated against a data source.

**Request**

- **Filter** – A `DataQualityRulesetEvaluationRunFilter` object.
  - The filter criteria.
- **NextToken** – UTF-8 string.
  - A paginated token to offset the results.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  - The maximum number of results to return.

**Response**

- **Runs** – An array of `DataQualityRulesetEvaluationRunDescription` objects.
  - A list of `DataQualityRulesetEvaluationRunDescription` objects representing data quality ruleset runs.
- **NextToken** – UTF-8 string.
  - A pagination token, if more results are available.

**Errors**

- **InvalidInputException**
• OperationTimeoutException
• InternalServiceException

StartDataQualityRuleRecommendationRun action (Python: start_data_quality_rule_recommendation_run)

Starts a recommendation run that is used to generate rules when you don't know what rules to write. AWS Glue Data Quality analyzes the data and comes up with recommendations for a potential ruleset. You can then triage the ruleset and modify the generated ruleset to your liking.

Recommendation runs are automatically deleted after 90 days.

Request

• DataSource – **Required**: A [DataSource](#) object.
  
The data source (AWS Glue table) associated with this run.

• Role – **Required**: UTF-8 string.
  
An IAM role supplied to encrypt the results of the run.

• NumberOfWorkers – Number (integer).
  
The number of G.1X workers to be used in the run. The default is 5.

• Timeout – Number (integer), at least 1.
  
The timeout for a run in minutes. This is the maximum time that a run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

• CreatedRulesetName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.
  
A name for the ruleset.

• ClientToken – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.
  
Used for idempotency and is recommended to be set to a random ID (such as a UUID) to avoid creating or starting multiple instances of the same resource.
Response

- RunId – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The unique run identifier associated with this run.

Errors

- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- ConflictException

CancelDataQualityRuleRecommendationRun action (Python: cancel_data_quality_rule_recommendation_run)

Cancels the specified recommendation run that was being used to generate rules.

Request

- RunId – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

The unique run identifier associated with this run.

Response

- No Response parameters.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
GetDataQualityRuleRecommendationRun action (Python: get_data_quality_rule_recommendation_run)

Gets the specified recommendation run that was used to generate rules.

**Request**

- **RunId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique run identifier associated with this run.

**Response**

- **RunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The unique run identifier associated with this run.

- **DataSource** – A `DataSource` object.

  The data source (an AWS Glue table) associated with this run.

- **Role** – UTF-8 string.

  An IAM role supplied to encrypt the results of the run.

- **NumberOfWorkers** – Number (integer).

  The number of G.1X workers to be used in the run. The default is 5.

- **Timeout** – Number (integer), at least 1.

  The timeout for a run in minutes. This is the maximum time that a run can consume resources before it is terminated and enters TIMEOUT status. The default is 2,880 minutes (48 hours).

- **Status** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT).

  The status for this run.

- **ErrorString** – UTF-8 string.

  The error strings that are associated with the run.
• StartedOn – Timestamp.
   The date and time when this run started.
• LastModifiedOn – Timestamp.
   A timestamp. The last point in time when this data quality rule recommendation run was modified.
• CompletedOn – Timestamp.
   The date and time when this run was completed.
• ExecutionTime – Number (integer).
   The amount of time (in seconds) that the run consumed resources.
• RecommendedRuleset – UTF-8 string, not less than 1 or more than 65536 bytes long.
   When a start rule recommendation run completes, it creates a recommended ruleset (a set of rules). This member has those rules in Data Quality Definition Language (DQDL) format.
• CreatedRulesetName – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
   The name of the ruleset that was created by the run.

Errors
• EntityNotFoundException
• InvalidInputException
• OperationTimeoutException
• InternalServiceException

**ListDataQualityRuleRecommendationRuns action (Python: list_data_quality_rule_recommendation_runs)**

Lists the recommendation runs meeting the filter criteria.

**Request**

• Filter – A DataQualityRuleRecommendationRunFilter object.
The filter criteria.

- **NextToken** – UTF-8 string.

  A paginated token to offset the results.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum number of results to return.

**Response**

- **Runs** – An array of `DataQualityRuleRecommendationRunDescription` objects.

  A list of `DataQualityRuleRecommendationRunDescription` objects.

- **NextToken** – UTF-8 string.

  A pagination token, if more results are available.

**Errors**

- **InvalidInputException**
- **OperationTimeoutException**
- **InternalServiceException**

**GetDataQualityResult action (Python: get_data_quality_result)**

Retrieves the result of a data quality rule evaluation.

**Request**

- **ResultId** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the
  Single-line string pattern.

  A unique result ID for the data quality result.
Response

- **ResultId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  A unique result ID for the data quality result.
- **Score** – Number (double), not more than 1.0.
  An aggregate data quality score. Represents the ratio of rules that passed to the total number of rules.
- **DataSource** – A [DataSource](#) object.
  The table associated with the data quality result, if any.
- **RulesetName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The name of the ruleset associated with the data quality result.
- **EvaluationContext** – UTF-8 string.
  In the context of a job in AWS Glue Studio, each node in the canvas is typically assigned some sort of name and data quality nodes will have names. In the case of multiple nodes, the evaluationContext can differentiate the nodes.
- **StartedOn** – Timestamp.
  The date and time when the run for this data quality result started.
- **CompletedOn** – Timestamp.
  The date and time when the run for this data quality result was completed.
- **JobName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The job name associated with the data quality result, if any.
- **JobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The job run ID associated with the data quality result, if any.
- **RulesetEvaluationRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  The job run ID associated with the data quality result, if any.
The unique run ID associated with the ruleset evaluation.

- **RuleResults** – An array of [DataQualityRuleResult](#) objects, not more than 2000 structures.

  A list of DataQualityRuleResult objects representing the results for each rule.

- **AnalyzerResults** – An array of DataQualityAnalyzerResult objects, not more than 2000 structures.

  A list of DataQualityAnalyzerResult objects representing the results for each analyzer.

- **Observations** – An array of DataQualityObservation objects, not more than 50 structures.

  A list of DataQualityObservation objects representing the observations generated after evaluating the rules and analyzers.

**Errors**

- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- EntityNotFoundException

**BatchGetDataQualityResult action (Python: batch_get_data_quality_result)**

Retrieves a list of data quality results for the specified result IDs.

**Request**

- **ResultIds** – *Required:* An array of UTF-8 strings, not less than 1 or more than 100 strings.

  A list of unique result IDs for the data quality results.

**Response**

- **Results** – *Required:* An array of DataQualityResult objects.

  A list of DataQualityResult objects representing the data quality results.
• ResultsNotFound – An array of UTF-8 strings, not less than 1 or more than 100 strings.

   A list of result IDs for which results were not found.

Errors

• InvalidInputException
• OperationTimeoutException
• InternalServiceException

ListDataQualityResults action (Python: list_data_quality_results)

Returns all data quality execution results for your account.

Request

• Filter – A DataQualityResultFilterCriteria object.

   The filter criteria.
• NextToken – UTF-8 string.

   A paginated token to offset the results.
• MaxResults – Number (integer), not less than 1 or more than 1000.

   The maximum number of results to return.

Response

• Results – Required: An array of DataQualityResultDescription objects.

   A list of DataQualityResultDescription objects.
• NextToken – UTF-8 string.

   A pagination token, if more results are available.

Errors

• InvalidInputException
- OperationTimeoutException
- InternalServiceException

**CreateDataQualityRuleset action (Python: create_data_quality_ruleset)**

Creates a data quality ruleset with DQDL rules applied to a specified AWS Glue table.

You create the ruleset using the Data Quality Definition Language (DQDL). For more information, see the AWS Glue developer guide.

**Request**

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  A unique name for the data quality ruleset.

- **Description** – Description string, not more than 2048 bytes long, matching the [URI address multi-line string pattern](#).
  
  A description of the data quality ruleset.

- **Ruleset** – *Required:* UTF-8 string, not less than 1 or more than 65536 bytes long.
  
  A Data Quality Definition Language (DQDL) ruleset. For more information, see the AWS Glue developer guide.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.
  
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  A list of tags applied to the data quality ruleset.

- **TargetTable** – A [DataQualityTargetTable](#) object.
  
  A target table associated with the data quality ruleset.

- **RecommendationRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](#).
  
  A unique run ID for the recommendation run.
• ClientToken – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

Used for idempotency and is recommended to be set to a random ID (such as a UUID) to avoid creating or starting multiple instances of the same resource.

**Response**

• Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  A unique name for the data quality ruleset.

**Errors**

• InvalidInputException
• AlreadyExistsException
• OperationTimeoutException
• InternalServiceException
• ResourceNumberLimitExceeded

**DeleteDataQualityRuleset action (Python: delete_data_quality_ruleset)**

Deletes a data quality ruleset.

**Request**

• Name – **Required**: UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  A name for the data quality ruleset.

**Response**

• No **Response parameters**.
Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException

GetDataQualityRuleset action (Python: get_data_quality_ruleset)

Returns an existing ruleset by identifier or name.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the ruleset.

Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the ruleset.
- Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the ruleset.
- Ruleset – UTF-8 string, not less than 1 or more than 65536 bytes long.

  A Data Quality Definition Language (DQDL) ruleset. For more information, see the AWS Glue developer guide.
- TargetTable – A DataQualityTargetTable object.

  The name and database name of the target table.
- CreatedOn – Timestamp.

  A timestamp. The time and date that this data quality ruleset was created.
• **LastModifiedOn** – Timestamp.

  A timestamp. The last point in time when this data quality ruleset was modified.

• **RecommendationRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/cезжаar/latest/dg/strings.html).

  When a ruleset was created from a recommendation run, this run ID is generated to link the two together.

**Errors**

- **EntityNotFoundException**
- **InvalidInputException**
- **OperationTimeoutException**
- **InternalServiceException**

**ListDataQualityRuleSets action (Python: list_data_quality_ruleSets)**

Returns a paginated list of rulesets for the specified list of AWS Glue tables.

**Request**

- **NextToken** – UTF-8 string.

  A paginated token to offset the results.

- **MaxResults** – Number (integer), not less than 1 or more than 1000.

  The maximum number of results to return.


  The filter criteria.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  A list of key-value pair tags.
Response

- Rulesets – An array of DataQualityRulesetListDetails objects.
  
  A paginated list of rulesets for the specified list of AWS Glue tables.
- NextToken – UTF-8 string.
  
  A pagination token, if more results are available.

Errors

- EntityNotFoundException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException

UpdateDataQualityRuleset action (Python: update_data_quality_ruleset)

Updates the specified data quality ruleset.

Request

- Name – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
  
  The name of the data quality ruleset.
- Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.
  
  A description of the ruleset.
- Ruleset – UTF-8 string, not less than 1 or more than 65536 bytes long.
  
  A Data Quality Definition Language (DQDL) ruleset. For more information, see the AWS Glue developer guide.
Response

- Name – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the data quality ruleset.

- Description – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A description of the ruleset.

- Ruleset – UTF-8 string, not less than 1 or more than 65536 bytes long.

  A Data Quality Definition Language (DQDL) ruleset. For more information, see the AWS Glue developer guide.

Errors

- EntityNotFoundException
- AlreadyExistsException
- IdempotentParameterMismatchException
- InvalidInputException
- OperationTimeoutException
- InternalServiceException
- ResourceNumberLimitExceeded Exception

Sensitive data detection API

The Sensitive data detection API describes the APIs used to detect sensitive data across the columns and rows of your structured data.

Data types

- CustomEntityType structure
CustomEntityType structure

An object representing a custom pattern for detecting sensitive data across the columns and rows of your structured data.

Fields

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A name for the custom pattern that allows it to be retrieved or deleted later. This name must be unique per AWS account.

- **RegexString** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A regular expression string that is used for detecting sensitive data in a custom pattern.

- **ContextWords** – An array of UTF-8 strings, not less than 1 or more than 20 strings.

  A list of context words. If none of these context words are found within the vicinity of the regular expression the data will not be detected as sensitive data.

  If no context words are passed only a regular expression is checked.

Operations

- **CreateCustomEntityType action (Python: create_custom_entity_type)**
- **DeleteCustomEntityType action (Python: delete_custom_entity_type)**
- **GetCustomEntityType action (Python: get_custom_entity_type)**
- **BatchGetCustomEntityTypes action (Python: batch_get_custom_entity_types)**
- **ListCustomEntityTypes action (Python: list_custom_entity_types)**

CreateCustomEntityType action (Python: create_custom_entity_type)

Creates a custom pattern that is used to detect sensitive data across the columns and rows of your structured data.
Each custom pattern you create specifies a regular expression and an optional list of context words. If no context words are passed only a regular expression is checked.

**Request**

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A name for the custom pattern that allows it to be retrieved or deleted later. This name must be unique per AWS account.

- **RegexString** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  A regular expression string that is used for detecting sensitive data in a custom pattern.

- **ContextWords** – An array of UTF-8 strings, not less than 1 or more than 20 strings.

  A list of context words. If none of these context words are found within the vicinity of the regular expression the data will not be detected as sensitive data.

  If no context words are passed only a regular expression is checked.

- **Tags** – A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  A list of tags applied to the custom entity type.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the custom pattern you created.

**Errors**

- **AccessDeniedException**

- **AlreadyExistsException**
DeleteCustomEntityType action (Python: delete_custom_entity_type)

Deletes a custom pattern by specifying its name.

**Request**

- **Name** – *Required*: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the custom pattern that you want to delete.

**Response**

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The name of the custom pattern you deleted.

**Errors**

- EntityNotFoundException
- AccessDeniedException
- InternalServiceException
- InvalidInputException
- OperationTimeoutException

GetCustomEntityType action (Python: get_custom_entity_type)

Retrieves the details of a custom pattern by specifying its name.
Request

- **Name** – *Required:* UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the custom pattern that you want to retrieve.

Response

- **Name** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  The name of the custom pattern that you retrieved.

- **RegexString** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the **Single-line string pattern**.

  A regular expression string that is used for detecting sensitive data in a custom pattern.

- **ContextWords** – An array of UTF-8 strings, not less than 1 or more than 20 strings.

  A list of context words if specified when you created the custom pattern. If none of these context words are found within the vicinity of the regular expression the data will not be detected as sensitive data.

Errors

- EntityNotFoundException
- AccessDeniedException
- InternalServiceException
- InvalidInputException
- OperationTimeoutException

**BatchGetCustomEntityTypes action (Python: batch_get_custom_entity_types)**

Retrieves the details for the custom patterns specified by a list of names.
Request

- **Names** – *Required:* An array of UTF-8 strings, not less than 1 or more than 50 strings.
  
  A list of names of the custom patterns that you want to retrieve.

Response

- **CustomEntityTypes** – An array of `CustomEntityTypeInfo` objects.
  
  A list of `CustomEntityTypeInfo` objects representing the custom patterns that have been created.
- **CustomEntityTypesNotFound** – An array of UTF-8 strings, not less than 1 or more than 50 strings.
  
  A list of the names of custom patterns that were not found.

Errors

- `InvalidInputException`
- `InternalServiceException`
- `OperationTimeoutException`

**ListCustomEntityTypes action (Python: list_custom_entity_types)**

Lists all the custom patterns that have been created.

Request

- **NextToken** – UTF-8 string.
  
  A paginated token to offset the results.
- **MaxResults** – Number (integer), not less than 1 or more than 1000.
  
  The maximum number of results to return.
- **Tags** – A map array of key-value pairs, not more than 50 pairs.
  
  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  
  Each value is a UTF-8 string, not more than 256 bytes long.
A list of key-value pair tags.

Response

- CustomEntityTypes – An array of CustomEntityType objects.
  A list of CustomEntityType objects representing custom patterns.
- NextToken – UTF-8 string.
  A pagination token, if more results are available.

Errors

- InvalidInputException
- OperationTimeoutException
- InternalServiceException

Tagging APIs in AWS Glue

Data types

- Tag structure

Tag structure

The Tag object represents a label that you can assign to an AWS resource. Each tag consists of a key and an optional value, both of which you define.

For more information about tags, and controlling access to resources in AWS Glue, see AWS Tags in AWS Glue and Specifying AWS Glue Resource ARNs in the developer guide.

Fields

- key – UTF-8 string, not less than 1 or more than 128 bytes long.
  The tag key. The key is required when you create a tag on an object. The key is case-sensitive, and must not contain the prefix aws.
• value – UTF-8 string, not more than 256 bytes long.

The tag value. The value is optional when you create a tag on an object. The value is case-sensitive, and must not contain the prefix `aws`.

**Operations**

• TagResource action (Python: `tag_resource`)
• UntagResource action (Python: `untag_resource`)
• GetTags action (Python: `get_tags`)

**TagResource action (Python: `tag_resource`)**

Adds tags to a resource. A tag is a label you can assign to an AWS resource. In AWS Glue, you can tag only certain resources. For information about what resources you can tag, see [AWS Tags in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-concepts-tags.html).

In addition to the tagging permissions to call tag related APIs, you also need the `glue:GetConnection` permission to call tagging APIs on connections, and the `glue:GetDatabase` permission to call tagging APIs on databases.

**Request**

• `ResourceArn` – *Required:* UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-concepts-tags.html).

  The ARN of the AWS Glue resource to which to add the tags. For more information about AWS Glue resource ARNs, see the [AWS Glue ARN string pattern](https://docs.aws.amazon.com/glue/latest/dg/aws-glue-concepts-tags.html).

• `TagsToAdd` – *Required:* A map array of key-value pairs, not more than 50 pairs.

  Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.

  Each value is a UTF-8 string, not more than 256 bytes long.

  Tags to add to this resource.
Response

• *No Response parameters.*

Errors

• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• EntityNotFoundException

UntagResource action *(Python: untag_resource)*

Removes tags from a resource.

Request

• ResourceArn – *Required:* UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#).

  The Amazon Resource Name (ARN) of the resource from which to remove the tags.

• TagsToRemove – *Required:* An array of UTF-8 strings, not more than 50 strings.

  Tags to remove from this resource.

Response

• *No Response parameters.*

Errors

• InvalidInputException
• InternalServiceException
• OperationTimeoutException
• EntityNotFoundException
GetTags action (Python: get_tags)

Retrieves a list of tags associated with a resource.

Request

- **ResourceArn** – *Required:* UTF-8 string, not less than 1 or more than 10240 bytes long, matching the [Custom string pattern #17](#). The Amazon Resource Name (ARN) of the resource for which to retrieve tags.

Response

- **Tags** – A map array of key-value pairs, not more than 50 pairs.
  - Each key is a UTF-8 string, not less than 1 or more than 128 bytes long.
  - Each value is a UTF-8 string, not more than 256 bytes long.
  - The requested tags.

Errors

- InvalidInputException
- InternalServiceException
- OperationTimeoutException
- EntityNotFoundException

Common data types

The Common data types describes miscellaneous common data types in AWS Glue.

Tag structure

The Tag object represents a label that you can assign to an AWS resource. Each tag consists of a key and an optional value, both of which you define.

For more information about tags, and controlling access to resources in AWS Glue, see [AWS Tags in AWS Glue](#) and [Specifying AWS Glue Resource ARNs](#) in the developer guide.
Fields

- key – UTF-8 string, not less than 1 or more than 128 bytes long.

  The tag key. The key is required when you create a tag on an object. The key is case-sensitive, and must not contain the prefix aws.

- value – UTF-8 string, not more than 256 bytes long.

  The tag value. The value is optional when you create a tag on an object. The value is case-sensitive, and must not contain the prefix aws.

DecimalNumber structure

Contains a numeric value in decimal format.

Fields

- UnscaledValue – Required: Blob.

  The unscaled numeric value.

- Scale – Required: Number (integer).

  The scale that determines where the decimal point falls in the unscaled value.

ErrorDetail structure

Contains details about an error.

Fields

- ErrorCode – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The code associated with this error.

- ErrorMessage – Description string, not more than 2048 bytes long, matching the URI address multi-line string pattern.

  A message describing the error.
PropertyPredicate structure

Defines a property predicate.

Fields

• Key – Value string, not more than 1024 bytes long.
  The key of the property.

• Value – Value string, not more than 1024 bytes long.
  The value of the property.

• Comparator – UTF-8 string (valid values: EQUALS | GREATER_THAN | LESS_THAN | GREATER_THAN_EQUALS | LESS_THAN_EQUALS).
  The comparator used to compare this property to others.

ResourceUri structure

The URIs for function resources.

Fields

• ResourceType – UTF-8 string (valid values: JAR | FILE | ARCHIVE).
  The type of the resource.

• Uri – Uniform resource identifier (uri), not less than 1 or more than 1024 bytes long, matching the URI address multi-line string pattern.
  The URI for accessing the resource.

ColumnStatistics structure

Represents the generated column-level statistics for a table or partition.

Fields

• ColumnName – Required: UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.
Name of column which statistics belong to.

- **ColumnType** – *Required:* Type name, not more than 20000 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/). The data type of the column.

- **AnalyzedTime** – *Required:* Timestamp. The timestamp of when column statistics were generated.


### ColumnStatisticsError structure

Encapsulates a ColumnStatistics object that failed and the reason for failure.

#### Fields


- **Error** – An [ErrorDetail](https://docs.aws.amazon.com/glue/latest/dg/) object. An error message with the reason for the failure of an operation.

### ColumnError structure

Encapsulates a column name that failed and the reason for failure.

#### Fields

- **ColumnName** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the [Single-line string pattern](https://docs.aws.amazon.com/glue/latest/dg/). The name of the column that failed.

- **Error** – An [ErrorDetail](https://docs.aws.amazon.com/glue/latest/dg/) object. An error message with the reason for the failure of an operation.
ColumnStatisticsData structure

Contains the individual types of column statistics data. Only one data object should be set and indicated by the Type attribute.

Fields

- **Type** – *Required:* UTF-8 string (valid values: BOOLEAN | DATE | DECIMAL | DOUBLE | LONG | STRING | BINARY).

  The type of column statistics data.


  Boolean column statistics data.

- **DateColumnStatisticsData** – A [DateColumnStatisticsData](#) object.

  Date column statistics data.

- **DecimalColumnStatisticsData** – A [DecimalColumnStatisticsData](#) object.

  Decimal column statistics data. UnscaledValues within are Base64-encoded binary objects storing big-endian, two's complement representations of the decimal's unscaled value.

- **DoubleColumnStatisticsData** – A [DoubleColumnStatisticsData](#) object.

  Double column statistics data.


  Long column statistics data.

- **StringColumnStatisticsData** – A [StringColumnStatisticsData](#) object.

  String column statistics data.

- **BinaryColumnStatisticsData** – A [BinaryColumnStatisticsData](#) object.

  Binary column statistics data.

BooleanColumnStatisticsData structure

Defines column statistics supported for Boolean data columns.
Fields

- **NumberOfTrues** – *Required:* Number (long), not more than None.
  
  The number of true values in the column.
- **NumberOfFalses** – *Required:* Number (long), not more than None.
  
  The number of false values in the column.
- **NumberOfNulls** – *Required:* Number (long), not more than None.
  
  The number of null values in the column.

**DateColumnStatisticsData structure**

Defines column statistics supported for timestamp data columns.

Fields

- **MinimumValue** – Timestamp.
  
  The lowest value in the column.
- **MaximumValue** – Timestamp.
  
  The highest value in the column.
- **NumberOfNulls** – *Required:* Number (long), not more than None.
  
  The number of null values in the column.
- **NumberOfDistinctValues** – *Required:* Number (long), not more than None.
  
  The number of distinct values in a column.

**DecimalColumnStatisticsData structure**

Defines column statistics supported for fixed-point number data columns.

Fields

- **MinimumValue** – A **DecimalNumber** object.
  
  The lowest value in the column.
• MaximumValue – A `DecimalNumber` object.

  The highest value in the column.

• NumberOfNulls – `Required`: Number (long), not more than None.

  The number of null values in the column.

• NumberOfDistinctValues – `Required`: Number (long), not more than None.

  The number of distinct values in a column.

**DoubleColumnStatisticsData structure**

Defines column statistics supported for floating-point number data columns.

**Fields**

• MinimumValue – Number (double).

  The lowest value in the column.

• MaximumValue – Number (double).

  The highest value in the column.

• NumberOfNulls – `Required`: Number (long), not more than None.

  The number of null values in the column.

• NumberOfDistinctValues – `Required`: Number (long), not more than None.

  The number of distinct values in a column.

**LongColumnStatisticsData structure**

Defines column statistics supported for integer data columns.

**Fields**

• MinimumValue – Number (long).

  The lowest value in the column.

• MaximumValue – Number (long).
The highest value in the column.

- **NumberOfNulls** – *Required*: Number (long), not more than None.

  The number of null values in the column.

- **NumberOfDistinctValues** – *Required*: Number (long), not more than None.

  The number of distinct values in a column.

### StringColumnStatisticsData structure

Defines column statistics supported for character sequence data values.

**Fields**

- **MaximumLength** – *Required*: Number (long), not more than None.
  
  The size of the longest string in the column.

- **AverageLength** – *Required*: Number (double), not more than None.
  
  The average string length in the column.

- **NumberOfNulls** – *Required*: Number (long), not more than None.
  
  The number of null values in the column.

- **NumberOfDistinctValues** – *Required*: Number (long), not more than None.
  
  The number of distinct values in a column.

### BinaryColumnStatisticsData structure

Defines column statistics supported for bit sequence data values.

**Fields**

- **MaximumLength** – *Required*: Number (long), not more than None.
  
  The size of the longest bit sequence in the column.

- **AverageLength** – *Required*: Number (double), not more than None.
The average bit sequence length in the column.

- **NumberOfNulls** – *Required:* Number (long), not more than None.

  The number of null values in the column.

### String patterns

The API uses the following regular expressions to define what is valid content for various string parameters and members:

- Single-line string pattern – "[ -퟿-�𐀀-􏿿 \t]*
- URI address multi-line string pattern – "[ -퟿-�𐀀-􏿿\r\n\t]*
- A Logstash Grok string pattern – "[ -퟿-�𐀀-􏿿\r\t]*"
- Identifier string pattern – "][^A-Za-z_][A-Za-z0-9-]*"
- AWS IAM ARN string pattern – "arn:aws:iam::\d{12}:role/.*"
- Version string pattern – "^[a-zA-Z0-9-\_]+$"
- Log group string pattern – "\.[\._/#A-Za-z0-9-]+"
- Log-stream string pattern – "[^:]*"*
- Custom string pattern #10 – "[^\r\n]"
- Custom string pattern #11 – "[^p{L}|p{N}|p{P}]"
- Custom string pattern #12 – "[a-f0-9]{8}+[a-f0-9]{4}-[a-f0-9]{4}-[a-f0-9]{4}-[a-f0-9]{12}"
- Custom string pattern #13 – "[a-zA-Z0-9-\_\#\.]+"
- Custom string pattern #14 – "^\w+\./\w+\./\w+\$"
- Custom string pattern #15 – "^\w+\./\w+\$"
- Custom string pattern #16 – "^[2-3]\[3[\_9]$"
- Custom string pattern #17 – "arn:(aws|aws-us-gov|aws-cn):glue::."
- Custom string pattern #18 – "(^arn:aws:iam::\w{12}:root)"
Exceptions

This section describes AWS Glue exceptions that you can use to find the source of problems and fix them. For more information on HTTP error codes and strings for exceptions related to machine learning, see the section called “AWS Glue machine learning exceptions”.

AccessDeniedException structure

Access to a resource was denied.
Fields

• Message – UTF-8 string.
  
  A message describing the problem.

AlreadyExistsException structure

A resource to be created or added already exists.

Fields

• Message – UTF-8 string.
  
  A message describing the problem.

ConcurrentModificationException structure

Two processes are trying to modify a resource simultaneously.

Fields

• Message – UTF-8 string.
  
  A message describing the problem.

ConcurrentRunsExceedededException structure

Too many jobs are being run concurrently.

Fields

• Message – UTF-8 string.
  
  A message describing the problem.

CrawlerNotRunningException structure

The specified crawler is not running.
Fields

- Message – UTF-8 string.

  A message describing the problem.

**CrawlerRunningException structure**

The operation cannot be performed because the crawler is already running.

Fields

- Message – UTF-8 string.

  A message describing the problem.

**CrawlerStoppingException structure**

The specified crawler is stopping.

Fields

- Message – UTF-8 string.

  A message describing the problem.

**EntityNotFoundException structure**

A specified entity does not exist

Fields

- Message – UTF-8 string.

  A message describing the problem.
- FromFederationSource – Boolean.

  Indicates whether or not the exception relates to a federated source.
FederationSourceException structure

A federation source failed.

Fields

  
  The error code of the problem.
- Message – UTF-8 string.
  
  The message describing the problem.

FederationSourceRetryableException structure

A federation source failed, but the operation may be retried.

Fields

- Message – UTF-8 string.
  
  A message describing the problem.

GlueEncryptionException structure

An encryption operation failed.

Fields

- Message – UTF-8 string.
  
  The message describing the problem.

IdempotentParameterMismatchException structure

The same unique identifier was associated with two different records.
Fields

- Message – UTF-8 string.
  
  A message describing the problem.

**IllegalWorkflowStateException structure**

The workflow is in an invalid state to perform a requested operation.

**Fields**

- Message – UTF-8 string.
  
  A message describing the problem.

**InternalServiceException structure**

An internal service error occurred.

**Fields**

- Message – UTF-8 string.
  
  A message describing the problem.

**InvalidExecutionEngineException structure**

An unknown or invalid execution engine was specified.

**Fields**

- message – UTF-8 string.
  
  A message describing the problem.

**InvalidInputException structure**

The input provided was not valid.
**Fields**

- **Message** – UTF-8 string.

  A message describing the problem.

- **FromFederationSource** – Boolean.

  Indicates whether or not the exception relates to a federated source.

**InvalidStateException structure**

An error that indicates your data is in an invalid state.

**Fields**

- **Message** – UTF-8 string.

  A message describing the problem.

**InvalidTaskStatusTransitionException structure**

Proper transition from one task to the next failed.

**Fields**

- **message** – UTF-8 string.

  A message describing the problem.

**JobDefinitionErrorException structure**

A job definition is not valid.

**Fields**

- **message** – UTF-8 string.

  A message describing the problem.
JobRunInTerminalStateException structure

The terminal state of a job run signals a failure.

**Fields**

- **message** – UTF-8 string.

  A message describing the problem.

JobRunInvalidStateTransitionException structure

A job run encountered an invalid transition from source state to target state.

**Fields**

- **jobRunId** – UTF-8 string, not less than 1 or more than 255 bytes long, matching the Single-line string pattern.

  The ID of the job run in question.

- **message** – UTF-8 string.

  A message describing the problem.

- **sourceState** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT | ERROR | WAITING).

  The source state.

- **targetState** – UTF-8 string (valid values: STARTING | RUNNING | STOPPING | STOPPED | SUCCEEDED | FAILED | TIMEOUT | ERROR | WAITING).

  The target state.

JobRunNotInTerminalStateException structure

A job run is not in a terminal state.

**Fields**

- **message** – UTF-8 string.
A message describing the problem.

**LateRunnerException structure**

A job runner is late.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**NoScheduleException structure**

There is no applicable schedule.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**OperationTimeoutException structure**

The operation timed out.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**ResourceNotReadyException structure**

A resource was not ready for a transaction.

**Fields**

- **Message** – UTF-8 string.
A message describing the problem.

**ResourceNumberLimitExceeded Exception structure**

A resource numerical limit was exceeded.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**SchedulerNotRunning Exception structure**

The specified scheduler is not running.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**SchedulerRunning Exception structure**

The specified scheduler is already running.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**SchedulerTransitioning Exception structure**

The specified scheduler is transitioning.

**Fields**

- **Message** – UTF-8 string.
A message describing the problem.

**UnrecognizedRunnerException structure**

The job runner was not recognized.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**ValidationException structure**

A value could not be validated.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.

**VersionMismatchException structure**

There was a version conflict.

**Fields**

- **Message** – UTF-8 string.
  
  A message describing the problem.
AWS Glue API code examples using AWS SDKs

The following code examples show how to use AWS Glue with an AWS software development kit (SDK).

*Actions* are code excerpts from larger programs and must be run in context. While actions show you how to call individual service functions, you can see actions in context in their related scenarios and cross-service examples.

*Scenarios* are code examples that show you how to accomplish a specific task by calling multiple functions within the same service.

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](#). This topic also includes information about getting started and details about previous SDK versions.

**Get started**

**Hello AWS Glue**

The following code examples show how to get started using AWS Glue.

**.NET**

**AWS SDK for .NET**

```csharp
namespace GlueActions;

public class HelloGlue
{
    private static ILogger logger = null!
;

    static async Task Main(string[] args)
    {
        // Set up dependency injection for AWS Glue.
```
using var host = Host.CreateDefaultBuilder(args)
    .ConfigureLogging(logging =>
        logging.AddFilter("System", LogLevel.Debug)
            .AddFilter<DebugLoggerProvider>("Microsoft",
                LogLevel.Information)
                .AddFilter<ConsoleLoggerProvider>("Microsoft",
                    LogLevel.Trace)
            .ConfigureServices((_, services) =>
                services.AddAWSService<IAmazonGlue>()
                    .AddTransient<GlueWrapper>()
                    )
        .Build();

    logger = LoggerFactory.Create(builder => { builder.AddConsole(); })
        .CreateLogger<HelloGlue>();
    var glueClient = host.Services.GetRequiredService<IAmazonGlue>();

    var request = new ListJobsRequest();
    var jobNames = new List<string>();

    do
    {
        var response = await glueClient.ListJobsAsync(request);
            jobNames.AddRange(response.JobNames);
                    request.NextToken = response.NextToken;
    } while (request.NextToken is not null);

    Console.Clear();
    Console.WriteLine("Hello, Glue. Let's list your existing Glue Jobs:");
    if (jobNames.Count == 0)
    {
        Console.WriteLine("You don't have any AWS Glue jobs.");
    }
    else
    {
        jobNames.ForEach(Console.WriteLine);
    }
}
For API details, see `ListJobs` in *AWS SDK for .NET API Reference*.

### C++

#### SDK for C++

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-cpp).

Code for the `CMakeLists.txt` CMake file.

```cmake
# Set the minimum required version of CMake for this project.
cmake_minimum_required(VERSION 3.13)

# Set the AWS service components used by this project.
set(SERVICE_COMPONENTS glue)

# Set this project's name.
project("hello_glue")

# Set the C++ standard to use to build this target.
# At least C++ 11 is required for the AWS SDK for C++.
set(CMAKE_CXX_STANDARD 11)

# Use the MSVC variable to determine if this is a Windows build.
set(WINDOWS_BUILD ${MSVC})

if (WINDOWS_BUILD) # Set the location where CMake can find the installed
    string(REPLACE ";" ";/aws-cpp-sdk-all;" SYSTEM_MODULE_PATH
    "${CMAKE_SYSTEM_PREFIX_PATH}/aws-cpp-sdk-all")
    list(APPEND CMAKE_PREFIX_PATH ${SYSTEM_MODULE_PATH})
endif ()

# Find the AWS SDK for C++ package.
find_package(AWSSDK REQUIRED COMPONENTS ${SERVICE_COMPONENTS})

if (WINDOWS_BUILD)
# Copy relevant AWS SDK for C++ libraries into the current binary directory for running and debugging.

# set(BIN_SUB_DIR "/Debug") # if you are building from the command line you may need to uncomment this

# and set the proper subdirectory to the executables' location.

AWSSDK_CPY_DYN_LIBS(SERVICE_COMPONENTS ""
${CMAKE_CURRENT_BINARY_DIR}${BIN_SUB_DIR})
endif()

add_executable(${PROJECT_NAME}
    hello_glue.cpp)

target_link_libraries(${PROJECT_NAME}
    ${AWSSDK_LINK_LIBRARIES})

Code for the hello_glue.cpp source file.

#include <aws/core/Aws.h>
#include <aws/glue/GlueClient.h>
#include <aws/glue/model/ListJobsRequest.h>
#include <iostream>

/*
 * A "Hello Glue" starter application which initializes an AWS Glue client and lists the
 * AWS Glue job definitions.
 * *
 * main function
 * *
 * Usage: 'hello_glue'
 * *
*/

int main(int argc, char **argv) {
    Aws::SDKOptions options;
    // Optionally change the log level for debugging.
    // options.loggingOptions.logLevel = Utils::Logging::LogLevel::Debug;
    Aws::InitAPI(options); // Should only be called once.
    int result = 0;}
```cpp
{  
    Aws::Client::ClientConfiguration clientConfig;
    // Optional: Set to the AWS Region (overrides config file).
    // clientConfig.region = "us-east-1";

    Aws::Glue::GlueClient glueClient(clientConfig);

    std::vector<Aws::String> jobs;

    Aws::String nextToken;  // Used for pagination.
    do {
        Aws::Glue::Model::ListJobsRequest listJobsRequest;
        if (!nextToken.empty()) {
            listJobsRequest.SetNextToken(nextToken);
        }

        Aws::Glue::Model::ListJobsOutcome listRunsOutcome = glueClient.ListJobs(
            listJobsRequest);

        if (listRunsOutcome.IsSuccess()) {
            const std::vector<Aws::String> &jobNames = listRunsOutcome.GetResult().GetJobNames();
            jobs.insert(jobs.end(), jobNames.begin(), jobNames.end());
            nextToken = listRunsOutcome.GetResult().GetNextToken();
        } else {
            std::cerr << "Error listing jobs. " << listRunsOutcome.GetError().GetMessage() << std::endl;
            result = 1;
            break;
        }
    } while (!nextToken.empty());

    std::cout << "Your account has " << jobs.size() << " jobs."
        << std::endl;
    for (size_t i = 0; i < jobs.size(); ++i) {
        std::cout << "   " << i + 1 << ". " << jobs[i] << std::endl;
    }
    Aws::ShutdownAPI(options);  // Should only be called once.
    return result;
}
For API details, see ListJobs in AWS SDK for C++ API Reference.

**Java**

**SDK for Java 2.x**

```
package com.example.glue;

import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.glue.GlueClient;
import software.amazon.awssdk.services.glue.model.ListJobsRequest;
import software.amazon.awssdk.services.glue.model.ListJobsResponse;
import java.util.List;

public class HelloGlue {
    public static void main(String[] args){
        GlueClient glueClient = GlueClient.builder()
            .region(Region.US_EAST_1)
            .build();

        listJobs(glueClient);
    }

    public static void listJobs(GlueClient glueClient) {
        ListJobsRequest request = ListJobsRequest.builder()
            .maxResults(10)
            .build();
        ListJobsResponse response = glueClient.listJobs(request);
        List<String> jobList = response.jobNames();
        jobList.forEach(job -> {
            System.out.println("Job Name: " + job);
        });
    }
}
```
• For API details, see ListJobs in AWS SDK for Java 2.x API Reference.

JavaScript

**SDK for JavaScript (v3)**

```javascript
import { ListJobsCommand, GlueClient } from '@aws-sdk/client-glue';

const client = new GlueClient({});

export const main = async () => {
    const command = new ListJobsCommand({});

    const { JobNames } = await client.send(command);
    const formattedJobNames = JobNames.join('
');
    console.log('Job names: ');
    console.log(formattedJobNames);
    return JobNames;
};
```

• For API details, see ListJobs in AWS SDK for JavaScript API Reference.

Rust

**SDK for Rust**

```rust
const { JobNames } = await client.send(command);
const formattedJobNames = JobNames.join('
');
console.log("Job names: ");
console.log(formattedJobNames);
return JobNames;
```

• For API details, see ListJobs in AWS SDK for JavaScript API Reference.

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
let mut list_jobs = glue.list_jobs().into_paginated().send();
while let Some(list_jobs_output) = list_jobs.next().await {
    match list_jobs_output {
        Ok(list_jobs) => {
            let names = list_jobs.job_names();
            info!(?names, "Found these jobs")
        }
        Err(err) => return Err(GlueMvpError::from_glue_sdk(err)),
    }
}

- For API details, see [ListJobs](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListJobs/) in *AWS SDK for Rust API reference*.

**Code examples**

- **Actions for AWS Glue using AWS SDKs**
  - [Create an AWS Glue crawler using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/CreateCrawler/)
  - [Create an AWS Glue job definition using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/CreateJobDefinition/)
  - [Delete an AWS Glue crawler using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/DeleteCrawler/)
  - [Delete a database from the AWS Glue Data Catalog using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/DeleteDatabase/)
  - [Delete an AWS Glue job definition using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/DeleteJobDefinition/)
  - [Delete a table from an AWS Glue Data Catalog database using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/DeleteTable/)
  - [Get an AWS Glue crawler using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/GetCrawler/)
  - [Get a database from the AWS Glue Data Catalog using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/GetDatabase/)
  - [Get an AWS Glue job run using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/GetJobRun/)
  - [Get database list from the AWS Glue Data Catalog using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListDatabases/)
  - [Get a job from the AWS Glue Data Catalog using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListJobs/)
  - [Get runs of an AWS Glue job using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListJobRuns/)
  - [Get tables from a database in the AWS Glue Data Catalog using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListTables/)
  - [List AWS Glue job definitions using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/ListJobDefinitions/)
  - [Start an AWS Glue crawler using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/StartCrawler/)
  - [Start an AWS Glue job run using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/StartJobRun/)

- **Scenarios for AWS Glue using AWS SDKs**
  - [Get started running AWS Glue crawlers and jobs using an AWS SDK](https://aws-sdk-rust.github.io/awssdk-rust/api_reference/)

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Actions for AWS Glue using AWS SDKs

The following code examples demonstrate how to perform individual AWS Glue actions with AWS SDKs. These excerpts call the AWS Glue API and are code excerpts from larger programs that must be run in context. Each example includes a link to GitHub, where you can find instructions for setting up and running the code.

The following examples include only the most commonly used actions. For a complete list, see the AWS Glue API Reference.

Examples

- Create an AWS Glue crawler using an AWS SDK
- Create an AWS Glue job definition using an AWS SDK
- Delete an AWS Glue crawler using an AWS SDK
- Delete a database from the AWS Glue Data Catalog using an AWS SDK
- Delete an AWS Glue job definition using an AWS SDK
- Delete a table from an AWS Glue Data Catalog database using an AWS SDK
- Get an AWS Glue crawler using an AWS SDK
- Get a database from the AWS Glue Data Catalog using an AWS SDK
- Get an AWS Glue job run using an AWS SDK
- Get database list from the AWS Glue Data Catalog using an AWS SDK
- Get a job from the AWS Glue Data Catalog using an AWS SDK
- Get runs of an AWS Glue job using an AWS SDK
- Get tables from a database in the AWS Glue Data Catalog using an AWS SDK
- List AWS Glue job definitions using an AWS SDK
- Start an AWS Glue crawler using an AWS SDK
- Start an AWS Glue job run using an AWS SDK

Create an AWS Glue crawler using an AWS SDK

The following code examples show how to create an AWS Glue crawler.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:
• Get started with crawlers and jobs

.NET

AWS SDK for .NET

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

/// <summary>
/// Create an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name for the crawler.</param>
/// <param name="crawlerDescription">A description of the crawler.</param>
/// <param name="role">The AWS Identity and Access Management (IAM) role to be assumed by the crawler.</param>
/// <param name="schedule">The schedule on which the crawler will be executed.</param>
/// <param name="s3Path">The path to the Amazon Simple Storage Service (Amazon S3) bucket where the Python script has been stored.</param>
/// <param name="dbName">The name to use for the database that will be created by the crawler.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> CreateCrawlerAsync(
    string crawlerName,
    string crawlerDescription,
    string role,
    string schedule,
    string s3Path,
    string dbName)
{
    var s3Target = new S3Target
    {
        Path = s3Path,
    };

    var targetList = new List<S3Target>
s3Target,
);

var targets = new CrawlerTargets
{
    S3Targets = targetList,
};

var crawlerRequest = new CreateCrawlerRequest
{
    DatabaseName = dbName,
    Name = crawlerName,
    Description = crawlerDescription,
    Targets = targets,
    Role = role,
    Schedule = schedule,
};

var response = await _amazonGlue.CreateCrawlerAsync(crawlerRequest);
}

- For API details, see [CreateCrawler](https://aws.dev) in AWS SDK for .NET API Reference.

### C++

#### SDK for C++

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://aws.dev).

```
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);
```
Aws::Glue::Model::S3Target s3Target;
s3Target.SetPath("s3://crawler-public-us-east-1/flight/2016/csv");
Aws::Glue::Model::CrawlerTargets crawlerTargets;
crawlerTargets.AddS3Targets(s3Target);

Aws::Glue::Model::CreateCrawlerRequest request;
request.SetTargets(crawlerTargets);
request.SetName(CRAWLER_NAME);
request.SetDatabaseName(CRAWLER_DATABASE_NAME);
request.SetTablePrefix(CRAWLER_DATABASE_PREFIX);
request.SetRole(roleArn);

Aws::Glue::Model::CreateCrawlerOutcome outcome =
client.CreateCrawler(request);

if (outcome.IsSuccess()) {
    std::cout << "Successfully created the crawler." << std::endl;
} else {
    std::cerr << "Error creating a crawler. " << outcome.GetError().GetMessage()
    << std::endl;
    deleteAssets("", CRAWLER_DATABASE_NAME, ",", bucketName,
    clientConfig);
    return false;
}

• For API details, see CreateCrawler in AWS SDK for C++ API Reference.

Java

**SDK for Java 2.x**

<details>
<summary>Note</summary>

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```java
import software.amazon.awssdk.regions.Region;
```
import software.amazon.awssdk.services.glue.GlueClient;
import software.amazon.awssdk.services.glue.model.CreateCrawlerRequest;
import software.amazon.awssdk.services.glue.model.CrawlerTargets;
import software.amazon.awssdk.services.glue.model.GlueException;
import software.amazon.awssdk.services.glue.model.S3Target;
import java.util.ArrayList;
import java.util.List;

/**
 * Before running this Java V2 code example, set up your development environment,
 * including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-started.html
 */
public class CreateCrawler {
    public static void main(String[] args) {
        final String usage = """";

            Usage:
                <IAM> <s3Path> <cron> <dbName> <crawlerName>

                Where:
                IAM - The ARN of the IAM role that has AWS Glue and S3 permissions.

                s3Path - The Amazon Simple Storage Service (Amazon S3) target
                that contains data (for example, CSV data).

                cron - A cron expression used to specify the schedule (i.e.,
                cron(15 12 * * ? *).

                dbName - The database name.

                crawlerName - The name of the crawler.

            """
;

            if (args.length != 5) {
                System.out.println(usage);
                System.out.println(usage);
                System.exit(1);
            }

            String iam = args[0];
            String s3Path = args[1];
            String cron = args[2];
            String dbName = args[3];
            String crawlerName = args[4];

            CreateCrawlerRequest request = CreateCrawlerRequest.builder()
                .name(crawlerName)
                .schedule(cron)
                .targets(CrawlerTargets.builder()
                    .s3Targets(S3Target.builder()
                        .path(s3Path)
                        .build())
                    .build())
                .databaseName(dbName)
                .role(iam)
                .build();

            GlueClient glueClient = GlueClient.builder().build();

            try {
                glueClient.createCrawler(request);
            } catch (GlueException e) {
                System.out.println("Failed to create crawler: " + e.getMessage());
            }
        }
    }
}
String crawlerName = args[4];
Region region = Region.US_EAST_1;
GlueClient glueClient = GlueClient.builder()
    .region(region)
    .build();

createGlueCrawler(glueClient, iam, s3Path, cron, dbName, crawlerName);
    glueClient.close();
}

public static void createGlueCrawler(GlueClient glueClient,
    String iam,
    String s3Path,
    String cron,
    String dbName,
    String crawlerName) {

    try {
        S3Target s3Target = S3Target.builder()
            .path(s3Path)
            .build();

        // Add the S3Target to a list.
        List<S3Target> targetList = new ArrayList<>();
        targetList.add(s3Target);

        CrawlerTargets targets = CrawlerTargets.builder()
            .s3Targets(targetList)
            .build();

        CreateCrawlerRequest crawlerRequest = CreateCrawlerRequest.builder()
            .databaseName(dbName)
            .name(crawlerName)
            .description("Created by the AWS Glue Java API")
            .targets(targets)
            .role(iam)
            .schedule(cron)
            .build();

        glueClient.createCrawler(crawlerRequest);
        System.out.println(crawlerName + " was successfully created");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
    }
• For API details, see CreateCrawler in AWS SDK for Java 2.x API Reference.

JavaScript

SDK for JavaScript (v3)

```javascript
const createCrawler = (name, role, dbName, tablePrefix, s3TargetPath) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new CreateCrawlerCommand({
    Name: name,
    Role: role,
    DatabaseName: dbName,
    TablePrefix: tablePrefix,
    Targets: {
      S3Targets: [{ Path: s3TargetPath }],
    },
  });

  return client.send(command);
};
```

• For API details, see CreateCrawler in AWS SDK for JavaScript API Reference.
suspend fun createGlueCrawler(
    iam: String?,
    s3Path: String?,
    cron: String?,
    dbName: String?,
    crawlerName: String
) {
    val s3Target = S3Target {
        path = s3Path
    }

    // Add the S3Target to a list.
    val targetList = mutableListOf<S3Target>()
    targetList.add(s3Target)

    val targetOb = CrawlerTargets {
        s3Targets = targetList
    }

    val request = CreateCrawlerRequest {
        databaseName = dbName
        name = crawlerName
        description = "Created by the AWS Glue Kotlin API"
        targets = targetOb
        role = iam
        schedule = cron
    }

    GlueClient { region = "us-west-2" }.use { glueClient ->
        glueClient.createCrawler(request)
        println("$crawlerName was successfully created")
    }
}

Create a crawler
- For API details, see CreateCrawler in AWS SDK for Kotlin API reference.

**PHP**

**SDK for PHP**

```
$crawlerName = "example-crawler-test-" . $uniqid;

$role = $iamService->getRole("AWSGlueServiceRole-DocExample");

$path = 's3://crawler-public-us-east-1/flight/2016/csv';
$glueService->createCrawler($crawlerName, $role['Arn'], $databaseName, $path);
```

```php
public function createCrawler($crawlerName, $role, $databaseName, $path):
    Result
    {
        return $this->customWaiter(function () use ($crawlerName, $role, $databaseName, $path) {
            return $this->glueClient->createCrawler(QIcon
                'Name' => $crawlerName,
                'Role' => $role,
                'DatabaseName' => $databaseName,
                'Targets' => [(QIcon
                    'S3Targets' => [(QIcon
                        'Path' => $path,
                    ]
                ]
            ]
        });
    }
```
For API details, see `CreateCrawler` in *AWS SDK for PHP API Reference*.

**Python**

**SDK for Python (Boto3)**

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def create_crawler(self, name, role_arn, db_name, db_prefix, s3_target):
        """
        Creates a crawler that can crawl the specified target and populate a database in your AWS Glue Data Catalog with metadata that describes the data in the target.

        :param name: The name of the crawler.
        :param role_arn: The Amazon Resource Name (ARN) of an AWS Identity and Access Management (IAM) role that grants permission to let AWS Glue access the resources it needs.
        :param db_name: The name to give the database that is created by the crawler.
        :param db_prefix: The prefix to give any database tables that are created by the crawler.
        """
```

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-samples).
try:
    self.glue_client.create_crawler(
        Name=name,
        Role=role_arn,
        DatabaseName=db_name,
        TablePrefix=db_prefix,
        Targets={"S3Targets": [{"Path": s3_target}],
    )
except ClientError as err:
    logger.error(  
        "Couldn't create crawler. Here's why: %s: %s",
        err.response["Error"]["Code"],  
        err.response["Error"]["Message"],
    )
    raise

• For API details, see CreateCrawler in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing
# a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods
# for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
    def initialize(glue_client, logger)
# Creates a new crawler with the specified configuration.
#
# @param name [String] The name of the crawler.
# @param role_arn [String] The ARN of the IAM role to be used by the crawler.
# @param db_name [String] The name of the database where the crawler stores its
# metadata.
# @param db_prefix [String] The prefix to be added to the names of tables that
# the crawler creates.
# @param s3_target [String] The S3 path that the crawler will crawl.
# @return [void]

def create_crawler(name, role_arn, db_name, db_prefix, s3_target)
  @glue_client.create_crawler(
    name: name,
    role: role_arn,
    database_name: db_name,
    targets: {
      s3_targets: [
        { path: s3_target
      ]
    }
  )

rescue Aws::Glue::Errors::GlueException => e
  @logger.error("Glue could not create crawler: \n#{e.message}"")
  raise
end

- For API details, see [CreateCrawler](#) in AWS SDK for Ruby API Reference.
Rust

SDK for Rust

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```rust
let create_crawler = glue
    .create_crawler()
    .name(self.crawler())
    .database_name(self.database())
    .role(self.iam_role.expose_secret())
    .targets(
        CrawlerTargets::builder()
            .s3_targets(S3Target::builder().path(CRAWLER_TARGET).build())
            .build(),
    )
    .send()
    .await;

match create_crawler {
    Err(err) => {
        let glue_err: aws_sdk_glue::Error = err.into();
        match glue_err {
            aws_sdk_glue::Error::AlreadyExistsException(_) => {
                info!("Using existing crawler");
                Ok(())
            }
            _ => Err(GlueMvpError::GlueSdk(glue_err)),
        }
    }
    Ok(_) => Ok(()),
}?
```

- For API details, see [CreateCrawler](#) in *AWS SDK for Rust API reference.*
Create an AWS Glue job definition using an AWS SDK

The following code examples show how to create an AWS Glue job definition.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs

AWS SDK for .NET

```csharp
/// <summary>
/// Create an AWS Glue job.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <param name="roleName">The name of the IAM role to be assumed by the job.</param>
/// <param name="description">A description of the job.</param>
/// <param name="scriptUrl">The URL to the script.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> CreateJobAsync(string dbName, string tableName, string bucketUrl, string jobName, string roleName, string description, string scriptUrl)
{
    var command = new JobCommand
    {
        PythonVersion = "3",
        Name = "glueetl",
        ScriptLocation = scriptUrl,
    }
    return true;
}
```
var arguments = new Dictionary<string, string>
{
    { "--input_database", dbName },
    { "--input_table", tableName },
    { "--output_bucket_url", bucketUrl }
};

var request = new CreateJobRequest
{
    Command = command,
    DefaultArguments = arguments,
    Description = description,
    GlueVersion = "3.0",
    Name = jobName,
    NumberOfWorkers = 10,
    Role = roleName,
    WorkerType = "G.1X"
};

var response = await _amazonGlue.CreateJobAsync(request);
return response.HttpStatusCode == HttpStatusCode.OK;

- For API details, see CreateJob in AWS SDK for .NET API Reference.

C++

SDK for C++

Nota

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
```
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::CreateJobRequest request;
request.SetName(JOB_NAME);
request.SetRole(roleArn);
request.SetGlueVersion(GLUE_VERSION);

Aws::Glue::Model::JobCommand command;
command.SetName(JOB_COMMAND_NAME);
command.SetPythonVersion(JOB_PYTHON_VERSION);
command.SetScriptLocation(Aws::String("s3://") + bucketName + "/" + PYTHON_SCRIPT);
request.SetCommand(command);

Aws::Glue::Model::CreateJobOutcome outcome = client.CreateJob(request);

if (outcome.IsSuccess()) {
   std::cout << "Successfully created the job." << std::endl;
}
else {
   std::cerr << "Error creating the job. " << outcome.GetError().GetMessage() << std::endl;
   deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",", bucketName, clientConfig);
   return false;
}

• For API details, see CreateJob in AWS SDK for C++ API Reference.

CLI

AWS CLI version 2

To create a job to transform data

The following create-job example creates a streaming job that runs a script stored in S3.

aws glue create-job \
   --name my-testing-job \

Create a job definition
Create a job definition

```
--role AWSGlueServiceRoleDefault \
--command '{ \
    "Name": "gluestreaming", \
    "ScriptLocation": "s3://DOC-EXAMPLE-BUCKET/folder/" \
} \n--region us-east-1 \n--output json \n--default-arguments '{ \n    "--job-language":"scala", \n    "--class":"GlueApp" \n} \n--profile my-profile \n--endpoint https://glue.us-east-1.amazonaws.com
```

Contents of test_script.scala:

```scala
import com.amazonaws.services.glue.ChoiceOption
import com.amazonaws.services.glue.GlueContext
import com.amazonaws.services.glue.MappingSpec
import com.amazonaws.services.glue.ResolveSpec
import com.amazonaws.services.glue.errors.CallSite
import com.amazonaws.services.glue.util.GlueArgParser
import com.amazonaws.services.glue.util.Job
import org.apache.spark.SparkContext
import scala.collection.JavaConverters._

object GlueApp {
    def main(sysArgs: Array[String]) {
        val spark: SparkContext = new SparkContext()
        val glueContext: GlueContext = new GlueContext(spark)
        // @params: [JOB_NAME]
        val args = GlueArgParser.getResolvedOptions(sysArgs,
            Seq("JOB_NAME").toArray)
        Job.init(args("JOB_NAME"), glueContext, args.asJava)
        // @type: DataSource
        // @args: [database = "tempdb", table_name = "s3-source", transformation_ctx = "datasource0"]
        // @return: datasource0
        // @inputs: []
        val datasource0 = glueContext.getCatalogSource(database = "tempdb", tableName = "s3-source", redshiftTmpDir = ", transformationContext = "datasource0").getDynamicFrame()
    }
}
```
// @type: ApplyMapping
// @args: 
// @return: applymapping1
// @inputs: 
val applymapping1 = datasource0.applyMapping(mappings = Seq(
    ("sensorid", "int", "sensorid", "int"),
    ("currenttemperature", "int", "currenttemperature", "int"),
    ("status", "string", "status", "string"),
    caseSensitive = false,
    transformationContext = "applymapping1"
)

// @type: SelectFields
// @args: 
// @return: selectfields2
// @inputs: 
val selectfields2 = applymapping1.selectFields(paths = Seq("sensorid",
    "currenttemperature", "status"), transformationContext = "selectfields2"
)

// @type: ResolveChoice
// @args: 
// @return: resolvechoice3
// @inputs: 
val resolvechoice3 = selectfields2.resolveChoice(choiceOption = Some(ChoiceOption("MATCH_CATALOG")),
    database = Some("tempdb"), tableName = Some("my-s3-sink"),
    transformationContext = "resolvechoice3"
)

// @type: DataSink
// @args: 
// @return: datasink4
// @inputs: 
val datasink4 = glueContext.getCatalogSink(database = "tempdb",
    tableName = "my-s3-sink", redshiftTmpDir = "",
    transformationContext = "datasink4").writeDynamicFrame(resolvechoice3)

Job.commit()

Output:

{
   "Name": "my-testing-job"
}
For more information, see "Authoring Jobs in AWS Glue" in the AWS Glue Developer Guide.

- For API details, see CreateJob in AWS CLI Command Reference.

### JavaScript

#### SDK for JavaScript (v3)

```javascript
const createJob = (name, role, scriptBucketName, scriptKey) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new CreateJobCommand({
    Name: name,
    Role: role,
    Command: {
      Name: "glueetl",
      PythonVersion: "3",
      ScriptLocation: `s3://${scriptBucketName}/${scriptKey}`,
    },
    GlueVersion: "3.0",
  });

  return client.send(command);
};
```

- For API details, see CreateJob in AWS SDK for JavaScript API Reference.
### SDK for PHP

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-php).

```php
$role = $iamService->getRole("AWSGlueServiceRole-DocExample");

$jobName = 'test-job-' . $uniqid;

$scriptLocation = "s3://$bucketName/run_job.py";

$job = $glueService->createJob($jobName, $role['Role']['Arn'], $scriptLocation);

public function createJob($jobName, $role, $scriptLocation, $pythonVersion = '3', $glueVersion = '3.0'): Result
{
    return $this->glueClient->createJob(
        ['Name' => $jobName,
         'Role' => $role,
         'Command' => [
             'Name' => 'glueetl',
             'ScriptLocation' => $scriptLocation,
             'PythonVersion' => $pythonVersion,
         ],
         'GlueVersion' => $glueVersion,
    ]);}

• For API details, see [CreateJob](https://docs.aws.amazon.com/sdk-for-php/v3/api/class/serviceName/CreateJob.html) in AWS SDK for PHP API Reference.
```
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def create_job(self, name, description, role_arn, script_location):
        """
        Creates a job definition for an extract, transform, and load (ETL) job
        that can
        be run by AWS Glue.

        :param name: The name of the job definition.
        :param description: The description of the job definition.
        :param role_arn: The ARN of an IAM role that grants AWS Glue the
        permissions
        it requires to run the job.
        :param script_location: The Amazon S3 URL of a Python ETL script that is
        run as
        part of the job. The script defines how the data
        is
        transformed.
        """
        try:
            self.glue_client.create_job(
                Name=name,
                Description=description,
                Role=role_arn,
Command={
    "Name": "glueetl",
    "ScriptLocation": script_location,
    "PythonVersion": "3",
},
GlueVersion="3.0",
)
except ClientError as err:
    logger.error(
        "Couldn't create job %s. Here's why: %s: %s",
        name,
        err.response["Error"]['Code'],
        err.response["Error"]['Message'],
    )
raise

• For API details, see CreateJob in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations. It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources. The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
# Creates a new job with the specified configuration.
#
# @param name [String] The name of the job.
# @param description [String] The description of the job.
# @param role_arn [String] The ARN of the IAM role to be used by the job.
# @param script_location [String] The location of the ETL script for the job.
# @return [void]
def create_job(name, description, role_arn, script_location)
    @glue_client.create_job(
        name: name,
        description: description,
        role: role_arn,
        command: {
            name: "glueetl",
            script_location: script_location,
            python_version: "3"
        },
        glue_version: "3.0"
    )
rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not create job #{name}: \n#{e.message}"")
    raise
end

- For API details, see [CreateJob](#) in *AWS SDK for Ruby API Reference*. 

Rust

**SDK for Rust**

```rust
let create_job = glue
    .create_job()
    .name(self.job())
    .role(self.iam_role.expose_secret())
```

---

Create a job definition 2267
For API details, see CreateJob in AWS SDK for Rust API reference.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

Delete an AWS Glue crawler using an AWS SDK

The following code examples show how to delete an AWS Glue crawler.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs
### .NET

**AWS SDK for .NET**

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-net).

```csharp
/// <summary>
/// Delete an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name of the crawler.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteCrawlerAsync(string crawlerName)
{
    var response = await _amazonGlue.DeleteCrawlerAsync(new DeleteCrawlerRequest { Name = crawlerName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}
```

- For API details, see [DeleteCrawler](https://docs.aws.amazon.com/sdk-for-net/v3/api/index.html#AmazonGlue.DeleteCrawler) in *AWS SDK for .NET API Reference*.

### C++

**SDK for C++**

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-cpp).

```cpp
Aws::Client::ClientConfiguration clientConfig;
    // Optional: Set to the AWS Region in which the bucket was created
    // (overrides config file).
    // clientConfig.region = "us-east-1";
```

Delete a crawler
For API details, see [DeleteCrawler](https://aws-sdk-docs.aws) in *AWS SDK for C++ API Reference*.

### JavaScript

#### SDK for JavaScript (v3)

```javascript
const deleteCrawler = (crawlerName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteCrawlerCommand({
    Name: crawlerName,
  });

  return client.send(command);
};
```

- For API details, see [DeleteCrawler](https://aws-sdk-docs.aws) in *AWS SDK for C++ API Reference*.  

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://aws-sdk-docs.aws).
For API details, see `DeleteCrawler` in *AWS SDK for JavaScript API Reference*.

**PHP**

**SDK for PHP**

```
Note
There's more on GitHub. Find the complete example and learn how to set up and run in the *AWS Code Examples Repository*.
```

echo "Delete the crawler.\n";
$glueClient->deleteCrawler([ 'Name' => $crawlerName,
]);

public function deleteCrawler($crawlerName)
{
    return $this->glueClient->deleteCrawler([ 'Name' => $crawlerName,
]);
}
```

For API details, see `DeleteCrawler` in *AWS SDK for PHP API Reference*.

**Python**

**SDK for Python (Boto3)**

```
Note
There's more on GitHub. Find the complete example and learn how to set up and run in the *AWS Code Examples Repository*.
```

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions.""
```
def __init__(self, glue_client):
    
    
    self.glue_client = glue_client

def delete_crawler(self, name):
    
    Deletes a crawler.

    :param name: The name of the crawler to delete.
    
    try:
        self.glue_client.delete_crawler(Name=name)
    except ClientError as err:
        logger.error(
            "Couldn't delete crawler %s. Here's why: %s: %s",
            name,
            err.response["Error"]["Code"],
            err.response["Error"]["Message"],
        )
        raise

• For API details, see DeleteCrawler in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources. The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.

class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Deletes a crawler with the specified name.
  # @param name [String] The name of the crawler to delete.
  # @return [void]
  def delete_crawler(name)
    @glue_client.delete_crawler(name: name)
    rescue Aws::Glue::Errors::ServiceError => e
      @logger.error("Glue could not delete crawler #{name}: #{e.message}")
      raise
  end
end

• For API details, see [DeleteCrawler](https://docs.aws.amazon.com/sdk-for-ruby/api/latest/api_reference/AWS/AmazonGlue.html#DeleteCrawler) in *AWS SDK for Ruby API Reference*.

## Rust

### SDK for Rust

```rust
let crawler = GlueWrapper::new(glue_client, logger).unwrap();
glue.delete_crawler()
  .name(crawler)
  .send()
  .await
  .map_err(GlueMvpError::from_glue_sdk)?;
```

- For API details, see [DeleteCrawler](https://docs.aws.amazon.com/sdk-for-ruby/api/latest/api_reference/AWS/AmazonGlue.html#DeleteCrawler) in *AWS SDK for Ruby API Reference*.
Delete a database from the AWS Glue Data Catalog using an AWS SDK

The following code examples show how to delete a database from the AWS Glue Data Catalog.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs

.NET

AWS SDK for .NET

/// <summary>
/// Delete the AWS Glue database.
/// </summary>
/// <param name="dbName">The name of the database.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteDatabaseAsync(string dbName)
{
    var response = await _amazonGlue.DeleteDatabaseAsync(new
DeleteDatabaseRequest { Name = dbName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}

- For API details, see [DeleteDatabase](https://docs.aws.amazon.com/sdk-for-net/v3/api/aws-glue.html) in [AWS SDK for .NET API Reference](https://docs.aws.amazon.com/sdk-for-net/v3/api/aws-glue.html).

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws-samples/aws-code-examples).
C++

**SDK for C++**

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-code-examples).

```cpp
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::DeleteDatabaseRequest request;
request.SetName(database);

Aws::Glue::Model::DeleteDatabaseOutcome outcome = client.DeleteDatabase(request);

if (outcome.IsSuccess()) {
    std::cout << "Successfully deleted the database." << std::endl;
} else {
    std::cerr << "Error deleting database. " << outcome.GetError().GetMessage() << std::endl;
    result = false;
}
```

- For API details, see [DeleteDatabase](https://docs.aws.amazon.com/sdk-for-cpp/v1/developer-guide/API_Glue_DeleteDatabase.html) in *AWS SDK for C++ API Reference*. 

Delete a database from the Data Catalog
JavaScript

### SDK for JavaScript (v3)

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-js-v3).

```javascript
callback deleteDatabase = (databaseName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteDatabaseCommand({
    Name: databaseName,
  });

  return client.send(command);
};
```

- For API details, see [DeleteDatabase](https://docs.aws.amazon.com/sdk-for-javascript/v3/api/index.html) in *AWS SDK for JavaScript API Reference*.

PHP

### SDK for PHP

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-php).

```php
echo "Delete the databases.\n";
$glueClient->deleteDatabase(["Name" => $databaseName,]);

public function deleteDatabase($databaseName)
{
```
return $this->glueClient->deleteDatabase([  'Name' => $databaseName,  ]);}

- For API details, see [DeleteDatabase](#) in *AWS SDK for PHP API Reference*.

### Python

**SDK for Python (Boto3)**

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """""""
        """""
        self.glue_client = glue_client

    def delete_database(self, name):
        """
        Deletes a metadata database from your Data Catalog.
        
        :param name: The name of the database to delete.
        """
        try:
            self.glue_client.delete_database(Name=name)
        except ClientError as err:
            logger.error(  "Couldn't delete database %s. Here's why: %s: %s",  name,  err.response["Error"]["Code"],  err.response["Error"]["Message"],
• For API details, see DeleteDatabase in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Removes a specified database from a Data Catalog.
  #
  # @param database_name [String] The name of the database to delete.
  # @return [void]
  def delete_database(database_name)
    @glue_client.delete_database(name: database_name)
    rescue Aws::Glue::Errors::ServiceError => e
      @logger.error("Glue could not delete database: \n#{e.message}")
  end
end

Delete a database from the Data Catalog
For API details, see DeleteDatabase in AWS SDK for Ruby API Reference.

Rust

**SDK for Rust**

```rust
glue.delete_database()
    .name(self.database())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;
```

For API details, see DeleteDatabase in AWS SDK for Rust API reference.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

**Delete an AWS Glue job definition using an AWS SDK**

The following code examples show how to delete an AWS Glue job definition and all associated runs.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs
AWS SDK for .NET

/// <summary>
/// Delete an AWS Glue job.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteJobAsync(string jobName)
{
    var response = await _amazonGlue.DeleteJobAsync(new DeleteJobRequest
    {
        JobName = jobName
    });
    return response.HttpStatusCode == HttpStatusCode.OK;
}

- For API details, see `DeleteJob` in *AWS SDK for .NET API Reference*.

C++

SDK for C++

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the *AWS Code Examples Repository*.

```cpp
Aws::Client::ClientConfiguration clientConfig;
    // Optional: Set to the AWS Region in which the bucket was created
    (overrides config file).
    // clientConfig.region = "us-east-1";
```
For API details, see [DeleteJob](#) in *AWS SDK for C++ API Reference*.

### CLI

**AWS CLI version 2**

To delete a job

The following `delete-job` example deletes a job that is no longer needed.

```
aws glue delete-job
  --job-name my-testing-job
```

Output:

```
{
  "JobName": "my-testing-job"
}
```

For more information, see [Working with Jobs on the AWS Glue Console](#) in the *AWS Glue Developer Guide*. 

---

AWS Glue

User Guide
• For API details, see DeleteJob in AWS CLI Command Reference.

JavaScript

SDK for JavaScript (v3)

```javascript
const deleteJob = (jobName) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new DeleteJobCommand({
        JobName: jobName,
    });

    return client.send(command);
};
```

• For API details, see DeleteJob in AWS SDK for JavaScript API Reference.

PHP

SDK for PHP

```php
echo "Delete the job.\n";
$glueClient->deleteJob([  
    'JobName' => $job['Name'],
]);
```

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
public function deleteJob($jobName)
{
    return $this->glueClient->deleteJob(["JobName" => $jobName,]);
}

- For API details, see DeleteJob in AWS SDK for PHP API Reference.

Python

SDK for Python (Boto3)

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def delete_job(self, job_name):
        """
        Deletes a job definition. This also deletes data about all runs that are associated with this job definition.
        
        :param job_name: The name of the job definition to delete.
        """
        try:
            self.glue_client.delete_job(JobName=job_name)
        except ClientError as err:
            logger.error(
```
"Couldn't delete job %s. Here's why: %s: %s",
job_name,
err.response["Error"]["Code"],
err.response["Error"]["Message"],
)
raise

- For API details, see DeleteJob in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

ℹ️ Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing
# a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods
# for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API
calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Deletes a job with the specified name.
  # @param job_name [String] The name of the job to delete.
  # @return [void]
  def delete_job(job_name)
    @glue_client.delete_job(job_name: job_name)
  rescue Aws::Glue::Errors::ServiceError => e
    @logger.error("Glue could not delete job: \n#{e.message}"")
  end
end
```

Delete a job definition
• For API details, see [DeleteJob](#) in *AWS SDK for Ruby API Reference*.

Rust

**SDK for Rust**

```rust
glue.delete_job()
    .job_name(self.job())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;
```

• For API details, see [DeleteJob](#) in *AWS SDK for Rust API reference*.

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](#). This topic also includes information about getting started and details about previous SDK versions.

## Delete a table from an AWS Glue Data Catalog database using an AWS SDK

The following code examples show how to delete a table from an AWS Glue Data Catalog database.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

• [Get started with crawlers and jobs](#)
### .NET

**AWS SDK for .NET**

- **Note**
  There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).

```csharp
/// <summary>
/// Delete a table from an AWS Glue database.
/// </summary>
/// <param name="tableName">The table to delete.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteTableAsync(string dbName, string tableName)
{
    var response = await _amazonGlue.DeleteTableAsync(new DeleteTableRequest
    { Name = tableName, DatabaseName = dbName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}
```

- For API details, see [DeleteTable](#) in *AWS SDK for .NET API Reference*.

### JavaScript

**SDK for JavaScript (v3)**

- **Note**
  There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).

```javascript
const deleteTable = (databaseName, tableName) => {
    const client = new GlueClient({ region: DEFAULT_REGION });
    const command = new DeleteTableCommand({
    Name = tableName, DatabaseName = dbName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}
```

Delete a table from a database
```
    DatabaseName: databaseName,
    Name: tableName,
  ]);

  return client.send(command);
};
```

- For API details, see [DeleteTable](#) in [AWS SDK for JavaScript API Reference](#).

### PHP

**SDK for PHP**

```php
    echo "Delete the tables.\n";
    foreach ($tables['TableList'] as $table) {
        $glueService->deleteTable($table['Name'], $databaseName);
    }

    public function deleteTable($tableName, $databaseName)
    {
        return $this->glueClient->deleteTable(["DatabaseName" => $databaseName,
            'Name' => $tableName,
        ]);  
    }
```

- For API details, see [DeleteTable](#) in [AWS SDK for PHP API Reference](#).

Delete a table from a database 2287
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """""""
        """""
        self.glue_client = glue_client

    def delete_table(self, db_name, table_name):
        """""""
        Deletes a table from a metadata database.

        :param db_name: The name of the database that contains the table.
        :param table_name: The name of the table to delete.
        """""
        try:
            self.glue_client.delete_table(DatabaseName=db_name, Name=table_name)
        except ClientError as err:
            logger.error(
                "Couldn't delete table %s. Here's why: %s: %s",
                table_name,
                err.response["Error"]["Code"],
                err.response["Error"]["Message"],
            )
        raise

• For API details, see DeleteTable in AWS SDK for Python (Boto3) API Reference.
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations. It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources. The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.

class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Deletes a table with the specified name.
  # @param database_name [String] The name of the catalog database in which the table resides.
  # @param table_name [String] The name of the table to be deleted.
  # @return [void]
  def delete_table(database_name, table_name)
    @glue_client.delete_table(database_name: database_name, name: table_name)
    rescue Aws::Glue::Errors::ServiceError => e
      @logger.error("Glue could not delete job: \n#{e.message}"")
  end

  • For API details, see DeleteTable in AWS SDK for Ruby API Reference.
For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

### Get an AWS Glue crawler using an AWS SDK

The following code examples show how to get an AWS Glue crawler.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- **Get started with crawlers and jobs**
• For API details, see GetCrawler in AWS SDK for .NET API Reference.
Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```cpp
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::GetCrawlerRequest request;
request.SetName(CRAWLER_NAME);

Aws::Glue::Model::GetCrawlerOutcome outcome = client.GetCrawler(request);

if (outcome.IsSuccess()) {
    Aws::Glue::Model::CrawlerState crawlerState =
    outcome.GetResult().GetCrawler().GetState();
    std::cout << "Retrieved crawler with state " <<
    Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
        crawlerState)
    ".” << std::endl;
}
else {
    std::cerr << "Error retrieving a crawler. "
    << outcome.GetError().GetMessage() << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",", bucketName,
                clientConfig);
    return false;
}
```

- For API details, see [GetCrawler](#) in AWS SDK for C++ API Reference.
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.glue.GlueClient;
import software.amazon.awssdk.services.glue.model.GetCrawlerRequest;
import software.amazon.awssdk.services.glue.model.GetCrawlerResponse;
import software.amazon.awssdk.services.glue.model.GlueException;
import java.time.Instant;
import java.time.ZoneId;
import java.time.format.DateTimeFormatter;
import java.time.format.FormatStyle;
import java.util.Locale;

/**
 * Before running this Java V2 code example, set up your development environment,
 * including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-started.html
 */
public class GetCrawler {
    public static void main(String[] args) {
        final String usage = ""
        Usage:
        <crawlerName>

        Where:
        crawlerName - The name of the crawler.

        if (args.length != 1) {
String crawlerName = args[0];
Region region = Region.US_EAST_1;
GlueClient glueClient = GlueClient.builder()
.region(region)
.build();

getSpecificCrawler(glueClient, crawlerName);
glueClient.close();

public static void getSpecificCrawler(GlueClient glueClient, String crawlerName) {
    try {
        GetCrawlerRequest crawlerRequest = GetCrawlerRequest.builder()
            .name(crawlerName)
            .build();

        GetCrawlerResponse response = glueClient.getCrawler(crawlerRequest);
        Instant createDate = response.crawler().creationTime();

        // Convert the Instant to readable date
        DateTimeFormatter formatter =
            DateTimeFormatter.ofLocalizedDateTime(FormatStyle.SHORT)
            .withLocale(Locale.US)
            .withZone(ZoneId.systemDefault());

        formatter.format(createDate);
        System.out.println("The create date of the Crawler is " +
            createDate);
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

* For API details, see [GetCrawler](https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/aws-sdk-java-get-crawler.html) in *AWS SDK for Java 2.x API Reference*.
### JavaScript

**SDK for JavaScript (v3)**

```javascript
const getCrawler = (name) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new GetCrawlerCommand({
        Name: name,
    });

    return client.send(command);
};
```

- For API details, see [GetCrawler](https://docs.aws.amazon.com/sdk-for-javascript/v3/api_reference/API_Glue_GetCrawler.html) in **AWS SDK for JavaScript API Reference**.

### Kotlin

**SDK for Kotlin**

```kotlin
suspend fun getSpecificCrawler(crawlerName: String?) {
    val request = GetCrawlerRequest {
        name = crawlerName
    }
    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.getCrawler(request)
    }
```

- For API details, see [GetCrawler](https://docs.aws.amazon.com/sdk-for-kotlin/api-reference/aws-glue/index.html#aws-glue.GetCrawler) in **AWS SDK for Kotlin API Reference**.
val role = response.crawler?.role
println("The role associated with this crawler is $role")
}
}

- For API details, see [GetCrawler](https://docs.aws.amazon.com/sdk-for-kotlin/v1/api/latest/ja/awsglue.html#awsglue.GetCrawler) in *AWS SDK for Kotlin API reference*.

### PHP

**SDK for PHP**

```php

echo "Waiting for crawler";
   do {
      $crawler = $glueService->getCrawler($crawlerName);
      echo ".";
      sleep(10);
   } while ($crawler['Crawler']['State'] != "READY");
   echo "\n";

   public function getCrawler($crawlerName)
   {
       return $this->customWaiter(function () use ($crawlerName) {
           return $this->glueClient->getCrawler(["Name" => $crawlerName,]);
       });
   }
```

- For API details, see [GetCrawler](https://docs.aws.amazon.com/sdk-for-php/api/latest/ja/awsglue.html#awsglue.GetCrawler) in *AWS SDK for PHP API Reference*.

---

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws-samples/aws-glue-code-examples).
class GlueWrapper:
   """Encapsulates AWS Glue actions."""

   def __init__(self, glue_client):
       """
       """
       self.glue_client = glue_client

   def get_crawler(self, name):
       """
       Gets information about a crawler.
       
       :param name: The name of the crawler to look up.
       :return: Data about the crawler.
       """
       crawler = None
       try:
           response = self.glue_client.get_crawler(Name=name)
           crawler = response["Crawler"]
       except ClientError as err:
           if err.response["Error"]["Code"] == "EntityNotFoundException":
               logger.info("Crawler %s doesn't exist.", name)
           else:
               logger.error(
                   "Couldn't get crawler %s. Here's why: %s: %s",
                   name,
                   err.response["Error"]["Code"],
                   err.response["Error"]["Message"],
               )
       raise
For API details, see `GetCrawler` in *AWS SDK for Python (Boto3) API Reference.*

Ruby

**SDK for Ruby**

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Retrieves information about a specific crawler.
  #
  # @param name [String] The name of the crawler to retrieve information about.
  # @return [Aws::Glue::Types::Crawler, nil] The crawler object if found, or nil if not found.
  def get_crawler(name)
    @glue_client.get_crawler(name: name)
  rescue Aws::Glue::Errors::EntityNotFoundException
    @logger.info("Crawler '#{name}' doesn't exist.")
    false
  rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not get crawler '#{name}': \
#{e.message}"")
    raise
  end
end
```

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-code-examples/).
For API details, see `GetCrawler` in *AWS SDK for Ruby API Reference*.

**Rust**

**SDK for Rust**

```
let tmp_crawler = glue
    .get_crawler()
    .name(self.crawler())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;
```

For API details, see `GetCrawler` in *AWS SDK for Rust API reference*.

For a complete list of AWS SDK developer guides and code examples, see *Using this service with an AWS SDK*. This topic also includes information about getting started and details about previous SDK versions.

**Get a database from the AWS Glue Data Catalog using an AWS SDK**

The following code examples show how to get a database from the AWS Glue Data Catalog.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- **Get started with crawlers and jobs**
AWS Glue User Guide

.NET

AWS SDK for .NET

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```csharp
/// <summary>
/// Get information about an AWS Glue database.
/// </summary>
/// <param name="dbName">The name of the database.</param>
/// <returns>A Database object containing information about the database.</returns>
public async Task<Database> GetDatabaseAsync(string dbName)
{
    var databasesRequest = new GetDatabaseRequest
    {
        Name = dbName,
    };

    var response = await _amazonGlue.GetDatabaseAsync(databasesRequest);
    return response.Database;
}
```

- For API details, see GetDatabase in AWS SDK for .NET API Reference.

C++

SDK for C++

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
```cpp
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::GetDatabaseRequest request;
request.SetName(CRAWLER_DATABASE_NAME);

Aws::Glue::Model::GetDatabaseOutcome outcome =
client.GetDatabase(request);

if (outcome.IsSuccess()) {
    const Aws::Glue::Model::Database &database =
    outcome.GetResult().GetDatabase();

    std::cout << "Successfully retrieve the database\n" <<
    database.Jsonize().View().WriteReadable() << "." <<
    std::endl;
} else {
    std::cerr << "Error getting the database. 
" <<
    outcome.GetError().GetMessage() << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",", bucketName,
    clientConfig);
    return false;
}
```

- For API details, see [GetDatabase](aws-sdk-cpp-docs) in *AWS SDK for C++ API Reference*.

Java

**SDK for Java 2.x**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-quickstart).

Get a database from the Data Catalog
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.glue.GlueClient;
import software.amazon.awssdk.services.glue.model.GetDatabaseRequest;
import software.amazon.awssdk.services.glue.model.GetDatabaseResponse;
import software.amazon.awssdk.services.glue.model.GlueException;
import java.time.Instant;
import java.time.ZoneId;
import java.time.format.DateTimeFormatter;
import java.time.format.FormatStyle;
import java.util.Locale;

/**
 * Before running this Java V2 code example, set up your development environment,
including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-started.html
 */

public class GetDatabase {
    public static void main(String[] args) {
        final String usage = ""
                             Usage: <databaseName>
                             Where:
                             databaseName - The name of the database.
                             ""
        
        if (args.length != 1) {
            System.out.println(usage);
            System.exit(1);
        }

        String databaseName = args[0];
        Region region = Region.US_EAST_1;
        GlueClient glueClient = GlueClient.builder()
                                       .region(region)
                                       .build();

        getSpecificDatabase(glueClient, databaseName);
```java
public static void getSpecificDatabase(GlueClient glueClient, String databaseName) {
    try {
        GetDatabaseRequest databasesRequest = GetDatabaseRequest.builder()
            .name(databaseName)
            .build();

        GetDatabaseResponse response =
            glueClient.getDatabase(databasesRequest);
        Instant createDate = response.database().createTime();

        // Convert the Instant to readable date.
        DateTimeFormatter formatter =
            DateTimeFormatter.ofLocalizedDateTime(FormatStyle.SHORT)
                .withLocale(Locale.US)
                .withZone(ZoneId.systemDefault());

        formatter.format(createDate);
        System.out.println("The create date of the database is "+
            createDate);
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}
```

- For API details, see [GetDatabase](https://aws-sdk-java-2.x.amazonaws.com/doc/api/v1/com.amazonaws.services.glue.model.GetDatabase.html) in *AWS SDK for Java 2.x API Reference*.

**JavaScript**

**SDK for JavaScript (v3)**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws-samples/aws-code-examples).
const getDatabase = (name) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new GetDatabaseCommand({
    Name: name,
  });

  return client.send(command);
};

• For API details, see GetDatabase in AWS SDK for JavaScript API Reference.

Kotlin

SDK for Kotlin

suspend fun getSpecificDatabase(databaseName: String?) {
  val request = GetDatabaseRequest {
    name = databaseName
  }

  GlueClient { region = "us-east-1" }.use { glueClient ->
    val response = glueClient.getDatabase(request)
    val dbDesc = response.database?.description
    println("The database description is $dbDesc")
  }
}

• For API details, see GetDatabase in AWS SDK for Kotlin API reference.
**SDK for PHP**

```php
$databaseName = "doc-example-database-$uniqid";

$database = $glueService->getDatabase($databaseName);
echo "Found a database named ". $database["Database"]['Name'] . "\n";

class GlueWrapper:
    """Encapsulates AWS Glue actions."""
```

- For API details, see [GetDatabase](#) in [AWS SDK for PHP API Reference](#).

---

**SDK for Python (Boto3)**

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""
```

- For API details, see [GetDatabase](#) in [AWS SDK for PHP API Reference](#).

---

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).
```python
def __init__(self, glue_client):
    
    
    self.glue_client = glue_client


def get_database(self, name):
    
    Gets information about a database in your Data Catalog.

    :param name: The name of the database to look up.
    :return: Information about the database.
    
    try:
        response = self.glue_client.get_database(Name=name)
    except ClientError as err:
        logger.error(
            "Couldn't get database %s. Here's why: %s: %s",
            name,
            err.response["Error"]['Code'],
            err.response["Error"]['Message'],
        )
        raise
    else:
        return response['Database']
```

- For API details, see `GetDatabase` in *AWS SDK for Python (Boto3) API Reference*.

Ruby

**SDK for Ruby**

ℹ️ **Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-ruby).
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.

class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Retrieves information about a specific database.
  #
  # @param name [String] The name of the database to retrieve information about.
  # @return [Aws::Glue::Types::Database, nil] The database object if found, or nil if not found.
  #
  # @api note
  def get_database(name)
    response = @glue_client.get_database(name: name)
    response.database
  rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not get database #{name}: \
    #{e.message}")
    raise
  end

For API details, see [GetDatabase](https://docs.aws.amazon.com/sdk-for-ruby/api/Aws/Glue/Types.html#GetDatabase) in *AWS SDK for Ruby API Reference*.

Rust

**SDK for Rust**

```rust
let database = glue
  .get_database()
  .name(self.database())
  .send()
```

*Note* There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-rust).
• For API details, see [GetDatabase](#) in *AWS SDK for Rust API reference*.

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](#). This topic also includes information about getting started and details about previous SDK versions.

**Get an AWS Glue job run using an AWS SDK**

The following code examples show how to get an AWS Glue job run.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

• [Get started with crawlers and jobs](#)

**.NET**

**AWS SDK for .NET**

```csharp
/// <summary>
/// Get information about a specific AWS Glue job run.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <param name="jobRunId">The Id of the job run.</param>
```

---

Note
---

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).
public async Task<JobRun> GetJobRunAsync(string jobName, string jobRunId)
{
    var response = await _amazonGlue.GetJobRunAsync(new GetJobRunRequest
    {
        JobName = jobName, RunId = jobRunId
    });
    return response.JobRun;
}

• For API details, see GetJobRun in AWS SDK for .NET API Reference.

C++

SDK for C++

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```cpp
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::GetJobRunRequest jobRunRequest;
jobRunRequest.SetJobName(jobName);
jobRunRequest.SetRunId(jobRunID);

Aws::Glue::Model::GetJobRunOutcome jobRunOutcome = client.GetJobRun(
    jobRunRequest);

if (jobRunOutcome.IsSuccess()) {
    std::cout << "Displaying the job run JSON description." << std::endl;
    std::cout << jobRunOutcome.GetResult().GetJobRun().Jsonize().View().WriteReadable()
        << std::endl;
```
} else {
    std::cerr << "Error get a job run. "
    << jobRunOutcome.GetError().GetMessage()
    << std::endl;
}

- For API details, see [GetJobRun](#) in [AWS SDK for C++ API Reference](#).

### CLI

**AWS CLI version 2**

To get information about a job run

The following `get-job-run` example retrieves information about a job run.

```bash
aws glue get-job-run \\
    --job-name "Combine legislators data" \\
    --run-id jr_012e176506505074d94d761755e5c62538ee1aad6f17d39f527e9140cf0c9a5e
```

**Output:**

```json
{
    "JobRun": {
        "Id": "jr_012e176506505074d94d761755e5c62538ee1aad6f17d39f527e9140cf0c9a5e",
        "Attempt": 0,
        "JobName": "Combine legislators data",
        "StartedOn": 1602873931.255,
        "LastModifiedOn": 1602874075.985,
        "CompletedOn": 1602874075.985,
        "JobRunState": "SUCCEEDED",
        "Arguments": {
            "--enable-continuous-cloudwatch-log": "true",
            "--enable-metrics": "",
            "--enable-spark-ui": "true",
            "--job-bookmark-option": "job-bookmark-enable",
            "--spark-event-logs-path": "s3://aws-glue-assets-111122223333-us-east-1/sparkHistoryLogs/"
        }
    }
}
```
"PredecessorRuns": [],
"AllocatedCapacity": 10,
"ExecutionTime": 117,
"Timeout": 2880,
"MaxCapacity": 10.0,
"WorkerType": "G.1X",
"NumberOfWorkers": 10,
"LogGroupName": "/aws-glue/jobs",
"GlueVersion": "2.0"
}

For more information, see Job Runs in the AWS Glue Developer Guide.

- For API details, see GetJobRun in AWS CLI Command Reference.

JavaScript

**SDK for JavaScript (v3)**

```javascript
const getJobRun = (jobName, jobRunId) => {
  const client = new GlueClient({ region: DEFAULT_REGION });
  const command = new GetJobRunCommand({
    JobName: jobName,
    RunId: jobRunId,
  });

  return client.send(command);
};
```

- For API details, see GetJobRun in AWS SDK for JavaScript API Reference.
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```php
$jobName = 'test-job-' . $uniqid;
$outputBucketUrl = "s3://$bucketName";
$runId = $glueService->startJobRun($jobName, $databaseName, $tables, $outputBucketUrl)['JobRunId'];

echo "waiting for job";
do {
    $jobRun = $glueService->getJobRun($jobName, $runId);
echo ".";
sleep(10);
} while (!array_intersect([$jobRun['JobRun']['JobRunState']], ['SUCCEEDED', 'STOPPED', 'FAILED', 'TIMEOUT']));
echo "\n";

public function getJobRun($jobName, $runId, $predecessorsIncluded = false):
    Result
    {
    return $this->glueClient->getJobRun(['
        'JobName' => $jobName,
        'RunId' => $runId,
        'PredecessorsIncluded' => $predecessorsIncluded,
    ]);}
```

- For API details, see GetJobRun in AWS SDK for PHP API Reference.
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def get_job_run(self, name, run_id):
        """
        Gets information about a single job run.

        :param name: The name of the job definition for the run.
        :param run_id: The ID of the run.
        :return: Information about the run.
        """
        try:
            response = self.glue_client.get_job_run(JobName=name, RunId=run_id)
        except ClientError as err:
            logger.error("Couldn't get job run %s/%s. Here's why: %s: %s", name, run_id, err.response["Error"]["Code"], err.response["Error"]["Message"],
            )
            raise
        else:
            return response["JobRun"]
- For API details, see [GetJobRun](#) in *AWS SDK for Python (Boto3) API Reference*.

Ruby

**SDK for Ruby**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Retrieves data for a specific job run.
  #
  # @param job_name [String] The name of the job run to retrieve data for.
  # @return [Glue::Types::GetJobRunResponse]
  def get_job_run(job_name, run_id)
    @glue_client.get_job_run(job_name: job_name, run_id: run_id)
    rescue Aws::Glue::Errors::GlueException => e
      @logger.error("Glue could not get job runs: \n#{e.message}\")
  end
end
```

- For API details, see [GetJobRun](#) in *AWS SDK for Ruby API Reference*.
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```rust
let get_job_run = || async {
    Ok::<JobRun, GlueMvpError>(
        glue.get_job_run()
            .job_name(self.job())
            .run_id(job_run_id.to_string())
            .send()
            .await
            .map_err(GlueMvpError::from_glue_sdk)?
            .job_run()
            .ok_or_else(|| GlueMvpError::Unknown("Failed to get job_run".into()))?
                .to_owned(),
    )
};

let mut job_run = get_job_run().await?
let mut state = job_run.job_run_state().unwrap_or(&unknown_state).to_owned();

while matches!(
    state,
    JobRunState::Starting | JobRunState::Stopping | JobRunState::Running
) {
    info!(?state, "Waiting for job to finish");
    tokio::time::sleep(self.wait_delay).await;

    job_run = get_job_run().await?
    state = job_run.job_run_state().unwrap_or(&unknown_state).to_owned();
}
```

- For API details, see [GetJobRun](#) in AWS SDK for Rust API reference.
For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

## Get database list from the AWS Glue Data Catalog using an AWS SDK

The following code examples show how to get a list of databases from the AWS Glue Data Catalog.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- [Get started with crawlers and jobs](#)

### CLI

#### AWS CLI version 2

To list the definitions of some or all of the databases in the AWS Glue Data Catalog

The following `get-databases` example returns information about the databases in the Data Catalog.

```bash
aws glue get-databases
```

**Output:**

```json
{
  "DatabaseList": [
    {
      "Name": "default",
      "Description": "Default Hive database",
      "LocationUri": "file:/spark-warehouse",
      "CreateTime": 1602084052.0,
      "CreateTableDefaultPermissions": [
        {
          "Principal": {
            "DataLakePrincipalIdentifier": "IAM_ALLOWED_PRINCIPALS"
          },
          "Permissions": ["ALL"
        ]
      ]
    }
  ]
}
```
Get databases from the Data Catalog
For more information, see Defining a Database in Your Data Catalog in the AWS Glue Developer Guide.

- For API details, see GetDatabases in AWS CLI Command Reference.

JavaScript

**SDK for JavaScript (v3)**

```javascript
const getDatabases = () => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new GetDatabasesCommand({});

    return client.send(command);
};
```

- For API details, see GetDatabases in AWS SDK for JavaScript API Reference.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

**Get a job from the AWS Glue Data Catalog using an AWS SDK**

The following code examples show how to get a job from the AWS Glue Data Catalog.
Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- **Get started with crawlers and jobs**

### CLI

**AWS CLI version 2**

**To retrieve information about a job**

The following `get-job` example retrieves information about a job.

```bash
aws glue get-job \
  --job-name my-testing-job
```

**Output:**

```json
{
  "Job": {
    "Name": "my-testing-job",
    "Role": "Glue_DefaultRole",
    "CreatedOn": 1602805698.167,
    "LastModifiedOn": 1602805698.167,
    "ExecutionProperty": {
      "MaxConcurrentRuns": 1
    },
    "Command": {
      "Name": "gluestreaming",
      "ScriptLocation": "s3://janetst-bucket-01/Scripts/test_script.scala",
      "PythonVersion": "2"
    },
    "DefaultArguments": {"--class": "GlueApp","--job-language": "scala"},
    "MaxRetries": 0,
    "AllocatedCapacity": 10,
    "MaxCapacity": 10.0,
    "GlueVersion": "1.0"
  }
}
```
For more information, see Jobs in the AWS Glue Developer Guide.

- For API details, see GetJob in AWS CLI Command Reference.

JavaScript

**SDK for JavaScript (v3)**

```javascript
const getJob = (jobName) => {
    const client = new GlueClient({
        region: DEFAULT_REGION
    });

    const command = new GetJobCommand({
        JobName: jobName,
    });

    return client.send(command);
};
```

- For API details, see GetJob in AWS SDK for JavaScript API Reference.

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.

**Get runs of an AWS Glue job using an AWS SDK**

The following code examples show how to get runs of an AWS Glue job.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs
/// <summary>
/// Get information about all AWS Glue runs of a specific job.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <returns>A list of JobRun objects.</returns>
public async Task<List<JobRun>> GetJobRunsAsync(string jobName)
{
    var jobRuns = new List<JobRun>();

    var request = new GetJobRunsRequest
    {
        JobName = jobName,
    };

    // No need to loop to get all the log groups--the SDK does it for us behind the scenes
    var paginatorForJobRuns =
        _amazonGlue.Paginators.GetJobRuns(request);

    await foreach (var response in paginatorForJobRuns.Responses)
    {
        response.JobRuns.ForEach(jobRun =>
        {
            jobRuns.Add(jobRun);
        });
    }

    return jobRuns;
}
- For API details, see [GetJobRuns](#) in *AWS SDK for .NET API Reference*.

### C++

**SDK for C++**

```cpp
// Optional: Set to the AWS Region in which the bucket was created (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::GetJobRunsRequest getJobRunsRequest;
getJobRunsRequest.SetJobName(jobName);

Aws::Glue::Model::GetJobRunsOutcome jobRunsOutcome = client.GetJobRuns(getJobRunsRequest);

if (jobRunsOutcome.IsSuccess()) {
    std::vector<Aws::Glue::Model::JobRun> jobRuns = jobRunsOutcome.GetResult().GetJobRuns();
    std::cout << "There are " << jobRuns.size() << " runs in the job '" <<
               jobName << "." << std::endl;

    for (size_t i = 0; i < jobRuns.size(); ++i) {
        std::cout << "   " << i + 1 << " " << jobRuns[i].GetJobName() << std::endl;
    }

    int runIndex = askQuestionForIntRange(
        Aws::String("Enter a number between 1 and ") +
        std::to_string(jobRuns.size()) +
        " to see details for a run: ",
        1, static_cast<int>(jobRuns.size()));
```
jobRunID = jobRuns[runIndex - 1].GetId();
}
else {
    std::cerr << "Error getting job runs. "
    << jobRunsOutcome.GetError().GetMessage()
    << std::endl;
}

- For API details, see [GetJobRuns](https://aws-sdk.github.io/aws-sdk-cpp/docs/api-ref/index.html) in *AWS SDK for C++ API Reference*.

**CLI**

**AWS CLI version 2**

**To get information about all job runs for a job**

The following `get-job-runs` example retrieves information about job runs for a job.

```
aws glue get-job-runs \
    --job-name "my-testing-job"
```

**Output:**

```
{
    "JobRuns": [
        {
            "Id": "jr_012e176506505074d94d761755e5c62538ee1aad6f17d39f527e9140cf0c9a5e",
            "Attempt": 0,
            "JobName": "my-testing-job",
            "StartedOn": 1602873931.255,
            "LastModifiedOn": 1602874075.985,
            "CompletedOn": 1602874075.985,
            "JobRunState": "SUCCEEDED",
            "Arguments": {
                "--enable-continuous-cloudwatch-log": "true",
                "--enable-metrics": "",
                "--enable-spark-ui": "true",
                "--job-bookmark-option": "job-bookmark-enable",
                "--spark-event-logs-path": "s3://aws-glue-assets-111122223333-us-
 east-1/sparkHistoryLogs/"
            }
        }
    ]
}
```
Get runs of a job

"PredecessorRuns": [],
"AllocatedCapacity": 10,
"ExecutionTime": 117,
"Timeout": 2880,
"MaxCapacity": 10.0,
"WorkerType": "G.1X",
"NumberOfWorkers": 10,
"LogGroupName": "/aws-glue/jobs",
"GlueVersion": "2.0"
},
{
  "Id":
  "jr_03cc19ddab11c4e244d3f735567de74ff93b0b3ef468a713ffe73e53d1ae08f_attempt_2",
  "Attempt": 2,
  "PreviousRunId":
  "jr_03cc19ddab11c4e244d3f735567de74ff93b0b3ef468a713ffe73e53d1ae08f_attempt_1",
  "JobName": "my-testing-job",
  "StartedOn": 1602811168.496,
  "LastModifiedOn": 1602811282.39,
  "CompletedOn": 1602811282.39,
  "JobRunState": "FAILED",
  "ErrorMessage": "An error occurred while calling o122.pyWriteDynamicFrame.

Access Denied (Service: Amazon S3; Status Code: 403; Error Code: AccessDenied);
Request ID: 021AAB703DB20A2D;
S3 Extended Request ID: teZk24Y09TkXzBvMPG502L5VJBhe9DJuWA9/TXtuGOqfByajkfFL/Tlqt5JBGdEGpigAqzdMDM/U=)",

"PredecessorRuns": [],
"AllocatedCapacity": 10,
"ExecutionTime": 110,
"Timeout": 2880,
"MaxCapacity": 10.0,
"WorkerType": "G.1X",
"NumberOfWorkers": 10,
"LogGroupName": "/aws-glue/jobs",
"GlueVersion": "2.0"
},
{
  "Id":
  "jr_03cc19ddab11c4e244d3f735567de74ff93b0b3ef468a713ffe73e53d1ae08f_attempt_1",
  "Attempt": 1,
  "PreviousRunId":
  "jr_03cc19ddab11c4e244d3f735567de74ff93b0b3ef468a713ffe73e53d1ae08f",

2324
"JobName": "my-testing-job",
"StartedOn": 1602811020.518,
"LastModifiedOn": 1602811138.364,
"CompletedOn": 1602811138.364,
"JobRunState": "FAILED",
"ErrorMessage": "An error occurred while calling
o122.pyWriteDynamicFrame.
Access Denied (Service: Amazon S3; Status Code: 403; Error Code:
AccessDenied;
Request ID: 2671D37856AE7ABB;
S3 Extended Request ID: RLJCJw20brV
+PpC6GpORahyF2fp9fB5Ssb2bTGPnUSPVizLXRl1PN3QZ1db+v1o9qRktyNYbW8=)",
"PredecessorRuns": [],
"AllocatedCapacity": 10,
"ExecutionTime": 113,
"Timeout": 2880,
"MaxCapacity": 10.0,
"WorkerType": "G.1X",
"NumberOfWorkers": 10,
"LogGroupName": "/aws-glue/jobs",
"GlueVersion": "2.0"
}
]}

For more information, see Job Runs in the AWS Glue Developer Guide.

- For API details, see GetJobRuns in AWS CLI Command Reference.

JavaScript

SDK for JavaScript (v3)

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

const getJobRuns = (jobName) => {
    const client = new GlueClient({ region: DEFAULT_REGION });
    const command = new GetJobRunsCommand({
For API details, see [GetJobRuns](https://aws.amazon.com/documentation/developer-guide/API_getJobRuns) in *AWS SDK for JavaScript API Reference*.

**PHP**

**SDK for PHP**

```php
$jobName = 'test-job-' . $uniqid;

$jobRuns = $glueService->getJobRuns($jobName);

public function getJobRuns($jobName, $maxResults = 0, $nextToken = ''):

Result

{ $arguments = [
    'JobName' => $jobName];
    if ($maxResults) {
        $arguments['MaxResults'] = $maxResults;
    }
    if ($nextToken) {
        $arguments['NextToken'] = $nextToken;
    }
    return $this->glueClient->getJobRuns($arguments);}
```

For API details, see [GetJobRuns](https://aws.amazon.com/documentation/developer-guide/API_getJobRuns) in *AWS SDK for PHP API Reference*.
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def get_job_runs(self, job_name):
        """
        Gets information about runs that have been performed for a specific job definition.

        :param job_name: The name of the job definition to look up.
        :return: The list of job runs.
        """
        try:
            response = self.glue_client.get_job_runs(JobName=job_name)
        except ClientError as err:
            logger.error("Couldn't get job runs for %s. Here's why: %s: %s",
                          job_name,
                          err.response["Error"]["Code"],
                          err.response["Error"]["Message"],
                      )
            raise
        else:
            return response["JobRuns"]
For API details, see [GetJobRuns](#) in *AWS SDK for Python (Boto3) API Reference*.

**Ruby**

SDK for Ruby

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Retrieves a list of job runs for the specified job.
  # @param job_name [String] The name of the job to retrieve job runs for.
  # @return [Array<Aws::Glue::Types::JobRun>]
  def get_job_runs(job_name)
    response = @glue_client.get_job_runs(job_name: job_name)
    response.job_runs
  rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not get job runs: \n#{e.message}"")
  end
end
```

For API details, see [GetJobRuns](#) in *AWS SDK for Ruby API Reference*.  

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).
For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](#). This topic also includes information about getting started and details about previous SDK versions.

## Get tables from a database in the AWS Glue Data Catalog using an AWS SDK

The following code examples show how to get tables from a database in the AWS Glue Data Catalog.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- [Get started with crawlers and jobs](#)

### .NET

#### AWS SDK for .NET

```csharp
/// <summary>
/// Get a list of tables for an AWS Glue database.
/// </summary>
/// <param name="dbName">The name of the database.</param>
/// <returns>A list of Table objects.</returns>
public async Task<List<Table>> GetTablesAsync(string dbName)
{
    var request = new GetTablesRequest { DatabaseName = dbName };  
    var tables = new List<Table>();

    // Get a paginator for listing the tables.
    var tablePaginator = _amazonGlue.Paginators.GetTables(request);

    await foreach (var response in tablePaginator.Responses) {
        // Get tables from a database
        2329
```
tables.AddRange(response.TableList);
}

return tables;
}

- For API details, see [GetTables](https://docs.aws.amazon.com/sdk-for-cpp/v1/api-reference/classaws__sdk__v1__core__client.html#AWS_Sdk_V1_Core_Client__GetTables) in *AWS SDK for .NET API Reference*.

### C++

**SDK for C++**

```cpp
Aws::Client::ClientConfiguration clientConfig;
  // Optional: Set to the AWS Region in which the bucket was created
  // (overrides config file).
  // clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::GetTablesRequest request;
request.SetDatabaseName(CRAWLER_DATABASE_NAME);

Aws::Glue::Model::GetTablesOutcome outcome = client.GetTables(request);

if (outcome.IsSuccess()) {
    const std::vector<Aws::Glue::Model::Table> &tables =
        outcome.GetResult().GetTableList();
    std::cout << "The database contains " << tables.size() << " tables."
        << (tables.size() == 1 ? " table." : " tables.") << std::endl;
    std::cout << "Here is a list of the tables in the database."
        << std::endl;
    for (size_t index = 0; index < tables.size(); ++index) {
        std::cout << "    " << index + 1 << " : " << tables[index].GetName()
            << std::endl;
    }
}
```

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-cpp).
if (!tables.empty()) {
    int tableIndex = askQuestionForIntRange("Enter an index to display the database detail ",
        1, static_cast<int>(tables.size()));
    std::cout << tables[tableIndex - 1].Jsonize().View().WriteReadable()
        << std::endl;
}
else {
    std::cerr << "Error getting the tables. " << outcome.GetError().GetMessage()
        << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, "", bucketName,
        clientConfig);
    return false;
}

• For API details, see GetTables in AWS SDK for C++ API Reference.

CLI

AWS CLI version 2

To list the definitions of some or all of the tables in the specified database

The following get-tables example returns information about the tables in the specified database.

aws glue get-tables --database-name 'tempdb'

Output:

{  
    "TableList": [  
    {  
        "Name": "my-s3-sink",  
        "DatabaseName": "tempdb",  
    }  
}
Get tables from a database
"Type": "int"
],
{
  "Name": "currenttemperature",
  "Type": "int"
],
{
  "Name": "status",
  "Type": "string"
}
 trouser Location": "s3://janetst-bucket-01/",
"Compressed": false,
"NumberOfBuckets": 0,
"SortColumns": [],
"StoredAsSubDirectories": false
},
"Parameters": {
  "classification": "json"
},
"CreatedBy": "arn:aws:iam::007436865787:user/JRSTERN",
"IsRegisteredWithLakeFormation": false,
"CatalogId": "007436865787"
},
{
  "Name": "test-kinesis-input",
  "DatabaseName": "tempdb",
  "CreateTime": 1601507001.0,
  "UpdateTime": 1601507001.0,
  "Retention": 0,
  "StorageDescriptor": {
    "Columns": [
      {
        "Name": "sensorid",
        "Type": "int"
      },
      {
        "Name": "currenttemperature",
        "Type": "int"
      },
      {
        "Name": "status",
        "Type": "string"
      }
    ]
  },
  "Parameters": {
    "classification": "json"
  },
  "CreatedBy": "arn:aws:iam::007436865787:user/JRSTERN",
  "IsRegisteredWithLakeFormation": false,
  "CatalogId": "007436865787"}
"Location": "my-testing-stream",
"Compressed": false,
"NumberOfBuckets": 0,
"SerdeInfo": {
  "SerializationLibrary": "org.openx.data.jsonserde.JsonSerDe"
},
"SortColumns": [],
"Parameters": {
  "kinesisUrl": "https://kinesis.us-east-1.amazonaws.com",
  "streamName": "my-testing-stream",
  "typeOfData": "kinesis"
},
"StoredAsSubDirectories": false
},
"Parameters": {
  "classification": "json"
},
"CreatedBy": "arn:aws:iam::170436865797:user/JRSTERN",
"IsRegisteredWithLakeFormation": false,
"CatalogId": "007436865797"
}
]

For more information, see Defining Tables in the AWS Glue Data Catalog in the AWS Glue Developer Guide.

- For API details, see GetTables in AWS CLI Command Reference.

Java

**SDK for Java 2.x**

```java
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.glue.GlueClient;
```

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
import software.amazon.awssdk.services.glue.model.GetTableRequest;
import software.amazon.awssdk.services.glue.model.GetTableResponse;
import software.amazon.awssdk.services.glue.model.GlueException;
import java.time.Instant;
import java.time.ZoneId;
import java.time.format.DateTimeFormatter;
import java.time.format.FormatStyle;
import java.util.Locale;

/**
 * Before running this Java V2 code example, set up your development environment, including your credentials.
 *
 * For more information, see the following documentation topic:
 *
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-started.html
 */
public class GetTable {
    public static void main(String[] args) {
        final String usage = ""
        "Usage:
        <dbName> <tableName>
        Where:
        dbName - The database name.
        tableName - The name of the table.
        ""
        if (args.length != 2) {
            System.out.println(usage);
            System.exit(1);
        }
        String dbName = args[0];
        String tableName = args[1];
        Region region = Region.US_EAST_1;
        GlueClient glueClient = GlueClient.builder()
                .region(region)
                .build();
        getGlueTable(glueClient, dbName, tableName);
        glueClient.close();
    }
}
public static void getGlueTable(GlueClient glueClient, String dbName, String tableName) {
    try {
        GetTableRequest tableRequest = GetTableRequest.builder()
            .databaseName(dbName)
            .name(tableName)
            .build();

        GetTableResponse tableResponse = glueClient.getTable(tableRequest);
        Instant createDate = tableResponse.table().createTime();

        // Convert the Instant to readable date.
        DateTimeFormatter formatter =
            DateTimeFormatter.ofLocalizedDateTime(FormatStyle.SHORT)
                .withLocale(Locale.US)
                .withZone(ZoneId.systemDefault());

        formatter.format(createDate);
        System.out.println("The create date of the table is " + createDate);
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

• For API details, see [GetTables](#GetTables) in *AWS SDK for Java 2.x API Reference*.

### JavaScript

**SDK for JavaScript (v3)**

ℹ️ **Note**
There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws-samples/aws-code-examples).
const getTables = (databaseName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new GetTablesCommand({
    DatabaseName: databaseName,
  });

  return client.send(command);
};

• For API details, see GetTables in AWS SDK for JavaScript API Reference.

PHP

SDK for PHP

ℹ️ Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

$databaseName = "doc-example-database-$uniqid";

$tables = $glueService->getTables($databaseName);

public function getTables($databaseName): Result {
  return $this->glueClient->getTables(["DatabaseName" => $databaseName,]);
}

• For API details, see GetTables in AWS SDK for PHP API Reference.
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def get_tables(self, db_name):
        """
        Gets a list of tables in a Data Catalog database.

        :param db_name: The name of the database to query.
        :return: The list of tables in the database.
        """
        try:
            response = self.glue_client.get_tables(DatabaseName=db_name)
        except ClientError as err:
            logger.error(  
                "Couldn't get tables %s. Here's why: %s: %s",
                db_name,  
                err.response["Error"]['Code'],  
                err.response["Error"]['Message'],
            )  
            raise
        else:
            return response['TableList']

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
Ruby

## SDK for Ruby

### Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-ruby).  

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.

class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Retrieves a list of tables in the specified database.
  # @param db_name [String] The name of the database to retrieve tables from.
  # @return [Array<Aws::Glue::Types::Table>]
  def get_tables(db_name)
    response = @glue_client.get_tables(database_name: db_name)
    response.table_list
  rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not get tables #{db_name}: \
#{e.message}")
    raise
  end

end
```

Rust

**SDK for Rust**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).

```rust
let tables = glue
    .get_tables()
    .database_name(self.database())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

let tables = tables.table_list();
```

• For API details, see [GetTables](#) in *AWS SDK for Rust API reference*.

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](#). This topic also includes information about getting started and details about previous SDK versions.

**List AWS Glue job definitions using an AWS SDK**

The following code examples show how to list AWS Glue job definitions.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

• [Get started with crawlers and jobs](#)
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```csharp
/// <summary>
/// List AWS Glue jobs using a paginator.
/// </summary>
/// <returns>A list of AWS Glue job names.</returns>
public async Task<List<string>> ListJobsAsync()
{
    var jobNames = new List<string>();

    var listJobsPaginator = _amazonGlue.Paginators.ListJobs(new ListJobsRequest { MaxResults = 10 });
    await foreach (var response in listJobsPaginator.Responses)
    {
        jobNames.AddRange(response.JobNames);
    }

    return jobNames;
}
```

- For API details, see ListJobs in AWS SDK for .NET API Reference.

C++

SDK for C++

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::ListJobsRequest listJobsRequest;
Aws::Glue::Model::ListJobsOutcome listRunsOutcome = client.ListJobs(
    listJobsRequest);

if (listRunsOutcome.IsSuccess()) {
    const std::vector<Aws::String> &jobNames = 
        listRunsOutcome.GetResult().GetJobNames();
    std::cout << "Your account has " << jobNames.size() << " jobs."
             << std::endl;
    for (size_t i = 0; i < jobNames.size(); ++i) {
        std::cout << "   " << i + 1 << " " << jobNames[i] << std::endl;
    }
    int jobIndex = askQuestionForIntRange(
        Aws::String("Enter a number between 1 and ") + 
        std::to_string(jobNames.size()) + 
        " to see the list of runs for a job: ", 
        1, static_cast<int>(jobNames.size()));

    jobName = jobNames[jobIndex - 1];
} else {
    std::cerr << "Error listing jobs. "
              << listRunsOutcome.GetError().GetMessage()
              << std::endl;
}

• For API details, see ListJobs in AWS SDK for C++ API Reference.
JavaScript

SDK for JavaScript (v3)

```javascript
const listJobs = () => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new ListJobsCommand({});

  return client.send(command);
};
```

- For API details, see [ListJobs](https://aws.amazon.com/sdk-for-javascript/api-reference/) in *AWS SDK for JavaScript API Reference*.

PHP

SDK for PHP

```php
$jobs = $glueService->listJobs();
echo "Current jobs:
";
foreach ($jobs['JobNames'] as $jobsName) {
  echo "{$jobsName}\n";
}
```

- For API details, see [ListJobs](https://aws.amazon.com/sdk-for-php/api-reference/) in *AWS SDK for PHP API Reference*.
```php
$arguments = []; if ($maxResults) { $arguments['MaxResults'] = $maxResults; } if ($nextToken) { $arguments['NextToken'] = $nextToken; } if (!empty($tags)) { $arguments['Tags'] = $tags; } return $this->glueClient->listJobs($arguments);
```

• For API details, see ListJobs in AWS SDK for PHP API Reference.

Python

**SDK for Python (Boto3)**

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """
        """
        self.glue_client = glue_client

    def list_jobs(self):
        """
        Lists the names of job definitions in your account.

        :return: The list of job definition names.
        """
```
try:
    response = self.glue_client.list_jobs()
except ClientError as err:
    logger.error(       
        "Couldn't list jobs. Here's why: %s: %s",
        err.response["Error"]["Code"],
        err.response["Error"]["Message"],
    )
    raise
else:
    return response["JobNames"]

• For API details, see ListJobs in AWS SDK for Python (Boto3) API Reference.

Ruby

SDK for Ruby

<i>Note</i>

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API calls and log any errors or informational messages.
class GlueWrapper
    def initialize(glue_client, logger)
        @glue_client = glue_client
        @logger = logger
    end

    # Retrieves a list of jobs in AWS Glue.
    #
    # @return [Aws::Glue::Types::ListJobsResponse]
def list_jobs
    @glue_client.list_jobs
    rescue Aws::Glue::Errors::GlueException => e
        @logger.error("Glue could not list jobs: \
#{e.message}"
    raise
end

• For API details, see **ListJobs** in *AWS SDK for Ruby API Reference*.

Rust

**SDK for Rust**

```
let mut list_jobs = glue.list_jobs().into_paginator().send();
while let Some(list_jobs_output) = list_jobs.next().await {
    match list_jobs_output {
        Ok(list_jobs) => {
            let names = list_jobs.job_names();
            info!(?names, "Found these jobs")
        }
        Err(err) => return Err(GlueMvpError::from_glue_sdk(err)),
    }
}
```

• For API details, see **ListJobs** in *AWS SDK for Rust API reference*.  

For a complete list of AWS SDK developer guides and code examples, see **Using this service with an AWS SDK**. This topic also includes information about getting started and details about previous SDK versions.
Start an AWS Glue crawler using an AWS SDK

The following code examples show how to start an AWS Glue crawler.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- Get started with crawlers and jobs

.NET

AWS SDK for .NET

/// <summary>
/// Start an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name of the crawler.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> StartCrawlerAsync(string crawlerName)
{
    var crawlerRequest = new StartCrawlerRequest
    {
        Name = crawlerName,
    };

    var response = await _amazonGlue.StartCrawlerAsync(crawlerRequest);

}

- For API details, see StartCrawler in AWS SDK for .NET API Reference.
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```cpp
Aws::Client::ClientConfiguration clientConfig;
    // Optional: Set to the AWS Region in which the bucket was created
    // (overrides config file).
    // clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::StartCrawlerRequest request;
    request.SetName(CRAWLER_NAME);

Aws::Glue::Model::StartCrawlerOutcome outcome =
    client.StartCrawler(request);

if (outcome.IsSuccess() || (Aws::Glue::GlueErrors::CRAWLER_RUNNING ==
    outcome.GetError().GetErrorType())) {
    if (!outcome.IsSuccess()) {
        std::cout << "Crawler was already started." << std::endl;
    }
    else {
        std::cout << "Successfully started crawler." << std::endl;
    }
}

std::cout << "This may take a while to run." << std::endl;

Aws::Glue::Model::CrawlerState crawlerState =
    Aws::Glue::Model::CrawlerState::NOT_SET;
int iterations = 0;
while (Aws::Glue::Model::CrawlerState::READY != crawlerState) {
    std::this_thread::sleep_for(std::chrono::seconds(1));
    ++iterations;
    if ((iterations % 10) == 0) { // Log status every 10 seconds.
        std::cout << "Current crawler state: " << crawlerState << std::endl;
        std::cout << "Current iterations: " << iterations << std::endl;
    }
}
```

Start a crawler

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std::cout << "Crawler status " <<

Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
crawlerState)
    << ". After " << iterations
    << " seconds elapsed."
    << std::endl;
}

Aws::Glue::Model::GetCrawlerRequest getCrawlerRequest;
getCrawlerRequest.SetName(CRAWLER_NAME);

Aws::Glue::Model::GetCrawlerOutcome getCrawlerOutcome =
client.GetCrawler(
    getCrawlerRequest);

if (getCrawlerOutcome.IsSuccess()) {
crawlerState =
getCrawlerOutcome.GetResult().GetCrawler().GetState();
}
else {
    std::cerr << "Error getting crawler. "
        << getCrawlerOutcome.GetError().GetMessage() <<
        std::endl;
    break;
}

if (Aws::Glue::Model::CrawlerState::READY == crawlerState) {
    std::cout << "Crawler finished running after " << iterations
        << " seconds."
        << std::endl;
}
else {
    std::cerr << "Error starting a crawler. "
        << outcome.GetError().GetMessage()
        << std::endl;

    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ", ", bucketName,
        clientConfig);
    return false;
}
• For API details, see StartCrawler in AWS SDK for C++ API Reference.

CLI

AWS CLI version 2

To start a crawler

The following start-crawler example starts a crawler.

```bash
aws glue start-crawler --name my-crawler
```

Output:

None

For more information, see Defining Crawlers in the AWS Glue Developer Guide.

• For API details, see StartCrawler in AWS CLI Command Reference.

Java

SDK for Java 2.x

```java
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.glue.GlueClient;
import software.amazon.awssdk.services.glue.model.GlueException;
import software.amazon.awssdk.services.glue.model.StartCrawlerRequest;

/**
 * Before running this Java V2 code example, set up your development environment, including your credentials.
 *
 * For more information, see the following documentation topic:
 *
```
public class StartCrawler {
    public static void main(String[] args) {
        final String usage = """"
            Usage:
            <crawlerName>

            Where:
            crawlerName - The name of the crawler.
            """",

        if (args.length != 1) {
            System.out.println(usage);
            System.exit(1);
        }

        String crawlerName = args[0];
        Region region = Region.US_EAST_1;
        GlueClient glueClient = GlueClient.builder()
            .region(region)
            .build();

        startSpecificCrawler(glueClient, crawlerName);
        glueClient.close();
    }

    public static void startSpecificCrawler(GlueClient glueClient, String crawlerName) {
        try {
            StartCrawlerRequest crawlerRequest = StartCrawlerRequest.builder()
                .name(crawlerName)
                .build();

            glueClient.startCrawler(crawlerRequest);
        } catch (GlueException e) {
            System.err.println(e.awsErrorDetails().errorMessage());
            System.exit(1);
        }
    }
}
• For API details, see StartCrawler in AWS SDK for Java 2.x API Reference.

JavaScript

**SDK for JavaScript (v3)**

```javascript
const startCrawler = (name) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new StartCrawlerCommand(
        { Name: name,
    });

    return client.send(command);
};
```

• For API details, see StartCrawler in AWS SDK for JavaScript API Reference.

Kotlin

**SDK for Kotlin**

```kotlin
suspend fun startSpecificCrawler(crawlerName: String?) {
```

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
val request = StartCrawlerRequest {
    name = crawlerName
}

GlueClient { region = "us-west-2" }.use { glueClient ->
    glueClient.startCrawler(request)
    println("$crawlerName was successfully started.")
}

• For API details, see [StartCrawler](https://docs.aws.amazon.com/sdk-for-kotlin/api/latest/api/java/com.amazonaws.services.glue/api/index.html#com.amazonaws.services.glue.model.StartCrawler) in *AWS SDK for Kotlin API reference*.

**PHP**

**SDK for PHP**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-php).  

$crawlerName = "example-crawler-test-" . $uniqid;

$databaseName = "doc-example-database-$uniqid";

$glueService->startCrawler($crawlerName);

public function startCrawler($crawlerName): Result {
    return $this->glueClient->startCrawler(['Name' => $crawlerName, ]);
}

• For API details, see [StartCrawler](https://docs.aws.amazon.com/sdk-for-php/api/latest/api/java/com.amazonaws.services.glue/api/index.html#com.amazonaws.services.glue.model.StartCrawler) in *AWS SDK for PHP API Reference*.
class GlueWrapper:
    """Encapsulates AWS Glue actions."""
    def __init__(self, glue_client):
        """"""
        """
        self.glue_client = glue_client

    def start_crawler(self, name):
        """"""
        Starts a crawler. The crawler crawls its configured target and creates
        metadata that describes the data it finds in the target data source.

        :param name: The name of the crawler to start.
        """
        try:
            self.glue_client.start_crawler(Name=name)
        except ClientError as err:
            logger.error("Couldn't start crawler %s. Here's why: %s: %s", name,
                         err.response["Error"]["Code"],
                         err.response["Error"]["Message"],
                      )
        raise

• For API details, see StartCrawler in AWS SDK for Python (Boto3) API Reference.
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing
# a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods
# for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API
# calls and log any errors or informational messages.

class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Starts a crawler with the specified name.
  #
  # @param name [String] The name of the crawler to start.
  # @return [void]
  def start_crawler(name)
    @glue_client.start_crawler(name: name)
    rescue Aws::Glue::Errors::ServiceError => e
      @logger.error("Glue could not start crawler #{name}: \n#{e.message}")
      raise
  end

end

- For API details, see [StartCrawler](https://aws-sdk-ruby.s3.amazonaws.com/api/1.19.20/aws_glue/Actions/StartCrawler.html) in *AWS SDK for Ruby API Reference*. 

Note
There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-code-examples).
Rust

**SDK for Rust**

![Note]

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-rust).

```rust
let start_crawler =
glue.start_crawler().name(self.crawler()).send().await;

match start_crawler {
    Ok(_) => Ok(()),
    Err(err) => {
        let glue_err: aws_sdk_glue::Error = err.into();
        match glue_err {
            aws_sdk_glue::Error::CrawlerRunningException(_) => Ok(()),
            _ => Err(GlueMvpError::GlueSdk(glue_err)),
        }
    }
};
```

- For API details, see [StartCrawler](https://docs.aws.amazon.com/sdk-for-rust/latest/api/services/glue/struct.Crawler.html#method.start_crawler) in [AWS SDK for Rust API reference](https://docs.aws.amazon.com/sdk-for-rust/latest/api/services/glue/).  

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](https://docs.aws.amazon.com/sdk-for-rust/latest/api/services/glue/). This topic also includes information about getting started and details about previous SDK versions.

**Start an AWS Glue job run using an AWS SDK**

The following code examples show how to start an AWS Glue job run.

Action examples are code excerpts from larger programs and must be run in context. You can see this action in context in the following code example:

- [Get started with crawlers and jobs](https://docs.aws.amazon.com/sdk-for-rust/latest/api/services/glue/)

---

Start a job run
### Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws-samples/aws-code-examples).

```csharp
/// <summary>
/// Start an AWS Glue job run.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <returns>A string representing the job run Id.</returns>
public async Task<string> StartJobRunAsync(
    string jobName,
    string inputDatabase,
    string inputTable,
    string bucketName)
{
    var request = new StartJobRunRequest
    {
        JobName = jobName,
        Arguments = new Dictionary<string, string>
        {
            {"--input_database", inputDatabase},
            {"--input_table", inputTable},
            {"--output_bucket_url", $"s3://{bucketName}/"}
        }
    };

    var response = await _amazonGlue.StartJobRunAsync(request);
    return response.JobRunId;
}
```

- For API details, see [StartJobRun](https://aws.amazon.com/sdk-for-net/api reference) in [AWS SDK for .NET API Reference](https://aws.amazon.com/sdk-for-net/api reference).
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.

```cpp
Aws::Client::ClientConfiguration clientConfig;
// Optional: Set to the AWS Region in which the bucket was created
// (overrides config file).
// clientConfig.region = "us-east-1";

Aws::Glue::GlueClient client(clientConfig);

Aws::Glue::Model::StartJobRunRequest request;
request.SetJobName(JOB_NAME);

Aws::Map<Aws::String, Aws::String> arguments;
arguments["--input_database"] = CRAWLER_DATABASE_NAME;
arguments["--input_table"] = tableName;
arguments["--output_bucket_url"] = Aws::String("s3://") + bucketName + "/";
request.SetArguments(arguments);

Aws::Glue::Model::StartJobRunOutcome outcome = client.StartJobRun(request);

if (outcome.IsSuccess()) {
    std::cout << "Successfully started the job." << std::endl;

    Aws::String jobRunId = outcome.GetResult().GetJobRunId();

    int iterator = 0;
    bool done = false;
    while (!done) {
        ++iterator;
        std::this_thread::sleep_for(std::chrono::seconds(1));
        Aws::Glue::Model::GetJobRunRequest jobRunRequest;
        jobRunRequest.SetJobName(JOB_NAME);
```

Start a job run
```cpp
jobRunRequest.SetRunId(jobRunId);

Aws::Glue::Model::GetJobRunOutcome jobRunOutcome =
client.GetJobRun(
    jobRunRequest);

if (jobRunOutcome.IsSuccess()) {
    const Aws::Glue::Model::JobRun &jobRun =
    jobRunOutcome.GetResult().GetJobRun();
    Aws::Glue::Model::JobRunState jobRunState =
    jobRun.GetJobRunState();

    if (jobRunState == Aws::Glue::Model::JobRunState::STOPPED ||
        jobRunState == Aws::Glue::Model::JobRunState::FAILED ||
        jobRunState == Aws::Glue::Model::JobRunState::TIMEOUT)
    {
        std::cerr << "Error running job. "
        << jobRun.GetErrorMessage()
        << std::endl;
        deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME,
                     JOB_NAME,
                     bucketName,
                     clientConfig);
        return false;
    }
    else if (jobRunState ==
             Aws::Glue::Model::JobRunState::SUCCEEDED) {
        std::cout << "Job run succeeded after " << iterator <<
                   " seconds elapsed." << std::endl;
        done = true;
    }
    else if ((iterator % 10) == 0) { // Log status every 10
        seconds.
        std::cout << "Job run status " <<
        Aws::Glue::Model::JobRunStateMapper::GetNameForJobRunState(
            jobRunState) <<
        ". " << iterator <<
        " seconds elapsed." << std::endl;
    }
} else {
    std::cerr << "Error retrieving job run state. "
```
AWS Glue User Guide

```cpp
    << jobRunOutcome.GetError().GetMessage()
    << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME, bucketName, clientConfig);
    return false;
```  

else {
    std::cerr << "Error starting a job. " << outcome.GetError().GetMessage()
    << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME, bucketName, clientConfig);
    return false;
}

• For API details, see StartJobRun in AWS SDK for C++ API Reference.

CLI

AWS CLI version 2

To start running a job

The following start-job-run example starts a job.

```
aws glue start-job-run \  
   --job-name my-job
```

Output:

```
{
   "JobRunId":
   "jr_22208b1f44eb5376a60569d4b21dd20fcb8621e1a366b4e7b2494af764b82ded"
}
```

For more information, see Authoring Jobs in the AWS Glue Developer Guide.

• For API details, see StartJobRun in AWS CLI Command Reference.

Start a job run
JavaScript

SDK for JavaScript (v3)

```javascript
const startJobRun = (jobName, dbName, tableName, bucketName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new StartJobRunCommand({
    JobName: jobName,
    Arguments: {
      "--input_database": dbName,
      "--input_table": tableName,
      "--output_bucket_url": `s3://${bucketName}/`,
    },
  });

  return client.send(command);
};
```

- For API details, see StartJobRun in AWS SDK for JavaScript API Reference.

PHP

SDK for PHP

```php
$jobName = 'test-job-' . uniqid;
```

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
$databaseName = "doc-example-database-$uniqid";
$tables = $glueService->getTables($databaseName);
$outputBucketUrl = "s3://$bucketName";
$runId = $glueService->startJobRun($jobName, $databaseName, $tables, $outputBucketUrl)['JobRunId'];

public function startJobRun($jobName, $databaseName, $tables, $outputBucketUrl): Result {
    return $this->glueClient->startJobRun(['JobName' => $jobName, 'Arguments' => [
        'input_database' => $databaseName, 'input_table' => $tables['TableList'][0]['Name'],
        'output_bucket_url' => $outputBucketUrl,
        '--input_database' => $databaseName, '--input_table' => $tables['TableList'][0]['Name'],
        '--output_bucket_url' => $outputBucketUrl,
    ],]);
}

• For API details, see StartJobRun in AWS SDK for PHP API Reference.

Python

SDK for Python (Boto3)

```python
class GlueWrapper:
    """Encapsulates AWS Glue actions.""

    def __init__(self, glue_client):
        """
```
def start_job_run(self, name, input_database, input_table, output_bucket_name):
    """
    Starts a job run. A job run extracts data from the source, transforms it, and loads it to the output bucket.
    
    :param name: The name of the job definition.
    :param input_database: The name of the metadata database that contains tables that describe the source data. This is typically created by a crawler.
    :param input_table: The name of the table in the metadata database that describes the source data.
    :param output_bucket_name: The S3 bucket where the output is written.
    :return: The ID of the job run.
    """
    try:
        # The custom Arguments that are passed to this function are used by the Python ETL script to determine the location of input and output data.
        response = self.glue_client.start_job_run(
            JobName=name,
            Arguments={
                "--input_database": input_database,
                "--input_table": input_table,
                "--output_bucket_url": f"s3://{output_bucket_name}/",
            },
        )
    except ClientError as err:
        logger.error("Couldn't start job run %s. Here's why: %s: %s", name, err.response["Error"]["Code"], err.response["Error"]["Message"],
        )
        raise
    else:
For API details, see [StartJobRun](#) in *AWS SDK for Python (Boto3) API Reference*.

### Ruby

**SDK for Ruby**

```ruby
Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).
```

```ruby
class GlueWrapper
  def initialize(glue_client, logger)
    @glue_client = glue_client
    @logger = logger
  end

  # Starts a job run for the specified job.
  def start_job_run(name, input_database, input_table, output_bucket_name)
    response = @glue_client.start_job_run(
      job_name: name,
      arguments: {
        '--input_database': input_database,
        '--input_table': input_table,
        '--output_bucket_name': output_bucket_name
      }
    )
    return response['JobRunId']
  end
end
```
For API details, see **StartJobRun** in *AWS SDK for Ruby API Reference*.

### Rust

**SDK for Rust**

```rust
let job_run_output = glue
    .start_job_run()
    .job_name(self.job())
    .arguments("--input_database", self.database())
    .arguments("--input_table",
        self.tables
            .get(0)
            .ok_or_else(|| GlueMvpError::Unknown("Missing crawler table".into()))?
            .name(),
    )
    .arguments("--output_bucket_url", self.bucket())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

let job = job_run_output
    .job_run_id()
```

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-rust).
• For API details, see [StartJobRun](https://docs.aws.amazon.com/sdk-for-rust/latest/api/aws/service/StartJobRun.html) in *AWS SDK for Rust API reference*.

For a complete list of AWS SDK developer guides and code examples, see [Using this service with an AWS SDK](https://docs.aws.amazon.com/sdk-for-rust/latest/api/aws/service/StartJobRun.html). This topic also includes information about getting started and details about previous SDK versions.

### Scenarios for AWS Glue using AWS SDKs

The following code examples show you how to implement common scenarios in AWS Glue with AWS SDKs. These scenarios show you how to accomplish specific tasks by calling multiple functions within AWS Glue. Each scenario includes a link to GitHub, where you can find instructions on how to set up and run the code.

**Examples**

- [Get started running AWS Glue crawlers and jobs using an AWS SDK](https://docs.aws.amazon.com/sdk-for-rust/latest/api/aws/service/StartJobRun.html)

### Get started running AWS Glue crawlers and jobs using an AWS SDK

The following code examples show how to:

- Create a crawler that crawls a public Amazon S3 bucket and generates a database of CSV-formatted metadata.
- List information about databases and tables in your AWS Glue Data Catalog.
- Create a job to extract CSV data from the S3 bucket, transform the data, and load JSON-formatted output into another S3 bucket.
- List information about job runs, view transformed data, and clean up resources.

For more information, see [Tutorial: Getting started with AWS Glue Studio](https://docs.aws.amazon.com/sdk-for-rust/latest/api/aws/service/StartJobRun.html).
Create a class that wraps AWS Glue functions that are used in the scenario.

```csharp
using System.Net;

namespace GlueActions;

public class GlueWrapper
{
    private readonly IAmazonGlue _amazonGlue;

    /// <summary>
    /// Constructor for the AWS Glue actions wrapper.
    /// </summary>
    /// <param name="amazonGlue"">The name for the crawler.</param>
    /// <param name="crawlerDescription"">A description of the crawler.</param>
    /// <param name="role"">The AWS Identity and Access Management (IAM) role to be assumed by the crawler.</param>
    /// <param name="schedule"">The schedule on which the crawler will be executed.</param>
    /// <param name="s3Path"">The path to the Amazon Simple Storage Service (Amazon S3) bucket where the Python script has been stored.</param>
    /// <param name="dbName"">The name to use for the database that will be
```
/// <summary>
/// Create an AWS Glue job.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// created by the crawler.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> CreateCrawlerAsync(
    string crawlerName,
    string crawlerDescription,
    string role,
    string schedule,
    string s3Path,
    string dbName)
{
    var s3Target = new S3Target
    {
        Path = s3Path,
    };

    var targetList = new List<S3Target>
    {
        s3Target,
    };

    var targets = new CrawlerTargets
    {
        S3Targets = targetList,
    };

    varcrawlerRequest = new CreateCrawlerRequest
    {
        DatabaseName = dbName,
        Name = crawlerName,
        Description = crawlerDescription,
        Targets = targets,
        Role = role,
        Schedule = schedule,
    };

    var response = await _amazonGlue.CreateCrawlerAsync(crawlerRequest);
}
public async Task<bool> CreateJobAsync(string dbName, string tableName, string bucketUrl, string jobName, string roleName, string description, string scriptUrl)
{
    var command = new JobCommand
    {
        PythonVersion = "3",
        Name = "glueetl",
        ScriptLocation = scriptUrl,
    };

    var arguments = new Dictionary<string, string>
    {
        { "--input_database", dbName },
        { "--input_table", tableName },
        { "--output_bucket_url", bucketUrl } ,
    };

    var request = new CreateJobRequest
    {
        Command = command,
        DefaultArguments = arguments,
        Description = description,
        GlueVersion = "3.0",
        Name = jobName,
        NumberOfWorkers = 10,
        Role = roleName,
        WorkerType = "G.1X"
    };

    var response = await _amazonGlue.CreateJobAsync(request);
    return response.HttpStatusCode == HttpStatusCode.OK;
}

/// <summary>
/// Delete an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name of the crawler.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteCrawlerAsync(string crawlerName)
{
    var response = await _amazonGlue.DeleteCrawlerAsync(new
    DeleteCrawlerRequest { Name = crawlerName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}

/// <summary>
/// Delete the AWS Glue database.
/// </summary>
/// <param name="dbName">The name of the database.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteDatabaseAsync(string dbName)
{
    var response = await _amazonGlue.DeleteDatabaseAsync(new
    DeleteDatabaseRequest { Name = dbName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}

/// <summary>
/// Delete an AWS Glue job.
/// </summary>
/// <param name="jobName">The name of the job.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteJobAsync(string jobName)
{
    var response = await _amazonGlue.DeleteJobAsync(new DeleteJobRequest
    { JobName = jobName });
    return response.HttpStatusCode == HttpStatusCode.OK;
}

/// <summary>
/// Delete a table from an AWS Glue database.
/// </summary>
/// <param name="tableName">The table to delete.</param>
/// <returns>A Boolean value indicating the success of the action.</returns>
public async Task<bool> DeleteTableAsync(string dbName, string tableName)
{
    var response = await _amazonGlue.DeleteTableAsync(new DeleteTableRequest
    { Name = tableName, DatabaseName = dbName });
}
return response.HttpStatusCode == HttpStatusCode.OK;
}

/// <summary>
/// Get information about an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name of the crawler.</param>
/// <returns>A Crawler object describing the crawler.</returns>
public async Task<Crawler?> GetCrawlerAsync(string crawlerName)
{
    var crawlerRequest = new GetCrawlerRequest
    {
        Name = crawlerName,
    };

    var response = await _amazonGlue.GetCrawlerAsync(crawlerRequest);
    {
        var databaseName = response.Crawler.DatabaseName;
        Console.WriteLine($"{crawlerName} has the database {databaseName}";
        return response.Crawler;
    }

    Console.WriteLine($"No information regarding {crawlerName} could be found.");
    return null;
}

/// <summary>
/// Get information about the state of an AWS Glue crawler.
/// </summary>
/// <param name="crawlerName">The name of the crawler.</param>
/// <returns>A value describing the state of the crawler.</returns>
public async Task<CrawlerState> GetCrawlerStateAsync(string crawlerName)
{
    var response = await _amazonGlue.GetCrawlerAsync(
        new GetCrawlerRequest
        {
            Name = crawlerName,
        };
    return response.Crawler.State;
}

/// <summary>
/// Get started with crawlers and jobs
/// </summary>
Get information about an AWS Glue database.

```csharp
public async Task<Database> GetDatabaseAsync(string dbName)
{
    var databasesRequest = new GetDatabaseRequest
    {
        Name = dbName,
    };

    var response = await _amazonGlue.GetDatabaseAsync(databasesRequest);
    return response.Database;
}
```

Get information about a specific AWS Glue job run.

```csharp
public async Task<JobRun> GetJobRunAsync(string jobName, string jobRunId)
{
    var response = await _amazonGlue.GetJobRunAsync(new GetJobRunRequest
    {
        JobName = jobName, RunId = jobRunId
    });
    return response.JobRun;
}
```

Get information about all AWS Glue runs of a specific job.

```csharp
public async Task<List<JobRun>> GetJobRunsAsync(string jobName)
{
    var jobRuns = new List<JobRun>();
    var request = new GetJobRunsRequest
    {
        JobName = jobName,
    };
```
// No need to loop to get all the log groups--the SDK does it for us behind the scenes
var paginatorForJobRuns =
    _amazonGlue.Paginators.GetJobRuns(request);

await foreach (var response in paginatorForJobRuns.Responses)
{
    response.JobRuns.ForEach(jobRun =>
    {
        jobRuns.Add(jobRun);
    });
}

return jobRuns;
}

/// <summary>
/// Get a list of tables for an AWS Glue database.
/// </summary>
/// <param name="dbName">The name of the database.</param>
/// <returns>A list of Table objects.</returns>
public async Task<List<Table>> GetTablesAsync(string dbName)
{
    var request = new GetTablesRequest { DatabaseName = dbName};
    var tables = new List<Table>();

    // Get a paginator for listing the tables.
    var tablePaginator = _amazonGlue.Paginators.GetTables(request);

    await foreach (var response in tablePaginator.Responses)
    {
        tables.AddRange(response.TableList);
    }

    return tables;
}

/// <summary>
/// List AWS Glue jobs using a paginator.
/// </summary>
/// <returns>A list of AWS Glue job names.</returns>
public async Task<List<string>> ListJobsAsync()
{
    var jobNames = new List<string>();

    var listJobsPaginator = _amazonGlue.Paginators.ListJobs(new
ListJobsRequest { MaxResults = 10 });
    await foreach (var response in listJobsPaginator.Responses)
    {
        jobNames.AddRange(response.JobNames);
    }

    return jobNames;
}

    /// <summary>
    /// Start an AWS Glue crawler.
    /// </summary>
    /// <param name="crawlerName">The name of the crawler.</param>
    /// <returns>A Boolean value indicating the success of the action.</returns>
    public async Task<bool> StartCrawlerAsync(string crawlerName)
    {
        var crawlerRequest = new StartCrawlerRequest
        {
            Name = crawlerName,
        };

        var response = await _amazonGlue.StartCrawlerAsync(crawlerRequest);

    }

    /// <summary>
    /// Start an AWS Glue job run.
    /// </summary>
    /// <param name="jobName">The name of the job.</param>
    /// <returns>A string representing the job run Id.</returns>
    public async Task<string> StartJobRunAsync(
        string jobName,
        string inputDatabase,
        string inputTable,
        string bucketName)
    {
        
    }
Create a class that runs the scenario.

```csharp
using Amazon.Glue;
using Amazon.S3;
using Amazon.S3.Model;

namespace GlueBasics;

public class GlueBasics
{
    private static ILogger logger = null!;
    private static IConfiguration _configuration;
```
static async Task Main(string[] args)
{
    // Set up dependency injection for AWS Glue.
    using var host = Host.CreateDefaultBuilder(args)
        .ConfigureLogging(logging =>
            logging.AddFilter("System", LogLevel.Debug)
            .AddFilter<DebugLoggerProvider>("Microsoft",
                LogLevel.Information)
            .AddFilter<ConsoleLoggerProvider>("Microsoft",
                LogLevel.Trace)
        .ConfigureServices((_, services) =>
            services.AddAWSService<IAmazonGlue>()
                .AddTransient<GlueWrapper>()
                .AddTransient<UiWrapper>()
        )
        .Build();

    logger = LoggerFactory.Create(builder => { builder.AddConsole(); })
        .CreateLogger<GlueBasics>();

    _configuration = new ConfigurationBuilder()
        .SetBasePath(Directory.GetCurrentDirectory())
        .Build();

    // These values are stored in settings.json
    // Once you have run the CDK script to deploy the resources,
    // edit the file to set "BucketName", "RoleName", and "ScriptURL"
    // to the appropriate values. Also set "CrawlerName" to the name
    // you want to give the crawler when it is created.
    string bucketName = _configuration["BucketName"];  
    string bucketUrl = _configuration["BucketUrl"];    
    string crawlerName = _configuration["CrawlerName"]; 
    string roleName = _configuration["RoleName"];     
    string sourceData = _configuration["SourceData"]; 
    string dbName = _configuration["DbName"];        
    string cron = _configuration["Cron"];             
    string scriptUrl = _configuration["ScriptURL"];  
    string jobName = _configuration["JobName"];      

    var wrapper = host.Services.GetRequiredService<GlueWrapper>();
    var uiWrapper = host.Services.GetRequiredService<UiWrapper>();
uiWrapper.DisplayOverview();
uiWrapper.PressEnter();

// Create the crawler and wait for it to be ready.
uiWrapper.DisplayTitle("Create AWS Glue crawler");
Console.WriteLine("Let's begin by creating the AWS Glue crawler.");

var crawlerDescription = "Crawler created for the AWS Glue Basics scenario.";
var crawlerCreated = await wrapper.CreateCrawlerAsync(crawlerName, crawlerDescription, roleName, cron, sourceData, dbName);
if (crawlerCreated)
{
    Console.WriteLine($"The crawler: {crawlerName} has been created. Now let's wait until it's ready.");
    CrawlerState crawlerState;
    do
    {
        crawlerState = await wrapper.GetCrawlerStateAsync(crawlerName);
    }
    while (crawlerState != "READY");
    Console.WriteLine($"The crawler {crawlerName} is now ready for use.");
}
else
{
    Console.WriteLine($"Couldn't create crawler {crawlerName}.");
    return; // Exit the application.
}

uiWrapper.DisplayTitle("Start AWS Glue crawler");
Console.WriteLine("Now let's wait until the crawler has successfully started.");
var crawlerStarted = await wrapper.StartCrawlerAsync(crawlerName);
if (crawlerStarted)
{
    CrawlerState crawlerState;
    do
    {
        crawlerState = await wrapper.GetCrawlerStateAsync(crawlerName);
    }
    while (crawlerState != "READY");
Console.WriteLine("The crawler {crawlerName} is now ready for use.");
}
else
{
    Console.WriteLine("Couldn't start the crawler {crawlerName}.");
    return; // Exit the application.
}

uiWrapper.PressEnter();

Console.WriteLine("\nLet's take a look at the database: {dbName}"
var database = await wrapper.GetDatabaseAsync(dbName);

if (database != null)
{
    uiWrapper.DisplayTitle("{database.Name} Details");
    Console.WriteLine("{database.Name} created on
{database.CreateTime}");
    Console.WriteLine(database.Description);
}

uiWrapper.PressEnter();

var tables = await wrapper.GetTablesAsync(dbName);
if (tables.Count > 0)
{
    tables.ForEach(table =>
    {
        Console.WriteLine("{table.Name}\tCreated: {table.CreateTime}\tUpdated: {table.UpdateTime}"
    });
}

uiWrapper.PressEnter();

uiWrapper.DisplayTitle("Create AWS Glue job");
Console.WriteLine("Creating a new AWS Glue job."
var description = "An AWS Glue job created using the AWS SDK for .NET";
await wrapper.CreateJobAsync(dbName, tables[0].Name, bucketUrl, jobName,
roleName, description, scriptUrl);

uiWrapper.PressEnter();
uiWrapper.DisplayTitle("Starting AWS Glue job");
Console.WriteLine("Starting the new AWS Glue job...");
var jobRunId = await wrapper.StartJobRunAsync(jobName, dbName, tables[0].Name, bucketName);
var jobRunComplete = false;
var jobRun = new JobRun();
do {
    jobRun = await wrapper.GetJobRunAsync(jobName, jobRunId);
    {
        jobRunComplete = true;
    }
} while (!jobRunComplete);
uiWrapper.DisplayTitle($"Data in {bucketName}"");

// Get the list of data stored in the S3 bucket.
var s3Client = new AmazonS3Client();

var response = await s3Client.ListObjectsAsync(new ListObjectsRequest
{
    BucketName = bucketName
});
response.S3Objects.ForEach(s3Object =>
{
    Console.WriteLine(s3Object.Key);
});

uiWrapper.DisplayTitle("AWS Glue jobs");
var jobNames = await wrapper.ListJobsAsync();
jobNames.ForEach(jobName =>
{
    Console.WriteLine(jobName);
});

uiWrapper.PressEnter();

uiWrapper.DisplayTitle("Get AWS Glue job run information");
Console.WriteLine("Getting information about the AWS Glue job.");
var jobRuns = await wrapper.GetJobRunsAsync(jobName);
jobRuns.ForEach(jobRun =>
{  
  Console.WriteLine($"{jobRun.JobName}\t{jobRun.JobRunState}\t{jobRun.CompletedOn}";
  });  
  
  uiWrapper.PressEnter();  
  
  uiWrapper.DisplayTitle("Deleting resources");  
  Console.WriteLine("Deleting the AWS Glue job used by the example.");  
  await wrapper.DeleteJobAsync(jobName);  
  
  Console.WriteLine("Deleting the tables from the database.");  
  tables.ForEach(async table =>  
  {  
    await wrapper.DeleteTableAsync(dbName, table.Name);
  });  
  
  Console.WriteLine("Deleting the database.");  
  await wrapper.DeleteDatabaseAsync(dbName);  
  
  Console.WriteLine("Deleting the AWS Glue crawler.");  
  await wrapper.DeleteCrawlerAsync(crawlerName);  
  
  Console.WriteLine("The AWS Glue scenario has completed.");  
  uiWrapper.PressEnter();  
}  
}  

namespace GlueBasics;  
public class UiWrapper  
{  
  public readonly string SepBar = new string('-', Console.WindowWidth);  

  /// <summary>  
  /// Show information about the scenario.  
  /// </summary>  
  public void DisplayOverview()  
  {  
    Console.Clear();  
    DisplayTitle("Amazon Glue: get started with crawlers and jobs");  
    Console.WriteLine("This example application does the following:");  
  

Console.WriteLine("\t 1. Create a crawler, pass it the IAM role and the URL to the public S3 bucket that contains the source data");
Console.WriteLine("\t 2. Start the crawler.");
Console.WriteLine("\t 3. Get the database created by the crawler and the tables in the database.");
Console.WriteLine("\t 4. Create a job.");
Console.WriteLine("\t 5. Start a job run.");
Console.WriteLine("\t 6. Wait for the job run to complete.");
Console.WriteLine("\t 7. Show the data stored in the bucket.");
Console.WriteLine("\t 8. List jobs for the account.");
Console.WriteLine("\t 9. Get job run details for the job that was run.");
Console.WriteLine("\t10. Delete the demo job.");
Console.WriteLine("\t11. Delete the database and tables created for the demo.");
Console.WriteLine("\t12. Delete the crawler.");
}
```csharp
{
    Console.WriteLine(SepBar);
    Console.WriteLine(CenterString(strTitle));
    Console.WriteLine(SepBar);
}
```

- For API details, see the following topics in *AWS SDK for .NET API Reference*.
  - [CreateCrawler](#)
  - [CreateJob](#)
  - [DeleteCrawler](#)
  - [DeleteDatabase](#)
  - [DeleteJob](#)
  - [DeleteTable](#)
  - [GetCrawler](#)
  - [GetDatabase](#)
  - [GetDatabases](#)
  - [GetJob](#)
  - [GetJobRun](#)
  - [GetJobRuns](#)
  - [GetTables](#)
  - [ListJobs](#)
  - [StartCrawler](#)
  - [StartJobRun](#)
### Note

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-cpp).
Get started with crawlers and jobs

// 2. Create a crawler.
{
    Aws::Glue::Model::S3Target s3Target;
    s3Target.SetPath("s3://crawler-public-us-east-1/flight/2016/csv");
    Aws::Glue::Model::CrawlerTargets crawlerTargets;
    crawlerTargets.AddS3Targets(s3Target);

    Aws::Glue::Model::CreateCrawlerRequest request;
    request.SetTargets(crawlerTargets);
    request.SetName(CRAWLER_NAME);
    request.SetDatabaseName(CRAWLER_DATABASE_NAME);
    request.SetTablePrefix(CRAWLER_DATABASE_PREFIX);
    request.SetRole(roleArn);

    Aws::Glue::Model::CreateCrawlerOutcome outcome =
    client.CreateCrawler(request);

    if (outcome.IsSuccess()) {
        std::cout << "Successfully created the crawler." << std::endl;
    } else {
        std::cerr << "Error creating a crawler. " <<
        outcome.GetError().GetMessage()
        << std::endl;
        deleteAssets("", CRAWLER_DATABASE_NAME, ",", bucketName,
        clientConfig);
        return false;
    }
}

{
    Aws::Glue::Model::GetCrawlerRequest request;
    request.SetName(CRAWLER_NAME);

    Aws::Glue::Model::GetCrawlerOutcome outcome = client.GetCrawler(request);

    if (outcome.IsSuccess()) {

    } else {
        std::cerr << "Error uploading the job file." << std::endl;
        return false;
    }
}
Aws::Glue::Model::CrawlerState crawlerState = outcome.GetResult().GetCrawler().GetState();
std::cout << "Retrieved crawler with state " <<

Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
crawlerState)
<< "." << std::endl;

else {
    std::cerr << "Error retrieving a crawler. "
    << outcome.GetError().GetMessage() << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",", bucketName,
    clientConfig);
    return false;
}
}

// 4. Start a crawler.
{
    Aws::Glue::Model::StartCrawlerRequest request;
    request.SetName(CRAWLER_NAME);

    Aws::Glue::Model::StartCrawlerOutcome outcome = client.StartCrawler(request);

    if (outcome.IsSuccess() || (Aws::Glue::GlueErrors::CRAWLER_RUNNING == 
    outcome.GetError().GetErrorType())) {
        if (!outcome.IsSuccess()) {
            std::cout << "Crawler was already started." << std::endl;
        }
        else {
            std::cout << "Successfully started crawler." << std::endl;
        }

        std::cout << "This may take a while to run." << std::endl;
    }

    Aws::Glue::Model::CrawlerState crawlerState = 
    Aws::Glue::Model::CrawlerState::NOT_SET;
    int iterations = 0;
    while (Aws::Glue::Model::CrawlerState::READY != crawlerState) {
        std::this_thread::sleep_for(std::chrono::seconds(1));
        ++iterations;
        if ((iterations % 10) == 0) { // Log status every 10 seconds.
            std::cout << "Current state: " << 
            Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
            crawlerState)
            << std::endl;
        }
        else {
            std::cout << "Current state: " << 
            Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
            crawlerState)
            << std::endl;
        }
    }
}
std::cout << "Crawler status " <<
Aws::Glue::Model::CrawlerStateMapper::GetNameForCrawlerState(
crawlerState)
<< ". After " << iterations
<< " seconds elapsed."
<< std::endl;
}
Aws::Glue::Model::GetCrawlerRequest getCrawlerRequest;
getCrawlerRequest.SetName(CRAWLER_NAME);

Aws::Glue::Model::GetCrawlerOutcome getCrawlerOutcome =
client.GetCrawler(
    getCrawlerRequest);

if (getCrawlerOutcome.IsSuccess()) {
crawlerState =
getCrawlerOutcome.GetResult().GetCrawler().GetState();
} else {
    std::cerr << "Error getting crawler. "
    << getCrawlerOutcome.GetError().GetMessage() << 
    std::endl;
    break;
}

if (Aws::Glue::Model::CrawlerState::READY == crawlerState) {
    std::cout << "Crawler finished running after " << iterations
                << " seconds."
    << std::endl;
} else {
    std::cerr << "Error starting a crawler. "
              << outcome.GetError().GetMessage()
              << std::endl;

deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",", bucketName, 
clientConfig);
    return false;
}
}
// 5. Get a database.
{
    Aws::Glue::Model::GetDatabaseRequest request;
    request.SetName(CRAWLER_DATABASE_NAME);

    Aws::Glue::Model::GetDatabaseOutcome outcome =
        client.GetDatabase(request);

    if (outcome.IsSuccess()) {
        const Aws::Glue::Model::Database &database =
            outcome.GetResult().GetDatabase();

        std::cout << "Successfully retrieve the database\n" <<
                  database.Jsonize().View().WriteReadable() << "]" <<
        std::endl;
    } else {
        std::cerr << "Error getting the database. " <<
                  outcome.GetError().GetMessage() << std::endl;

        deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ",
                      bucketName, clientConfig);
        return false;
    }
}

Aws::String tableName;
{
    Aws::Glue::Model::GetTablesRequest request;
    request.SetDatabaseName(CRAWLER_DATABASE_NAME);

    Aws::Glue::Model::GetTablesOutcome outcome = client.GetTables(request);

    if (outcome.IsSuccess()) {
        const std::vector<Aws::Glue::Model::Table> &tables =
            outcome.GetResult().GetTableList();

        std::cout << "The database contains " << tables.size() <<
                  " table."
                << std::endl;

        std::cout << "Here is a list of the tables in the database."
        for (size_t index = 0; index < tables.size(); ++index) {
            std::cout << "    " << index + 1 << ": " <<
                      tables[index].GetName() << std::endl;
        }
    }
```cpp
if (!tables.empty()) {
    int tableIndex = askQuestionForIntRange(
        "Enter an index to display the database detail ",
        1, static_cast<int>(tables.size()));
    std::cout << tables[tableIndex - 1].Jsonize().View().WriteReadable()
        << std::endl;
} } else {
    std::cerr << "Error getting the tables. " << outcome.GetError().GetMessage() << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, ":", bucketName, clientConfig);
    return false;
}

// 7. Create a job.
{
    Aws::Glue::Model::CreateJobRequest request;
    request.SetName(JOB_NAME);
    request.SetRole(roleArn);
    request.SetGlueVersion(GLUE_VERSION);

    Aws::Glue::Model::JobCommand command;
    command.SetName(JOB_COMMAND_NAME);
    command.SetPythonVersion(JOB_PYTHON_VERSION);
    command.SetScriptLocation(Aws::String("s3://") + bucketName + ":" + PYTHON_SCRIPT);
    request.SetCommand(command);

    Aws::Glue::Model::CreateJobOutcome outcome = client.CreateJob(request);

    if (outcome.IsSuccess()) {
        std::cout << "Successfully created the job." << std::endl;
    } else {
        std::cerr << "Error creating the job. " << outcome.GetError().GetMessage() << std::endl;
```
```cpp
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, "", bucketName, 
    clientConfig);
    return false;
  }
}

// 8. Start a job run.
{
  Aws::Glue::Model::StartJobRunRequest request;
  request.SetJobName(JOB_NAME);
  Aws::Map<Aws::String, Aws::String> arguments;
  arguments["--input_database"] = CRAWLER_DATABASE_NAME;
  arguments["--input_table"] = tableName;
  arguments["--output_bucket_url"] = Aws::String("s3://") + bucketName + 
  "/";
  request.SetArguments(arguments);

  Aws::Glue::Model::StartJobRunOutcome outcome = 
  client.StartJobRun(request);

  if (outcome.IsSuccess()) {
    std::cout << "Successfully started the job.\n" << std::endl;
    Aws::String jobRunId = outcome.GetResult().GetJobRunId();

    int iterator = 0;
    bool done = false;
    while (!done) {
      ++iterator;
      std::this_thread::sleep_for(std::chrono::seconds(1));
      Aws::Glue::Model::GetJobRunRequest jobRunRequest;
      jobRunRequest.SetJobName(JOB_NAME);
      jobRunRequest.SetRunId(jobRunId);

      Aws::Glue::Model::GetJobRunOutcome jobRunOutcome = 
      client.GetJobRun(
        jobRunRequest);

      if (jobRunOutcome.IsSuccess()) {
        const Aws::Glue::Model::JobRun &jobRun = 
        jobRunOutcome.GetResult().GetJobRun();
        Aws::Glue::Model::JobRunState jobRunState = 
        jobRun.GetJobRunState();
```
if ((jobRunState == Aws::Glue::Model::JobRunState::STOPPED) ||
    (jobRunState == Aws::Glue::Model::JobRunState::FAILED) ||
    (jobRunState == Aws::Glue::Model::JobRunState::TIMEOUT))
{
    std::cerr << "Error running job. "
              << jobRun.GetErrorMessage()
              << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME,
                 bucketName, clientConfig);
    return false;
} else if (jobRunState ==
    Aws::Glue::Model::JobRunState::SUCCEEDED) {
    std::cout << "Job run succeeded after " << iterator << " seconds elapsed." << std::endl;
    done = true;
}
else if ((iterator % 10) == 0) { // Log status every 10 seconds.
    std::cout << "Job run status " <<
    Aws::Glue::Model::JobRunStateMapper::GetNameForJobRunState(
        jobRunState) << ". " << iterator << " seconds elapsed." << std::endl;
}
else {
    std::cerr << "Error retrieving job run state. "
              << jobRunOutcome.GetError().GetMessage()
              << std::endl;
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME,
                  bucketName, clientConfig);
    return false;
}
}
else {
    std::cerr << "Error starting a job. " <<
              outcome.GetError().GetMessage()
<< std::endl;
deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME,
bucketName,
        clientConfig);
    return false;
}

// 9. List the output data stored in the S3 bucket.
{
    Aws::S3::S3Client s3Client;
    Aws::S3::Model::ListObjectsRequest request;
    request.SetBucket(bucketName);
    request.SetPrefix(OUTPUT_FILE_PREFIX);

    Aws::S3::Model::ListObjectsOutcome outcome =
    s3Client.ListObjects(request);

    if (outcome.IsSuccess()) {
        const std::vector<Aws::S3::Model::Object> &objects =
        outcome.GetResult().GetContents();
        std::cout << "Data from your job is in " << objects.size() << 
        " files in the S3 bucket, " << bucketName << "." << 
        std::endl;

        for (size_t i = 0; i < objects.size(); ++i) {
            std::cout << "    " << i + 1 << ". " << objects[i].GetKey() 
            << std::endl;
        }

        int objectIndex = askQuestionForIntRange(
            std::string("Enter the number of a block to download it and see 
            the first ") +
            std::to_string(LINES_OF_RUN_FILE_TO_DISPLAY) + 
            " lines of JSON output in the block: ", 1,
            static_cast<int>(objects.size()));

        Aws::String objectKey = objects[objectIndex - 1].GetKey();

        std::stringstream stringStream;
        if (getObjectFromBucket(bucketName, objectKey, stringStream, 
            clientConfig)) {
            stringStream << std::endl;
            deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME,
                bucketName,
                clientConfig);
            return false;
        }
    }
}
for (int i = 0; i < LINES_OF_RUN_FILE_TO_DISPLAY && stringStream;
++i) {
    std::string line;
    std::getline(stringStream, line);
    std::cout << "    " << line << std::endl;
}
}
else {
    deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME,
bucketName,
    clientConfig);
    return false;
}
}
else {
    std::cerr << "Error listing objects. " <<
outcome.GetError().GetMessage()
    << std::endl;
}
}

// 10. List all the jobs.
Aws::String jobName;
{
    Aws::Glue::Model::ListJobsRequest listJobsRequest;
    Aws::Glue::Model::ListJobsOutcome listRunsOutcome = client.ListJobs(
        listJobsRequest);

    if (listRunsOutcome.IsSuccess()) {
        const std::vector<Aws::String> &jobNames =
listRunsOutcome.GetResult().GetJobNames();
        std::cout << "Your account has " << jobNames.size() << " jobs."
        << std::endl;
        for (size_t i = 0; i < jobNames.size(); ++i) {
            std::cout << "   " << i + 1 << ". " << jobNames[i] << std::endl;
        }
    int jobIndex = askQuestionForIntRange(
        Aws::String("Enter a number between 1 and ") +
        std::to_string(jobNames.size()) +
        " to see the list of runs for a job: ",
    1, static_cast<int>(jobNames.size()));

    jobName = jobNames[jobIndex - 1];
}
else {
    std::cerr << "Error listing jobs. "
    << listRunsOutcome.GetError().GetMessage()
    << std::endl;
}
}

// 11. Get the job runs for a job.
Aws::String jobRunID;
if (!jobName.empty()) {
    Aws::Glue::Model::GetJobRunsRequest getJobRunsRequest;
    getJobRunsRequest.SetJobName(jobName);

    Aws::Glue::Model::GetJobRunsOutcome jobRunsOutcome = client.GetJobRuns(
        getJobRunsRequest);

    if (jobRunsOutcome.IsSuccess()) {
        std::vector<Aws::Glue::Model::JobRun> jobRuns =
            jobRunsOutcome.GetResult().GetJobRuns();
        std::cout << "There are " << jobRuns.size() << " runs in the job " "
        << jobName << "." << std::endl;

        for (size_t i = 0; i < jobRuns.size(); ++i) {
            std::cout << "   " << i + 1 << ". " << jobRuns[i].GetJobName()
                << std::endl;
        }

        int runIndex = askQuestionForIntRange(
            Aws::String("Enter a number between 1 and ") +
            std::to_string(jobRuns.size()) +
            " to see details for a run: ",
            1, static_cast<int>(jobRuns.size()));
        jobRunID = jobRuns[runIndex - 1].GetId();
    } else {
        std::cerr << "Error getting job runs. "
        << jobRunsOutcome.GetError().GetMessage()
        << std::endl;
    }
}

if (!jobRunID.empty()) {
Aws::Glue::Model::GetJobRunRequest jobRunRequest;
jobRunRequest.SetJobName(jobName);
jobRunRequest.SetRunId(jobRunID);

Aws::Glue::Model::GetJobRunOutcome jobRunOutcome = client.GetJobRun(
    jobRunRequest);

if (jobRunOutcome.IsSuccess()) {
    std::cout << "Displaying the job run JSON description."
    << std::endl;
    std::cout << jobRunOutcome.GetResult().GetJobRun().Jsonize().View().WriteReadable()
    << std::endl;
} else {
    std::cerr << "Error get a job run."
    << jobRunOutcome.GetError().GetMessage()
    << std::endl;
}

return deleteAssets(CRAWLER_NAME, CRAWLER_DATABASE_NAME, JOB_NAME, bucketName, clientConfig);

//! Cleanup routine to delete created assets.
/*! 
\sa deleteAssets()
\param crawler: Name of an AWS Glue crawler.
\param database: The name of an AWS Glue database.
\param job: The name of an AWS Glue job.
\param bucketName: The name of an S3 bucket.
\param clientConfig: AWS client configuration.
\return bool: Successful completion.
*/
bool AwsDoc::Glue::deleteAssets(const Aws::String &crawler, const Aws::String &database,
    const Aws::String &job, const Aws::String &bucketName,
    const Aws::Client::ClientConfiguration &clientConfig) {
    const Aws::Glue::GlueClient client(clientConfig);
    bool result = true;
if (!job.empty()) {
    Aws::Glue::Model::DeleteJobRequest request;
    request.SetJobName(job);

    Aws::Glue::Model::DeleteJobOutcome outcome = client.DeleteJob(request);

    if (outcome.IsSuccess()) {
        std::cout << "Successfully deleted the job." << std::endl;
    } else {
        std::cerr << "Error deleting the job. " << outcome.GetError().GetMessage()
                  << std::endl;
        result = false;
    }
}

if (!database.empty()) {
    Aws::Glue::Model::DeleteDatabaseRequest request;
    request.SetName(database);

    Aws::Glue::Model::DeleteDatabaseOutcome outcome = client.DeleteDatabase(request);

    if (outcome.IsSuccess()) {
        std::cout << "Successfully deleted the database." << std::endl;
    } else {
        std::cerr << "Error deleting database. " << outcome.GetError().GetMessage()
                  << std::endl;
        result = false;
    }
}

// 15. Delete a crawler.
if (!crawler.empty()) {
    Aws::Glue::Model::DeleteCrawlerRequest request;
    request.SetName(crawler);
Aws::Glue::Model::DeleteCrawlerOutcome outcome =
client.DeleteCrawler(request);

if (outcome.IsSuccess()) {
    std::cout << "Successfully deleted the crawler."
               << std::endl;
} else {
    std::cerr << "Error deleting the crawler."
               << outcome.GetError().GetMessage()
               << std::endl;
    result = false;
}

// 16. Delete the job script and run data from the S3 bucket.
result &= AwsDoc::Glue::deleteAllObjectsInS3Bucket(bucketName,
                                                   clientConfig);

return result;

//! Routine which uploads a file to an S3 bucket.
/*! 
\sa uploadFile()
\param bucketName: An S3 bucket created in the setup.
\param filePath: The path of the file to upload.
\param fileName The name for the uploaded file.
\param clientConfig: AWS client configuration.
\return bool: Successful completion.
 */
bool
AwsDoc::Glue::uploadFile(const Aws::String &bucketName,
                           const Aws::String &filePath,
                           const Aws::String &fileName,
                           const Aws::Client::ClientConfiguration &clientConfig) {
    Aws::S3::S3Client s3_client(clientConfig);

    Aws::S3::Model::PutObjectRequest request;
    request.SetBucket(bucketName);
    request.SetKey(fileName);

    std::shared_ptr<Aws::IOStream> inputData =
        Aws::MakeShared<Aws::FStream>("SampleAllocationTag",
                                        "SampleAllocationTag",
                                        std::ios_base::in | std::ios_base::binary);
if (!*inputData) {
    std::cerr << "Error unable to read file " << filePath << std::endl;
    return false;
}

request.SetBody(inputData);

Aws::S3::Model::PutObjectOutcome outcome =
    s3_client.PutObject(request);

if (!outcome.IsSuccess()) {
    std::cerr << "Error: PutObject: " <<
               outcome.GetError().GetMessage() << std::endl;
}
else {
    std::cout << "Added object '" << filePath << '" to bucket '"
               << bucketName << "." << std::endl;
}

return outcome.IsSuccess();

//! Routine which deletes all objects in an S3 bucket.
/*! \sa deleteAllObjectsInS3Bucket()
\param bucketName: The S3 bucket name.
\param clientConfig: AWS client configuration.
\return bool: Successful completion.
*/
bool AwsDoc::Glue::deleteAllObjectsInS3Bucket(const Aws::String &bucketName,
                                            const
                                            Aws::Client::ClientConfiguration &clientConfig) {
    Aws::S3::S3Client client(clientConfig);
    Aws::S3::Model::ListObjectsRequest listObjectsRequest;
    listObjectsRequest.SetBucket(bucketName);

    Aws::S3::Model::ListObjectsOutcome listObjectsOutcome = client.ListObjects(
        listObjectsRequest);

    bool result = false;
    if (listObjectsOutcome.IsSuccess()) {
        // Code here
    } else {
        // Code here
    }

    return result;
}
const std::vector<Aws::S3::Model::Object> &objects =
listObjectsOutcome.GetResult().GetContents();
if (!objects.empty()) {
    Aws::S3::Model::DeleteObjectsRequest deleteObjectsRequest;
    deleteObjectsRequest.SetBucket(bucketName);

    std::vector<Aws::S3::Model::ObjectIdentifier> objectIdentifiers;
    for (const Aws::S3::Model::Object &object: objects) {
        objectIdentifiers.push_back(Aws::S3::Model::ObjectIdentifier().WithKey(object.GetKey()));
    }
    Aws::S3::Model::Delete objectsDelete;
    objectsDelete.SetObjects(objectIdentifiers);
    objectsDelete.SetQuiet(true);
    deleteObjectsRequest.SetDelete(objectsDelete);

    Aws::S3::Model::DeleteObjectsOutcome deleteObjectsOutcome =
    client.DeleteObjects(deleteObjectsRequest);

    if (!deleteObjectsOutcome.IsSuccess()) {
        std::cerr << "Error deleting objects. " <<
                   deleteObjectsOutcome.GetError().GetMessage() << std::endl;
    } else {
        std::cout << "Successfully deleted the objects." << std::endl;
        result = true;
    }
} else {
    std::cout << "No objects to delete in " << bucketName << ":" << std::endl;
}
else {
    std::cerr << "Error listing objects. "
               << listObjectsOutcome.GetError().GetMessage() << std::endl;
}

return result;

//! Routine which retrieves an object from an S3 bucket.
/**
 * \sa \ref getObjectFromBucket
 * \param bucketName: The S3 bucket name.
 * \param objectKey: The object's name.
 * \param objectStream: A stream to receive the retrieved data.
 * \param clientConfig: AWS client configuration.
 * \return bool: Successful completion.
 */

bool AwsDoc::Glue::getObjectFromBucket(const Aws::String &bucketName,
                                        const Aws::String &objectKey,
                                        std::ostream &objectStream,
                                        const Aws::Client::ClientConfiguration
                                        &clientConfig) {
    Aws::S3::S3Client client(clientConfig);
    Aws::S3::Model::GetObjectRequest request;
    request.SetBucket(bucketName);
    request.SetKey(objectKey);
    
    Aws::S3::Model::GetObjectOutcome outcome = client.GetObject(request);
    
    if (outcome.IsSuccess()) {
        std::cout << "Successfully retrieved " << objectKey << "." << std::endl;
        auto &body = outcome.GetResult().GetBody();
        objectStream << body.rdbuf();
    } else {
        std::cerr << "Error retrieving object. " << outcome.GetError().GetMessage()
                   << std::endl;
    }

    return outcome.IsSuccess();
}

- For API details, see the following topics in AWS SDK for C++ API Reference.
  - CreateCrawler
  - CreateJob
  - DeleteCrawler
• **DeleteDatabase**
• **DeleteJob**
• **DeleteTable**
• **GetCrawler**
• **GetDatabase**
• **GetDatabases**
• **GetJob**
• **GetJobRun**
• **GetJobRuns**
• **GetTables**
• **ListJobs**
• **StartCrawler**
• **StartJobRun**

Java

**SDK for Java 2.x**

```java
/**
 * Before running this Java V2 code example, set up your development environment, including your credentials.
 * For more information, see the following documentation topic:
 * https://docs.aws.amazon.com/sdk-for-java/latest/developer-guide/get-started.html
 * To set up the resources, see this documentation topic:
 */
```

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://github.com/aws/aws-sdk-java).
* https://docs.aws.amazon.com/glue/latest/ug/tutorial-add-crawler.html

* This example performs the following tasks:

* 1. Create a database.
* 2. Create a crawler.
* 3. Get a crawler.
* 4. Start a crawler.
* 5. Get a database.
* 7. Create a job.
* 8. Start a job run.
* 9. List all jobs.
* 11. Delete a job.
* 12. Delete a database.
* 13. Delete a crawler.
*/

public class GlueScenario {
   public static final String DASHES = new String(new char[80]).replace("\0", "-");
   public static void main(String[] args) throws InterruptedException {
      final String usage = ""
   
      Usage:
      
      <iam> <s3Path> <cron> <dbName> <crawlerName> <jobName>
   
      Where:
      
      iam - The ARN of the IAM role that has AWS Glue and S3 permissions.
   
      s3Path - The Amazon Simple Storage Service (Amazon S3) target that contains data (for example, CSV data).
   
      cron - A cron expression used to specify the schedule (i.e., cron(15 12 * * ? *)).
   
      dbName - The database name.
   
      crawlerName - The name of the crawler.
   
      jobName - The name you assign to this job definition.
   
      scriptLocation - The Amazon S3 path to a script that runs a job.
   
      locationUri - The location of the database
   
      bucketNameSc - The Amazon S3 bucket name used when creating a job
   """;
if (args.length != 9) {
    System.out.println(usage);
    System.exit(1);
}

String iam = args[0];
String s3Path = args[1];
String cron = args[2];
String dbName = args[3];
String crawlerName = args[4];
String jobName = args[5];
String scriptLocation = args[6];
String locationUri = args[7];
String bucketNameSc = args[8];

Region region = Region.US_EAST_1;
GlueClient glueClient = GlueClient.builder()
    .region(region)
    .build();
System.out.println(DASHES);
System.out.println("Welcome to the AWS Glue scenario.");
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("1. Create a database.");
createDatabase(glueClient, dbName, locationUri);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("2. Create a crawler.");
createGlueCrawler(glueClient, iam, s3Path, cron, dbName, crawlerName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("3. Get a crawler.");
getSpecificCrawler(glueClient, crawlerName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("4. Start a crawler.");
startSpecificCrawler(glueClient, crawlerName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("5. Get a database.");
getSpecificDatabase(glueClient, dbName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("*** Wait 5 min for the tables to become available");
TimeUnit.MINUTES.sleep(5);
System.out.println("6. Get tables.");
String myTableName = getGlueTables(glueClient, dbName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("7. Create a job.");
createJob(glueClient, jobName, iam, scriptLocation);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("8. Start a Job run.");
startJob(glueClient, jobName, dbName, myTableName, bucketNameSc);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("9. List all jobs.");
getAllJobs(glueClient);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("10. Get job runs.");
getJobRuns(glueClient, jobName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("11. Delete a job.");
deleteJob(glueClient, jobName);
System.out.println("*** Wait 5 MIN for the "+crawlerName +" to stop");
TimeUnit.MINUTES.sleep(5);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("12. Delete a database.");
deleteDatabase(glueClient, dbName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("Delete a crawler.");
deleteSpecificCrawler(glueClient, crawlerName);
System.out.println(DASHES);

System.out.println(DASHES);
System.out.println("Successfully completed the AWS Glue Scenario");
System.out.println(DASHES);
}

public static void createDatabase(GlueClient glueClient, String dbName,
String locationUri ) {
    try {
        DatabaseInput input = DatabaseInput.builder()
            .description("Built with the AWS SDK for Java V2")
            .name(dbName)
            .locationUri(locationUri)
            .build();

        CreateDatabaseRequest request = CreateDatabaseRequest.builder()
            .databaseInput(input)
            .build();

        glueClient.createDatabase(request);
        System.out.println(dbName +" was successfully created");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

public static void createGlueCrawler(GlueClient glueClient,
String iam,
String s3Path,
String cron,
String dbName,
String crawlerName) {
    try {
        S3Target s3Target = S3Target.builder()
            .path(s3Path)
            .build();

        List<S3Target> targetList = new ArrayList<>();
```java
targetList.add(s3Target);
CrawlerTargets targets = CrawlerTargets.builder()
   .s3Targets(targetList)
   .build();

CreateCrawlerRequest crawlerRequest = CreateCrawlerRequest.builder()
   .databaseName(dbName)
   .name(crawlerName)
   .description("Created by the AWS Glue Java API")
   .targets(targets)
   .role(iam)
   .schedule(cron)
   .build();

glueClient.createCrawler(crawlerRequest);
System.out.println(crawlerName + " was successfully created");

} catch (GlueException e) {
    System.err.println(e.awsErrorDetails().errorMessage());
    System.exit(1);
}

public static void getSpecificCrawler(GlueClient glueClient, String crawlerName) {
    try {
        GetCrawlerRequest crawlerRequest = GetCrawlerRequest.builder()
            .name(crawlerName)
            .build();

        boolean ready = false;
        while(!ready) {
            GetCrawlerResponse response = glueClient.getCrawler(crawlerRequest);
            String status = response.crawler().stateAsString();
            if (status.compareTo("READY") == 0) {
                ready = true;
            }
            Thread.sleep(3000);
        }

        System.out.println("The crawler is now ready");
    } catch (GlueException | InterruptedException e) {
```

---

**Get started with crawlers and jobs**

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System.err.println(e.getMessage());
System.exit(1);
}
}

public static void startSpecificCrawler(GlueClient glueClient, String crawlerName) {
    try {
        StartCrawlerRequest crawlerRequest = StartCrawlerRequest.builder()
            .name(crawlerName)
            .build();

        glueClient.startCrawler(crawlerRequest);
        System.out.println(crawlerName + " was successfully started!");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

public static void getSpecificDatabase(GlueClient glueClient, String databaseName) {
    try {
        GetDatabaseRequest databasesRequest = GetDatabaseRequest.builder()
            .name(databaseName)
            .build();

        GetDatabaseResponse response =
            glueClient.getDatabase(databasesRequest);
        Instant createDate = response.database().createTime();

        // Convert the Instant to readable date.
        DateTimeFormatter formatter =
            DateTimeFormatter.ofLocalizedDateTime( FormatStyle.SHORT )
                .withLocale( Locale.US)
                .withZone( ZoneId.systemDefault() );

        formatter.format( createDate );
        System.out.println("The create date of the database is " +
            createDate );
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
    }
}
public static String getGlueTables(GlueClient glueClient, String dbName) {
    String myTableName = "";
    try {
        GetTablesRequest tableRequest = GetTablesRequest.builder()
            .databaseName(dbName)
            .build();

        GetTablesResponse response = glueClient.getTables(tableRequest);
        List<Table> tables = response.tableList();
        if (tables.isEmpty()) {
            System.out.println("No tables were returned");
        } else {
            for (Table table : tables) {
                myTableName = table.name();
                System.out.println("Table name is: " + myTableName);
            }
        }
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
    return myTableName;
}

public static void startJob(GlueClient glueClient, String jobName, String
    inputDatabase, String inputTable, String outBucket) {
    try {
        Map<String,String> myMap = new HashMap<>();
        myMap.put("--input_database", inputDatabase);
        myMap.put("--input_table", inputTable);
        myMap.put("--output_bucket_url", outBucket);

        StartJobRunRequest runRequest = StartJobRunRequest.builder()
            .workerType(WorkerType.G_1_X)
            .numberOfWorkers(10)
            .arguments(myMap)
            .jobName(jobName)
            .build();
    }
StartJobRunResponse response = glueClient.startJobRun(runRequest);
System.out.println("The request Id of the job is " +
response.responseMetadata().requestId());
}

get started with crawlers and jobs
GetJobsResponse jobsResponse = glueClient.getJobs(jobsRequest);
List<Job> jobs = jobsResponse.jobs();
for (Job job: jobs) {
    System.out.println("Job name is : "+job.name());
    System.out.println("The job worker type is :
    "+job.workerType().name());
}
}

public static void getJobRuns(GlueClient glueClient, String jobName) {
    try {
        GetJobRunsRequest runsRequest = GetJobRunsRequest.builder()
            .jobName(jobName)
            .maxResults(20)
            .build();

        boolean jobDone = false;
        while (!jobDone) {
            GetJobRunsResponse response = glueClient.getJobRuns(runsRequest);
            List<JobRun> jobRuns = response.jobRuns();
            for (JobRun jobRun : jobRuns) {
                String jobState = jobRun.jobRunState().name();
                if (jobState.compareTo("SUCCEEDED") == 0) {
                    System.out.println(jobName + " has succeeded");
                    jobDone = true;
                } else if (jobState.compareTo("STOPPED") == 0) {
                    System.out.println("Job run has stopped");
                    jobDone = true;
                } else if (jobState.compareTo("FAILED") == 0) {
                    System.out.println("Job run has failed");
                    jobDone = true;
                } else if (jobState.compareTo("TIMEOUT") == 0) {
                    System.out.println("Job run has timed out");
                    jobDone = true;
                } else {
                    System.out.println("Unknown job state: " + jobState);
                }
            }
        }
    }
}
System.out.println("*** Job run state is " +
jobRun.jobRunState().name());
System.out.println("Job run Id is " + jobRun.id());
System.out.println("The Glue version is " +
jobRun.glueVersion());
    }
    TimeUnit.SECONDS.sleep(5);
}
}
}
}
} catch (GlueException | InterruptedException e) {
    System.err.println(e.getMessage());
    System.exit(1);
}
}

public static void deleteJob(GlueClient glueClient, String jobName) {
    try {
        DeleteJobRequest jobRequest = DeleteJobRequest.builder()
            .jobName(jobName)
            .build();

        glueClient.deleteJob(jobRequest);
        System.out.println(jobName +" was successfully deleted");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

public static void deleteDatabase(GlueClient glueClient, String databaseName) {
    try {
        DeleteDatabaseRequest request = DeleteDatabaseRequest.builder()
            .name(databaseName)
            .build();

        glueClient.deleteDatabase(request);
        System.out.println(databaseName +" was successfully deleted");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}

public static void deleteSpecificCrawler(GlueClient glueClient, String crawlerName) {
    try {
        DeleteCrawlerRequest deleteCrawlerRequest =
              DeleteCrawlerRequest.builder()
                   .name(crawlerName)
                   .build();

        glueClient.deleteCrawler(deleteCrawlerRequest);
        System.out.println(crawlerName +" was deleted");
    } catch (GlueException e) {
        System.err.println(e.awsErrorDetails().errorMessage());
        System.exit(1);
    }
}
JavaScript

SDK for JavaScript (v3)

Create and run a crawler that crawls a public Amazon Simple Storage Service (Amazon S3) bucket and generates a metadata database that describes the CSV-formatted data it finds.

```javascript
const createCrawler = (name, role, dbName, tablePrefix, s3TargetPath) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new CreateCrawlerCommand({
        Name: name,
        Role: role,
        DatabaseName: dbName,
        TablePrefix: tablePrefix,
        Targets: {
            S3Targets: [{ Path: s3TargetPath }],
        },
    });

    return client.send(command);
};

const getCrawler = (name) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new GetCrawlerCommand({
        Name: name,
    });

    return client.send(command);
};
```
const startCrawler = (name) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new StartCrawlerCommand({
        Name: name,
    });

    return client.send(command);
};

const crawlerExists = async ({ getCrawler }, crawlerName) => {
    try {
        await getCrawler(crawlerName);
        return true;
    } catch {
        return false;
    }
};

const makeCreateCrawlerStep = (actions) => async (context) => {
    if (await crawlerExists(actions, process.env.CRAWLER_NAME)) {
        log("Crawler already exists. Skipping creation.");
    } else {
        await actions.createCrawler(
            process.env.CRAWLER_NAME,
            process.env.ROLE_NAME,
            process.env.DATABASE_NAME,
            process.env.TABLE_PREFIX,
            process.env.S3_TARGET_PATH
        );

        log("Crawler created successfully.", { type: "success" });
    }

    return { ...context };
};

/**
 * @param {(name: string) => Promise<import('@aws-sdk/client-glue').GetCrawlerCommandOutput>} getBrowser
 * @param {string} crawlerName
 */
const waitForCrawler = async (getCrawler, crawlerName) => {

const waitTimeInSeconds = 30;
const { Crawler } = await getCrawler(crawlerName);

if (!Crawler) {
    throw new Error(`Crawler with name ${crawlerName} not found.`);
}

if (Crawler.State === "READY") {
    return;
}

log(`Crawler is ${Crawler.State}. Waiting ${waitTimeInSeconds} seconds...`);
await wait(waitTimeInSeconds);
return waitForCrawler(getCrawler, crawlerName);

const makeStartCrawlerStep =
    ({ startCrawler, getCrawler }) =>
        async (context) => {
            log("Starting crawler.");
            await startCrawler(process.env.CRAWLER_NAME);
            log("Crawler started.", { type: "success" });

            log("Waiting for crawler to finish running. This can take a while.");
            await waitForCrawler(getCrawler, process.env.CRAWLER_NAME);
            log("Crawler ready.", { type: "success" });

            return { ...context };}
    ;

List information about databases and tables in your AWS Glue Data Catalog.

const getDatabase = (name) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new GetDatabaseCommand({
        Name: name,
    });

    return client.send(command);
}
Create and run a job that extracts CSV data from the source Amazon S3 bucket, transforms it by removing and renaming fields, and loads JSON-formatted output into another Amazon S3 bucket.

```javascript
const createJob = (name, role, scriptBucketName, scriptKey) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new CreateJobCommand({
        Name: name,
        Role: role,
        Command: {
            Name: "glueetl",
            PythonVersion: "3",
        },
    });

    return client.send(command);
};
```

```javascript
const getTables = (databaseName) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new GetTablesCommand({
        DatabaseName: databaseName,
    });

    return client.send(command);
};
```

```javascript
const makeGetDatabaseStep =
    ({ getDatabase }) =>
    async (context) => {
        const {
            Database: { Name },
        } = await getDatabase(process.env.DATABASE_NAME);
        log(`Database: ${Name}`);
        return { ...context };
    };
```

```javascript
const makeGetTablesStep =
    ({ getTables }) =>
    async (context) => {
        const { TableList } = await getTables(process.env.DATABASE_NAME);
        log("Tables: ");
        log(TableList.map((table) => `  • ${table.Name}
`));
        return { ...context };
    };
```

Create and run a job that extracts CSV data from the source Amazon S3 bucket, transforms it by removing and renaming fields, and loads JSON-formatted output into another Amazon S3 bucket.
const startJobRun = (jobName, dbName, tableName, bucketName) => {
    const client = new GlueClient({ region: DEFAULT_REGION });

    const command = new StartJobRunCommand({
        JobName: jobName,
        Arguments: {
            "--input_database": dbName,
            "--input_table": tableName,
            "--output_bucket_url": `s3://${bucketName}/`,
        },
    });

    return client.send(command);
};

const makeCreateJobStep = ({ createJob }) => {
    async (context) => {
        log("Creating Job.");
        await createJob(
            process.env.JOB_NAME,
            process.env.ROLE_NAME,
            process.env.BUCKET_NAME,
            process.env.PYTHON_SCRIPT_KEY,
        );
        log("Job created.", { type: "success" });

        return { ...context };}
    }

    /**
     * @param {Function} (name: string, runId: string) => Promise<
     * @param {string} jobName
     * @param {string} jobRunId
     */
const waitForJobRun = async (getJobRun, jobName, jobRunId) => {
    const waitTimeInSeconds = 30;
    const { JobRun } = await getJobRun(jobName, jobRunId);

    if (!JobRun) {
        throw new Error(`Job run with id ${jobRunId} not found.`);
    }

    switch (JobRun.JobRunState) {
        case "FAILED":
        case "TIMEOUT":
        case "STOPPED":
            throw new Error(`Job ${JobRun.JobRunState}. Error: ${JobRun.ErrorMessage}`);
        case "RUNNING":
            break;
        case "SUCCEEDED":
            return;
        default:
            throw new Error(`Unknown job run state: ${JobRun.JobRunState}`);
    }

    log(`Job ${JobRun.JobRunState}. Waiting ${waitTimeInSeconds} more seconds...
    `);
    await wait(waitTimeInSeconds);
    return waitForJobRun(getJobRun, jobName, jobRunId);
};

/**
 * @param {{ prompter: { prompt: () => Promise<{ shouldOpen: boolean }>} }}
 * context
 */
const promptToOpen = async (context) => {
    const { shouldOpen } = await context.prompter.prompt({
        name: "shouldOpen",
        type: "confirm",
        message: "Open the output bucket in your browser?",
    });

    if (shouldOpen) {
        return open(2417

Get started with crawlers and jobs
List information about job runs and view some of the transformed data.

```javascript
const getJobRuns = (jobName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });
  const command = new GetJobRunsCommand({
    JobName: jobName,
  });

  return client.send(command);
};

const getJobRun = (jobName, jobRunId) => {
  const client = new GlueClient({ region: DEFAULT_REGION });
  const command = new GetJobRunCommand({
    JobName: jobName,
    JobRunId: jobRunId,
  });

  return client.send(command);
};
```
RunId: jobRunId,
});

return client.send(command);
};

const logJobRunDetails = async (getJobRun, jobName, jobRunId) => {
  const { JobRun } = await getJobRun(jobName, jobRunId);
  log(JobRun, { type: "object" });
};

const makePickJobRunStep =
  ({ getJobRuns, getJobRun }) =>
  async (context) => {
    if (context.selectedJobName) {
      const { JobRuns } = await getJobRuns(context.selectedJobName);

      const { jobRunId } = await context.prompter.prompt({
        name: "jobRunId",
        type: "list",
        message: "Select a job run to see details.",
        choices: JobRuns.map((run) => run.Id),
      });

      logJobRunDetails(getJobRun, context.selectedJobName, jobRunId);
    }

    return { ...context };
  };

Delete all resources created by the demo.

const deleteJob = (jobName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteJobCommand({
    JobName: jobName,
  });

  return client.send(command);
};
const deleteTable = (databaseName, tableName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteTableCommand(
    DatabaseName: databaseName,
    Name: tableName,
  );

  return client.send(command);
};

const deleteDatabase = (databaseName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteDatabaseCommand(
    Name: databaseName,
  );

  return client.send(command);
};

const deleteCrawler = (crawlerName) => {
  const client = new GlueClient({ region: DEFAULT_REGION });

  const command = new DeleteCrawlerCommand(
    Name: crawlerName,
  );

  return client.send(command);
};

const handleDeleteJobs = async (deleteJobFn, jobNames, context) => {
  const { selectedJobNames } = await context.prompter.prompt({
    name: "selectedJobNames",
    type: "checkbox",
    message: "Let's clean up jobs. Select jobs to delete.",
    choices: jobNames,
  });

  if (selectedJobNames.length === 0) {
    log("No jobs selected.");
  } else {
    log("Deleting jobs.");
    await Promise.all(
      selectedJobNames.map(async (job) => { deleteJobFn(job); })
    );
  }
};
const makeCleanUpJobsStep =
  ({ listJobs, deleteJob }) =>
  async (context) => {
    const { JobNames } = await listJobs();
    if (JobNames.length > 0) {
      await handleDeleteJobs(deleteJob, JobNames, context);
    }

    return { ...context };}

const deleteTables = (deleteTable, databaseName, tableNames) =>
  Promise.all(
    tableNames.map((tableName) =>
      deleteTable(databaseName, tableName).catch(console.error)
    )
  );

const makeCleanUpTablesStep =
  ({ getTables, deleteTable }) =>
  async (context) => {
    const { TableList } = await getTables(process.env.DATABASE_NAME).catch(
      () => ({ TableList: null })
    );

    if (TableList && TableList.length > 0) {
      const { tableNames } = await context.prompter.prompt({
        name: "tableNames",
        type: "checkbox",
        message: "Let's clean up tables. Select tables to delete.",
        choices: TableList.map((t) => t.Name),
      });

      if (tableNames.length === 0) {
        log("No tables selected.");
      } else {
        log("Deleting tables.");
        await deleteTables(deleteTable, process.env.DATABASE_NAME, tableNames);
      }
    } else {
      log("No tables selected.");
    }
  }

export default {
  makeCleanUpJobsStep,
  makeCleanUpTablesStep,
};
log("Tables deleted.", { type: "success" });

return { ...context };;

const deleteDatabases = (deleteDatabase, databaseNames) =>
Promise.all(
    databaseNames.map((dbName) => deleteDatabase(dbName).catch(console.error))
);

const makeCleanUpDatabasesStep =
({ getDatabases, deleteDatabase }) =>
async (context) => {
    const { DatabaseList } = await getDatabases();

    if (DatabaseList.length > 0) {
        const { dbNames } = await context.prompter.prompt({
            name: "dbNames",
            type: "checkbox",
            message: "Let's clean up databases. Select databases to delete.",
            choices: DatabaseList.map((db) => db.Name),
        });

        if (dbNames.length === 0) {
            log("No databases selected.");
        } else {
            log("Deleting databases.");
            await deleteDatabases(deleteDatabase, dbNames);
            log("Databases deleted.", { type: "success" });
        }
    }

    return { ...context };;
};

const cleanUpCrawlerStep = async (context) => {
    log(`Deleting crawler.");

    try {
        await deleteCrawler(process.env.CRAWLER_NAME);
        log("Crawler deleted.", { type: "success" });
    } catch (err) {
        
    }
```javascript
if (err.name === "EntityNotFoundException") {
    log(`Crawler is already deleted.`);
} else {
    throw err;
}
```

return {...context};

• For API details, see the following topics in *AWS SDK for JavaScript API Reference*.

  - CreateCrawler
  - CreateJob
  - DeleteCrawler
  - DeleteDatabase
  - DeleteJob
  - DeleteTable
  - GetCrawler
  - GetDatabase
  - GetDatabases
  - GetJob
  - GetJobRun
  - GetJobRuns
  - GetTables
  - ListJobs
  - StartCrawler
  - StartJobRun
suspend fun main(args: Array<String>) {

    val usage = ""
    Usage:
    <iam> <s3Path> <cron> <dbName> <crawlerName> <jobName>
    <scriptLocation> <locationUri>

    Where:
    iam - The Amazon Resource Name (ARN) of the AWS Identity and Access Management (IAM) role that has AWS Glue and Amazon Simple Storage Service (Amazon S3) permissions.
    s3Path - The Amazon Simple Storage Service (Amazon S3) target that contains data (for example, CSV data).
    cron - A cron expression used to specify the schedule (for example, cron(15 12 * * ? *)).
    dbName - The database name.
    crawlerName - The name of the crawler.
    jobName - The name you assign to this job definition.
    scriptLocation - Specifies the Amazon S3 path to a script that runs a job.
    locationUri - Specifies the location of the database

    ""

    if (args.size != 8) {
        println(usage)
        exitProcess(1)
    }

    val iam = args[0]
    val s3Path = args[1]
    val cron = args[2]
    val dbName = args[3]
    val crawlerName = args[4]
    val jobName = args[5]
    val scriptLocation = args[6]
    val locationUri = args[7]
}

Note

There's more on GitHub. Find the complete example and learn how to set up and run in the AWS Code Examples Repository.
val crawlerName = args[4]
val jobName = args[5]
val scriptLocation = args[6]
val locationUri = args[7]

println("About to start the AWS Glue Scenario")
createDatabase(dbName, locationUri)
createCrawler(iam, s3Path, cron, dbName, crawlerName)
getCrawler(crawlerName)
startCrawler(crawlerName)
getDatabase(dbName)
getGlueTables(dbName)
createJob(jobName, iam, scriptLocation)
startJob(jobName)
getJobs()
getJobRuns(jobName)
deleteJob(jobName)
println("*** Wait for 5 MIN so the $crawlerName is ready to be deleted")
TimeUnit.MINUTES.sleep(5)
deleteMyDatabase(dbName)
deleteCrawler(crawlerName)
}

suspend fun createDatabase(dbName: String?, locationUriVal: String?) {

    val input = DatabaseInput {
        description = "Built with the AWS SDK for Kotlin"
        name = dbName
        locationUri = locationUriVal
    }

    val request = CreateDatabaseRequest {
        databaseInput = input
    }

    glueClient { region = "us-east-1" }.use { glueClient ->
       glueClient.createDatabase(request)
       println("The database was successfully created")
    }
}

suspend fun createCrawler(iam: String?, s3Path: String?, cron: String?, dbName: String?,
crawlerName: String) {
val s3Target = S3Target {
    path = s3Path
}

val targetList = ArrayList<S3Target>()
targetList.add(s3Target)

val targetOb = CrawlerTargets {
    s3Targets = targetList
}

val crawlerRequest = CreateCrawlerRequest {
    databaseName = dbName
    name = crawlerName
    description = "Created by the AWS Glue Java API"
    targets = targetOb
    role = iam
    schedule = cron
}

GlueClient { region = "us-east-1" }.use { glueClient ->
    glueClient.createCrawler(crawlerRequest)
    println("$crawlerName was successfully created")
}

suspend fun getCrawler(crawlerName: String?) {
    val request = GetCrawlerRequest {
        name = crawlerName
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.getCrawler(request)
        val role = response.crawler?.role
        println("The role associated with this crawler is $role")
    }
}

suspend fun startCrawler(crawlerName: String) {
    val crawlerRequest = StartCrawlerRequest {
        name = crawlerName
    }
}
GlueClient { region = "us-east-1" }.use { glueClient ->
    glueClient.startCrawler(crawlerRequest)
    println("crawlerName was successfully started.")
}
}

suspend fun getDatabase(databaseName: String?) {

    val request = GetDatabaseRequest {
        name = databaseName
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.getDatabase(request)
        val dbDesc = response.database?.description
        println("The database description is $dbDesc")
    }
}

suspend fun getGlueTables(dbName: String?) {

    val tableRequest = GetTablesRequest {
        databaseName = dbName
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.getTables(tableRequest)
        response.tableList?.forEach { tableName ->
            println("Table name is ${tableName.name}")
        }
    }
}

suspend fun startJob(jobNameVal: String?) {

    val runRequest = StartJobRunRequest {
        workerType = WorkerType.G1X
        numberOfWorkers = 10
        jobName = jobNameVal
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.startJobRun(runRequest)
    }
}
println("The job run Id is \${response.jobRunId}\")
}
}
suspend fun createJob(jobName: String, iam: String?, scriptLocationVal: String?) {
    val commandOb = JobCommand {
        pythonVersion = "3"
        name = "MyJob1"
        scriptLocation = scriptLocationVal
    }
    val jobRequest = CreateJobRequest {
        description = "A Job created by using the AWS SDK for Java V2"
        glueVersion = "2.0"
        workerType = WorkerType.G1X
        numberOfWorkers = 10
        name = jobName
        role = iam
        command = commandOb
    }
    GlueClient { region = "us-east-1" }.use { glueClient ->
        glueClient.createJob(jobRequest)
        println("$jobName was successfully created."")
    }
}
suspend fun getJobs() {
    val request = GetJobsRequest {
        maxResults = 10
    }
    GlueClient { region = "us-east-1" }.use { glueClient ->
        val response = glueClient.getJobs(request)
        response.jobs?.forEach { job ->
            println("Job name is \${job.name}\")
        }
    }
}
suspend fun getJobRuns(jobNameVal: String?) {
```kotlin
val request = GetJobRunsRequest {
    jobName = jobNameVal
}

GlueClient { region = "us-east-1" }.use { glueClient ->
    val response = glueClient.getJobRuns(request)
    response.jobRuns?.forEach { job ->
        println("Job name is 
    }
}
}

suspend fun deleteJob(jobNameVal: String) {
    val jobRequest = DeleteJobRequest {
        jobName = jobNameVal
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        glueClient.deleteJob(jobRequest)
        println("$jobNameVal was successfully deleted")
    }
}

suspend fun deleteMyDatabase(databaseName: String) {
    val request = DeleteDatabaseRequest {
        name = databaseName
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        glueClient.deleteDatabase(request)
        println("$databaseName was successfully deleted")
    }
}

suspend fun deleteCrawler(crawlerName: String) {
    val request = DeleteCrawlerRequest {
        name = crawlerName
    }

    GlueClient { region = "us-east-1" }.use { glueClient ->
        glueClient.deleteCrawler(request)
    }
```
println("$crawlerName was deleted")
}
}

- For API details, see the following topics in *AWS SDK for Kotlin API reference*.
  - [CreateCrawler](#)
  - [CreateJob](#)
  - [DeleteCrawler](#)
  - [DeleteDatabase](#)
  - [DeleteJob](#)
  - [DeleteTable](#)
  - [GetCrawler](#)
  - [GetDatabase](#)
  - [GetDatabases](#)
  - [GetJob](#)
  - [GetJobRun](#)
  - [GetJobRuns](#)
  - [GetTables](#)
  - [ListJobs](#)
  - [StartCrawler](#)
  - [StartJobRun](#)

**PHP**

**SDK for PHP**

**Note**

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](#).

```php
namespace Glue;
```
use Aws\Glue\GlueClient;
use Aws\S3\S3Client;
use AwsUtilities\AWSServiceClass;
use GuzzleHttp\Psr7\Stream;
use Iam\IAMService;

class GettingStartedWithGlue
{
    public function run()
    {
        echo("\n");
        echo("--------------------------------------\n");
        print("Welcome to the AWS Glue getting started demo using PHP!\n");
        echo("--------------------------------------\n");

        $clientArgs = [
            'region' => 'us-west-2',
            'version' => 'latest',
            'profile' => 'default',
        ];
        $uniqid = uniqid();

        $glueClient = new GlueClient($clientArgs);
        $glueService = new GlueService($glueClient);
        $iamService = new IAMService();
        $crawlerName = "example-crawler-test-" . $uniqid;

        AWSServiceClass::$waitTime = 5;
        AWSServiceClass::$maxWaitAttempts = 20;

        $role = $iamService->getRole("AWSGlueServiceRole-DocExample");

        $databaseName = "doc-example-database-$uniqid";
        $path = 's3://crawler-public-us-east-1/flight/2016/csv';
        $glueService->createCrawler($crawlerName, $role['Role']['Arn'],
            $databaseName, $path);
        $glueService->startCrawler($crawlerName);

        echo "Waiting for crawler";
        do {
            $crawler = $glueService->getCrawler($crawlerName);
            echo ".";
            sleep(10);
        } while ($crawler['Crawler']['State'] != "READY");
```

echo "\n";

$database = $glueService->getDatabase($databaseName);
$database['Name'] . "\n"

//Upload job script
$s3client = new S3Client($clientArgs);
$bucketName = "test-glue-bucket-" . $uniqid;
$s3client->createBucket(
    'Bucket' => $bucketName,
    'CreateBucketConfiguration' => ['LocationConstraint' => 'us-west-2'],
);

$s3client->putObject(
    'Bucket' => $bucketName,
    'Key' => 'run_job.py',
    'SourceFile' => __DIR__ . '/flight_etl_job_script.py'
);

$s3client->putObject(
    'Bucket' => $bucketName,
    'Key' => 'setup_scenario_getting_started.yaml',
    'SourceFile' => __DIR__ . '/setup_scenario_getting_started.yaml'
);

$tables = $glueService->getTables($databaseName);

$jobName = 'test-job-' . $uniqid;
$scriptLocation = "s3://$bucketName/run_job.py";
$job = $glueService->createJob($jobName, $role['Arn'], $scriptLocation);

$outputBucketUrl = "s3://$bucketName";
$runId = $glueService->startJobRun($jobName, $databaseName, $tables, $outputBucketUrl)['JobRunId'];

echo "waiting for job";
do {
    $jobRun = $glueService->getJobRun($jobName, $runId);
    echo ".";
    sleep(10);
} while (!array_intersect($jobRun['JobRunState'], ['SUCCEEDED', 'STOPPED', 'FAILED', 'TIMEOUT']));

```
$jobRuns = $glueService->getJobRuns($jobName);

$objects = $s3client->listObjects([  'Bucket' => $bucketName,])[\'Contents\'];

foreach ($objects as $object) {
    echo $object[\'Key\'] . "\n";
}

echo "Downloading " . $objects[2][\'Key\'] . "\n";
/** @var Stream $downloadObject */
$downloadObject = $s3client->getObject([  'Bucket' => $bucketName,  'Key' => $objects[2][\'Key\'],])[\'Body\']->getContents();
echo "Here is the first 1000 characters in the object.";
echo substr($downloadObject, 0, 1000);

$jobs = $glueService->listJobs();
echo "Current jobs:\n";
foreach ($jobs[\'JobNames\'] as $jobsName) {
    echo "$\{jobsName\}\n";
}

echo "Delete the job.\n";
$glueClient->deleteJob([  'JobName' => $job[\'Name\'],]);

echo "Delete the tables.\n";
foreach ($tables[\'TableList\'] as $table) {
    $glueService->deleteTable($table[\'Name\'], $databaseName);
}

echo "Delete the databases.\n";
$glueClient->deleteDatabase([  'Name' => $databaseName,]);

echo "Delete the crawler.\n";
$glueClient->deleteCrawler([  'Name' => $crawlerName,]);
$deleteObjects = $s3client->listObjectsV2(
    'Bucket' => $bucketName,
); 
echo "Delete all objects in the bucket.\n"; 
$deleteObjects = $s3client->deleteObjects(
    'Bucket' => $bucketName, 
    'Delete' => [
        'Objects' => $deleteObjects['Contents'],
    ]
); 
echo "Delete the bucket.\n"; 
$s3client->deleteBucket(['Bucket' => $bucketName]);

    echo "This job was brought to you by the number $uniqid\n";
}
}

namespace Glue;

use Aws\Glue\GlueClient;
use Aws\Result;

use function PHPUnit\Framework\isEmpty;

class GlueService extends \AwsUtilities\AWSServiceClass
{
    protected GlueClient $glueClient;

    public function __construct($glueClient)
    {
        $this->glueClient = $glueClient;
    }

    public function getCrawler($crawlerName)
    {
        return $this->customWaiter(function () use ($crawlerName) {
            return $this->glueClient->getCrawler(
                'Name' => $crawlerName,
            );
        });
    }
public function createCrawler($crawlerName, $role, $databaseName, $path):
Result
{
    return $this->customWaiter(function () use ($crawlerName, $role, $databaseName, $path) {
        return $this->glueClient->createCrawler(
            'Name' => $crawlerName,
            'Role' => $role,
            'DatabaseName' => $databaseName,
            'Targets' => [
                'S3Targets' => [
                    ['Path' => $path],
                ],
            ],
        );
    });
}

public function startCrawler($crawlerName): Result
{
    return $this->glueClient->startCrawler(
        'Name' => $crawlerName,
    );
}

public function getDatabase(string $databaseName): Result
{
    return $this->customWaiter(function () use ($databaseName) {
        return $this->glueClient->getDatabase(
            'Name' => $databaseName,
        );
    });
}

public function getTables($databaseName): Result
{
    return $this->glueClient->getTables(
        'DatabaseName' => $databaseName,
    );
}

public function createJob($jobName, $role, $scriptLocation, $pythonVersion = '3', $glueVersion = '3.0'): Result
{ return $this->glueClient->createJob(
    'Name' => $jobName,
    'Role' => $role,
    'Command' => [
        'Name' => 'glueetl',
        'ScriptLocation' => $scriptLocation,
        'PythonVersion' => $pythonVersion,
    ],
    'GlueVersion' => $glueVersion,
); }

public function startJobRun($jobName, $databaseName, $tables, $outputBucketUrl): Result
{
    return $this->glueClient->startJobRun(
        'JobName' => $jobName,
        'Arguments' => [
            'input_database' => $databaseName,
            'input_table' => $tables['TableList'][0]['Name'],
            'output_bucket_url' => $outputBucketUrl,
            '--input_database' => $databaseName,
            '--input_table' => $tables['TableList'][0]['Name'],
            '--output_bucket_url' => $outputBucketUrl,
        ],
    );
}

public function listJobs($maxResults = null, $nextToken = null, $tags = []): Result
{
    $arguments = [];
    if ($maxResults) {
        $arguments['MaxResults'] = $maxResults;
    }
    if ($nextToken) {
        $arguments['NextToken'] = $nextToken;
    }
    if (!empty($tags)) {
        $arguments['Tags'] = $tags;
    }
    return $this->glueClient->listJobs($arguments);
}
public function getJobRuns($jobName, $maxResults = 0, $nextToken = ''):
    
    $arguments = ['JobName' => $jobName];
    if ($maxResults) {
        $arguments['MaxResults'] = $maxResults;
    }
    if ($nextToken) {
        $arguments['NextToken'] = $nextToken;
    }
    return $this->glueClient->getJobRuns($arguments);

    
public function getJobRun($jobName, $runId, $predecessorsIncluded = false):
    
    return $this->glueClient->getJobRun(['
        'JobName' => $jobName,
        'RunId' => $runId,
        'PredecessorsIncluded' => $predecessorsIncluded,
    ']);

    
public function deleteJob($jobName)
    
    return $this->glueClient->deleteJob(['
        'JobName' => $jobName,
    ']);

    
public function deleteTable($tableName, $databaseName)
    
    return $this->glueClient->deleteTable(['
        'DatabaseName' => $databaseName,
        'Name' => $tableName,
    ']);

    
public function deleteDatabase($databaseName)
    
    return $this->glueClient->deleteDatabase(['
        'Name' => $databaseName,
    ']);
public function deleteCrawler($crawlerName)
{
    return $this->glueClient->deleteCrawler([`
        'Name' => $crawlerName,
    ]);`
}

• For API details, see the following topics in *AWS SDK for PHP API Reference*.
  • CreateCrawler
  • CreateJob
  • DeleteCrawler
  • DeleteDatabase
  • DeleteJob
  • DeleteTable
  • GetCrawler
  • GetDatabase
  • GetDatabases
  • GetJob
  • GetJobRun
  • GetJobRuns
  • GetTables
  • ListJobs
  • StartCrawler
  • StartJobRun
Create a class that wraps AWS Glue functions used in the scenario.

class GlueWrapper:
    """Encapsulates AWS Glue actions."""

    def __init__(self, glue_client):
        """""""
        """"
        self.glue_client = glue_client

    def get_crawler(self, name):
        """"""
        Gets information about a crawler.

        :param name: The name of the crawler to look up.
        :return: Data about the crawler.
        """"
        crawler = None
        try:
            response = self.glue_client.get_crawler(Name=name)
            crawler = response["Crawler"]
        except ClientError as err:
            if err.response["Error"]['Code'] == "EntityNotFoundException":
                logger.info("Crawler %s doesn't exist.", name)
            else:
                logger.error("Couldn't get crawler %s. Here's why: %s: %s",
                             name,
                             err.response["Error"]['Code'],
                             err.response["Error"]['Message'],
                             )
def create_crawler(self, name, role_arn, db_name, db_prefix, s3_target):
    
    Creates a crawler that can crawl the specified target and populate a
database in your AWS Glue Data Catalog with metadata that describes the
data
in the target.

    :param name: The name of the crawler.
    :param role_arn: The Amazon Resource Name (ARN) of an AWS Identity and
          Access
          Management (IAM) role that grants permission to let AWS Glue
          access the resources it needs.
    :param db_name: The name to give the database that is created by the
crawler.
    :param db_prefix: The prefix to give any database tables that are created
          by
          the crawler.
    :param s3_target: The URL to an S3 bucket that contains data that is
          the target of the crawler.
    
    try:
        self.glue_client.create_crawler(  
            Name=name,  
            Role=role_arn,  
            DatabaseName=db_name,  
            TablePrefix=db_prefix,  
            Targets={"S3Targets": ["Path": s3_target]},  
        )
    except ClientError as err:
        logger.error(  
            "Couldn't create crawler. Here's why: %s: %s",  
            err.response["Error"]['Code'],  
            err.response["Error"]['Message'],
        )
        raise

    def start_crawler(self, name):
        
        return crawler
Starts a crawler. The crawler crawls its configured target and creates metadata that describes the data it finds in the target data source.

:param name: The name of the crawler to start.

```
try:
    self.glue_client.start_crawler(Name=name)
except ClientError as err:
    logger.error(
        "Couldn't start crawler %s. Here's why: %s: %s",
        name,
        err.response["Error"]["Code"],
        err.response["Error"]["Message"],
    )
    raise
```

```python
def get_database(self, name):
    """
    Gets information about a database in your Data Catalog.

    :param name: The name of the database to look up.
    :return: Information about the database.
    """
    try:
        response = self.glue_client.get_database(Name=name)
    except ClientError as err:
        logger.error(
            "Couldn't get database %s. Here's why: %s: %s",
            name,
            err.response["Error"]["Code"],
            err.response["Error"]["Message"],
        )
        raise
    else:
        return response["Database"]
```

```python
def get_tables(self, db_name):
    """
    Gets a list of tables in a Data Catalog database.

    :param db_name: The name of the database to query.
    :return: The list of tables in the database.
    """
```
```python
def create_job(self, name, description, role_arn, script_location):
    ""
    Creates a job definition for an extract, transform, and load (ETL) job
    that can
    be run by AWS Glue.
    :param name: The name of the job definition.
    :param description: The description of the job definition.
    :param role_arn: The ARN of an IAM role that grants AWS Glue the
    permissions
    it requires to run the job.
    :param script_location: The Amazon S3 URL of a Python ETL script that is run as
    part of the job. The script defines how the data
    is
    transformed.
    ""
    try:
        self.glue_client.create_job(
            Name=name,
            Description=description,
            Role=role_arn,
            Command={
                "Name": "glueetl",
                "ScriptLocation": script_location,
                "PythonVersion": "3",
            },
            GlueVersion="3.0",
        )
```
except ClientError as err:
    logger.error(
        "Couldn't create job %s. Here's why: %s: %s",
        name,
        err.response["Error"]["Code"],
        err.response["Error"]["Message"],
    )
    raise

def start_job_run(self, name, input_database, input_table, output_bucket_name):
    ""
    Starts a job run. A job run extracts data from the source, transforms it, and loads it to the output bucket.
    
    :param name: The name of the job definition.
    :param input_database: The name of the metadata database that contains tables that describe the source data. This is typically created by a crawler.
    :param input_table: The name of the table in the metadata database that describes the source data.
    :param output_bucket_name: The S3 bucket where the output is written.
    :return: The ID of the job run.
    ""
    try:
        # The custom Arguments that are passed to this function are used by the Python ETL script to determine the location of input and output data.
        response = self.glue_client.start_job_run(
            JobName=name,
            Arguments={
                "--input_database": input_database,
                "--input_table": input_table,
                "--output_bucket_url": f"s3://{output_bucket_name}/",
            },
        )
    except ClientError as err:
        logger.error(
            "Couldn't start job run %s. Here's why: %s: %s",
            name,
err.response["Error"]['Code'],
    err.response["Error"]['Message'],
)
    raise
else:
    return response['JobRunId']

def list_jobs(self):
    """
    Lists the names of job definitions in your account.
    
    :return: The list of job definition names.
    """
    try:
        response = self.glue_client.list_jobs()
    except ClientError as err:
        logger.error(
            "Couldn't list jobs. Here's why: %s: %s",
            err.response["Error"]['Code'],
            err.response["Error"]['Message'],
        )
        raise
    else:
        return response['JobNames']

def get_job_runs(self, job_name):
    """
    Gets information about runs that have been performed for a specific job definition.
    
    :param job_name: The name of the job definition to look up.
    :return: The list of job runs.
    """
    try:
        response = self.glue_client.get_job_runs(JobName=job_name)
    except ClientError as err:
        logger.error(
            "Couldn't get job runs for %s. Here's why: %s: %s",
            job_name,
            err.response["Error"]['Code'],
            err.response["Error"]['Message'],
        )
raise
else:
    return response["JobRuns"]

def get_job_run(self, name, run_id):
    """
    Gets information about a single job run.
    :param name: The name of the job definition for the run.
    :param run_id: The ID of the run.
    :return: Information about the run.
    """
    try:
        response = self.glue_client.get_job_run(JobName=name, RunId=run_id)
    except ClientError as err:
        logger.error(
            "Couldn't get job run %s/%s. Here's why: %s: %s",
            name,
            run_id,
            err.response["Error"]["Code"],
            err.response["Error"]["Message"],
        )
        raise
    else:
        return response["JobRun"]

def delete_job(self, job_name):
    """
    Deletes a job definition. This also deletes data about all runs that are
    associated with this job definition.
    :param job_name: The name of the job definition to delete.
    """
    try:
        self.glue_client.delete_job(JobName=job_name)
    except ClientError as err:
        logger.error(
            "Couldn't delete job %s. Here's why: %s: %s",
            job_name,
            err.response["Error"]["Code"],
            err.response["Error"]["Message"],
        )
def delete_table(self, db_name, table_name):
    """
    Deletes a table from a metadata database.
    
    :param db_name: The name of the database that contains the table.
    :param table_name: The name of the table to delete.
    """
    try:
        self.glue_client.delete_table(DatabaseName=db_name, Name=table_name)
    except ClientError as err:
        logger.error(
            "Couldn't delete table %s. Here's why: %s: %s",
            table_name,
            err.response['Error']["Code"],
            err.response['Error']["Message"],
        )
    raise

def delete_database(self, name):
    """
    Deletes a metadata database from your Data Catalog.
    
    :param name: The name of the database to delete.
    """
    try:
        self.glue_client.delete_database(Name=name)
    except ClientError as err:
        logger.error(
            "Couldn't delete database %s. Here's why: %s: %s",
            name,
            err.response['Error']["Code"],
            err.response['Error']["Message"],
        )
    raise

def delete_crawler(self, name):
    """
    Deletes a crawler.
    """
Create a class that runs the scenario.

class GlueCrawlerJobScenario:  
    """
    Encapsulates a scenario that shows how to create an AWS Glue crawler and job 
    and use 
    them to transform data from CSV to JSON format.
    """

    def __init__(self, glue_client, glue_service_role, glue_bucket):  
        """
        :param glue_service_role: An AWS Identity and Access Management (IAM) 
        role 
        that AWS Glue can assume to gain access to the 
        resources it requires.
        :param glue_bucket: An S3 bucket that can hold a job script and output 
        data 
        from AWS Glue job runs.
        """

        self.glue_client = glue_client
        self.glue_service_role = glue_service_role
        self.glue_bucket = glue_bucket

        @staticmethod
        def wait(seconds, tick=12):
Waits for a specified number of seconds, while also displaying an animated spinner.

:param seconds: The number of seconds to wait.
:param tick: The number of frames per second used to animate the spinner.

```
progress = "|/-\\"
waited = 0
while waited < seconds:
    for frame in range(tick):
        sys.stdout.write(f"\r{progress[frame % len(progress)]}")
        sys.stdout.flush()
        time.sleep(1 / tick)
    waited += 1
```

```python
def upload_job_script(self, job_script):
    """
    Uploads a Python ETL script to an S3 bucket. The script is used by the AWS Glue job to transform data.
    
    :param job_script: The relative path to the job script.
    """
    try:
        self.glue_bucket.upload_file(Filename=job_script, Key=job_script)
        print(f"Uploaded job script '{job_script}' to the example bucket.")
    except S3UploadFailedError as err:
        logger.error("Couldn't upload job script. Here's why: %s", err)
        raise
```

```python
def run(self, crawler_name, db_name, db_prefix, data_source, job_script, job_name):
    """
    Runs the scenario. This is an interactive experience that runs at a command prompt and asks you for input throughout.
    
    :param crawler_name: The name of the crawler used in the scenario. If the crawler does not exist, it is created.
    :param db_name: The name to give the metadata database created by the crawler.
    :param db_prefix: The prefix to give tables added to the database by the
```
crawler.
:param data_source: The location of the data source that is targeted by
the
crawler and extracted during job runs.
:param job_script: The job script that is used to transform data during
job
runs.
:param job_name: The name to give the job definition that is created
during the
scenario.

""
wrapper = GlueWrapper(self.glue_client)
print(f"Checking for crawler {crawler_name}.")
crawler = wrapper.get_crawler(crawler_name)
if crawler is None:
    print(f"Creating crawler {crawler_name}.")
    wrapper.create_crawler(
        crawler_name,
        self.glue_service_role.arn,
        db_name,
        db_prefix,
        data_source,
    )
    print(f"Created crawler {crawler_name}.")
    crawler = wrapper.get_crawler(crawler_name)
pprint(crawler)
print("-" * 88)

print(
    f"When you run the crawler, it crawls data stored in {data_source}
and "
    f"creates a metadata database in the AWS Glue Data Catalog that
describes "
    f"the data in the data source."
)
print("In this example, the source data is in CSV format.")
ready = False
while not ready:
    ready = Question.ask_question(
        "Ready to start the crawler? (y/n) ", Question.is_yesno
    )
wrapper.start_crawler(crawler_name)
print("Let's wait for the crawler to run. This typically takes a few
minutes.")
crawler_state = None
while crawler_state != "READY":
    self.wait(10)
    crawler = wrapper.get_crawler(crawler_name)
    crawler_state = crawler["State"]
    print(f"Crawler is {crawler["State"]}")
print("-" * 88)

database = wrapper.get_database(db_name)
print(f"The crawler created database {db_name}:")
pprint(database)
print(f"The database contains these tables:")
tables = wrapper.get_tables(db_name)
for index, table in enumerate(tables):
    print(f"\t{index + 1}. {table["Name"]}")
table_index = Question.ask_question(f"Enter the number of a table to see more detail: ",
    Question.is_int,
    Question.in_range(1, len(tables)),
)
pprint(tables[table_index - 1])
print("-" * 88)

print(f"Creating job definition {job_name}.")
wrapper.create_job(
    job_name,
    "Getting started example job.",
    self.glue_service_role.arn,
    f"s3://{self.glue_bucket.name}/{job_script}",
)
print("Created job definition.")
print(f"When you run the job, it extracts data from {data_source},
transforms it "
    f"by using the {job_script} script, and loads the output into "
    f"S3 bucket {self.glue_bucket.name}."
)
print(  
    "In this example, the data is transformed from CSV to JSON, and only a few "
    "fields are included in the output."
)
job_run_status = None
if Question.ask_question(f"Ready to run? (y/n) ", Question.is_yesno):

job_run_id = wrapper.start_job_run(
    job_name, db_name, tables[0]["Name"], self.glue_bucket.name
)

print(f"Job {job_name} started. Let's wait for it to run.")

while job_run_status not in ["SUCCEEDED", "STOPPED", "FAILED", "TIMEOUT"]:
    self.wait(10)
    job_run = wrapper.get_job_run(job_name, job_run_id)
    job_run_status = job_run["JobRunState"]
    print(f"Job {job_name}/{job_run_id} is {job_run_status}.")
    print("-" * 88)

if job_run_status == "SUCCEEDED":
    print(
        f"Data from your job run is stored in your S3 bucket '{self.glue_bucket.name}':"
    )
    try:
        keys = [
            obj.key for obj in
            self.glue_bucket.objects.filter(Prefix="run-")
        ]
        for index, key in enumerate(keys):
            print(f"\t{index + 1}: {key}")
        lines = 4
        key_index = Question.ask_question(
            f"Enter the number of a block to download it and see the first {lines} "
            f"lines of JSON output in the block: ",
            Question.is_int,
            Question.in_range(1, len(keys)),
        )
        job_data = io.BytesIO()
        self.glue_bucket.download_fileobj(keys[key_index - 1], job_data)
        job_data.seek(0)
        for _ in range(lines):
            print(job_data.readline().decode("utf-8"))
    except ClientError as err:
        logger.error(
            "Couldn't get job run data. Here's why: %s: %s",
            err.response["Error"]["Code"],
            err.response["Error"]["Message"],
        )
        raise
print("-" * 88)

job_names = wrapper.list_jobs()
if job_names:
    print(f"Your account has {len(job_names)} jobs defined:")
    for index, job_name in enumerate(job_names):
        print(f"{index + 1}. {job_name}"
    job_index = Question.ask_question(f"Enter a number between 1 and {len(job_names)} to see the list of runs for "
    "a job: ",
    Question.is_int,
    Question.in_range(1, len(job_names)),
    )
    job_runs = wrapper.get_job_runs(job_names[job_index - 1])
    if job_runs:
        print(f"Found {len(job_runs)} runs for job {job_names[job_index - 1]}:")
        for index, job_run in enumerate(job_runs):
            print(f"{index + 1}. {job_run["JobRunState"]} on {job_run["CompletedOn"][0:10]}")
        run_index = Question.ask_question(f"Enter a number between 1 and {len(job_runs)} to see details for a run: ",
        Question.is_int,
        Question.in_range(1, len(job_runs)),
        )
        pprint(job_runs[run_index - 1])
    else:
        print(f"No runs found for job {job_names[job_index - 1]}")
else:
    print("Your account doesn't have any jobs defined.")
print("-" * 88)

print(f"Let's clean up. During this example we created job definition '{job_name}'.")
if Question.ask_question("Do you want to delete the definition and all runs? (y/n) ",
    Question.is_yesno,
):
wrapper.delete_job(job_name)
print(f"Job definition '{job_name}' deleted.")
tables = wrapper.get_tables(db_name)
print(f"We also created database '{db_name}' that contains these
tables:")
for table in tables:
    print(f"\t{table['Name']}")
if Question.ask_question(
    "Do you want to delete the tables and the database? (y/n) ",
    Question.is_yesno,
):
    for table in tables:
        wrapper.delete_table(db_name, table['Name'])
        print(f"Deleted table {table['Name']}.")
wrapper.delete_database(db_name)
print(f"Deleted database {db_name}.")
print(f"We also created crawler '{crawler_name}'.")
if Question.ask_question(
    "Do you want to delete the crawler? (y/n) ", Question.is_yesno
):
    wrapper.delete_crawler(crawler_name)
    print(f"Deleted crawler {crawler_name}.")

print("-" * 88)

def parse_args(args):
    """
    Parse command line arguments.
    
    :param args: The command line arguments.
    :return: The parsed arguments.
    """
    parser = argparse.ArgumentParser(
        description="Runs the AWS Glue getting started with crawlers and jobs scenario."
        "Before you run this scenario, set up scaffold resources by running "
        "'python scaffold.py deploy'."
    )
    parser.add_argument("role_name",
        help="The name of an IAM role that AWS Glue can assume. This role must grant access "
        "to Amazon S3 and to the permissions granted by the AWSGlueServiceRole "
        "managed policy.",
    )
Get started with crawlers and jobs

```python
parser.add_argument("bucket_name",
               help="The name of an S3 bucket that AWS Glue can access to get the job
               script and ",
               "put job results.",

            )

parser.add_argument(
    "--job_script",
    default="flight_etl_job_script.py",
    help="The name of the job script file that is used in the scenario.",

            )

return parser.parse_args(args)

def main():
    args = parse_args(sys.argv[1:])
    try:
        print("-" * 88)
        print(
            "Welcome to the AWS Glue getting started with crawlers and jobs
scenario."
        )
        print("-" * 88)
        scenario = GlueCrawlerJobScenario(
            boto3.client("glue"),
            boto3.resource("iam").Role(args.role_name),
            boto3.resource("s3").Bucket(args.bucket_name),

        )
        scenario.upload_job_script(args.job_script)
        scenario.run(
            "doc-example-crawler",
            "doc-example-database",
            "doc-example-",
            "s3://crawler-public-us-east-1/flight/2016/csv",
            args.job_script,
            "doc-example-job",

        )
        print("-" * 88)
        print(
            "To destroy scaffold resources, including the IAM role and S3 bucket
"
            "used in this scenario, run 'python scaffold.py destroy'."
        )
```
Create an ETL script that is used by AWS Glue to extract, transform, and load data during job runs.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

""
These custom arguments must be passed as Arguments to the StartJobRun request.
--input_database    The name of a metadata database that is contained in
your
AWS Glue Data Catalog and that contains tables that
describe
the data to be processed.
--input_table       The name of a table in the database that describes the
data to
be processed.
--output_bucket_url An S3 bucket that receives the transformed output data.
""
args = getResolvedOptions(
    sys.argv, ["JOB_NAME", "input_database", "input_table", "output_bucket_url"]
)
sc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args["JOB_NAME"], args)

# Script generated for node S3 Flight Data.
S3FlightData_node1 = glueContext.create_dynamic_frame.from_catalog(
    database=args["input_database"],
    table_name=args["input_table"],
)
```

Get started with crawlers and jobs
transformation_ctx="S3FlightData_node1",
)

# This mapping performs two main functions:
# 1. It simplifies the output by removing most of the fields from the data.
# 2. It renames some fields. For example, `fl_date` is renamed to `flight_date`.
ApplyMapping_node2 = ApplyMapping.apply(
    frame=S3FlightData_node1,
    mappings=[
        ("year", "long", "year", "long"),
        ("month", "long", "month", "tinyint"),
        ("day_of_month", "long", "day", "tinyint"),
        ("fl_date", "string", "flight_date", "string"),
        ("carrier", "string", "carrier", "string"),
        ("fl_num", "long", "flight_num", "long"),
        ("origin_city_name", "string", "origin_city_name", "string"),
        ("origin_state_abr", "string", "origin_state_abr", "string"),
        ("dest_city_name", "string", "dest_city_name", "string"),
        ("dest_state_abr", "string", "dest_state_abr", "string"),
        ("dep_time", "long", "departure_time", "long"),
        ("wheels_off", "long", "wheels_off", "long"),
        ("wheels_on", "long", "wheels_on", "long"),
        ("arr_time", "long", "arrival_time", "long"),
        ("mon", "string", "mon", "string"),
    ],
    transformation_ctx="ApplyMapping_node2",
)

# Script generated for node Revised Flight Data.
RevisedFlightData_node3 = glueContext.write_dynamic_frame.from_options(
    frame=ApplyMapping_node2,
    connection_type="s3",
    format="json",
    connection_options={'path': args['output_bucket_url'], 'partitionKeys': []},
    transformation_ctx="RevisedFlightData_node3",
)

job.commit()

- For API details, see the following topics in *AWS SDK for Python (Boto3) API Reference.*
  - CreateCrawler
  - CreateJob
Create a class that wraps AWS Glue functions used in the scenario.

```ruby
# The `GlueWrapper` class serves as a wrapper around the AWS Glue API, providing
# a simplified interface for common operations.
# It encapsulates the functionality of the AWS SDK for Glue and provides methods
# for interacting with Glue crawlers, databases, tables, jobs, and S3 resources.
# The class initializes with a Glue client and a logger, allowing it to make API
# calls and log any errors or informational messages.
class GlueWrapper
  def initialize(glue_client, logger)
```

Note
---

There's more on GitHub. Find the complete example and learn how to set up and run in the [AWS Code Examples Repository](https://aws.amazon.com/code-examples/).
```ruby
@glue_client = glue_client
@logger = logger
end

# Retrieves information about a specific crawler.
#
# @param name [String] The name of the crawler to retrieve information about.
# @return [Aws::Glue::Types::Crawler, nil] The crawler object if found, or nil if not found.
def get_crawler(name)
  @glue_client.get_crawler(name: name)
rescue Aws::Glue::Errors::EntityNotFoundException
  @logger.info("Crawler #{name} doesn't exist.")
  false
rescue Aws::Glue::Errors::GlueException => e
  @logger.error("Glue could not get crawler #{name}: \n#{e.message}")
  raise
end

# Creates a new crawler with the specified configuration.
#
# @param name [String] The name of the crawler.
# @param role_arn [String] The ARN of the IAM role to be used by the crawler.
# @param db_name [String] The name of the database where the crawler stores its metadata.
# @param db_prefix [String] The prefix to be added to the names of tables that the crawler creates.
# @param s3_target [String] The S3 path that the crawler will crawl.
# @return [void]
def create_crawler(name, role_arn, db_name, db_prefix, s3_target)
  @glue_client.create_crawler(
    name: name,
    role: role_arn,
    database_name: db_name,
    targets: {
      s3_targets: [
        { path: s3_target
      ]
    }
  )
rescue Aws::Glue::Errors::GlueException => e
  @logger.error("Glue could not create crawler: \n#{e.message}")
```
raise
end

# Starts a crawler with the specified name.
#
# @param name [String] The name of the crawler to start.
# @return [void]
def start_crawler(name)
  @glue_client.start_crawler(name: name)
rescue Aws::Glue::Errors::ServiceError => e
  @logger.error("Glue could not start crawler #{name}: \
#{e.message}")
  raise
end

# Deletes a crawler with the specified name.
#
# @param name [String] The name of the crawler to delete.
# @return [void]
def delete_crawler(name)
  @glue_client.delete_crawler(name: name)
rescue Aws::Glue::Errors::ServiceError => e
  @logger.error("Glue could not delete crawler #{name}: \
#{e.message}")
  raise
end

# Retrieves information about a specific database.
#
# @param name [String] The name of the database to retrieve information about.
# @return [Aws::Glue::Types::Database, nil] The database object if found, or
# nil if not found.
def get_database(name)
  response = @glue_client.get_database(name: name)
  response.database
rescue Aws::Glue::Errors::GlueException => e
  @logger.error("Glue could not get database #{name}: \
#{e.message}")
  raise
end

# Retrieves a list of tables in the specified database.
#
# @param db_name [String] The name of the database to retrieve tables from.
# @return [Array<Aws::Glue::Types::Table>]
def get_tables(db_name)
  response = @glue_client.get_tables(database_name: db_name)
end
# Creates a new job with the specified configuration.
#
# @param name [String] The name of the job.
# @param description [String] The description of the job.
# @param role_arn [String] The ARN of the IAM role to be used by the job.
# @param script_location [String] The location of the ETL script for the job.
# @return [void]
def create_job(name, description, role_arn, script_location)
  @glue_client.create_job(
    name: name,
    description: description,
    role: role_arn,
    command: {
      name: "glueetl",
      script_location: script_location,
      python_version: "3"
    },
    glue_version: "3.0"
  )
  rescue Aws::Glue::Errors::GlueException => e
    @logger.error("Glue could not create job #{name}: \n#{e.message}")
    raise
end

# Starts a job run for the specified job.
#
# @param name [String] The name of the job to start the run for.
# @param input_database [String] The name of the input database for the job.
# @param input_table [String] The name of the input table for the job.
# @param output_bucket_name [String] The name of the output S3 bucket for the job.
# @return [String] The ID of the started job run.
def start_job_run(name, input_database, input_table, output_bucket_name)
  response = @glue_client.start_job_run(
    job_name: name,
    arguments: {
      '--input_database': input_database,
      '--input_table': input_table,
      ...}
Get started with crawlers and jobs
def delete_job(job_name)
    @glue_client.delete_job(job_name: job_name)
rescue Aws::Glue::Errors::ServiceError => e
    @logger.error("Glue could not delete job: \n#{e.message}")
end

# Deletes a table with the specified name.
#
# @param database_name [String] The name of the catalog database in which the
table resides.
# @param table_name [String] The name of the table to be deleted.
# @return [void]
def delete_table(database_name, table_name)
    @glue_client.delete_table(database_name: database_name, name: table_name)
rescue Aws::Glue::Errors::ServiceError => e
    @logger.error("Glue could not delete job: \n#{e.message}")
end

# Removes a specified database from a Data Catalog.
#
# @param database_name [String] The name of the database to delete.
# @return [void]
def delete_database(database_name)
    @glue_client.delete_database(name: database_name)
rescue Aws::Glue::Errors::ServiceError => e
    @logger.error("Glue could not delete database: \n#{e.message}")
end

# Uploads a job script file to an S3 bucket.
#
# @param file_path [String] The local path of the job script file.
# @param bucket_resource [Aws::S3::Bucket] The S3 bucket resource to upload the
file to.
# @return [void]
def upload_job_script(file_path, bucket_resource)
    File.open(file_path) do |file|
        bucket_resource.client.put_object({
            body: file,
            bucket: bucket_resource.name,
            key: file_path
        })
    end
rescue Aws::S3::Errors::S3UploadFailedError => e
    @logger.error("S3 could not upload job script: \n#{e.message}")
Create a class that runs the scenario.

class GlueCrawlerJobScenario
  def initialize(glue_client, glue_service_role, glue_bucket, logger)
    @glue_client = glue_client
    @glue_service_role = glue_service_role
    @glue_bucket = glue_bucket
    @logger = logger
  end

  def run(crawler_name, db_name, db_prefix, data_source, job_script, job_name)
    wrapper = GlueWrapper.new(@glue_client, @logger)

    new_step(1, "Create a crawler")
    puts "Checking for crawler #{crawler_name}."
    crawler = wrapper.get_crawler(crawler_name)
    if crawler == false
      puts "Creating crawler #{crawler_name}."
      wrapper.create_crawler(crawler_name, @glue_service_role.arn, db_name, db_prefix, data_source)
      puts "Successfully created #{crawler_name}:
      crawler = wrapper.get_crawler(crawler_name)
      puts JSON.pretty_generate(crawler).yellow
    end
    print "\nDone!\n".green

    new_step(2, "Run a crawler to output a database.")
    puts "Location of input data analyzed by crawler: #{data_source}"
    puts "Outputs: a Data Catalog database in CSV format containing metadata on input."
    wrapper.start_crawler(crawler_name)
    puts "Starting crawler... (this typically takes a few minutes)"
    crawler_state = nil
    while crawler_state != "READY"
      custom_wait(15)
      crawler = wrapper.get_crawler(crawler_name)
      crawler_state = crawler[0]["state"]
  end
end
print "Status check: #{crawler_state}".yellow
end
print "\nDone!\n".green

new_step(3, "Query the database.")
database = wrapper.get_database(db_name)
puts "The crawler created database #{db_name}:
print "#{database}".yellow
puts "\nThe database contains these tables:
tables = wrapper.get_tables(db_name)
tables.each_with_index do |table, index|
  print "\t#{index + 1}. #{table['name']}".yellow
end
print "\nDone!\n".green

new_step(4, "Create a job definition that runs an ETL script.")
puts "Uploading Python ETL script to S3..."
wrapper.upload_job_script(job_script, @glue_bucket)
puts "Creating job definition #{job_name}:
response = wrapper.create_job(job_name, "Getting started example job.",
@glue_service_role.arn, "s3://#{@glue_bucket.name}/#{job_script}"
puts JSON.pretty_generate(response).yellow
print "\nDone!\n".green

new_step(5, "Start a new job")
job_run_status = nil
job_run_id = wrapper.start_job_run(
  job_name,
  db_name,
  tables[0]['name'],
  @glue_bucket.name
)
puts "Job #{job_name} started. Let's wait for it to run."
until ['SUCCEEDED', 'STOPPED', 'FAILED', 'TIMEOUT'].include?(job_run_status)
  custom_wait(10)
  job_run = wrapper.get_job_runs(job_name)
  job_run_status = job_run[0]['job_run_state']
  print "Status check: #{job_name}/#{job_run_id} - #{job_run_status}".yellow
end
print "\nDone!\n".green

new_step(6, "View results from a successful job run.")
if job_run_status == "SUCCEEDED"
puts "Data from your job run is stored in your S3 bucket '#{@glue_bucket.name}'. Files include:

begin

    # Print the key name of each object in the bucket.
    @glue_bucket.objects.each do |object_summary|
        if object_summary.key.include?("run-")
            print "#{object_summary.key}".yellow
        end
    end

    # Print the first 256 bytes of a run file
    desired_sample_objects = 1
    @glue_bucket.objects.each do |object_summary|
        if object_summary.key.include?("run-")
            if desired_sample_objects > 0
                sample_object = @glue_bucket.object(object_summary.key)
                sample = sample_object.get(range: "bytes=0-255").body.read
                puts "\nSample run file contents:
print "#{sample}".yellow
                desired_sample_objects -= 1
            end
        end
    end

rescue Aws::S3::Errors::ServiceError => e
    logger.error(
        "Couldn't get job run data. Here's why: %s: %s",
        e.response.error.code, e.response.error.message
    )
    raise
end

print "\nDone!\n".green

new_step(7, "Delete job definition and crawler.")
wrapper.delete_job(job_name)
puts "Job deleted: #{job_name}."
wrapper.delete_crawler(crawler_name)
puts "Crawler deleted: #{crawler_name}."
wrapper.delete_table(db_name, tables[0]["name"])
puts "Table deleted: #{tables[0]["name"]} in #{db_name}."
wrapper.delete_database(db_name)
puts "Database deleted: #{db_name}."
print "\nDone!\n".green
def main

  banner("../../helpers/banner.txt")
  puts
  "######################################################################################################".yellow
  puts "#".yellow
     # EXAMPLE CODE DEMO:
  puts "#".yellow
     AWS Glue
  puts "#".yellow
  puts "#".yellow
  puts
 "######################################################################################################".yellow
  puts "You have launched a demo of AWS Glue using the AWS for Ruby v3 SDK. Over the next 60 seconds, it will"
  puts "do the following:"
  puts "  1. Create a crawler."
  puts "  2. Run a crawler to output a database."
  puts "  3. Query the database."
  puts "  4. Create a job definition that runs an ETL script."
  puts "  5. Start a new job."
  puts "  6. View results from a successful job run."
  puts "  7. Delete job definition and crawler."
  puts ""

  confirm_begin
  billing
  security
  puts "\e[H\e[2J"

  # Set input file names
  job_script_filepath = "job_script.py"
  resource_names = YAML.load_file("resource_names.yaml")

  # Instantiate existing IAM role.
  iam = Aws::IAM::Resource.new(region: "us-east-1")
  iam_role_name = resource_names["glue_service_role"]
  iam_role = iam.role(iam_role_name)
# Instantiate existing S3 bucket.
s3 = Aws::S3::Resource.new(region: "us-east-1")
s3_bucket_name = resource_names["glue_bucket"]
s3_bucket = s3.bucket(s3_bucket_name)

scenario = GlueCrawlerJobScenario.new(
    Aws::Glue::Client.new(region: "us-east-1"),
    iam_role,
    s3_bucket,
    @logger
)

random_int = rand(10 ** 4)
scenario.run(
    "doc-example-crawler-#{random_int}",
    "doc-example-database-#{random_int}",
    "doc-example-#{random_int}",
    "s3://crawler-public-us-east-1/flight/2016/csv",
    job_script_filepath,
    "doc-example-job-#{random_int}"
)

puts "-" * 88
puts "You have reached the end of this tour of AWS Glue."
puts "To destroy CDK-created resources, run:\n       cdk destroy"
puts "-" * 88
end

Create an ETL script that is used by AWS Glue to extract, transform, and load data during job runs.

```python
import sys
from awsglue.transforms import *
from awsglue.utils import getResolvedOptions
from pyspark.context import SparkContext
from awsglue.context import GlueContext
from awsglue.job import Job

""
These custom arguments must be passed as Arguments to the StartJobRun request.
```
--input_database    The name of a metadata database that is contained in your AWS Glue Data Catalog and that contains tables that describe the data to be processed.
--input_table       The name of a table in the database that describes the data to be processed.
--output_bucket_url An S3 bucket that receives the transformed output data.

args = getResolvedOptions(sys.argv, [
    "JOB_NAME", "input_database", "input_table", "output_bucket_url"])
scc = SparkContext()
glueContext = GlueContext(sc)
spark = glueContext.spark_session
job = Job(glueContext)
job.init(args["JOB_NAME"], args)

# Script generated for node S3 Flight Data.
S3FlightData_node1 = glueContext.create_dynamic_frame.from_catalog(
    database=args['input_database'],
    table_name=args['input_table'],
    transformation_ctx="S3FlightData_node1",
)

# This mapping performs two main functions:
# 1. It simplifies the output by removing most of the fields from the data.
# 2. It renames some fields. For example, `fl_date` is renamed to `flight_date`.
ApplyMapping_node2 = ApplyMapping.apply(
    frame=S3FlightData_node1,
    mappings=[
        ("year", "long", "year", "long"),
        ("month", "long", "month", "tinyint"),
        ("day_of_month", "long", "day", "tinyint"),
        ("fl_date", "string", "flight_date", "string"),
        ("carrier", "string", "carrier", "string"),
        ("fl_num", "long", "flight_num", "long"),
        ("origin_city_name", "string", "origin_city_name", "string"),
        ("origin_state_abr", "string", "origin_state_abr", "string"),
        ("dest_city_name", "string", "dest_city_name", "string"),
        ("dest_state_abr", "string", "dest_state_abr", "string"),
        ("dep_time", "long", "departure_time", "long"),
        ("wheels_off", "long", "wheels_off", "long"),
        ("wheels_on", "long", "wheels_on", "long"),
    ],
)
("arr_time", "long", "arrival_time", "long"),
("mon", "string", "mon", "string"),
)

transformation_ctx=ApplyMapping_node2,

# Script generated for node Revised Flight Data.
RevisedFlightData_node3 = glueContext.write_dynamic_frame.from_options(
    frame=ApplyMapping_node2,
    connection_type="s3",
    format="json",
    connection_options={"path": args['output_bucket_url'], "partitionKeys": []},
    transformation_ctx="RevisedFlightData_node3",
)

job.commit()

• For API details, see the following topics in **AWS SDK for Ruby API Reference**.
  
  • [CreateCrawler](#)
  
  • [CreateJob](#)
  
  • [DeleteCrawler](#)
  
  • [DeleteDatabase](#)
  
  • [DeleteJob](#)
  
  • [DeleteTable](#)
  
  • [GetCrawler](#)
  
  • [GetDatabase](#)
  
  • [GetDatabases](#)
  
  • [GetJob](#)
  
  • [GetJobRun](#)
  
  • [GetJobRuns](#)
  
  • [GetTables](#)
  
  • [ListJobs](#)
  
  • [StartCrawler](#)
  
  • [StartJobRun](#)
Create and run a crawler that crawls a public Amazon Simple Storage Service (Amazon S3) bucket and generates a metadata database that describes the CSV-formatted data it finds.

```rust
let create_crawler = glue
    .create_crawler()
    .name(self.crawler())
    .database_name(self.database())
    .role(self.iam_role.expose_secret())
    .targets(
        CrawlerTargets::builder()
            .s3_targets(S3Target::builder().path(CRAWLER_TARGET).build())
            .build(),
    )
    .send()
    .await;

match create_crawler {
    Err(err) => {
        let glue_err: aws_sdk_glue::Error = err.into();
        match glue_err {
            aws_sdk_glue::Error::AlreadyExistsException(_) => {
                info!("Using existing crawler");
                Ok(())
            }
            _ => Err(GlueMvpError::GlueSdk(glue_err)),
        }
    }
    Ok(_) => Ok(()),
}?

let start_crawler =
    glue.start_crawler().name(self.crawler()).send().await;
```
match start_crawler {
    Ok(_) => Ok(()),
    Err(err) => {
        let glue_err: aws_sdk_glue::Error = err.into();
        match glue_err {
            aws_sdk_glue::Error::CrawlerRunningException(_) => Ok(()),
            _ => Err(GlueMvpError::GlueSdk(glue_err)),
        }
    }
}?

List information about databases and tables in your AWS Glue Data Catalog.

let database = glue
    .get_database()
    .name(self.database())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?
    .to_owned();
let database = database
    .database()
    .ok_or_else(|| GlueMvpError::Unknown("Could not find database".into()))?;

let tables = glue
    .get_tables()
    .database_name(self.database())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

let tables = tables.table_list();

Create and run a job that extracts CSV data from the source Amazon S3 bucket, transforms it by removing and renaming fields, and loads JSON-formatted output into another Amazon S3 bucket.

let create_job = glue
    .create_job()
.name(self.job())
.role(self.iam_role.expose_secret())
.command(
    JobCommand::builder()
        .name("glueetl")
        .python_version("3")
        .script_location(format!("s3://{}/job.py", self.bucket()))
        .build(),
)
.glue_version("3.0")
.send()
.await
.map_err(GlueMvpError::from_glue_sdk)?;

let job_name = create_job.name().ok_or_else(|| {
    GlueMvpError::Unknown("Did not get job name after creating job".into())
})?;

let job_run_output = glue
    .start_job_run()
    .job_name(self.job())
    .arguments("--input_database", self.database())
    .arguments("--input_table",
        self.tables
            .get(0)
            .ok_or_else(|| GlueMvpError::Unknown("Missing crawler table".into()))?
            .name(),
    )
    .arguments("--output_bucket_url", self.bucket())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

let job = job_run_output
    .job_run_id().ok_or_else(|| GlueMvpError::Unknown("Missing run id from just started job".into()))?
        .to_string();
Delete all resources created by the demo.

```rust
    glue.delete_job()
    .job_name(self.job())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

    for t in &self.tables {
        glue.delete_table()
        .name(t.name())
        .database_name(self.database())
        .send()
        .await
        .map_err(GlueMvpError::from_glue_sdk)?;
    }

    glue.delete_database()
    .name(self.database())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;

    glue.delete_crawler()
    .name(self.crawler())
    .send()
    .await
    .map_err(GlueMvpError::from_glue_sdk)?;
```

- For API details, see the following topics in *AWS SDK for Rust API reference*.
  - CreateCrawler
  - CreateJob
  - DeleteCrawler
  - DeleteDatabase
  - DeleteJob
  - DeleteTable
  - GetCrawler
  - GetDatabase
• GetDatabases
• GetJob
• GetJobRun
• GetJobRuns
• GetTables
• ListJobs
• StartCrawler
• StartJobRun

For a complete list of AWS SDK developer guides and code examples, see Using this service with an AWS SDK. This topic also includes information about getting started and details about previous SDK versions.
Security in AWS Glue

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that is built to meet the requirements of the most security-sensitive organizations.

Security is a shared responsibility between AWS and you. The shared responsibility model describes this as security of the cloud and security in the cloud:

- **Security of the cloud** – AWS is responsible for protecting the infrastructure that runs AWS services in the AWS Cloud. AWS also provides you with services that you can use securely. Third-party auditors regularly test and verify the effectiveness of our security as part of the AWS compliance programs. To learn about the compliance programs that apply to AWS Glue, see AWS Services in Scope by Compliance Program.

- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your company’s requirements, and applicable laws and regulations.

This documentation helps you understand how to apply the shared responsibility model when using AWS Glue. The following topics show you how to configure AWS Glue to meet your security and compliance objectives. You also learn how to use other AWS services that help you to monitor and secure your AWS Glue resources.

**Topics**

- [Data protection in AWS Glue](#)
- [Identity and access management for AWS Glue](#)
- [Logging and monitoring in AWS Glue](#)
- [Compliance validation for AWS Glue](#)
- [Resilience in AWS Glue](#)
- [Infrastructure security in AWS Glue](#)

**Data protection in AWS Glue**

AWS Glue offers several features that are designed to help protect your data.
AWS Glue supports data encryption at rest for Building visual ETL jobs with AWS Glue Studio and Developing scripts using development endpoints. You can configure extract, transform, and load (ETL) jobs and development endpoints to use AWS Key Management Service (AWS KMS) keys to write encrypted data at rest. You can also encrypt the metadata stored in the AWS Glue Data Catalog using keys that you manage with AWS KMS. Additionally, you can use AWS KMS keys to encrypt job bookmarks and the logs generated by crawlers and ETL jobs.

You can encrypt metadata objects in your AWS Glue Data Catalog in addition to the data written to Amazon Simple Storage Service (Amazon S3) and Amazon CloudWatch Logs by jobs, crawlers, and development endpoints. When you create jobs, crawlers, and development endpoints in AWS Glue, you can provide encryption settings by attaching a security configuration. Security configurations contain Amazon S3-managed server-side encryption keys (SSE-S3) or customer master keys (CMKs) stored in AWS KMS (SSE-KMS). You can create security configurations using the AWS Glue console.

You can also turn on encryption of the entire Data Catalog in your account. You do so by specifying CMKs stored in AWS KMS.

⚠️ Important
AWS Glue supports only symmetric CMKs. For more information, see Customer Master Keys (CMKs) in the AWS Key Management Service Developer Guide.

With encryption turned on, when you add Data Catalog objects, run crawlers, run jobs, or start development endpoints, SSE-S3 or SSE-KMS keys are used to write data at rest. In addition, you can configure AWS Glue to only access Java Database Connectivity (JDBC) data stores through a trusted Transport Layer Security (TLS) protocol.
In AWS Glue, you control encryption settings in the following places:

- The settings of your Data Catalog.
- The security configurations that you create.
- The server-side encryption setting (SSE-S3 or SSE-KMS) that is passed as a parameter to your AWS Glue ETL (extract, transform, and load) job.

For more information about how to set up encryption, see [Setting up encryption in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/encryption-in-glue.html).

**Topics**
- Encrypting your Data Catalog
- Encrypting connection passwords
- Encrypting data written by AWS Glue

**Encrypting your Data Catalog**

You can turn on encryption of your AWS Glue Data Catalog objects in the **Settings** of the Data Catalog on the AWS Glue console. You can turn on or turn off encryption settings for the entire Data Catalog. In the process, you specify an AWS KMS key that is automatically used when objects, such as tables, are written to the Data Catalog. The encrypted objects include the following:

- Databases
- Tables
- Partitions
- Table versions
- Connections
- User-defined functions

You can set this behavior using the AWS Management Console or AWS Command Line Interface (AWS CLI).

**To turn on encryption using the console**

2. Choose **Settings** in the navigation pane.

3. On the **Data catalog settings** page, select **Metadata encryption**, and choose an AWS KMS key.

⚠️ **Important**
AWS Glue supports only symmetric customer master keys (CMKs). The **AWS KMS key** list displays only symmetric keys. However, if you select **Choose a AWS KMS key ARN**, the console lets you enter an ARN for any key type. Ensure that you enter only ARNs for symmetric keys.

When encryption is turned on, all future Data Catalog objects are encrypted. The default key is the AWS Glue AWS KMS key that is created for your account by AWS. If you clear this setting, objects are no longer encrypted when they are written to the Data Catalog. Any encrypted objects in the Data Catalog can continue to be accessed with the key.

**To turn on encryption using the SDK or AWS CLI**

- Use the `PutDataCatalogEncryptionSettings` API operation. If no key is specified, the default AWS Glue encryption key for the customer account is used.

⚠️ **Important**
The AWS KMS key must remain available in the AWS KMS key store for any objects that are encrypted with it in the Data Catalog. If you remove the key, the objects can no longer be decrypted. You might want this in some scenarios to prevent access to Data Catalog metadata.

When encryption is turned on, the client that is accessing the Data Catalog must have the following AWS KMS permissions in its policy:

- `kms:Decrypt`
- `kms:Encrypt`
- `kms:GenerateDataKey`
For example, when you define a crawler or a job, the IAM role that you provide in the definition must have these AWS KMS permissions.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "kms:Decrypt",
        "kms:Encrypt",
        "kms:GenerateDataKey"
      ],
      "Resource": "ARN-of-key-used-to-encrypt-data-catalog"
    }
  ]
}
```

**Encrypting connection passwords**

You can retrieve connection passwords in the AWS Glue Data Catalog by using the GetConnection and GetConnections API operations. These passwords are stored in the Data Catalog connection and are used when AWS Glue connects to a Java Database Connectivity (JDBC) data store. When the connection was created or updated, an option in the Data Catalog settings determined whether the password was encrypted, and if so, what AWS Key Management Service (AWS KMS) key was specified.

On the AWS Glue console, you can turn on this option on the **Data catalog settings** page.

**To encrypt connection passwords**

2. Choose **Settings** in the navigation pane.
3. On the **Data catalog settings** page, select **Encrypt connection passwords**, and choose an AWS KMS key.
Important
AWS Glue supports only symmetric customer master keys (CMKs). The AWS KMS key list displays only symmetric keys. However, if you select Choose a AWS KMS key ARN, the console lets you enter an ARN for any key type. Ensure that you enter only ARNs for symmetric keys.

For more information, see Working with Data Catalog settings on the AWS Glue console.

Encrypting data written by AWS Glue

A security configuration is a set of security properties that can be used by AWS Glue. You can use a security configuration to encrypt data at rest. The following scenarios show some of the ways that you can use a security configuration.

- Attach a security configuration to an AWS Glue crawler to write encrypted Amazon CloudWatch Logs.
- Attach a security configuration to an extract, transform, and load (ETL) job to write encrypted Amazon Simple Storage Service (Amazon S3) targets and encrypted CloudWatch Logs.
- Attach a security configuration to an ETL job to write its jobs bookmarks as encrypted Amazon S3 data.
- Attach a security configuration to a development endpoint to write encrypted Amazon S3 targets.

Important
Currently, a security configuration overrides any server-side encryption (SSE-S3) setting that is passed as an ETL job parameter. Thus, if both a security configuration and an SSE-S3 parameter are associated with a job, the SSE-S3 parameter is ignored.

For more information about security configurations, see Working with security configurations on the AWS Glue console.

Topics
• Setting Up AWS Glue to use security configurations
• Creating a route to AWS KMS for VPC jobs and crawlers
• Working with security configurations on the AWS Glue console

Setting Up AWS Glue to use security configurations

Follow these steps to set up your AWS Glue environment to use security configurations.

1. Create or update your AWS Key Management Service (AWS KMS) keys to grant AWS KMS permissions to the IAM roles that are passed to AWS Glue crawlers and jobs to encrypt CloudWatch Logs. For more information, see Encrypt Log Data in CloudWatch Logs Using AWS KMS in the Amazon CloudWatch Logs User Guide.

In the following example, "role1", "role2", and "role3" are IAM roles that are passed to crawlers and jobs.

```
{
    "Effect": "Allow",
    "Principal": { "Service": "logs.region.amazonaws.com",
    "AWS": [ "role1",
    "role2",
    "role3"
    ] },
    "Action": [ "kms:Encrypt*",
    "kms:Decrypt*",
    "kms:ReEncrypt*",
    "kms:GenerateDataKey*",
    "kms:Describe*"
    ],
    "Resource": "*"
}
```

The Service statement, shown as "Service": "logs.region.amazonaws.com", is required if you use the key to encrypt CloudWatch Logs.

2. Ensure that the AWS KMS key is ENABLED before it is used.

3. Ensure that the AWS Glue job includes the following code in the beginning of your script for the security setting to take effect.
job = Job(glueContext)
job.init(args['JOB_NAME'], args)

Note
If you are using Iceberg as your data lake framework, Iceberg tables have their own mechanisms to enable server-side encryption. You should enable these configuration in addition to AWS Glue's security configurations. To enable server-side encryption on Iceberg tables, review the guidance from Iceberg documentation.

Creating a route to AWS KMS for VPC jobs and crawlers

You can connect directly to AWS KMS through a private endpoint in your virtual private cloud (VPC) instead of connecting over the internet. When you use a VPC endpoint, communication between your VPC and AWS KMS is conducted entirely within the AWS network.

You can create an AWS KMS VPC endpoint within a VPC. Without this step, your jobs or crawlers might fail with a kms timeout on jobs or an internal service exception on crawlers. For detailed instructions, see Connecting to AWS KMS Through a VPC Endpoint in the AWS Key Management Service Developer Guide.

As you follow these instructions, on the VPC console, you must do the following:

- Select Enable Private DNS name.
- Choose the Security group (with self-referencing rule) that you use for your job or crawler that accesses Java Database Connectivity (JDBC). For more information about AWS Glue connections, see Connecting to data.

When you add a security configuration to a crawler or job that accesses JDBC data stores, AWS Glue must have a route to the AWS KMS endpoint. You can provide the route with a network address translation (NAT) gateway or with an AWS KMS VPC endpoint. To create a NAT gateway, see NAT Gateways in the Amazon VPC User Guide.
Working with security configurations on the AWS Glue console

⚠ Warning
AWS Glue security configurations are not currently supported in Ray jobs.

A security configuration in AWS Glue contains the properties that are needed when you write encrypted data. You create security configurations on the AWS Glue console to provide the encryption properties that are used by crawlers, jobs, and development endpoints.

To see a list of all the security configurations that you have created, open the AWS Glue console at https://console.aws.amazon.com/glue/ and choose Security configurations in the navigation pane.

The Security configurations list displays the following properties about each configuration:

Name

The unique name you provided when you created the configuration. The name may contain letters (A-Z), numbers (0-9), hypens (-), or underscores (_), and be up to 255 characters long.

Enable Amazon S3 encryption

If turned on, the Amazon Simple Storage Service (Amazon S3) encryption mode such as SSE-KMS or SSE-S3 is enabled for metadata store in the data catalog.

Enable Amazon CloudWatch logs encryption

If turned on, the Amazon S3 encryption mode such as SSE-KMS is enabled when writing logs to Amazon CloudWatch.

Advanced settings: Enable job bookmark encryption

If turned on, the Amazon S3 encryption mode such as CSE-KMS is enabled when jobs are bookmarked.

You can add or delete configurations in the Security configurations section on the console. To see more details for a configuration, choose the configuration name in the list. Details include the information that you defined when you created the configuration.
Adding a security configuration

To add a security configuration using the AWS Glue console, on the Security configurations page, choose Add security configuration.

Add security configuration

Choose encryption and permission options for your accounts data catalog.

Security configuration properties

Name

Enter a unique security configuration name

Name may contain letters (A-Z), numbers (0-9), hyphens (-), or underscores (_), and can be up to 255 characters long.

Encryption settings

Enable and choose options for at-rest encryption.

- Enable S3 encryption
  Enable at-rest encryption for metadata stored in the data catalog.

- Enable CloudWatch logs encryption
  Enable at-rest encryption when writing logs to Amazon CloudWatch.

Advanced settings

- Enable job bookmark encryption
  Enable at-rest encryption of job bookmark.

Security configuration properties

Enter a unique security configuration name. The name may contain letters (A-Z), numbers (0-9), hyphens (-), or underscores (_), and can be up to 255 characters long.

Encryption settings

You can enable at-rest encryption for metadata stored in the Data Catalog in Amazon S3 and logs in Amazon CloudWatch. To set up encryption of data and metadata with AWS Key Management...
Service (AWS KMS) keys on the AWS Glue console, add a policy to the console user. This policy must specify the allowed resources as key Amazon Resource Names (ARNs) that are used to encrypt Amazon S3 data stores, as in the following example.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "kms:GenerateDataKey",
                "kms:Decrypt",
                "kms:Encrypt"
            ],
            "Resource": "arn:aws:kms:region:account-id:key/key-id"
        }
    ]
}
```

⚠️ Important

When a security configuration is attached to a crawler or job, the IAM role that is passed must have AWS KMS permissions. For more information, see [Encrypting data written by AWS Glue](#).

When you define a configuration, you can provide values for the following properties:

### Enable S3 encryption

When you are writing Amazon S3 data, you use either server-side encryption with Amazon S3 managed keys (SSE-S3) or server-side encryption with AWS KMS managed keys (SSE-KMS). This field is optional. To allow access to Amazon S3, choose an AWS KMS key, or choose **Enter a key ARN** and provide the ARN for the key. Enter the ARN in the form `arn:aws:kms:region:account-id:key/key-id`. You can also provide the ARN as a key alias, such as `arn:aws:kms:region:account-id:alias/alias-name`.

If you enable Spark UI for your job, the Spark UI log file uploaded to Amazon S3 will be applied with the same encryption.

⚠️ Important

AWS Glue supports only symmetric customer master keys (CMKs). The **AWS KMS key** list displays only symmetric keys. However, if you select **Choose a AWS KMS key ARN**,
the console lets you enter an ARN for any key type. Ensure that you enter only ARNs for symmetric keys.

Enable CloudWatch Logs encryption

Server-side (SSE-KMS) encryption is used to encrypt CloudWatch Logs. This field is optional. To turn it on, choose an AWS KMS key, or choose Enter a key ARN and provide the ARN for the key. Enter the ARN in the form `arn:aws:kms:region:account-id:key/key-id`. You can also provide the ARN as a key alias, such as `arn:aws:kms:region:account-id:alias/alias-name`.

Advanced settings: Job bookmark encryption

Client-side (CSE-KMS) encryption is used to encrypt job bookmarks. This field is optional. The bookmark data is encrypted before it is sent to Amazon S3 for storage. To turn it on, choose an AWS KMS key, or choose Enter a key ARN and provide the ARN for the key. Enter the ARN in the form `arn:aws:kms:region:account-id:key/key-id`. You can also provide the ARN as a key alias, such as `arn:aws:kms:region:account-id:alias/alias-name`.

For more information, see the following topics in the Amazon Simple Storage Service User Guide:

- For information about SSE-S3, see Protecting Data Using Server-Side Encryption with Amazon S3-Managed Encryption Keys (SSE-S3).
- For information about SSE-KMS, see Protecting Data Using Server-Side Encryption with AWS KMS keys.
- For information about CSE-KMS, see Using a KMS key stored in AWS KMS.

Encryption in transit

AWS provides Transport Layer Security (TLS) encryption for data in motion. You can configure encryption settings for crawlers, ETL jobs, and development endpoints using security configurations in AWS Glue. You can turn on AWS Glue Data Catalog encryption via the settings for the Data Catalog.

As of September 4, 2018, AWS KMS (bring your own key and server-side encryption) for AWS Glue ETL and the AWS Glue Data Catalog is supported.
FIPS compliance

If you require FIPS 140-2 validated cryptographic modules when accessing AWS through a command line interface or an API, use a FIPS endpoint. For more information about the available FIPS endpoints, see Federal Information Processing Standard (FIPS) 140-2.

Key management

You can use AWS Identity and Access Management (IAM) with AWS Glue to define users, AWS resources, groups, roles and fine-grained policies regarding access, denial, and more.

You can define the access to the metadata using both resource-based and identity-based policies, depending on your organization’s needs. Resource-based policies list the principals that are allowed or denied access to your resources, allowing you to set up policies such as cross-account access. Identity policies are specifically attached to users, groups, and roles within IAM.

For a step-by-step example, see Restrict access to your AWS Glue Data Catalog with resource-level IAM permissions and resource-based policies on the AWS Big Data Blog.

The fine-grained access portion of the policy is defined within the Resource clause. This portion defines both the AWS Glue Data Catalog object that the action can be performed on, and what resulting objects get returned by that operation.

A development endpoint is an environment that you can use to develop and test your AWS Glue scripts. You can add, delete, or rotate the SSH key of a development endpoint.

As of September 4, 2018, AWS KMS (bring your own key and server-side encryption) for AWS Glue ETL and the AWS Glue Data Catalog is supported.

AWS Glue dependency on other AWS services

For a user to work with the AWS Glue console, that user must have a minimum set of permissions that allows them to work with the AWS Glue resources for their AWS account. In addition to these AWS Glue permissions, the console requires permissions from the following services:

- Amazon CloudWatch Logs permissions to display logs.
- AWS Identity and Access Management (IAM) permissions to list and pass roles.
- AWS CloudFormation permissions to work with stacks.
• Amazon Elastic Compute Cloud (Amazon EC2) permissions to list virtual private clouds (VPCs), subnets, security groups, instances, and other objects (to set up Amazon EC2 items such as VPCs when running jobs, crawlers, and creating development endpoints).

• Amazon Simple Storage Service (Amazon S3) permissions to list buckets and objects, and to retrieve and save scripts.

• Amazon Redshift permissions to work with clusters.

• Amazon Relational Database Service (Amazon RDS) permissions to list instances.

**Development endpoints**

A development endpoint is an environment that you can use to develop and test your AWS Glue scripts. You can use AWS Glue to create, edit, and delete development endpoints. You can list all the development endpoints that are created. You can add, delete, or rotate the SSH key of a development endpoint. You can also create notebooks that use the development endpoint.

You provide configuration values to provision the development environments. These values tell AWS Glue how to set up the network so that you can access the development endpoint securely, and so that your endpoint can access your data stores. Then, you can create a notebook that connects to the development endpoint. You use your notebook to author and test your ETL script.

Use an AWS Identity and Access Management (IAM) role with permissions similar to the IAM role that you use to run AWS Glue ETL jobs. Use a virtual private cloud (VPC), a subnet, and a security group to create a development endpoint that can connect to your data resources securely. You generate an SSH key pair to connect to the development environment using SSH.

You can create development endpoints for Amazon S3 data and within a VPC that you can use to access datasets using JDBC.

You can install a Jupyter notebook client on your local machine and use it to debug and test ETL scripts on a development endpoint. Or, you can use a Sagemaker notebook to author ETL scripts in JupyterLab on AWS. See [Use a SageMaker notebook with your development endpoint](#).

AWS Glue tags Amazon EC2 instances with a name that is prefixed with `aws-glue-dev-endpoint`.

You can set up a notebook server on a development endpoint to run PySpark with AWS Glue extensions.
Identity and access management for AWS Glue

AWS Identity and Access Management (IAM) is an AWS service that helps an administrator securely control access to AWS resources. IAM administrators control who can be authenticated (signed in) and authorized (have permissions) to use AWS Glue resources. IAM is an AWS service that you can use with no additional charge.

Note

You can grant access to your data in the AWS Glue Data Catalog using either AWS Glue methods or AWS Lake Formation grants. You can use AWS Identity and Access Management (IAM) policies to set fine-grained access control with AWS Glue methods. Lake Formation uses a simpler GRANT/REVOKE permissions model that is similar to the GRANT/REVOKE commands in a relational database system.

This section includes information about how to use the AWS Glue methods. For information about using Lake Formation grants, see Granting Lake Formation permissions in the AWS Lake Formation Developer Guide.

Topics

- Audience
- Authenticating with identities
- Managing access using policies
- How AWS Glue works with IAM
- Configuring IAM permissions for AWS Glue
- AWS Glue access control policy examples
- AWS managed policies for AWS Glue
- Specifying AWS Glue resource ARNs
- Granting cross-account access
- Troubleshooting AWS Glue identity and access
**Audience**

How you use AWS Identity and Access Management (IAM) differs, depending on the work that you do in AWS Glue.

**Service user** – If you use the AWS Glue service to do your job, then your administrator provides you with the credentials and permissions that you need. As you use more AWS Glue features to do your work, you might need additional permissions. Understanding how access is managed can help you request the right permissions from your administrator. If you cannot access a feature in AWS Glue, see [Troubleshooting AWS Glue identity and access](#).

**Service administrator** – If you’re in charge of AWS Glue resources at your company, you probably have full access to AWS Glue. It’s your job to determine which AWS Glue features and resources your service users should access. You must then submit requests to your IAM administrator to change the permissions of your service users. Review the information on this page to understand the basic concepts of IAM. To learn more about how your company can use IAM with AWS Glue, see [How AWS Glue works with IAM](#).

**IAM administrator** – If you’re an IAM administrator, you might want to learn details about how you can write policies to manage access to AWS Glue. To view example AWS Glue identity-based policies that you can use in IAM, see [Identity-based policy examples for AWS Glue](#).

**Authenticating with identities**

Authentication is how you sign in to AWS using your identity credentials. You must be *authenticated* (signed in to AWS) as the AWS account root user, as an IAM user, or by assuming an IAM role.

You can sign in to AWS as a federated identity by using credentials provided through an identity source. AWS IAM Identity Center (IAM Identity Center) users, your company's single sign-on authentication, and your Google or Facebook credentials are examples of federated identities. When you sign in as a federated identity, your administrator previously set up identity federation using IAM roles. When you access AWS by using federation, you are indirectly assuming a role.

Depending on the type of user you are, you can sign in to the AWS Management Console or the AWS access portal. For more information about signing in to AWS, see [How to sign in to your AWS account](#) in the [AWS Sign-In User Guide](#).

If you access AWS programmatically, AWS provides a software development kit (SDK) and a command line interface (CLI) to cryptographically sign your requests by using your credentials. If
you don't use AWS tools, you must sign requests yourself. For more information about using the recommended method to sign requests yourself, see Signing AWS API requests in the IAM User Guide.

Regardless of the authentication method that you use, you might be required to provide additional security information. For example, AWS recommends that you use multi-factor authentication (MFA) to increase the security of your account. To learn more, see Multi-factor authentication in the AWS IAM Identity Center User Guide and Using multi-factor authentication (MFA) in AWS in the IAM User Guide.

**AWS account root user**

When you create an AWS account, you begin with one sign-in identity that has complete access to all AWS services and resources in the account. This identity is called the AWS account root user and is accessed by signing in with the email address and password that you used to create the account. We strongly recommend that you don't use the root user for your everyday tasks. Safeguard your root user credentials and use them to perform the tasks that only the root user can perform. For the complete list of tasks that require you to sign in as the root user, see Tasks that require root user credentials in the IAM User Guide.

**Federated identity**

As a best practice, require human users, including users that require administrator access, to use federation with an identity provider to access AWS services by using temporary credentials.

A federated identity is a user from your enterprise user directory, a web identity provider, the AWS Directory Service, the Identity Center directory, or any user that accesses AWS services by using credentials provided through an identity source. When federated identities access AWS accounts, they assume roles, and the roles provide temporary credentials.

For centralized access management, we recommend that you use AWS IAM Identity Center. You can create users and groups in IAM Identity Center, or you can connect and synchronize to a set of users and groups in your own identity source for use across all your AWS accounts and applications. For information about IAM Identity Center, see What is IAM Identity Center? in the AWS IAM Identity Center User Guide.

**IAM users and groups**

An IAM user is an identity within your AWS account that has specific permissions for a single person or application. Where possible, we recommend relying on temporary credentials instead of creating
IAM users who have long-term credentials such as passwords and access keys. However, if you have specific use cases that require long-term credentials with IAM users, we recommend that you rotate access keys. For more information, see Rotate access keys regularly for use cases that require long-term credentials in the IAM User Guide.

An IAM group is an identity that specifies a collection of IAM users. You can’t sign in as a group. You can use groups to specify permissions for multiple users at a time. Groups make permissions easier to manage for large sets of users. For example, you could have a group named IAMAdmins and give that group permissions to administer IAM resources.

Users are different from roles. A user is uniquely associated with one person or application, but a role is intended to be assumable by anyone who needs it. Users have permanent long-term credentials, but roles provide temporary credentials. To learn more, see When to create an IAM user (instead of a role) in the IAM User Guide.

IAM roles

An IAM role is an identity within your AWS account that has specific permissions. It is similar to an IAM user, but is not associated with a specific person. You can temporarily assume an IAM role in the AWS Management Console by switching roles. You can assume a role by calling an AWS CLI or AWS API operation or by using a custom URL. For more information about methods for using roles, see Using IAM roles in the IAM User Guide.

IAM roles with temporary credentials are useful in the following situations:

- **Federated user access** – To assign permissions to a federated identity, you create a role and define permissions for the role. When a federated identity authenticates, the identity is associated with the role and is granted the permissions that are defined by the role. For information about roles for federation, see Creating a role for a third-party Identity Provider in the IAM User Guide. If you use IAM Identity Center, you configure a permission set. To control what your identities can access after they authenticate, IAM Identity Center correlates the permission set to a role in IAM. For information about permissions sets, see Permission sets in the AWS IAM Identity Center User Guide.

- **Temporary IAM user permissions** – An IAM user or role can assume an IAM role to temporarily take on different permissions for a specific task.

- **Cross-account access** – You can use an IAM role to allow someone (a trusted principal) in a different account to access resources in your account. Roles are the primary way to grant cross-account access. However, with some AWS services, you can attach a policy directly to a resource.
(instead of using a role as a proxy). To learn the difference between roles and resource-based policies for cross-account access, see How IAM roles differ from resource-based policies in the IAM User Guide.

- **Cross-service access** – Some AWS services use features in other AWS services. For example, when you make a call in a service, it's common for that service to run applications in Amazon EC2 or store objects in Amazon S3. A service might do this using the calling principal's permissions, using a service role, or using a service-linked role.

- **Forward access sessions (FAS)** – When you use an IAM user or role to perform actions in AWS, you are considered a principal. When you use some services, you might perform an action that then initiates another action in a different service. FAS uses the permissions of the principal calling an AWS service, combined with the requesting AWS service to make requests to downstream services. FAS requests are only made when a service receives a request that requires interactions with other AWS services or resources to complete. In this case, you must have permissions to perform both actions. For policy details when making FAS requests, see Forward access sessions.

- **Service role** – A service role is an IAM role that a service assumes to perform actions on your behalf. An IAM administrator can create, modify, and delete a service role from within IAM. For more information, see Creating a role to delegate permissions to an AWS service in the IAM User Guide.

- **Service-linked role** – A service-linked role is a type of service role that is linked to an AWS service. The service can assume the role to perform an action on your behalf. Service-linked roles appear in your AWS account and are owned by the service. An IAM administrator can view, but not edit the permissions for service-linked roles.

- **Applications running on Amazon EC2** – You can use an IAM role to manage temporary credentials for applications that are running on an EC2 instance and making AWS CLI or AWS API requests. This is preferable to storing access keys within the EC2 instance. To assign an AWS role to an EC2 instance and make it available to all of its applications, you create an instance profile that is attached to the instance. An instance profile contains the role and enables programs that are running on the EC2 instance to get temporary credentials. For more information, see Using an IAM role to grant permissions to applications running on Amazon EC2 instances in the IAM User Guide.

To learn whether to use IAM roles or IAM users, see When to create an IAM role (instead of a user) in the IAM User Guide.
Managing access using policies

You control access in AWS by creating policies and attaching them to AWS identities or resources. A policy is an object in AWS that, when associated with an identity or resource, defines their permissions. AWS evaluates these policies when a principal (user, root user, or role session) makes a request. Permissions in the policies determine whether the request is allowed or denied. Most policies are stored in AWS as JSON documents. For more information about the structure and contents of JSON policy documents, see Overview of JSON policies in the IAM User Guide.

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

By default, users and roles have no permissions. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies. The administrator can then add the IAM policies to roles, and users can assume the roles.

IAM policies define permissions for an action regardless of the method that you use to perform the operation. For example, suppose that you have a policy that allows the `iam:GetRole` action. A user with that policy can get role information from the AWS Management Console, the AWS CLI, or the AWS API.

Identity-based policies

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, group of users, or role. These policies control what actions users and roles can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM policies in the IAM User Guide.

Identity-based policies can be further categorized as inline policies or managed policies. Inline policies are embedded directly into a single user, group, or role. Managed policies are standalone policies that you can attach to multiple users, groups, and roles in your AWS account. Managed policies include AWS managed policies and customer managed policies. To learn how to choose between a managed policy or an inline policy, see Choosing between managed policies and inline policies in the IAM User Guide.

Resource-based policies

Resource-based policies are JSON policy documents that you attach to a resource. Examples of resource-based policies are IAM role trust policies and Amazon S3 bucket policies. In services that support resource-based policies, service administrators can use them to control access to a specific
resource. For the resource where the policy is attached, the policy defines what actions a specified principal can perform on that resource and under what conditions. You must specify a principal in a resource-based policy. Principals can include accounts, users, roles, federated users, or AWS services.

Resource-based policies are inline policies that are located in that service. You can't use AWS managed policies from IAM in a resource-based policy.

**Access control lists (ACLs)**

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

Amazon S3, AWS WAF, and Amazon VPC are examples of services that support ACLs. To learn more about ACLs, see [Access control list (ACL) overview](https://docs.aws.amazon.com/AmazonS3/latest/userguide/acl.html) in the *Amazon Simple Storage Service Developer Guide*.

**Other policy types**

AWS supports additional, less-common policy types. These policy types can set the maximum permissions granted to you by the more common policy types.

- **Permissions boundaries** – A permissions boundary is an advanced feature in which you set the maximum permissions that an identity-based policy can grant to an IAM entity (IAM user or role). You can set a permissions boundary for an entity. The resulting permissions are the intersection of an entity's identity-based policies and its permissions boundaries. Resource-based policies that specify the user or role in the `Principal` field are not limited by the permissions boundary. An explicit deny in any of these policies overrides the allow. For more information about permissions boundaries, see [Permissions boundaries for IAM entities](https://docs.aws.amazon.com/IAM/latest/userguide/permissions-boundaries.html) in the *IAM User Guide*.

- **Service control policies (SCPs)** – SCPs are JSON policies that specify the maximum permissions for an organization or organizational unit (OU) in AWS Organizations. AWS Organizations is a service for grouping and centrally managing multiple AWS accounts that your business owns. If you enable all features in an organization, then you can apply service control policies (SCPs) to any or all of your accounts. The SCP limits permissions for entities in member accounts, including each AWS account root user. For more information about Organizations and SCPs, see [How SCPs work](https://docs.aws.amazon.com/organizations/latest/userguide/how-scp-work.html) in the *AWS Organizations User Guide*.

- **Session policies** – Session policies are advanced policies that you pass as a parameter when you programmatically create a temporary session for a role or federated user. The resulting session's
permissions are the intersection of the user or role's identity-based policies and the session policies. Permissions can also come from a resource-based policy. An explicit deny in any of these policies overrides the allow. For more information, see Session policies in the IAM User Guide.

**Multiple policy types**

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy evaluation logic in the IAM User Guide.

**How AWS Glue works with IAM**

Before you use IAM to manage access to AWS Glue, learn what IAM features are available to use with AWS Glue.

**IAM features you can use with AWS Glue**

<table>
<thead>
<tr>
<th>IAM feature</th>
<th>AWS Glue support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity-based policies</td>
<td>Yes</td>
</tr>
<tr>
<td>Resource-based policies</td>
<td>Partial</td>
</tr>
<tr>
<td>Policy actions</td>
<td>Yes</td>
</tr>
<tr>
<td>Policy resources</td>
<td>Yes</td>
</tr>
<tr>
<td>Policy condition keys (service-specific)</td>
<td>Yes</td>
</tr>
<tr>
<td>ACLs</td>
<td>No</td>
</tr>
<tr>
<td>ABAC (tags in policies)</td>
<td>Partial</td>
</tr>
<tr>
<td>Temporary credentials</td>
<td>Yes</td>
</tr>
<tr>
<td>Principal permissions</td>
<td>No</td>
</tr>
<tr>
<td>Service roles</td>
<td>Yes</td>
</tr>
<tr>
<td>Service-linked roles</td>
<td>No</td>
</tr>
</tbody>
</table>
To get a high-level view of how AWS Glue and other AWS services work with most IAM features, see AWS services that work with IAM in the IAM User Guide.

Identity-based policies for AWS Glue

Supports identity-based policies: Yes

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, group of users, or role. These policies control what actions users and roles can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM policies in the IAM User Guide.

With IAM identity-based policies, you can specify allowed or denied actions and resources as well as the conditions under which actions are allowed or denied. You can't specify the principal in an identity-based policy because it applies to the user or role to which it is attached. To learn about all of the elements that you can use in a JSON policy, see IAM JSON policy elements reference in the IAM User Guide.

AWS Glue supports identity-based policies (IAM policies) for all AWS Glue operations. By attaching a policy, you can grant permissions to create, access, or modify an AWS Glue resource, such as a table in the AWS Glue Data Catalog.

Identity-based policy examples for AWS Glue

To view examples of AWS Glue identity-based policies, see Identity-based policy examples for AWS Glue.

Resource-based policies within AWS Glue

Supports resource-based policies: Partial

Resource-based policies are JSON policy documents that you attach to a resource. Examples of resource-based policies are IAM role trust policies and Amazon S3 bucket policies. In services that support resource-based policies, service administrators can use them to control access to a specific resource. For the resource where the policy is attached, the policy defines what actions a specified principal can perform on that resource and under what conditions. You must specify a principal
in a resource-based policy. Principals can include accounts, users, roles, federated users, or AWS services.

To enable cross-account access, you can specify an entire account or IAM entities in another account as the principal in a resource-based policy. Adding a cross-account principal to a resource-based policy is only half of establishing the trust relationship. When the principal and the resource are in different AWS accounts, an IAM administrator in the trusted account must also grant the principal entity (user or role) permission to access the resource. They grant permission by attaching an identity-based policy to the entity. However, if a resource-based policy grants access to a principal in the same account, no additional identity-based policy is required. For more information, see How IAM roles differ from resource-based policies in the IAM User Guide.

Note

You can only use an AWS Glue resource policy to manage permissions for Data Catalog resources. You can't attach it to any other AWS Glue resources such as jobs, triggers, development endpoints, crawlers, or classifiers. Only one resource policy is allowed per catalog, and its size is limited to 10 KB.

In AWS Glue, a resource policy is attached to a catalog, which is a virtual container for all the kinds of Data Catalog resources mentioned previously. Each AWS account owns a single catalog in an AWS Region whose catalog ID is the same as the AWS account ID. You cannot delete or modify a catalog.

A resource policy is evaluated for all API calls to the catalog where the caller principal is included in the "Principal" block of the policy document.

To view examples of AWS Glue resource-based policies, see Resource-based policy examples for AWS Glue.

Policy actions for AWS Glue

| Supports policy actions | Yes |

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.
The `Action` element of a JSON policy describes the actions that you can use to allow or deny access in a policy. Policy actions usually have the same name as the associated AWS API operation. There are some exceptions, such as `permission-only actions` that don't have a matching API operation. There are also some operations that require multiple actions in a policy. These additional actions are called `dependent actions`.

Include actions in a policy to grant permissions to perform the associated operation.

To see a list of AWS Glue actions, see [Actions defined by AWS Glue](#) in the [Service Authorization Reference](#).

Policy actions in AWS Glue use the following prefix before the action:

```
"Action": [  
    "glue:action1",
    "glue:action2"
  ]
```

To specify multiple actions in a single statement, separate them with commas.

You can specify multiple actions using wildcards (*). For example, to specify all actions that begin with the word `Get`, include the following action:

```
"Action": "glue:Get***"
```

To view example policies, see [AWS Glue access control policy examples](#).

**Policy resources for AWS Glue**

<table>
<thead>
<tr>
<th>Supports policy resources</th>
<th>Yes</th>
</tr>
</thead>
</table>

Administrators can use AWS JSON policies to specify who has access to what. That is, which `principal` can perform `actions` on what `resources`, and under what `conditions`. 
The Resource JSON policy element specifies the object or objects to which the action applies. Statements must include either a Resource or a NotResource element. As a best practice, specify a resource using its Amazon Resource Name (ARN). You can do this for actions that support a specific resource type, known as resource-level permissions.

For actions that don't support resource-level permissions, such as listing operations, use a wildcard (*) to indicate that the statement applies to all resources.

"Resource": "*"

For more information about how to control access to AWS Glue resources using ARNs, see Specifying AWS Glue resource ARNs.

To see a list of AWS Glue resource types and their ARNs, see Resources defined by AWS Glue in the Service Authorization Reference. To learn which actions you can use to specify the ARN of each resource, see Actions defined by AWS Glue.

**Policy condition keys for AWS Glue**

<table>
<thead>
<tr>
<th>Supports service-specific policy condition keys</th>
<th>Yes</th>
</tr>
</thead>
</table>

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Condition element (or Condition block) lets you specify conditions in which a statement is in effect. The Condition element is optional. You can create conditional expressions that use condition operators, such as equals or less than, to match the condition in the policy with values in the request.

If you specify multiple Condition elements in a statement, or multiple keys in a single Condition element, AWS evaluates them using a logical AND operation. If you specify multiple values for a single condition key, AWS evaluates the condition using a logical OR operation. All of the conditions must be met before the statement's permissions are granted.

You can also use placeholder variables when you specify conditions. For example, you can grant an IAM user permission to access a resource only if it is tagged with their IAM user name. For more information, see IAM policy elements: variables and tags in the IAM User Guide.
AWS supports global condition keys and service-specific condition keys. To see all AWS global condition keys, see [AWS global condition context keys](#) in the IAM User Guide.

To see a list of AWS Glue condition keys, see [Condition keys for AWS Glue](#) in the Service Authorization Reference. To learn which actions and resources you can use a condition key with, see Actions defined by AWS Glue.

To view example policies, see [Control settings using condition keys or context keys](#).

### ACLs in AWS Glue

| Supports ACLs | No |

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

### ABAC with AWS Glue

| Supports ABAC (tags in policies) | Partial |

Attribute-based access control (ABAC) is an authorization strategy that defines permissions based on attributes. In AWS, these attributes are called tags. You can attach tags to IAM entities (users or roles) and to many AWS resources. Tagging entities and resources is the first step of ABAC. Then you design ABAC policies to allow operations when the principal's tag matches the tag on the resource that they are trying to access.

ABAC is helpful in environments that are growing rapidly and helps with situations where policy management becomes cumbersome.

To control access based on tags, you provide tag information in the condition element of a policy using the aws:ResourceTag/*key-name*, aws:RequestTag/*key-name*, or aws:TagKeys condition keys.

If a service supports all three condition keys for every resource type, then the value is Yes for the service. If a service supports all three condition keys for only some resource types, then the value is Partial.
For more information about ABAC, see What is ABAC? in the IAM User Guide. To view a tutorial with steps for setting up ABAC, see Use attribute-based access control (ABAC) in the IAM User Guide.

⚠️ Important

The condition context keys apply only to AWS Glue API actions on crawlers, jobs, triggers, and development endpoints. For more information about which API operations are affected, see Condition keys for AWS Glue.

The AWS Glue Data Catalog API operations don't currently support the aws:referer and aws:UserAgent global condition context keys.

To view an example identity-based policy for limiting access to a resource based on the tags on that resource, see Grant access using tags.

**Using temporary credentials with AWS Glue**

<table>
<thead>
<tr>
<th>Supports temporary credentials</th>
<th>Yes</th>
</tr>
</thead>
</table>

Some AWS services don't work when you sign in using temporary credentials. For additional information, including which AWS services work with temporary credentials, see AWS services that work with IAM in the IAM User Guide.

You are using temporary credentials if you sign in to the AWS Management Console using any method except a user name and password. For example, when you access AWS using your company’s single sign-on (SSO) link, that process automatically creates temporary credentials. You also automatically create temporary credentials when you sign in to the console as a user and then switch roles. For more information about switching roles, see Switching to a role (console) in the IAM User Guide.

You can manually create temporary credentials using the AWS CLI or AWS API. You can then use those temporary credentials to access AWS. AWS recommends that you dynamically generate temporary credentials instead of using long-term access keys. For more information, see Temporary security credentials in IAM.
Cross-service principal permissions for AWS Glue

| Supports forward access sessions (FAS) | No |

When you use an IAM user or role to perform actions in AWS, you are considered a principal. When you use some services, you might perform an action that then initiates another action in a different service. FAS uses the permissions of the principal calling an AWS service, combined with the requesting AWS service to make requests to downstream services. FAS requests are only made when a service receives a request that requires interactions with other AWS services or resources to complete. In this case, you must have permissions to perform both actions. For policy details when making FAS requests, see [Forward access sessions](#).

Service roles for AWS Glue

| Supports service roles | Yes |

A service role is an [IAM role](#) that a service assumes to perform actions on your behalf. An IAM administrator can create, modify, and delete a service role from within IAM. For more information, see [Creating a role to delegate permissions to an AWS service](#) in the [IAM User Guide](#).

⚠️ **Warning**

Changing the permissions for a service role might break AWS Glue functionality. Edit service roles only when AWS Glue provides guidance to do so.

For detailed instructions on creating a service role for AWS Glue, see [Step 1: Create an IAM policy for the AWS Glue service](#) and [Step 2: Create an IAM role for AWS Glue](#).

Service-linked roles for AWS Glue

| Supports service-linked roles | No |

A service-linked role is a type of service role that is linked to an AWS service. The service can assume the role to perform an action on your behalf. Service-linked roles appear in your AWS
account and are owned by the service. An IAM administrator can view, but not edit the permissions for service-linked roles.

For details about creating or managing service-linked roles, see AWS services that work with IAM. Find a service in the table that includes a Yes in the Service-linked role column. Choose the Yes link to view the service-linked role documentation for that service.

Configuring IAM permissions for AWS Glue

You use AWS Identity and Access Management (IAM) to define policies and roles that AWS Glue uses to access resources. The following steps lead you through various options for setting up the permissions for AWS Glue. Depending on your business needs, you might have to add or reduce access to your resources.

Note

To get started with basic IAM permissions for AWS Glue instead, see Setting up IAM permissions for AWS Glue.

1. Create an IAM policy for the AWS Glue service: Create a service policy that allows access to AWS Glue resources.
2. Create an IAM role for AWS Glue: Create an IAM role, and attach the AWS Glue service policy and a policy for your Amazon Simple Storage Service (Amazon S3) resources that are used by AWS Glue.
3. Attach a policy to users or groups that access AWS Glue: Attach policies to any users or groups that sign in to the AWS Glue console.
4. Create an IAM policy for notebooks: Create a notebook server policy to use in the creation of notebook servers on development endpoints.
5. Create an IAM role for notebooks: Create an IAM role and attach the notebook server policy.
6. Create an IAM policy for Amazon SageMaker notebooks: Create an IAM policy to use when creating Amazon SageMaker notebooks on development endpoints.
7. Create an IAM role for Amazon SageMaker notebooks: Create an IAM role and attach the policy to grant permissions when creating Amazon SageMaker notebooks on development endpoints.
Step 1: Create an IAM policy for the AWS Glue service

For any operation that accesses data on another AWS resource, such as accessing your objects in Amazon S3, AWS Glue needs permission to access the resource on your behalf. You provide those permissions by using AWS Identity and Access Management (IAM).

Note
You can skip this step if you use the AWS managed policy AWSGlueServiceRole.

In this step, you create a policy that is similar to AWSGlueServiceRole. You can find the most current version of AWSGlueServiceRole on the IAM console.

To create an IAM policy for AWS Glue

This policy grants permission for some Amazon S3 actions to manage resources in your account that are needed by AWS Glue when it assumes the role using this policy. Some of the resources that are specified in this policy refer to default names that are used by AWS Glue for Amazon S3 buckets, Amazon S3 ETL scripts, CloudWatch Logs, and Amazon EC2 resources. For simplicity, AWS Glue writes some Amazon S3 objects into buckets in your account prefixed with aws-glue-* by default.

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/
2. In the left navigation pane, choose Policies.
3. Choose Create Policy.
4. On the Create Policy screen, navigate to a tab to edit JSON. Create a policy document with the following JSON statements, and then choose Review policy.

Note
Add any permissions needed for Amazon S3 resources. You might want to scope the resources section of your access policy to only those resources that are required.

```json
{
    "Version": "2012-10-17",
```
"Statement": [  
  {  
    "Effect": "Allow",
    "Action": [  
      "glue:*",
      "s3:GetBucketLocation",
      "s3:ListBucket",
      "s3:ListAllMyBuckets",
      "s3:GetBucketAcl",
      "ec2:DescribeVpcEndpoints",
      "ec2:DescribeRouteTables",
      "ec2:CreateNetworkInterface",
      "ec2:DeleteNetworkInterface",
      "ec2:DescribeNetworkInterfaces",
      "ec2:DescribeSecurityGroups",
      "ec2:DescribeSubnets",
      "ec2:DescribeVpcAttribute",
      "iam:ListRolePolicies",
      "iam:GetRole",
      "iam:GetRolePolicy",
      "cloudwatch:PutMetricData"
    ],
    "Resource": [  
      "*
    ]
  },
  {  
    "Effect": "Allow",
    "Action": [  
      "s3:CreateBucket",
      "s3:PutBucketPublicAccessBlock"
    ],
    "Resource": [  
      "arn:aws:s3:::aws-glue-*"
    ]
  },
  {  
    "Effect": "Allow",
    "Action": [  
      "s3:GetObject",
      "s3:PutObject",
      "s3:DeleteObject"
    ],
    "Resource": [  
      "*
    ]
  ]
]
Configuring IAM permissions for AWS Glue

"arn:aws:s3:::aws-glue-*/*",
"arn:aws:s3:::*/*aws-glue-*/*"
],
}
{
"Effect": "Allow",
"Action": [
"s3:GetObject"
],
"Resource": [
"arn:aws:s3:::crawler-public*",
"arn:aws:s3:::aws-glue-*"
]
},
{
"Effect": "Allow",
"Action": [
"logs:CreateLogGroup",
"logs:CreateLogStream",
"logs:PutLogEvents",
"logs:AssociateKmsKey"
],
"Resource": [
"arn:aws:logs:*:*:log-group:/aws-glue/*"
]
},
{
"Effect": "Allow",
"Action": [
"ec2:CreateTags",
"ec2:DeleteTags"
],
"Condition": {
"ForAllValues:StringEquals": {
"aws:TagKeys": [
"aws-glue-service-resource"
]
}
},
"Resource": [
"arn:aws:ec2:*:*:network-interface/*",
"arn:aws:ec2:*:*:security-group/*",
"arn:aws:ec2:*:*:instance/*"]
The following table describes the permissions granted by this policy.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;glue:*&quot;</td>
<td>&quot;*&quot;</td>
<td>Grants permission to run all AWS Glue API operations.</td>
</tr>
<tr>
<td>&quot;s3:GetBucketLocation&quot;, &quot;s3:ListBucket&quot;, &quot;s3:ListAllMyBuckets&quot;, &quot;s3:GetBucketAcl&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing of Amazon S3 buckets from crawlers, jobs, development endpoints, and notebook servers.</td>
</tr>
<tr>
<td>&quot;ec2:DescribeVpcEndpoints&quot;, &quot;ec2:DescribeRouteTables&quot;, &quot;ec2:CreateNetwork Interface&quot;, &quot;ec2:DeleteNetworkInterface&quot;, &quot;ec2:DescribeNetworkInterfaces&quot;, &quot;ec2:DescribeSecurityGroups&quot;, &quot;ec2:DescribeSubnets&quot;, &quot;ec2:DescribeVpcAttribute&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows the setup of Amazon EC2 network items, such as virtual private clouds (VPCs) when running jobs, crawlers, and development endpoints.</td>
</tr>
<tr>
<td>&quot;iam:ListRolePolicies&quot;, &quot;iam:GetRole&quot;, &quot;iam:GetRolePolicy&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing IAM roles from crawlers, jobs, development endpoints, and notebook servers.</td>
</tr>
<tr>
<td>&quot;cloudwatch:PutMetricData&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows writing CloudWatch metrics for jobs.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| "s3:CreateBucket", "s3:PutBucketPublicAccessBlock" | "arn:aws:s3:::aws-glue-*" | Allows the creation of Amazon S3 buckets in your account from jobs and notebook servers. 
Naming convention: Uses Amazon S3 folders named `aws-glue-`. 
Enables AWS Glue to create buckets that block public access. |
| "s3:GetObject", "s3:PutObject", "s3:DeleteObject" | "arn:aws:s3:::aws-glue-*/**", "arn:aws:s3:::*/*aws-glue-*/**" | Allows get, put, and delete of Amazon S3 objects into your account when storing objects such as ETL scripts and notebook server locations. 
Naming convention: Grants permission to Amazon S3 buckets or folders whose names are prefixed with `aws-glue-`. |
| "s3:GetObject" | "arn:aws:s3:::crawler-public*/**, "arn:aws:s3:::aws-glue-*" | Allows get of Amazon S3 objects used by examples and tutorials from crawlers and jobs. 
Naming convention: Amazon S3 bucket names begin with `crawler-public` and `aws-glue-`. |
<table>
<thead>
<tr>
<th><strong>Action</strong></th>
<th><strong>Resource</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
</table>

5. On the **Review Policy** screen, enter your **Policy Name**, for example **GlueServiceRolePolicy**. Enter an optional description, and when you're satisfied with the policy, choose **Create policy**.

### Step 2: Create an IAM role for AWS Glue

You need to grant your IAM role permissions that AWS Glue can assume when calling other services on your behalf. This includes access to Amazon S3 for any sources, targets, scripts, and temporary directories that you use with AWS Glue. Permission is needed by crawlers, jobs, and development endpoints.

You provide those permissions by using AWS Identity and Access Management (IAM). Add a policy to the IAM role that you pass to AWS Glue.

**To create an IAM role for AWS Glue**

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).
2. In the left navigation pane, choose **Roles**.
3. Choose **Create role**.
4. For role type, choose **AWS Service**, find and choose **Glue**, and choose **Next: Permissions**.

5. On the **Attach permissions policy** page, choose the policies that contain the required permissions; for example, the AWS managed policy **AWSGlueServiceRole** for general AWS Glue permissions and the AWS managed policy **AmazonS3FullAccess** for access to Amazon S3 resources. Then choose **Next: Review**.

**Note**

Ensure that one of the policies in this role grants permissions to your Amazon S3 sources and targets. You might want to provide your own policy for access to specific Amazon S3 resources. Data sources require `s3:ListBucket` and `s3:GetObject` permissions. Data targets require `s3:ListBucket`, `s3:PutObject`, and `s3:DeleteObject` permissions. For more information about creating an Amazon S3 policy for your resources, see [Specifying Resources in a Policy](#). For an example Amazon S3 policy, see [Writing IAM Policies: How to Grant Access to an Amazon S3 Bucket](#).

If you plan to access Amazon S3 sources and targets that are encrypted with SSE-KMS, attach a policy that allows AWS Glue crawlers, jobs, and development endpoints to decrypt the data. For more information, see [Protecting Data Using Server-Side Encryption with AWS KMS-Managed Keys (SSE-KMS)](#).

The following is an example.

```json
{
    "Version":"2012-10-17",
    "Statement":[
        {
            "Effect":"Allow",
            "Action":[
                "kms:Decrypt"
            ],
            "Resource":[
                "arn:aws:kms:*:account-id-without-hyphens:key/key-id"
            ]
        }
    ]
}
```

6. For **Role name**, enter a name for your role; for example, **AWSGlueServiceRoleDefault**. Create the role with the name prefixed with the string **AWSGlueServiceRole** to allow the
role to be passed from console users to the service. AWS Glue provided policies expect IAM service roles to begin with AWSGlueServiceRole. Otherwise, you must add a policy to allow your users the `iam:PassRole` permission for IAM roles to match your naming convention. Choose **Create Role**.

**Note**

When you create a notebook with a role, that role is then passed to interactive sessions so that the same role can be used in both places. As such, the `iam:PassRole` permission needs to be part of the role's policy.

Create a new policy for your role using the following example. Replace the account number with your own and the role name.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": "iam:PassRole",
         "Resource": "arn:aws:iam::090000000210:role/<role_name>"
      }
   ]
}
```

**Step 3: Attach a policy to users or groups that access AWS Glue**

The administrator must assign permissions to any users, groups, or roles using the AWS Glue console or AWS Command Line Interface (AWS CLI). You provide those permissions by using AWS Identity and Access Management (IAM), through policies. This step describes assigning permissions to users or groups.

When you finish this step, your user or group has the following policies attached:

- The AWS managed policy `AWSGlueConsoleFullAccess` or the custom policy `GlueConsoleAccessPolicy`
- `AWSGlueConsoleSageMakerNotebookFullAccess`
To attach an inline policy and embed it in a user or group

You can attach an AWS managed policy or an inline policy to a user or group to access the AWS Glue console. Some of the resources specified in this policy refer to default names that are used by AWS Glue for Amazon S3 buckets, Amazon S3 ETL scripts, CloudWatch Logs, AWS CloudFormation, and Amazon EC2 resources. For simplicity, AWS Glue writes some Amazon S3 objects into buckets in your account prefixed with `aws-glue-*` by default.

**Note**

You can skip this step if you use the AWS managed policy `AWSGlueConsoleFullAccess`.

**Important**

AWS Glue needs permission to assume a role that is used to perform work on your behalf. To accomplish this, you add the `iam:PassRole` permissions to your AWS Glue users or groups. This policy grants permission to roles that begin with `AWSGlueServiceRole` for AWS Glue service roles, and `AWSGlueServiceNotebookRole` for roles that are required when you create a notebook server. You can also create your own policy for `iam:PassRole` permissions that follows your naming convention. Per security best practices, it is recommended to restrict access by tightening policies to further restrict access to Amazon S3 bucket and Amazon CloudWatch log groups. For an example Amazon S3 policy, see [Writing IAM Policies: How to Grant Access to an Amazon S3 Bucket](https://docs.aws.amazon.com/iam/latest/userguide/s3-policy-examples.html).

In this step, you create a policy that is similar to `AWSGlueConsoleFullAccess`. You can find the most current version of `AWSGlueConsoleFullAccess` on the IAM console.

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).
2. In the navigation pane, choose Users or User groups.
3. In the list, choose the name of the user or group to embed a policy in.

4. Choose the Permissions tab and, if necessary, expand the Permissions policies section.

5. Choose the Add Inline policy link.

6. On the Create Policy screen, navigate to a tab to edit JSON. Create a policy document with the following JSON statements, and then choose Review policy.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
      }
   ]
}
```
Configuring IAM permissions for AWS Glue

```
"cloudwatch:GetMetricData",
"cloudwatch:ListDashboards"
],
"Resource": [ "*
"
],
}
{
"Effect": "Allow",
"Action": [ "s3:GetObject",
"s3:PutObject"
],
"Resource": [ "arn:aws:s3:::*/*aws-glue-*/", "arn:aws:s3:::aws-glue-*"
]
},
{
"Effect": "Allow",
"Action": [ "tag:GetResources"
],
"Resource": [ "*
"
]
},
{
"Effect": "Allow",
"Action": [ "s3:CreateBucket",
"s3:PutBucketPublicAccessBlock" ],
"Resource": [ "arn:aws:s3:::aws-glue-*"
]
},
{
"Effect": "Allow",
"Action": [ "logs:GetLogEvents"
],
"Resource": [ "arn:aws:logs:::aws-glue/**"
]
```
Configuring IAM permissions for AWS Glue

```json
],
{
  "Effect": "Allow",
  "Action": [
    "cloudformation:CreateStack",
    "cloudformation:DeleteStack"
  ],
  "Resource": "arn:aws:cloudformation:*:*:stack/aws-glue*/*"
},
{
  "Effect": "Allow",
  "Action": [
    "ec2:RunInstances"
  ],
  "Resource": [
    "arn:aws:ec2:*:*:instance/**",
    "arn:aws:ec2:*:*:key-pair/**",
    "arn:aws:ec2:*:*:image/**",
    "arn:aws:ec2:*:*:security-group/**",
    "arn:aws:ec2:*:*:network-interface/**",
    "arn:aws:ec2:*:*:subnet/**",
    "arn:aws:ec2:*:*:volume/**"
  ]
},
{
  "Action": [
    "iam:PassRole"
  ],
  "Effect": "Allow",
  "Resource": "arn:aws:iam::*:role/AWSGlueServiceRole*",
  "Condition": {
    "StringLike": {
      "iam:PassedToService": [
        "glue.amazonaws.com"
      ]
    }
  }
},
{
  "Action": [
    "iam:PassRole"
  ],
  "Effect": "Allow",
  "Resource": "arn:aws:iam::*:role/AWSGlueServiceNotebookRole*",
}
The following table describes the permissions granted by this policy.
<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;glue:*&quot;</td>
<td>&quot;*&quot;</td>
<td>Grants permission to run all AWS Glue API operations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If you had previously created your policy without the &quot;glue:*&quot; action, you must add the following individual permissions to your policy:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:ListCrawlers&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:BatchGetCrawlers&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:ListTriggers&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:BatchGetTriggers&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:ListDevEndpoints&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:BatchGetDevEndpoints&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:ListJobs&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;glue:BatchGetJobs&quot;</td>
</tr>
<tr>
<td>&quot;redshift:Describe Clusters&quot;, &quot;redshift:DescribeClusterSubnetGroups&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows creation of connections to Amazon Redshift.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;iam:ListRoles&quot;, &quot;iam:ListRolePolicies&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing IAM roles when working with crawlers, jobs, development endpoints, and notebook servers.</td>
</tr>
<tr>
<td>&quot;iam:GetRole&quot;, &quot;iam:GetRolePolicy&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;iam:ListAttachedRolePolicies&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;ec2:DescribeSecurityGroups&quot;, &quot;ec2:DescribeSubnets&quot;, &quot;ec2:DescribeVpcs&quot;, &quot;ec2:DescribeVpcEndpoints&quot;, &quot;ec2:DescribeRouteTables&quot;, &quot;ec2:DescribeVpcAttribute&quot;, &quot;ec2:DescribeKeyPairs&quot;, &quot;ec2:DescribeInstances&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows setup of Amazon EC2 network items, such as VPCs, when running jobs, crawlers, and development endpoints.</td>
</tr>
<tr>
<td>&quot;rds:DescribeDBInstances&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows creation of connections to Amazon RDS.</td>
</tr>
<tr>
<td>&quot;s3:ListAllMyBuckets&quot;, &quot;s3:ListBucket&quot;, &quot;s3:GetBucketAcl&quot;, &quot;s3:GetBucketLocation&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing of Amazon S3 buckets when working with crawlers, jobs, development endpoints, and notebook servers.</td>
</tr>
<tr>
<td>&quot;dynamodb:ListTables&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing of DynamoDB tables.</td>
</tr>
<tr>
<td>&quot;kms:ListAliases&quot;, &quot;kms:DescribeKey&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows working with KMS keys.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;cloudwatch:GetMetricData&quot;, &quot;cloudwatch:ListDashboards&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows working with CloudWatch metrics.</td>
</tr>
<tr>
<td>&quot;s3:GetObject&quot;, &quot;s3:PutObject&quot;</td>
<td>&quot;arn:aws:s3::: aws-glue-<em>/</em>&quot;, &quot;arn:aws:s3::: <em>/<em>aws-glue-</em>/</em>&quot;, &quot;arn:aws:s3::: aws-glue-*&quot;</td>
<td>Allows get and put of Amazon S3 objects into your account when storing objects such as ETL scripts and notebook server locations. Naming convention: Grants permission to Amazon S3 buckets or folders whose names are prefixed with <code>aws-glue-</code>.</td>
</tr>
<tr>
<td>&quot;tag:GetResources&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows retrieval of AWS tags.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;s3:CreateBucket&quot;,</td>
<td>&quot;arn:aws:s3::: aws-glue-*&quot;</td>
<td>Allows creation of an Amazon S3 bucket into your account when storing objects such as ETL scripts and notebook server locations. Naming convention: Grants permission to Amazon S3 buckets whose names are prefixed with <strong>aws-glue-</strong>. Enables AWS Glue to create buckets that block public access.</td>
</tr>
<tr>
<td>&quot;s3:PutBucketPublicAccessBlock&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;logs:GetLogEvents&quot;</td>
<td>&quot;arn:aws:logs:::<em>:: /aws-glue/</em>&quot;</td>
<td>Allows retrieval of CloudWatch Logs. Naming convention: AWS Glue writes logs to log groups whose names begin with <strong>aws-glue-</strong>.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;cloudformation:CreateStack&quot;, &quot;cloudformation:DeleteStack&quot;</td>
<td>&quot;arn:aws:cloudformation:<em>:</em>:stack/aws-glue*/*&quot;</td>
<td>Allows managing AWS CloudFormation stacks when working with notebook servers. Naming convention: AWS Glue creates stacks whose names begin with <strong>aws-glue</strong>.</td>
</tr>
<tr>
<td>&quot;iam:PassRole&quot;</td>
<td>&quot;arn:aws:iam::*:role/ AWSGlueServiceRole&quot;</td>
<td>Allows AWS Glue to assume PassRole permission for roles that begin with AWSGlueServiceRole.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;iam:PassRole&quot;</td>
<td>&quot;arn:aws:iam::<em>:role/ AWSGlueServiceNotebookRole</em>&quot;</td>
<td>Allows Amazon EC2 to assume PassRole permission for roles that begin with AWSGlueServiceNotebookRole.</td>
</tr>
<tr>
<td>&quot;iam:PassRole&quot;</td>
<td>&quot;arn:aws:iam::<em>:role/service-role/ AWSGlueServiceRole</em>&quot;</td>
<td>Allows AWS Glue to assume PassRole permission for roles that begin with service-role/ AWSGlueServiceRole.</td>
</tr>
</tbody>
</table>

7. On the **Review policy** screen, enter a name for the policy, for example **GlueConsoleAccessPolicy**. When you're satisfied with the policy, choose **Create policy**. Ensure that no errors appear in a red box at the top of the screen. Correct any that are reported.

**Note**

If **Use autoformatting** is selected, the policy is reformatted whenever you open a policy or choose **Validate Policy**.

---

**To attach the AWSGlueConsoleFullAccess managed policy**

You can attach the **AWSGlueConsoleFullAccess** policy to provide permissions that are required by the AWS Glue console user.

**Note**

You can skip this step if you created your own policy for AWS Glue console access.
1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.

2. In the navigation pane, choose Policies.

3. In the list of policies, select the check box next to the **AWSGlueConsoleFullAccess**. You can use the Filter menu and the search box to filter the list of policies.

4. Choose Policy actions, and then choose Attach.

5. Choose the user to attach the policy to. You can use the Filter menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose Attach policy.

To attach the **AWSGlueConsoleSageMakerNotebookFullAccess** managed policy

You can attach the **AWSGlueConsoleSageMakerNotebookFullAccess** policy to a user to manage SageMaker notebooks created on the AWS Glue console. In addition to other required AWS Glue console permissions, this policy grants access to resources needed to manage SageMaker notebooks.

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.

2. In the navigation pane, choose Policies.

3. In the list of policies, select the check box next to the **AWSGlueConsoleSageMakerNotebookFullAccess**. You can use the Filter menu and the search box to filter the list of policies.

4. Choose Policy actions, and then choose Attach.

5. Choose the user to attach the policy to. You can use the Filter menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose Attach policy.

To attach the **CloudWatchLogsReadOnlyAccess** managed policy

You can attach the **CloudWatchLogsReadOnlyAccess** policy to a user to view the logs created by AWS Glue on the CloudWatch Logs console.

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane, choose **Policies**.

3. In the list of policies, select the check box next to the **CloudWatchLogsReadOnlyAccess**. You can use the **Filter** menu and the search box to filter the list of policies.

4. Choose **Policy actions**, and then choose **Attach**.

5. Choose the user to attach the policy to. You can use the **Filter** menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose **Attach policy**.

**To attach the AWSCloudFormationReadOnlyAccess managed policy**

You can attach the **AWSCloudFormationReadOnlyAccess** policy to a user to view the AWS CloudFormation stacks used by AWS Glue on the AWS CloudFormation console.

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).

2. In the navigation pane, choose **Policies**.

3. In the list of policies, select the check box next to **AWSCloudFormationReadOnlyAccess**. You can use the **Filter** menu and the search box to filter the list of policies.

4. Choose **Policy actions**, and then choose **Attach**.

5. Choose the user to attach the policy to. You can use the **Filter** menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose **Attach policy**.

**To attach the AmazonAthenaFullAccess managed policy**

You can attach the **AmazonAthenaFullAccess** policy to a user to view Amazon S3 data in the Athena console.

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).

2. In the navigation pane, choose **Policies**.

3. In the list of policies, select the check box next to **AmazonAthenaFullAccess**. You can use the **Filter** menu and the search box to filter the list of policies.

4. Choose **Policy actions**, and then choose **Attach**.
5. Choose the user to attach the policy to. You can use the Filter menu and the search box to filter the list of principal entities. After choosing the user to attach the policy to, choose Attach policy.

**Step 4: Create an IAM policy for notebook servers**

If you plan to use notebooks with development endpoints, you must specify permissions when you create the notebook server. You provide those permissions by using AWS Identity and Access Management (IAM).

This policy grants permission for some Amazon S3 actions to manage resources in your account that are needed by AWS Glue when it assumes the role using this policy. Some of the resources that are specified in this policy refer to default names used by AWS Glue for Amazon S3 buckets, Amazon S3 ETL scripts, and Amazon EC2 resources. For simplicity, AWS Glue defaults writing some Amazon S3 objects into buckets in your account prefixed with aws-glue-*.  

⚠️ **Note**

You can skip this step if you use the AWS managed policy AWSGlueServiceNotebookRole.

In this step, you create a policy that is similar to AWSGlueServiceNotebookRole. You can find the most current version of AWSGlueServiceNotebookRole on the IAM console.

### To create an IAM policy for notebooks

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).
2. In the left navigation pane, choose Policies.
3. Choose Create Policy.
4. On the Create Policy screen, navigate to a tab to edit JSON. Create a policy document with the following JSON statements, and then choose Review policy.

```json
{
    "Version":"2012-10-17",
    "Statement":[
        
```
"Effect": "Allow",
"Action": [
  "glue:CreateDatabase",
  "glue:CreatePartition",
  "glue:CreateTable",
  "glue:DeleteDatabase",
  "glue:DeletePartition",
  "glue:DeleteTable",
  "glue:GetDatabase",
  "glue:GetDatabases",
  "glue:GetPartition",
  "glue:GetPartitions",
  "glue:GetTable",
  "glue:GetTableVersions",
  "glue:GetTables",
  "glue:UpdateDatabase",
  "glue:UpdatePartition",
  "glue:UpdateTable",
  "glue:GetJobBookmark",
  "glue:ResetJobBookmark",
  "glue:CreateConnection",
  "glue:CreateJob",
  "glue:DeleteConnection",
  "glue:DeleteJob",
  "glue:GetConnection",
  "glue:GetConnections",
  "glue:GetDevEndpoint",
  "glue:GetDevEndpoints",
  "glue:GetJob",
  "glue:GetJobs",
  "glue:UpdateJob",
  "glue:BatchDeleteConnection",
  "glue:UpdateConnection",
  "glue:GetUserDefinedFunction",
  "glue:UpdateUserDefinedFunction",
  "glue:GetUserDefinedFunctions",
  "glue:DeleteUserDefinedFunction",
  "glue:CreateUserDefinedFunction",
  "glue:BatchGetPartition",
  "glue:BatchDeletePartition",
  "glue:BatchCreatePartition",
  "glue:BatchDeleteTable",
  "glue:UpdateDevEndpoint",
  "s3:GetBucketLocation",
]
"s3:ListBucket",
  "s3:ListAllMyBuckets",
  "s3:GetBucketAcl"
],
"Resource": [  "*"
]
},
{
  "Effect": "Allow",
  "Action": [  "s3:GetObject"
  ],
  "Resource": [  "arn:aws:s3:::crawler-public*",  "arn:aws:s3:::aws-glue*"
  ]
},
{
  "Effect": "Allow",
  "Action": [  "s3:PutObject",
  "s3:DeleteObject"
  ],
  "Resource": [  "arn:aws:s3:::aws-glue*"
  ]
},
{
  "Effect": "Allow",
  "Action": [  "ec2:CreateTags",
  "ec2:DeleteTags"
  ],
  "Condition": {
    "ForAllValues:StringEquals": {
      "aws:TagKeys": [  "aws-glue-service-resource"
    ]
  }
},
The following table describes the permissions granted by this policy.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;glue:*&quot;</td>
<td>&quot;*&quot;</td>
<td>Grants permission to run all AWS Glue API operations.</td>
</tr>
<tr>
<td>&quot;s3:GetBucketLocation&quot;, &quot;s3:ListBucket&quot;, &quot;s3:ListAllMyBuckets&quot;, &quot;s3:GetBucketAcl&quot;</td>
<td>&quot;*&quot;</td>
<td>Allows listing of Amazon S3 buckets from notebook servers.</td>
</tr>
<tr>
<td>&quot;s3:GetObject&quot;</td>
<td>&quot;arn:aws:s3:::crawler-public*&quot;, &quot;arn:aws:s3:::aws-glue-*&quot;</td>
<td>Allows get of Amazon S3 objects used by examples and tutorials from notebooks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Naming convention: Amazon S3 bucket names begin with <strong>crawler-public</strong> and <strong>aws-glue</strong>.</td>
</tr>
<tr>
<td>&quot;s3:PutObject&quot;, &quot;s3:DeleteObject&quot;</td>
<td>&quot;arn:aws:s3:::aws-glue*&quot;</td>
<td>Allows put and delete of Amazon S3 objects into your account from notebooks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Naming convention: Uses Amazon S3 folders named <strong>aws-glue</strong>.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;ec2:DeleteTags&quot;</td>
<td>&quot;arn:aws:ec2:<em>:</em>:instance/*&quot;</td>
<td>Naming convention: AWS Glue tags Amazon EC2 instances with <code>aws-glue-service-resource</code>.</td>
</tr>
</tbody>
</table>

5. On the **Review Policy** screen, enter your **Policy Name**, for example **GlueServiceNotebookPolicyDefault**. Enter an optional description, and when you're satisfied with the policy, choose **Create policy**.

**Step 5: Create an IAM role for notebook servers**

If you plan to use notebooks with development endpoints, you need to grant the IAM role permissions. You provide those permissions by using AWS Identity and Access Management IAM, through an IAM role.

**Note**

When you create an IAM role using the IAM console, the console creates an instance profile automatically and gives it the same name as the role to which it corresponds.

**To create an IAM role for notebooks**

1. Sign in to the AWS Management Console and open the IAM console at [https://console.aws.amazon.com/iam/](https://console.aws.amazon.com/iam/).
2. In the left navigation pane, choose **Roles**.
3. Choose **Create role**.
4. For role type, choose **AWS Service**, find and choose **EC2**, and choose the **EC2** use case, then choose **Next: Permissions**.
5. On the **Attach permissions policy** page, choose the policies that contain the required permissions; for example, **AWSGlueServiceNotebookRole** for general AWS Glue permissions.
and the AWS managed policy **AmazonS3FullAccess** for access to Amazon S3 resources. Then choose **Next: Review**.

**Note**

Ensure that one of the policies in this role grants permissions to your Amazon S3 sources and targets. Also confirm that your policy allows full access to the location where you store your notebook when you create a notebook server. You might want to provide your own policy for access to specific Amazon S3 resources. For more information about creating an Amazon S3 policy for your resources, see **Specifying Resources in a Policy**.

If you plan to access Amazon S3 sources and targets that are encrypted with SSE-KMS, attach a policy that allows notebooks to decrypt the data. For more information, see **Protecting Data Using Server-Side Encryption with AWS KMS-Managed Keys (SSE-KMS)**.

The following is an example.

```json
{
    "Version":"2012-10-17",
    "Statement":[
    {
        "Effect":"Allow",
        "Action": [
            "kms:Decrypt"
        ],
        "Resource": [
            "arn:aws:kms:*
account-id-without-hyphens:*
key-id"
        ]
    }
    ]
}
```

6. For **Role name**, enter a name for your role. Create the role with the name prefixed with the string **AWSGlueServiceNotebookRole** to allow the role to be passed from console users to the notebook server. AWS Glue provided policies expect IAM service roles to begin with **AWSGlueServiceNotebookRole**. Otherwise you must add a policy to your users to allow the **iam:PassRole** permission for IAM roles to match your naming convention. For example, enter **AWSGlueServiceNotebookRoleDefault**. Then choose **Create role**.
Step 6: Create an IAM policy for SageMaker notebooks

If you plan to use SageMaker notebooks with development endpoints, you must specify permissions when you create the notebook. You provide those permissions by using AWS Identity and Access Management (IAM).

To create an IAM policy for SageMaker notebooks

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the left navigation pane, choose Policies.
3. Choose Create Policy.
4. On the Create Policy page, navigate to a tab to edit the JSON. Create a policy document with the following JSON statements. Edit `bucket-name`, `region-code`, and `account-id` for your environment.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "s3:ListBucket"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:s3:::bucket-name"
            ]
        },
        {
            "Action": [
                "s3:GetObject"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:s3:::bucket-name*"
            ]
        },
        {
            "Action": [
                "logs:CreateLogStream",
                "logs:DescribeLogStreams",
                "logs:PutLogEvents"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:logs:*:*:log-group:/aws/sagemaker/*"
            ]
        }
    ]
}
```
Then choose **Review policy**.

The following table describes the permissions granted by this policy.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;s3:ListBucket*&quot;</td>
<td>&quot;arn:aws:s3:: bucket-name&quot;</td>
<td>Grants permission to list Amazon S3 buckets.</td>
</tr>
<tr>
<td>Action</td>
<td>Resource</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;s3:GetObject&quot;</td>
<td>&quot;arn:aws:s3::: bucket-name *&quot;</td>
<td>Grants permission to get Amazon S3 objects that are used by SageMaker notebooks.</td>
</tr>
<tr>
<td>&quot;glue:GetDevEndpoints&quot;</td>
<td>&quot;arn:aws:glue: region-code :account-id :devEndpoint/*&quot;</td>
<td></td>
</tr>
</tbody>
</table>

5. On the **Review Policy** screen, enter your **Policy Name**, for example **AWSGlueSageMakerNotebook**. Enter an optional description, and when you're satisfied with the policy, choose **Create policy**.
Step 7: Create an IAM role for SageMaker notebooks

If you plan to use SageMaker notebooks with development endpoints, you need to grant the IAM role permissions. You provide those permissions by using AWS Identity and Access Management (IAM), through an IAM role.

To create an IAM role for SageMaker notebooks

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the left navigation pane, choose Roles.
3. Choose Create role.
4. For role type, choose AWS Service, find and choose SageMaker, and then choose the SageMaker - Execution use case. Then choose Next: Permissions.
5. On the Attach permissions policy page, choose the policies that contain the required permissions; for example, AmazonSageMakerFullAccess. Choose Next: Review.

   If you plan to access Amazon S3 sources and targets that are encrypted with SSE-KMS, attach a policy that allows notebooks to decrypt the data, as shown in the following example. For more information, see Protecting Data Using Server-Side Encryption with AWS KMS-Managed Keys (SSE-KMS).

   ```json
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": ["kms:Decrypt"],
         "Resource": [
           "arn:aws:kms:*:account-id-without-hyphens:key/key-id"
         ]
       }
     ]
   }
   ```

6. For Role name, enter a name for your role. To allow the role to be passed from console users to SageMaker, use a name that is prefixed with the string AWSGlueServiceSageMakerNotebookRole. AWS Glue provided policies expect IAM roles...
to begin with AWSServiceSageMakerNotebookRole. Otherwise you must add a policy to your users to allow the iam:PassRole permission for IAM roles to match your naming convention.

For example, enter AWSServiceSageMakerNotebookRole-Default, and then choose Create role.

7. After you create the role, attach the policy that allows additional permissions required to create SageMaker notebooks from AWS Glue.

Open the role that you just created, AWSServiceSageMakerNotebookRole-Default, and choose Attach policies. Attach the policy that you created named AWSServiceSageMakerNotebook to the role.

AWS Glue access control policy examples

This section contains examples of both identity-based (IAM) access control policies and AWS Glue resource policies.

Contents
- Identity-based policy examples for AWS Glue
  - Policy best practices
  - Resource-level permissions only apply to specific AWS Glue objects
- Using the AWS Glue console
- Allow users to view their own permissions
- Grant read-only permission to a table
- Filter tables by GetTables permission
- Grant full access to a table and all partitions
- Control access by name prefix and explicit denial
- Grant access using tags
- Deny access using tags
- Use tags with list and batch API operations
- Control settings using condition keys or context keys
  - Control policies that control settings using condition keys
  - Control policies that control settings using context keys
- Deny an identity the ability to create data preview sessions
- Resource-based policy examples for AWS Glue
  - Considerations for using resource-based policies with AWS Glue
  - Use a resource policy to control access in the same account

Identity-based policy examples for AWS Glue

By default, users and roles don’t have permission to create or modify AWS Glue resources. They also can’t perform tasks by using the AWS Management Console, AWS Command Line Interface (AWS CLI), or AWS API. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies. The administrator can then add the IAM policies to roles, and users can assume the roles.

To learn how to create an IAM identity-based policy by using these example JSON policy documents, see Creating IAM policies in the IAM User Guide.

For details about actions and resource types defined by AWS Glue, including the format of the ARNs for each of the resource types, see Actions, resources, and condition keys for AWS Glue in the Service Authorization Reference.

**Note**
The examples provided in this section all use the us-west-2 Region. You can replace this with the AWS Region that you want to use.

Topics

- Policy best practices
- Resource-level permissions only apply to specific AWS Glue objects
- Using the AWS Glue console
- Allow users to view their own permissions
- Grant read-only permission to a table
- Filter tables by GetTables permission
- Grant full access to a table and all partitions
- Control access by name prefix and explicit denial
- Grant access using tags
- Deny access using tags
- Use tags with list and batch API operations
- Control settings using condition keys or context keys
- Deny an identity the ability to create data preview sessions

Policy best practices

Identity-based policies determine whether someone can create, access, or delete AWS Glue resources in your account. These actions can incur costs for your AWS account. When you create or edit identity-based policies, follow these guidelines and recommendations:

- **Get started with AWS managed policies and move toward least-privilege permissions** – To get started granting permissions to your users and workloads, use the *AWS managed policies* that grant permissions for many common use cases. They are available in your AWS account. We recommend that you reduce permissions further by defining AWS customer managed policies that are specific to your use cases. For more information, see [AWS managed policies](https://docs.aws.amazon.com/IAM/latest/userguide/using-managed-policies.html) or [AWS managed policies for job functions](https://docs.aws.amazon.com/IAM/latest/userguide/using-managed-policies-for-job-functions.html) in the *IAM User Guide*.

- **Apply least-privilege permissions** – When you set permissions with IAM policies, grant only the permissions required to perform a task. You do this by defining the actions that can be taken on specific resources under specific conditions, also known as *least-privilege permissions*. For more information about using IAM to apply permissions, see [Policies and permissions in IAM](https://docs.aws.amazon.com/IAM/latest/userguide/policies-and-permissions-in-iam.html) in the *IAM User Guide*.

- **Use conditions in IAM policies to further restrict access** – You can add a condition to your policies to limit access to actions and resources. For example, you can write a policy condition to specify that all requests must be sent using SSL. You can also use conditions to grant access to service actions if they are used through a specific AWS service, such as AWS CloudFormation. For more information, see [IAM JSON policy elements: Condition](https://docs.aws.amazon.com/IAM/latest/userguide/iam-policy-syntax-condition.html) in the *IAM User Guide*.

- **Use IAM Access Analyzer to validate your IAM policies to ensure secure and functional permissions** – IAM Access Analyzer validates new and existing policies so that the policies adhere to the IAM policy language (JSON) and IAM best practices. IAM Access Analyzer provides more than 100 policy checks and actionable recommendations to help you author secure and functional policies. For more information, see [IAM Access Analyzer policy validation](https://docs.aws.amazon.com/IAM/latest/userguide/iam-access-analyzer-overview.html) in the *IAM User Guide*. 
• **Require multi-factor authentication (MFA)** – If you have a scenario that requires IAM users or a root user in your AWS account, turn on MFA for additional security. To require MFA when API operations are called, add MFA conditions to your policies. For more information, see [Configuring MFA-protected API access](#) in the *IAM User Guide*.

For more information about best practices in IAM, see [Security best practices in IAM](#) in the *IAM User Guide*.

**Resource-level permissions only apply to specific AWS Glue objects**

You can only define fine-grained control for specific objects in AWS Glue. Therefore you must write your client's IAM policy so that API operations that allow Amazon Resource Names (ARNs) for the Resource statement are not mixed with API operations that don't allow ARNs.

For example, the following IAM policy allows API operations for `GetClassifier` and `GetJobRun`. It defines the Resource as `*` because AWS Glue doesn't allow ARNs for classifiers and job runs. Because ARNs are allowed for specific API operations such as `GetDatabase` and `GetTable`, ARNs can be specified in the second half of the policy.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetClassifier*",
                "glue:GetJobRun*"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "glue:Get*"
            ],
            "Resource": [
                "arn:aws:glue:us-east-1:123456789012:catalog",
                "arn:aws:glue:us-east-1:123456789012:table/default/e*1*",
                "arn:aws:glue:us-east-1:123456789012:connection/connection2"
            ]
        }
    ]
}
```
For a list of AWS Glue objects that allow ARNs, see Resource ARNs.

### Using the AWS Glue console

To access the AWS Glue console, you must have a minimum set of permissions. These permissions must allow you to list and view details about the AWS Glue resources in your AWS account. If you create an identity-based policy that is more restrictive than the minimum required permissions, the console won't function as intended for entities (users or roles) with that policy.

You don't need to allow minimum console permissions for users that are making calls only to the AWS CLI or the AWS API. Instead, allow access to only the actions that match the API operation that they're trying to perform.

To ensure that users and roles can still use the AWS Glue console, also attach the AWS Glue ConsoleAccess or ReadOnly AWS managed policy to the entities. For more information, see Adding permissions to a user in the IAM User Guide.

For a user to work with the AWS Glue console, that user must have a minimum set of permissions that allows them to work with the AWS Glue resources for their AWS account. In addition to these AWS Glue permissions, the console requires permissions from the following services:

- Amazon CloudWatch Logs permissions to display logs.
- AWS Identity and Access Management (IAM) permissions to list and pass roles.
- AWS CloudFormation permissions to work with stacks.
- Amazon Elastic Compute Cloud (Amazon EC2) permissions to list VPCs, subnets, security groups, instances, and other objects.
- Amazon Simple Storage Service (Amazon S3) permissions to list buckets and objects, and to retrieve and save scripts.
- Amazon Redshift permissions to work with clusters.
- Amazon Relational Database Service (Amazon RDS) permissions to list instances.

For more information about the permissions that users require to view and work with the AWS Glue console, see Step 3: Attach a policy to users or groups that access AWS Glue.
If you create an IAM policy that is more restrictive than the minimum required permissions, the console won’t function as intended for users with that IAM policy. To ensure that those users can still use the AWS Glue console, also attach the AWSGlueConsoleFullAccess managed policy as described in AWS managed (predefined) policies for AWS Glue.

Allow users to view their own permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "ViewOwnUserInfo",
         "Effect": "Allow",
         "Action": [
            "iam:GetUserPolicy",
            "iam:ListGroupsForUser",
            "iam:ListAttachedUserPolicies",
            "iam:ListUserPolicies",
            "iam:GetUser"
         ],
         "Resource": ["arn:aws:iam::*:user/${aws:username}"],
      },
      {
         "Sid": "NavigateInConsole",
         "Effect": "Allow",
         "Action": [
            "iam:GetGroupPolicy",
            "iam:GetPolicyVersion",
            "iam:GetPolicy",
            "iam:ListAttachedGroupPolicies",
            "iam:ListGroupPolicies",
            "iam:ListPolicyVersions",
            "iam:ListPolicies",
            "iam:ListUsers"
         ],
         "Resource": "*"
      }
   ]
}
```
Grant read-only permission to a table

The following policy grants read-only permission to a books table in database db1. For more information about resource Amazon Resource Names (ARNs), see Data Catalog ARNs.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "GetTablesActionOnBooks",
            "Effect": "Allow",
            "Action": [
                "glue:GetTables",
                "glue:GetTable"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:123456789012:table/db1/books"
            ]
        }
    ]
}
```

This policy grants read-only permission to a table named books in the database named db1. To grant Get permission to a table, permission to the catalog and database resources is also required.

The following policy grants the minimum necessary permissions to create table tb1 in database db1:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["glue:CreateTable"],
            "Resource": [
            ]
        }
    ]
}
```
Filter tables by GetTables permission

Assume that there are three tables—customers, stores, and store_sales—in database db1. The following policy grants GetTables permission to stores and store_sales, but not to customers. When you call GetTables with this policy, the result contains only the two authorized tables (the customers table is not returned).

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "GetTablesExample",
      "Effect": "Allow",
      "Action": [
        "glue:GetTables"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:123456789012:table/db1/stores"
      ]
    }
  ]
}
```

You can simplify the preceding policy by using store* to match any table names that start with store.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "GetTablesExample2",
      "Effect": "Allow",
      "Action": [
        "glue:GetTables"
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:123456789012:table/db1/stores"
      ]
    }
  ]
}
```
Similarly, using /db1/* to match all tables in db1, the following policy grants GetTables access to all the tables in db1.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "GetTablesReturnAll",
            "Effect": "Allow",
            "Action": ["glue:GetTables"],
            "Resource": [
            ]
        }
    ]
}
```

If no table ARN is provided, a call to GetTables succeeds, but it returns an empty list.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "GetTablesEmptyResults",
            "Effect": "Allow",
            "Action": ["glue:GetTables"
        }
    ]
}
```
If the database ARN is missing in the policy, a call to GetTables fails with an AccessDeniedException.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "GetTablesAccessDeny",
            "Effect": "Allow",
            "Action": [
                "glue:GetTables"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:123456789012:table/db1/*"
            ]
        }
    ]
}
```

**Grant full access to a table and all partitions**

The following policy grants all permissions on a table named books in database db1. This includes read and write permissions on the table itself, on archived versions of it, and on all its partitions.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "FullAccessOnTable",
            "Effect": "Allow",
            "Action": [
                "glue:CreateTable",
                "glue:GetTable",
                "glue:GetTableVersion",
                "glue:GetPartitions",
                "glue:GetPartitionValues",
                "glue:GetTableSchedule",
                "glue:GetTableVersionSchedule",
                "glue:GetTableVersions",
                "glue:DeleteTable",
                "glue:PutTable",
                "glue:DeleteTableVersion",
                "glue:DeletePartitions",
                "glue:UpdateCatalog",
                "glue:TagResource",
                "glue:UntagResource",
                "glue:DeleteCatalog",
                "glue:DescribeTable",
                "glue:DescribeTableVersion",
                "glue:CreatePartition",
                "glue:CreatePartitionVersion",
                "glue:DeletePartition",
                "glue:ListTableVersions"
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:123456789012:table/db1/according_to_pol"
            ]
        }
    ]
}
```
The preceding policy can be simplified in practice.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "FullAccessOnTable",
      "Effect": "Allow",
      "Action": [
        "glue:*Table*",
        "glue:*Partition*
      ],
      "Resource": [
        "arn:aws:glue:us-west-2:123456789012:table/db1/books"
      ]
    }
  ]
}
```
Notice that the minimum granularity of fine-grained access control is at the table level. This means that you can’t grant a user access to some partitions in a table but not others, or to some table columns but not to others. A user either has access to all of a table, or to none of it.

Control access by name prefix and explicit denial

In this example, suppose that the databases and tables in your AWS Glue Data Catalog are organized using name prefixes. The databases in the development stage have the name prefix `dev-`, and those in production have the name prefix `prod-`. You can use the following policy to grant developers full access to all databases, tables, UDFs, and so on, that have the `dev-` prefix. But you grant read-only access to everything with the `prod-` prefix.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "DevAndProdFullAccess",
            "Effect": "Allow",
            "Action": [
                "glue:*Database*",
                "glue:*Table*",
                "glue:*Partition*",
                "glue:*UserDefinedFunction*",
                "glue:*Connection*
            ],
            "Resource": [
                "arn:aws:glue:us-west-2:123456789012:userDefinedFunction/*/dev-*",
            ]
        }
    ]
}
```
The second statement in the preceding policy uses explicit deny. You can use explicit deny to overwrite any allow permissions that are granted to the principal. This lets you lock down access to critical resources and prevent another policy from accidentally granting access to them.

In the preceding example, even though the first statement grants full access to prod- resources, the second statement explicitly revokes write access to them, leaving only read access to prod- resources.

**Grant access using tags**

For example, suppose that you want to limit access to a trigger t2 to a specific user named Tom in your account. All other users, including Sam, have access to trigger t1. The triggers t1 and t2 have the following properties.
The AWS Glue administrator attached a tag value Tom (aws:ResourceTag/Name: "Tom") to trigger t2. The AWS Glue administrator also gave Tom an IAM policy with a condition statement based on the tag. As a result, Tom can only use an AWS Glue operation that acts on resources with the tag value Tom.

```
{
    "Version": "2012-10-17",
    "Statement": [  
        {  
            "Effect": "Allow",
            "Action": "glue:*",
            "Resource": "*",
            "Condition": {  
                "StringEquals": {  
                    "aws:ResourceTag/Name": "Tom"
                }
            }
        }
    ]
}
```
When Tom tries to access the trigger \( t_1 \), he receives an access denied message. Meanwhile, he can successfully retrieve trigger \( t_2 \).

```bash
aws glue get-trigger --name t1
```

An error occurred (AccessDeniedException) when calling the GetTrigger operation:

User: Tom is not authorized to perform: glue:GetTrigger on resource: arn:aws:glue:us-east-1:123456789012:trigger/t1

```json
aws glue get-trigger --name t2
{
   "Trigger": {
      "State": "CREATED",
      "Type": "SCHEDULED",
      "Name": "t2",
      "Actions": [
         { "JobName": "j1"
      ],
      "Schedule": "cron(0 0/1 * * ? *)"
   }
}
```

Tom can't use the plural GetTriggers API operation to list triggers because this operation doesn't support filtering on tags.

To give Tom access to GetTriggers, the AWS Glue administrator creates a policy that splits the permissions into two sections. One section allows Tom access to all triggers with the GetTriggers API operation. The second section allows Tom access to API operations that are tagged with the value Tom. With this policy, Tom is allowed both GetTriggers and GetTrigger access to trigger \( t_2 \).

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": "glue:GetTriggers",
```
Deny access using tags

Another resource policy approach is to explicitly deny access to resources.

⚠️ Important

An explicit denial policy does not work for plural API operations such as GetTriggers.

In the following example policy, all AWS Glue job operations are allowed. However, the second Effect statement *explicitly* denies access to jobs tagged with the Team key and Special value.

When an administrator attaches the following policy to an identity, the identity can access all jobs except those tagged with the Team key and Special value.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "glue:*",
      "Resource": "*",
      "Condition": {
        "StringEquals": {
          "aws:ResourceTag/Name": "Tom"
        }
      }
    },
    {
      "Effect": "Deny",
      "Action": "glue:*",
      "Resource": "arn:aws:glue:us-east-1:123456789012:job/*",
    }
  ]
}
```
Use tags with list and batch API operations

A third approach to writing a resource policy is to allow access to resources using a List API operation to list out resources for a tag value. Then, use the corresponding Batch API operation to allow access to details of specific resources. With this approach, the administrator doesn't need to allow access to the plural GetCrawlers, GetDevEndpoints, GetJobs, or GetTriggers API operations. Instead, you can allow the ability to list the resources with the following API operations:

- ListCrawlers
- ListDevEndpoints
- ListJobs
- ListTriggers

And, you can allow the ability to get details about individual resources with the following API operations:

- BatchGetCrawlers
- BatchGetDevEndpoints
- BatchGetJobs
- BatchGetTriggers

As an administrator, to use this approach, you can do the following:

1. Add tags to your crawlers, development endpoints, jobs, and triggers.
2. Deny user access to Get API operations such as GetCrawlers, GetDevEndpoints, GetJobs, and GetTriggers.
3. To enable users to find out which tagged resources they have access to, allow user access to List API operations such as ListCrawlers, ListDevEndpoints, ListJobs, and ListTriggers.

4. Deny user access to AWS Glue tagging APIs, such as TagResource and UntagResource.

5. Allow user access to resource details with BatchGet API operations such as BatchGetCrawlers, BatchGetDevEndpoints, BatchGetJobs, and BatchGetTriggers.

For example, when calling the ListCrawlers operation, provide a tag value to match the user name. Then the result is a list of crawlers that match the provided tag values. Provide the list of names to BatchGetCrawlers to get details about each crawler with the given tag.

For example, if Tom should only be able to retrieve details of triggers that are tagged with Tom, the administrator can add tags to triggers for Tom, deny access to the GetTriggers API operation to all users, and allow access to all users to ListTriggers and BatchGetTriggers.

The following is the resource policy that the AWS Glue administrator grants to Tom. In the first section of the policy, AWS Glue API operations are denied for GetTriggers. In the second section of the policy, ListTriggers is allowed for all resources. However, in the third section, those resources tagged with Tom are allowed access with the BatchGetTriggers access.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Action": "glue:GetTriggers",
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "glue:ListTriggers"
            ],
            "Resource": [
                "*"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
```
Using the same triggers as the previous example, Tom can access trigger t2, but not trigger t1. The following example shows the results when Tom tries to access t1 and t2 with `BatchGetTriggers`.

```bash
aws glue batch-get-triggers --trigger-names t2
{
    "Triggers": {
        "State": "CREATED",
        "Type": "SCHEDULED",
        "Name": "t2",
        "Actions": [
            { "JobName": "j2"
        ],
        "Schedule": "cron(0 0/1 * * ? *)"
    }
}
aws glue batch-get-triggers --trigger-names t1

An error occurred (AccessDeniedException) when calling the BatchGetTriggers operation: No access to any requested resource.

The following example shows the results when Tom tries to access both trigger t2 and trigger t3 (which does not exist) in the same `BatchGetTriggers` call. Notice that because Tom has access to trigger t2 and it exists, only t2 is returned. Although Tom is allowed to access trigger t3, trigger t3 does not exist, so t3 is returned in the response in a list of "TriggersNotFoundException": [].
aws glue batch-get-triggers --trigger-names t2 t3
{
  "Triggers": {
    "State": "CREATED",
    "Type": "SCHEDULED",
    "Name": "t2",
    "Actions": [
      {
        "JobName": "j2"
      }
    ],
    "TriggersNotFound": ["t3"],
    "Schedule": "cron(0 0/1 * * ? *)"
  }
}

Control settings using condition keys or context keys

You can use condition keys or context keys when granting permissions to create and update jobs. These sections discuss the keys:

- [Control policies that control settings using condition keys](#)
- [Control policies that control settings using context keys](#)

Control policies that control settings using condition keys

AWS Glue provides three IAM condition keys `glue:VpcIds`, `glue:SubnetIds`, and `glue:SecurityGroupIds`. You can use the condition keys in IAM policies when granting permissions to create and update jobs. You can use this setting to ensure that jobs or sessions are not created (or updated to) to run outside of a desired VPC environment. The VPC setting information is not a direct input from the `CreateJob` request, but inferred from the job "connections" field that points to an AWS Glue connection.

Example usage

Create an AWS Glue network type connection named "traffic-monitored-connection" with the desired VpcId "vpc-id1234", SubnetIds, and SecurityGroupIds.

Specify the condition keys condition for the `CreateJob` and `UpdateJob` action in the IAM policy.

```
You can create a similar IAM policy to prohibit creating an AWS Glue job without specifying connection information.

**Restricting sessions on VPCs**

To enforce created sessions to run within a specified VPC, you restrict role permission by adding a Deny effect on the `glue:CreateSession` action with the condition that the `glue:vpc-id` not equal to `vpc-<123>`. For example:

```json
"Effect": "Deny",
"Action": [  
  "glue:CreateSession"
],
"Condition": {  
  "StringNotEquals" : {"glue:VpcIds" : ["vpc-123"]}
}
```

You also can enforce created sessions to run within a VPC by adding a Deny effect on the `glue:CreateSession` action with the condition that the `glue:vpc-id` is null. For example:

```json
{
  "Effect": "Deny",
  "Action": [  
    "glue:CreateSession"
  
  
}
```
Control policies that control settings using context keys

AWS Glue provides a context key (glue:CredentialIssuingService=glue.amazonaws.com) to each role session that AWS Glue makes available to the job and developer endpoint. This allows you to implement security controls for the actions taken by AWS Glue scripts. AWS Glue provides another context key (glue:RoleAssumedBy=glue.amazonaws.com) to each role session where AWS Glue makes a call to another AWS service on the customer's behalf (not by a job/dev endpoint, but directly by the AWS Glue service).

Example usage

Specify the conditional permission in an IAM policy and attach it to the role to be used by an AWS Glue job. This ensures certain actions are allowed/denied based on whether the role session is used for an AWS Glue job runtime environment.

```json
{
   "Effect": "Allow",
   "Action": "s3:GetObject",
   "Resource": "arn:aws:s3:::confidential-bucket/*",
   "Condition": {
      "StringEquals": {
         "glue:CredentialIssuingService": "glue.amazonaws.com"
      }
   }
}
```
Deny an identity the ability to create data preview sessions

This section contains an IAM policy example used to deny an identity the ability to create data preview sessions. Attach this policy to the identity, which is separate from the role used by the data preview session during its run.

```
{
    "Sid": "DatapreviewDeny",
    "Effect": "Deny",
    "Action": [
        "glue:CreateSession"
    ],
    "Resource": [
        "arn:aws:glue:*::*:session/glue-studio-datapreview*"
    ]
}
```

Resource-based policy examples for AWS Glue

This section contains example resource-based policies, including policies that grant cross-account access.

The examples use the AWS Command Line Interface (AWS CLI) to interact with AWS Glue service API operations. You can perform the same operations on the AWS Glue console or using one of the AWS SDKs.

⚠️ Important

By changing an AWS Glue resource policy, you might accidentally revoke permissions for existing AWS Glue users in your account and cause unexpected disruptions. Try these examples only in development or test accounts, and ensure that they don't break any existing workflows before you make the changes.

Topics

- Considerations for using resource-based policies with AWS Glue
- Use a resource policy to control access in the same account
Considerations for using resource-based policies with AWS Glue

Note
Both IAM policies and an AWS Glue resource policy take a few seconds to propagate. After you attach a new policy, you might notice that the old policy is still in effect until the new policy has propagated through the system.

You use a policy document written in JSON format to create or modify a resource policy. The policy syntax is the same as for an identity-based IAM policy (see IAM JSON policy reference), with the following exceptions:

- A "Principal" or "NotPrincipal" block is required for each policy statement.
- The "Principal" or "NotPrincipal" must identify valid existing principals. Wildcard patterns (like arn:aws:iam::account-id:user/*) are not allowed.
- The "Resource" block in the policy requires all resource ARNs to match the following regular expression syntax (where the first %s is the region, and the second %s is the account-id):

  *arn:aws:glue:%s:%s:(\*[\a-zA-Z\*]+\/[\\.*]*)

  For example, both arn:aws:glue:us-west-2:account-id:* and arn:aws:glue:us-west-2:account-id:database/default are allowed, but * is not allowed.

- Unlike identity-based policies, an AWS Glue resource policy must only contain Amazon Resource Names (ARNs) of resources that belong to the catalog that the policy is attached to. Such ARNs always start with arn:aws:glue:.

- A policy cannot cause the identity that creates it to be locked out of further policy creation or modification.

- A resource-policy JSON document cannot exceed 10 KB in size.

Use a resource policy to control access in the same account

In this example, an admin user in Account A creates a resource policy that grants IAM user Alice in Account A full access to the catalog. Alice has no IAM policy attached.

To do this, the admin user runs the following AWS CLI command.
# Run as admin of Account A

$ aws glue put-resource-policy --profile administrator-name --region us-west-2 --policy-in-json '{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Principal": {
                "AWS": [
                    "arn:aws:iam::account-A-id:user/Alice"
                ]
            },
            "Effect": "Allow",
            "Action": [
                "glue:*"
            ],
            "Resource": [
            ]
        }
    ]
}'}

Instead of entering the JSON policy document as a part of your AWS CLI command, you can save a policy document in a file and reference the file path in the AWS CLI command, prefixed by file://. The following is an example of how you might do that.

$ echo '{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Principal": {
                "AWS": [
                    "arn:aws:iam::account-A-id:user/Alice"
                ]
            },
            "Effect": "Allow",
            "Action": [
                "glue:*"
            ],
            "Resource": [
            ]
        }
    ]
}'}
After this resource policy has propagated, Alice can access all AWS Glue resources in Account A, as follows.

### Run as user Alice

```bash
$ aws glue create-database --profile alice --region us-west-2 --database-input '{
   "Name": "new_database",
   "Description": "A new database created by Alice",
   "LocationUri": "s3://my-bucket"
}'
```

```bash
$ aws glue get-table --profile alice --region us-west-2 --database-name "default" --table-name "tbl1"
```

In response to Alice's `get-table` call, the AWS Glue service returns the following.

```
{
   "Table": {
      "Name": "tbl1",
      "PartitionKeys": [],
      "StorageDescriptor": {
         ....
      },
      ....
   }
}
```

### AWS managed policies for AWS Glue

An AWS managed policy is a standalone policy that is created and administered by AWS. AWS managed policies are designed to provide permissions for many common use cases so that you can start assigning permissions to users, groups, and roles.

Keep in mind that AWS managed policies might not grant least-privilege permissions for your specific use cases because they're available for all AWS customers to use. We recommend that you
reduce permissions further by defining customer managed policies that are specific to your use cases.

You cannot change the permissions defined in AWS managed policies. If AWS updates the permissions defined in an AWS managed policy, the update affects all principal identities (users, groups, and roles) that the policy is attached to. AWS is most likely to update an AWS managed policy when a new AWS service is launched or new API operations become available for existing services.

For more information, see AWS managed policies in the IAM User Guide.

**AWS managed (predefined) policies for AWS Glue**

AWS addresses many common use cases by providing standalone IAM policies that are created and administered by AWS. These AWS managed policies grant necessary permissions for common use cases so that you can avoid having to investigate what permissions are needed. For more information, see AWS managed policies in the IAM User Guide.

The following AWS managed policies, which you can attach to identities in your account, are specific to AWS Glue and are grouped by use case scenario:

- **AWSGlueConsoleFullAccess** – Grants full access to AWS Glue resources when an identity that the policy is attached to uses the AWS Management Console. If you follow the naming convention for resources specified in this policy, users have full console capabilities. This policy is typically attached to users of the AWS Glue console.

- **AWSGlueServiceRole** – Grants access to resources that various AWS Glue processes require to run on your behalf. These resources include AWS Glue, Amazon S3, IAM, CloudWatch Logs, and Amazon EC2. If you follow the naming convention for resources specified in this policy, AWS Glue processes have the required permissions. This policy is typically attached to roles specified when defining crawlers, jobs, and development endpoints.

- **AwsGlueSessionUserRestrictedServiceRole** – Provides full access to all AWS Glue resources except for sessions. It allows users to create and use only the interactive sessions that are associated with the user. This policy includes other permissions needed by AWS Glue to manage AWS Glue resources in other AWS services. The policy also allows adding tags to AWS Glue resources in other AWS services.
Note
To achieve the full security benefits, do not grant this policy to a user that was assigned the AWSGlueServiceRole, AWSGlueConsoleFullAccess, or AWSGlueConsoleSageMakerNotebookFullAccess policy.

- **AwsGlueSessionUserRestrictedPolicy** – Provides access to create AWS Glue interactive sessions using the CreateSession API operation only if a tag key “owner” and value that match the assignee's AWS user ID are provided. This identity policy is attached to the IAM user that invokes the CreateSession API operation. This policy also permits the assignee to interact with the AWS Glue interactive session resources that were created with an “owner” tag and value that match their AWS user ID. This policy denies permission to change or remove "owner" tags from an AWS Glue session resource after the session is created.

Note
To achieve the full security benefits, do not grant this policy to a user that was assigned the AWSGlueServiceRole, AWSGlueConsoleFullAccess, or AWSGlueConsoleSageMakerNotebookFullAccess policy.

- **AwsGlueSessionUserRestrictedNotebookServiceRole** – Provides sufficient access to the AWS Glue Studio notebook session to interact with specific AWS Glue interactive session resources. These are resources that are created with the “owner” tag value that matches the AWS user ID of the principal (IAM user or role) that creates the notebook. For more information about these tags, see the [Principal key values](#) chart in the [IAM User Guide](#).

This service-role policy is attached to the role that is specified with a magic command within the notebook or is passed as a role to the CreateSession API operation. This policy also permits the principal to create an AWS Glue interactive session from the AWS Glue Studio notebook interface only if a tag key “owner” and value match the AWS user ID of the principal. This policy denies permission to change or remove "owner" tags from an AWS Glue session resource after the session is created. This policy also includes permissions for writing and reading from Amazon S3 buckets, writing CloudWatch logs, and creating and deleting tags for Amazon EC2 resources used by AWS Glue.
To achieve the full security benefits, do not grant this policy to a role that was assigned the AWSGlueServiceRole, AWSGlueConsoleFullAccess, or AWSGlueConsoleSageMakerNotebookFullAccess policy.

- **AwsGlueSessionUserRestrictedNotebookPolicy** – Provides access to create an AWS Glue interactive session from the AWS Glue Studio notebook interface only if there is a tag key “owner” and value that match the AWS user ID of the principal (IAM user or role) that creates the notebook. For more information about these tags, see the Principal key values chart in the IAM User Guide.

This policy is attached to the principal (IAM user or role) that creates sessions from the AWS Glue Studio notebook interface. This policy also permits sufficient access to the AWS Glue Studio notebook to interact with specific AWS Glue interactive session resources. These are resources that are created with the “owner” tag value that matches the AWS user ID of the principal. This policy denies permission to change or remove "owner" tags from an AWS Glue session resource after the session is created.

- **AWSGlueServiceNotebookRole** – Grants access to AWS Glue sessions started in an AWS Glue Studio notebook. This policy allows listing and getting session information for all sessions, but only permits users to create and use the sessions tagged with their AWS user ID. This policy denies permission to change or remove “owner” tags from AWS Glue session resources tagged with their AWS ID.

Assign this policy to the AWS user who creates jobs using the notebook interface in AWS Glue Studio.

- **AWSGlueConsoleSageMakerNotebookFullAccess** – Grants full access to AWS Glue and SageMaker resources when the identity that the policy is attached to uses the AWS Management Console. If you follow the naming convention for resources specified in this policy, users have full console capabilities. This policy is typically attached to users of the AWS Glue console who manage SageMaker notebooks.

- **AWSGlueSchemaRegistryFullAccess** – Grants full access to AWS Glue Schema Registry resources when the identity that the policy is attached to uses the AWS Management Console or AWS CLI. If you follow the naming convention for resources specified in this policy, users have full console capabilities. This policy is typically attached to users of the AWS Glue console or AWS CLI who manage the AWS Glue Schema Registry.
- **AWSGlueSchemaRegistryReadOnlyAccess** – Grants read-only access to AWS Glue Schema Registry resources when an identity that the policy is attached to uses the AWS Management Console or AWS CLI. If you follow the naming convention for resources specified in this policy, users have full console capabilities. This policy is typically attached to users of the AWS Glue console or AWS CLI who use the AWS Glue Schema Registry.

**Note**
You can review these permissions policies by signing in to the IAM console and searching for specific policies there.

You can also create your own custom IAM policies to allow permissions for AWS Glue actions and resources. You can attach these custom policies to the IAM users or groups that require those permissions.

**AWS Glue updates to AWS managed policies**

View details about updates to AWS managed policies for AWS Glue since this service began tracking these changes. For automatic alerts about changes to this page, subscribe to the RSS feed on the AWS Glue Document history page.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AwsGlueSessionUserRestrictedNotebookPolicy</td>
<td>Add glue:StartCompletion and glue:GetCompletion to policy. Required for the AWS Glue integration for Amazon Q.</td>
<td>Nov 29, 2023</td>
</tr>
<tr>
<td>AWSGlueServiceNotebookRole</td>
<td>Add codewhisperer:GenerateRecommendations to policy. Required for a new feature where AWS Glue generates CodeWhisperer recommendations.</td>
<td>Oct 9, 2023</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
<td>Date</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>AWSGlueServiceRole – Minor update to an existing policy.</td>
<td>Tighten scope of CloudWatch permissions to better reflect AWS Glue logging.</td>
<td>Aug 4, 2023</td>
</tr>
<tr>
<td>AWSGlueConsoleFullAccess – Minor update to an existing policy.</td>
<td>Add databrew recipe List and Describe permissions to policy. Required to provide full administrative access for new features where AWS Glue can access recipes.</td>
<td>May 9, 2023</td>
</tr>
<tr>
<td>AWSGlueConsoleFullAccess – Minor update to an existing policy.</td>
<td>Add cloudformation:ListStacks to policy. Preserves existing capabilities after changes to AWS CloudFormation authorization requirements.</td>
<td>March 28, 2023</td>
</tr>
<tr>
<td>New managed policies added for the interactive sessions feature:</td>
<td>These policies were designed to provide additional security for interactive sessions and notebooks in AWS Glue Studio. The policies restrict access to the CreateSession API operation so that only the owner has access.</td>
<td>November 30, 2021</td>
</tr>
<tr>
<td>• AwsGlueSessionUser RestrictedServiceRole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• AwsGlueSessionUser RestrictedPolicy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• AwsGlueSessionUser RestrictedNotebookServiceRole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• AwsGlueSessionUser RestrictedNotebookPolicy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AWS managed policies
<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
</table>
| AWSGlueConsoleSage MakerNotebookFullAccess – Update to an existing policy. | Removed a redundant resource ARN (arn:aws:s3:::aws-glue-*/* ) for the action that grants read/write permissions on Amazon S3 buckets that AWS Glue uses to store scripts and temporary files.  
Fixed a syntax issue by changing "StringEquals" to "ForAnyValue:StringLike", and moved the "Effect": "Allow" lines to precede the "Action": line in each place where they were out of order. | July 15, 2021 |
| AWSGlueConsoleFullAccess – Update to an existing policy. | Removed a redundant resource ARN (arn:aws:s3:::aws-glue-*/* ) for the action that grants read/write permissions on Amazon S3 buckets that AWS Glue uses to store scripts and temporary files. | July 15, 2021 |
| AWS Glue started tracking changes.          | AWS Glue started tracking changes for its AWS managed policies.                                                                                                                                          | June 10, 2021 |
Specifying AWS Glue resource ARNs

In AWS Glue, you can control access to resources using an AWS Identity and Access Management (IAM) policy. In a policy, you use an Amazon Resource Name (ARN) to identify the resource that the policy applies to. Not all resources in AWS Glue support ARNs.

Topics

• Data Catalog ARNs
• ARNs for non-catalog objects in AWS Glue
• Access control for AWS Glue non-catalog singular API operations
• Access control for AWS Glue non-catalog API operations that retrieve multiple items
• Access control for AWS Glue non-catalog BatchGet API operations

Data Catalog ARNs

Data Catalog resources have a hierarchical structure, with catalog as the root.

```
arn:aws:glue:region:account-id:catalog
```

Each AWS account has a single Data Catalog in an AWS Region with the 12-digit account ID as the catalog ID. Resources have unique ARNs associated with them, as shown in the following table.

<table>
<thead>
<tr>
<th>Resource type</th>
<th>ARN format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalog</td>
<td><code>arn:aws:glue:</code> <code>region:account-id</code> <code>:catalog</code></td>
</tr>
<tr>
<td></td>
<td>For example: <code>arn:aws:glue:us-east-1:123456789012:catalog</code></td>
</tr>
<tr>
<td>Database</td>
<td><code>arn:aws:glue:</code> <code>region:account-id</code> <code>:database/</code> <code>database name</code></td>
</tr>
<tr>
<td></td>
<td>For example: <code>arn:aws:glue:us-east-1:123456789012:database/db1</code></td>
</tr>
<tr>
<td>Table</td>
<td><code>arn:aws:glue:</code> <code>region:account-id</code> <code>:table/database name/table name</code></td>
</tr>
<tr>
<td>Resource type</td>
<td>ARN format</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>table/db1/tbl1</td>
<td>arn:aws:glue:us-east-1:123456789012:table/db1/tbl1</td>
</tr>
<tr>
<td>userDefinedFunction/db1/func1</td>
<td>arn:aws:glue:region:account-id:userDefinedFunction/database name/user-defined function name</td>
</tr>
<tr>
<td>connection/connection1</td>
<td>arn:aws:glue:region:account-id:connection/connection name</td>
</tr>
<tr>
<td>interactive session</td>
<td>arn:aws:glue:region:account-id:session/interactive session id</td>
</tr>
</tbody>
</table>

To enable fine-grained access control, you can use these ARNs in your IAM policies and resource policies to grant and deny access to specific resources. Wildcards are allowed in the policies. For example, the following ARN matches all tables in database default.

`arn:aws:glue:us-east-1:123456789012:table/default/*`

**Important**

All operations performed on a Data Catalog resource require permission on the resource and all the ancestors of that resource. For example, to create a partition for a table requires permission on the table, database, and catalog where the table is located. The following example shows the permission required to create partitions on table PrivateTable in database PrivateDatabase in the Data Catalog.

```json
{
}
```
In addition to permission on the resource and all its ancestors, all delete operations require permission on all children of that resource. For example, deleting a database requires permission on all the tables and user-defined functions in the database, in addition to the database and the catalog where the database is located. The following example shows the permission required to delete database PrivateDatabase in the Data Catalog.

```json
{
    "Sid": "GrantDeleteDatabase",
    "Effect": "Allow",
    "Action": [
        "glue:DeleteDatabase"
    ],
    "Resource": [
        "arn:aws:glue:us-east-1:123456789012:table/PrivateDatabase/PrivateTable",
        "arn:aws:glue:us-east-1:123456789012:database/PrivateDatabase",
        "arn:aws:glue:us-east-1:123456789012:catalog"
    ]
}
```

In summary, actions on Data Catalog resources follow these permission rules:

- Actions on the catalog require permission on the catalog only.
- Actions on a database require permission on the database and catalog.
- Delete actions on a database require permission on the database and catalog plus all tables and user-defined functions in the database.
• Actions on a table, partition, or table version require permission on the table, database, and catalog.
• Actions on a user-defined function require permission on the user-defined function, database, and catalog.
• Actions on a connection require permission on the connection and catalog.

ARNs for non-catalog objects in AWS Glue

Some AWS Glue resources allow resource-level permissions to control access using an ARN. You can use these ARNs in your IAM policies to enable fine-grained access control. The following table lists the resources that can contain resource ARNs.

<table>
<thead>
<tr>
<th>Resource type</th>
<th>ARN format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crawler</td>
<td>arn:aws:glue: region:account-id :crawler/ crawler-name</td>
</tr>
<tr>
<td></td>
<td>For example: arn:aws:glue:us-east-1:123456789012: crawler/mycrawler</td>
</tr>
<tr>
<td>Job</td>
<td>arn:aws:glue: region:account-id :job/job-name</td>
</tr>
<tr>
<td></td>
<td>For example: arn:aws:glue:us-east-1:123456789012: job/testjob</td>
</tr>
<tr>
<td></td>
<td>For example: arn:aws:glue:us-east-1:123456789012: trigger/sampletrigger</td>
</tr>
<tr>
<td>Development endpoint</td>
<td>arn:aws:glue: region:account-id :devEndpoint/ development-endpoint-name</td>
</tr>
<tr>
<td></td>
<td>For example: arn:aws:glue:us-east-1:123456789012: devEndpoint/temporarydevendpoint</td>
</tr>
<tr>
<td>Resource type</td>
<td>ARN format</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>For example: <code>arn:aws:glue:us-east-1:123456789012: mlTransform/tfm-1234567890</code></td>
</tr>
</tbody>
</table>

**Access control for AWS Glue non-catalog singular API operations**

AWS Glue non-catalog *singular* API operations act on a single item (development endpoint). Examples are GetDevEndpoint, CreateUpdateDevEndpoint, and UpdateDevEndpoint. For these operations, a policy must put the API name in the "action" block and the resource ARN in the "resource" block.

Suppose that you want to allow a user to call the GetDevEndpoint operation. The following policy grants the minimum necessary permissions to an endpoint named `myDevEndpoint-1`.

```json
{
   "Version": "2012-10-17",
   "Statement": [ 
      {
         "Sid": "MinimumPermissions",
         "Effect": "Allow",
         "Action": "glue:GetDevEndpoint",
         "Resource": "arn:aws:glue:us-east-1:123456789012:devEndpoint/myDevEndpoint-1"
      }
   ]
}
```

The following policy allows UpdateDevEndpoint access to resources that match `myDevEndpoint` - with a wildcard (`*`).

```json
{
   "Version": "2012-10-17",
   "Statement": [ 
      {
         "Sid": "PermissionWithWildcard",
         "Effect": "Allow",
```
You can combine the two policies as in the following example. You might see `EntityNotFoundException` for any development endpoint whose name begins with `A`. However, an access denied error is returned when you try to access other development endpoints.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CombinedPermissions",
            "Effect": "Allow",
            "Action": [
                "glue:UpdateDevEndpoint",
                "glue:GetDevEndpoint"
            ],
            "Resource": "arn:aws:glue:us-east-1:123456789012:devEndpoint/A*
        }
    ]
}
```

**Access control for AWS Glue non-catalog API operations that retrieve multiple items**

Some AWS Glue API operations retrieve multiple items (such as multiple development endpoints); for example, `GetDevEndpoints`. For this operation, you can specify only a wildcard (*) resource, and not specific ARNs.

For example, to include `GetDevEndpoints` in the policy, the resource must be scoped to the wildcard (*). The singular operations (`GetDevEndpoint`, `CreateDevEndpoint`, and `DeleteDevendpoint`) are also scoped to all (*) resources in the example.

```json
{
    "Sid": "PluralAPIIncluded",
    "Effect": "Allow",
    "Action": [
```
Access control for AWS Glue non-catalog BatchGet API operations

Some AWS Glue API operations retrieve multiple items (such as multiple development endpoints); for example, BatchGetDevEndpoints. For this operation, you can specify an ARN to limit the scope of resources that can be accessed.

For example, to allow access to a specific development endpoint, include BatchGetDevEndpoints in the policy with its resource ARN.

```
{
   "Sid": "BatchGetAPIIncluded",
   "Effect": "Allow",
   "Action": [
      "glue:BatchGetDevEndpoints"
   ],
   "Resource": [
      "arn:aws:glue:us-east-1:123456789012:devEndpoint/de1"
   ]
}
```

With this policy, you can successfully access the development endpoint named de1. However, if you try to access the development endpoint named de2, an error is returned.

An error occurred (AccessDeniedException) when calling the BatchGetDevEndpoints operation: No access to any requested resource.
**Important**

For alternative approaches to setting up IAM policies, such as using `List` and `BatchGet` API operations, see [Identity-based policy examples for AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/identity-based-policy-examples.html).

---

**Granting cross-account access**

Granting access to Data Catalog resources across accounts enables your extract, transform, and load (ETL) jobs to query and join data from different accounts.

**Topics**

- Methods for granting cross-account access in AWS Glue
- Adding or updating the Data Catalog resource policy
- Making a cross-account API call
- Making a cross-account ETL call
- Cross-account CloudTrail logging
- Cross-account resource ownership and billing
- Cross-account access limitations

**Methods for granting cross-account access in AWS Glue**

You can grant access to your data to external AWS accounts by using AWS Glue methods or by using AWS Lake Formation cross-account grants. The AWS Glue methods use AWS Identity and Access Management (IAM) policies to achieve fine-grained access control. Lake Formation uses a simpler `GRANT/REVOKE` permissions model similar to the `GRANT/REVOKE` commands in a relational database system.

This section describes using the AWS Glue methods. For information about using Lake Formation cross-account grants, see [Granting Lake Formation Permissions](https://docs.aws.amazon.com/lakeformation/latest/dg/permissions-granting-lakeformation.html) in the *AWS Lake Formation Developer Guide*.

There are two AWS Glue methods for granting cross-account access to a resource:

- Use a Data Catalog resource policy
- Use an IAM role
Granting cross-account access using a resource policy

The following are the general steps for granting cross-account access using a Data Catalog resource policy:

1. An administrator (or other authorized identity) in Account A attaches a resource policy to the Data Catalog in Account A. This policy grants Account B specific cross-account permissions to perform operations on a resource in Account A's catalog.

2. An administrator in Account B attaches an IAM policy to an IAM identity in Account B that delegates the permissions received from Account A.

   The identity in Account B now has access to the specified resource in Account A.

   The identity needs permission from both the resource owner (Account A) and their parent account (Account B) to be able to access the resource.

Granting cross-account access using an IAM role

The following are the general steps for granting cross-account access using an IAM role:

1. An administrator (or other authorized identity) in the account that owns the resource (Account A) creates an IAM role.

2. The administrator in Account A attaches a policy to the role that grants cross-account permissions for access to the resource in question.

3. The administrator in Account A attaches a trust policy to the role that identifies an IAM identity in a different account (Account B) as the principal who can assume the role.

   The principal in the trust policy can also be an AWS service principal if you want to grant an AWS service permission to assume the role.

4. An administrator in Account B now delegates permissions to one or more IAM identities in Account B so that they can assume that role. Doing so gives those identities in Account B access to the resource in account A.

For more information about using IAM to delegate permissions, see Access management in the IAM User Guide. For more information about users, groups, roles, and permissions, see Identities (users, groups, and roles) in the IAM User Guide.
For a comparison of these two approaches, see How IAM roles differ from resource-based policies in the IAM User Guide. AWS Glue supports both options, with the restriction that a resource policy can grant access only to Data Catalog resources.

For example, to give the Dev role in Account B access to database db1 in Account A, attach the following resource policy to the catalog in Account A.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetDatabase"
            ],
            "Principal": {"AWS": [
                "arn:aws:iam::account-B-id:role/Dev"
            ]},
            "Resource": [
                "arn:aws:glue:us-east-1:account-A-id:database/db1"
            ]
        }
    ]
}
```

In addition, Account B would have to attach the following IAM policy to the Dev role before it would actually get access to db1 in Account A.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "glue:GetDatabase"
            ],
            "Resource": [
                "arn:aws:glue:us-east-1:account-A-id:database/db1"
            ]
        }
    ]
}
```
Adding or updating the Data Catalog resource policy

You can add or update the AWS Glue Data Catalog resource policy using the console, API, or AWS Command Line Interface (AWS CLI).

**Important**

If you have already made cross-account permission grants from your account with AWS Lake Formation, adding or updating the Data Catalog resource policy requires an extra step. For more information, see [Managing cross-account permissions using both AWS Glue and Lake Formation](https://docs.aws.amazon.com/glue/latest/dg/managed-catalog-permissions.html) in the *AWS Lake Formation Developer Guide*.

To determine if Lake Formation cross-account grants exist, use the `glue:GetResourcePolicies` API operation or the AWS CLI. If `glue:GetResourcePolicies` returns any policies other than an already existing Data Catalog policy, then Lake Formation grants exist. For more information, see [Viewing all cross-account grants using the GetResourcePolicies API operation](https://docs.aws.amazon.com/glue/latest/dg/managed-catalog-permissions.html) in the *AWS Lake Formation Developer Guide*.

To add or update the Data Catalog resource policy (console)


   Sign in as an AWS Identity and Access Management (IAM) administrative user who has the `glue:PutResourcePolicy` permission.

2. In the navigation pane, choose **Settings**.

3. On the **Data catalog settings** page, under **Permissions**, paste a resource policy into the text area. Then choose **Save**.

   If the console displays a alert stating that the permissions in the policy will be in addition to any permissions granted using Lake Formation, choose **Proceed**.
To add or update the Data Catalog resource policy (AWS CLI)

- Submit an `aws glue put-resource-policy` command. If Lake Formation grants already exist, ensure that you include the `--enable-hybrid` option with the value 'TRUE'.

  For examples of using this command, see Resource-based policy examples for AWS Glue.

Making a cross-account API call

All AWS Glue Data Catalog operations have a CatalogId field. If the required permissions have been granted to enable cross-account access, a caller can make Data Catalog API calls across accounts. The caller does this by passing the target AWS account ID in CatalogId so as to access the resource in that target account.

If no CatalogId value is provided, AWS Glue uses the caller's own account ID by default, and the call is not cross-account.

Making a cross-account ETL call

Some AWS Glue PySpark and Scala APIs have a catalog ID field. If all the required permissions have been granted to enable cross-account access, an ETL job can make PySpark and Scala calls to API operations across accounts by passing the target AWS account ID in the catalog ID field to access Data Catalog resources in a target account.

If no catalog ID value is provided, AWS Glue uses the caller's own account ID by default, and the call is not cross-account.

For PySpark APIs that support `catalog_id`, see GlueContext class. For Scala APIs that support `catalogId`, see AWS Glue Scala GlueContext APIs.

The following example shows the permissions required by the grantee to run an ETL job. In this example, `grantee-account-id` is the catalog-id of the client running the job and `grantor-account-id` is the owner of the resource. This example grants permission to all catalog resources in the grantor's account. To limit the scope of resources granted, you can provide specific ARNs for the catalog, database, table, and connection.

```json
{
  "Version": "2012-10-17",
  "Statement": [
```
Note

If a table in the grantor's account points to an Amazon S3 location that is also in the grantor's account, the IAM role used to run an ETL job in the grantee's account must have permission to list and get objects from the grantor's account.

Given that the client in Account A already has permission to create and run ETL jobs, the following are the basic steps to set up an ETL job for cross-account access:

1. Allow cross-account data access (skip this step if Amazon S3 cross-account access is already set up).
   a. Update the Amazon S3 bucket policy in Account B to allow cross-account access from Account A.
   b. Update the IAM policy in Account A to allow access to the bucket in Account B.

2. Allow cross-account Data Catalog access.
   a. Create or update the resource policy attached to the Data Catalog in Account B to allow access from Account A.
   b. Update the IAM policy in Account A to allow access to the Data Catalog in Account B.
Cross-account CloudTrail logging

When an AWS Glue extract, transform, and load (ETL) job accesses the underlying data of a Data Catalog table shared through AWS Lake Formation cross-account grants, there is additional AWS CloudTrail logging behavior.

For purposes of this discussion, the AWS account that shared the table is the owner account, and the account that the table was shared with is the recipient account. When an ETL job in the recipient account accesses data in the table in the owner account, the data-access CloudTrail event that is added to the logs for the recipient account gets copied to the owner account's CloudTrail logs. This is so owner accounts can track data accesses by the various recipient accounts. By default, the CloudTrail events do not include a human-readable principal identifier (principal ARN). An administrator in the recipient account can opt in to include the principal ARN in the logs.

For more information, see Cross-account CloudTrail logging in the AWS Lake Formation Developer Guide.

See Also

- the section called “Logging and monitoring”

Cross-account resource ownership and billing

When a user in one AWS account (Account A) creates a new resource such as a database in a different account (Account B), that resource is then owned by Account B, the account where it was created. An administrator in Account B automatically gets full permissions to access the new resource, including reading, writing, and granting access permissions to a third account. The user in Account A can access the resource that they just created only if they have the appropriate permissions granted by Account B.

Storage costs and other costs that are directly associated with the new resource are billed to Account B, the resource owner. The cost of requests from the user who created the resource are billed to the requester's account, Account A.

For more information about AWS Glue billing and pricing, see How AWS Pricing Works.

Cross-account access limitations

AWS Glue cross-account access has the following limitations:
• Cross-account access to AWS Glue is not allowed if you created databases and tables using Amazon Athena or Amazon Redshift Spectrum prior to a region’s support for AWS Glue and the resource owner account has not migrated the Amazon Athena data catalog to AWS Glue. You can find the current migration status using the `GetCatalogImportStatus (get_catalog_import_status)`.

For more details on how to migrate an Athena catalog to AWS Glue, see [Upgrading to the AWS Glue Data Catalog step-by-step](https://docs.aws.amazon.com/AmazonAthena/latest/ug/upgrading-data-catalog.html) in the *Amazon Athena User Guide*.

• Cross-account access is only supported for Data Catalog resources, including databases, tables, user-defined functions, and connections.

• Cross-account access to the Data Catalog is not supported when using an AWS Glue crawler.

• Cross-account access to the Data Catalog from Athena requires you to register the catalog as an Athena `DataCatalog` resource. For instructions, see [Registering an AWS Glue Data Catalog from another account](https://docs.aws.amazon.com/AmazonAthena/latest/ug/register-data-catalog.html) in the *Amazon Athena User Guide*.

### Troubleshooting AWS Glue identity and access

Use the following information to help you diagnose and fix common issues that you might encounter when working with AWS Glue and IAM.

**Topics**

- [I am not authorized to perform an action in AWS Glue](#)
- [I am not authorized to perform iam:PassRole](#)
- [I want to allow people outside of my AWS account to access my AWS Glue resources](#)

#### I am not authorized to perform an action in AWS Glue

If you receive an error that you're not authorized to perform an action, your policies must be updated to allow you to perform the action.

The following example error occurs when the `mateojackson` IAM user tries to use the console to view details about a fictional `my-example-widget` resource but doesn't have the fictional glue:`GetWidget` permissions.

```
User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform:
glue:GetWidget on resource: my-example-widget
```
In this case, the policy for the mateojackson user must be updated to allow access to the *my-example-widget* resource by using the glue:*GetWidget* action.

If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

**I am not authorized to perform iam:PassRole**

If you receive an error that you're not authorized to perform the *iam:PassRole* action, your policies must be updated to allow you to pass a role to AWS Glue.

Some AWS services allow you to pass an existing role to that service instead of creating a new service role or service-linked role. To do this, you must have permissions to pass the role to the service.

The following example error occurs when an IAM user named marymajor tries to use the console to perform an action in AWS Glue. However, the action requires the service to have permissions that are granted by a service role. Mary does not have permissions to pass the role to the service.

```
User: arn:aws:iam::123456789012:user/marymajor is not authorized to perform:
iam:PassRole
```

In this case, Mary's policies must be updated to allow her to perform the *iam:PassRole* action.

If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

**I want to allow people outside of my AWS account to access my AWS Glue resources**

You can create a role that users in other accounts or people outside of your organization can use to access your resources. You can specify who is trusted to assume the role. For services that support resource-based policies or access control lists (ACLs), you can use those policies to grant people access to your resources.

To learn more, consult the following:

- To learn whether AWS Glue supports these features, see [How AWS Glue works with IAM](https://docs.aws.amazon.com/glue/latest/dg/how-aws-glue-works-with-iam.html).
- To learn how to provide access to your resources across AWS accounts that you own, see [Providing access to an IAM user in another AWS account that you own](https://docs.aws.amazon.com/IAM/latest/UserGuide/id通行证-restrict-access-account.html) in the *IAM User Guide*.  

Troubleshooting
• To learn how to provide access to your resources to third-party AWS accounts, see Providing access to AWS accounts owned by third parties in the IAM User Guide.

• To learn how to provide access through identity federation, see Providing access to externally authenticated users (identity federation) in the IAM User Guide.

• To learn the difference between using roles and resource-based policies for cross-account access, see How IAM roles differ from resource-based policies in the IAM User Guide.

Logging and monitoring in AWS Glue

You can automate the running of your ETL (extract, transform, and load) jobs. AWS Glue provides metrics for crawlers and jobs that you can monitor. After you set up the AWS Glue Data Catalog with the required metadata, AWS Glue provides statistics about the health of your environment. You can automate the invocation of crawlers and jobs with a time-based schedule based on cron. You can also trigger jobs when an event-based trigger fires.

AWS Glue is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or AWS service in AWS Glue. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon Simple Storage Service (Amazon S3) bucket, Amazon CloudWatch Logs, and Amazon CloudWatch Events. Every event or log entry contains information about who generated the request.

Use Amazon CloudWatch Events to automate your AWS services and respond automatically to system events such as application availability issues or resource changes. Events from AWS services are delivered to CloudWatch Events in near-real time. You can write simple rules to indicate which events are of interest and what automated actions to take when an event matches a rule.

See also

• Automating AWS Glue with CloudWatch Events
• Cross-account CloudTrail logging

An important facet of security in the cloud is logging. You must configure logging in a way that does not capture secrets and confidential material while capturing information necessary to debug and secure your cloud infrastructure. Make sure to familiarize yourself with what is being logged.
Compliance validation for AWS Glue

To learn whether an AWS service is within the scope of specific compliance programs, see AWS services in Scope by Compliance Program and choose the compliance program that you are interested in. For general information, see AWS Compliance Programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading Reports in AWS Artifact.

Your compliance responsibility when using AWS services is determined by the sensitivity of your data, your company's compliance objectives, and applicable laws and regulations. AWS provides the following resources to help with compliance:

- **Security and Compliance Quick Start Guides** – These deployment guides discuss architectural considerations and provide steps for deploying baseline environments on AWS that are security and compliance focused.

- **Architecting for HIPAA Security and Compliance on Amazon Web Services** – This whitepaper describes how companies can use AWS to create HIPAA-eligible applications.

  Note

  Not all AWS services are HIPAA eligible. For more information, see the HIPAA Eligible Services Reference.

- **AWS Compliance Resources** – This collection of workbooks and guides might apply to your industry and location.

- **AWS Customer Compliance Guides** – Understand the shared responsibility model through the lens of compliance. The guides summarize the best practices for securing AWS services and map the guidance to security controls across multiple frameworks (including National Institute of Standards and Technology (NIST), Payment Card Industry Security Standards Council (PCI), and International Organization for Standardization (ISO)).

- **Evaluating Resources with Rules** in the AWS Config Developer Guide – The AWS Config service assesses how well your resource configurations comply with internal practices, industry guidelines, and regulations.

- **AWS Security Hub** – This AWS service provides a comprehensive view of your security state within AWS. Security Hub uses security controls to evaluate your AWS resources and to check your...
compliance against security industry standards and best practices. For a list of supported services and controls, see Security Hub controls reference.

- **AWS Audit Manager** – This AWS service helps you continuously audit your AWS usage to simplify how you manage risk and compliance with regulations and industry standards.

## Resilience in AWS Glue

The AWS global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency, high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between Availability Zones without interruption. Availability Zones are more highly available, fault tolerant, and scalable than traditional single or multiple data center infrastructures.

For more information about AWS Regions and Availability Zones, see [AWS Global Infrastructure](https://aws.amazon.com/global-infrastructure/).

## Infrastructure security in AWS Glue

As a managed service, AWS Glue is protected by the AWS global network security procedures that are described in the Amazon Web Services: Overview of Security Processes whitepaper.

You use AWS published API calls to access AWS Glue through the network. Clients must support Transport Layer Security (TLS) 1.0 or later. We recommend TLS 1.2 or later. Clients must also support cipher suites with perfect forward secrecy (PFS) such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Ephemeral Diffie-Hellman (ECDHE). Most modern systems such as Java 7 and later support these modes.

Additionally, requests must be signed by using an access key ID and a secret access key that is associated with an IAM principal. Or you can use the [AWS Security Token Service](https://aws.amazon.com/sts/) (AWS STS) to generate temporary security credentials to sign requests.

### Topics

- **AWS Glue and interface VPC endpoints (AWS PrivateLink)**
- **Shared Amazon VPCs**
AWS Glue and interface VPC endpoints (AWS PrivateLink)

You can establish a private connection between your VPC and AWS Glue by creating an interface VPC endpoint. Interface endpoints are powered by AWS PrivateLink, a technology that enables you to privately access AWS Glue APIs without an internet gateway, NAT device, VPN connection, or AWS Direct Connect connection. Instances in your VPC don’t need public IP addresses to communicate with AWS Glue APIs. Traffic between your VPC and AWS Glue does not leave the Amazon network.

Each interface endpoint is represented by one or more Elastic Network Interfaces in your subnets.

For more information, see Interface VPC endpoints (AWS PrivateLink) in the Amazon VPC User Guide.

Considerations for AWS Glue VPC endpoints

Before you set up an interface VPC endpoint for AWS Glue, ensure that you review Interface endpoint properties and limitations in the Amazon VPC User Guide.

AWS Glue supports making calls to all of its API actions from your VPC.

Creating an interface VPC endpoint for AWS Glue

You can create a VPC endpoint for the AWS Glue service using either the Amazon VPC console or the AWS Command Line Interface (AWS CLI). For more information, see Creating an interface endpoint in the Amazon VPC User Guide.

Create a VPC endpoint for AWS Glue using the following service name:

- com.amazonaws.region.glue

If you enable private DNS for the endpoint, you can make API requests to AWS Glue using its default DNS name for the Region, for example, glue.us-east-1.amazonaws.com.

For more information, see Accessing a service through an interface endpoint in the Amazon VPC User Guide.

Creating a VPC endpoint policy for AWS Glue

You can attach an endpoint policy to your VPC endpoint that controls access to AWS Glue. The policy specifies the following information:
• The principal that can perform actions.
• The actions that can be performed.
• The resources on which actions can be performed.

For more information, see Controlling access to services with VPC endpoints in the Amazon VPC User Guide.

Example: VPC endpoint policy for AWS Glue to allow job creation and update

The following is an example of an endpoint policy for AWS Glue. When attached to an endpoint, this policy grants access to the listed AWS Glue actions for all principals on all resources.

```json
{
    "Statement": [ 
    {
        "Principal": "*",
        "Effect": "Allow",
        "Action": [
            "glue:CreateJob",
            "glue:UpdateJob",
            "iam:PassRole"
        ],
        "Resource": "*"
    }
    ]
}
```

Example: VPC endpoint policy to allow read-only Data Catalog access

The following is an example of an endpoint policy for AWS Glue. When attached to an endpoint, this policy grants access to the listed AWS Glue actions for all principals on all resources.

```json
{
    "Statement": [ 
    {
        "Principal": "*",
        "Effect": "Allow",
        "Action": [ 
            "glue:GetDatabase",
            "glue:GetDatabases",
            "glue:GetTable",
```
Shared Amazon VPCs

AWS Glue supports shared virtual private clouds (VPCs) in Amazon Virtual Private Cloud. Amazon VPC sharing allows multiple AWS accounts to create their application resources, such as Amazon EC2 instances and Amazon Relational Database Service (Amazon RDS) databases, into shared, centrally-managed Amazon VPCs. In this model, the account that owns the VPC (owner) shares one or more subnets with other accounts (participants) that belong to the same organization from AWS Organizations. After a subnet is shared, the participants can view, create, modify, and delete their application resources in the subnets that are shared with them.

In AWS Glue, to create a connection with a shared subnet, you must create a security group within your account and attach the security group to the shared subnet.

For more information, see these topics:

- [Working with Shared VPCs](#) in the [Amazon VPC User Guide](#)
- [What Is AWS Organizations?](#) in the [AWS Organizations User Guide](#)
Troubleshooting AWS Glue

Topics

- Gathering AWS Glue troubleshooting information
- Troubleshooting errors in AWS Glue for Spark
- Troubleshooting AWS Glue for Ray errors from logs
- AWS Glue machine learning exceptions
- AWS Glue quotas

Gathering AWS Glue troubleshooting information

If you encounter errors or unexpected behavior in AWS Glue and need to contact AWS Support, you should first gather information about names, IDs, and logs that are associated with the failed action. Having this information available enables AWS Support to help you resolve the problems you're experiencing.

Along with your account ID, gather the following information for each of these types of failures:

When a crawler fails, gather the following information:

- Crawler name

  Logs from crawler runs are located in CloudWatch Logs under /aws-glue/crawlers.

When a test connection fails, gather the following information:

- Connection name
- Connection ID
- JDBC connection string in the form jdbc:protocol://host:port/database-name.

  Logs from test connections are located in CloudWatch Logs under /aws-glue/testconnection.

When a job fails, gather the following information:

- Job name
- Job run ID in the form jr_xxxxx.

  Logs from job runs are located in CloudWatch Logs under /aws-glue/jobs.
Troubleshooting errors in AWS Glue for Spark

If you encounter errors in AWS Glue, use the following solutions to help you find the source of the problems and fix them.

Note
The AWS Glue GitHub repository contains additional troubleshooting guidance in AWS Glue Frequently Asked Questions.

Topics

- Error: Resource unavailable
- Error: Could not find S3 endpoint or NAT gateway for subnetId in VPC
- Error: Inbound rule in security group required
- Error: Outbound rule in security group required
- Error: Job run failed because the role passed should be given assume role permissions for the AWS Glue service
- Error: DescribeVpcEndpoints action is unauthorized. unable to validate VPC ID vpc-id
- Error: DescribeRouteTables action is unauthorized. unable to validate subnet id: Subnet-id in VPC id: vpc-id
- Error: Failed to call ec2:DescribeSubnets
- Error: Failed to call ec2:DescribeSecurityGroups
- Error: Could not find subnet for AZ
- Error: Job run exception when writing to a JDBC target
- Error: Amazon S3 timeout
- Error: Amazon S3 access denied
- Error: Amazon S3 access key ID does not exist
- Error: Job run fails when accessing Amazon S3 with an s3a:// URI
- Error: Amazon S3 service token expired
- Error: No private DNS for network interface found
- Error: Development endpoint provisioning failed
- **Error: Notebook server CREATE_FAILED**
- **Error: Local notebook fails to start**
- **Error: Running crawler failed**
- **Error: Partitions were not updated**
- **Error: Upgrading Athena Data Catalog**
- **Error: Job bookmark update failed due to version mismatch**
- **Error: A job is reprocessing data when job bookmarks are enabled**
- **Error: Failover behavior between VPCs in AWS Glue**
- **Troubleshoot crawler errors when the crawler is using Lake Formation credentials**

### Error: Resource unavailable

If AWS Glue returns a resource unavailable message, you can view error messages or logs to help you learn more about the issue. The following tasks describe general methods for troubleshooting.

- For any connections and development endpoints that you use, check that your cluster has not run out of elastic network interfaces.

### Error: Could not find S3 endpoint or NAT gateway for subnetId in VPC

Check the subnet ID and VPC ID in the message to help you diagnose the issue.

- Check that you have an Amazon S3 VPC endpoint set up, which is required with AWS Glue. In addition, check your NAT gateway if that's part of your configuration. For more information, see [Amazon VPC endpoints for Amazon S3](https://docs.aws.amazon.com/vpc/latest/userguide/vpc-endpoints-s3.html).

### Error: Inbound rule in security group required

At least one security group must open all ingress ports. To limit traffic, the source security group in your inbound rule can be restricted to the same security group.

- For any connections that you use, check your security group for an inbound rule that is self-referencing. For more information, see [Setting up network access to data stores](https://docs.aws.amazon.com/glue/latest/dg/network-access.html).
- When you are using a development endpoint, check your security group for an inbound rule that is self-referencing. For more information, see [Setting up network access to data stores](https://docs.aws.amazon.com/glue/latest/dg/network-access.html).
Error: Outbound rule in security group required

At least one security group must open all egress ports. To limit traffic, the source security group in your outbound rule can be restricted to the same security group.

- For any connections that you use, check your security group for an outbound rule that is self-referencing. For more information, see Setting up network access to data stores.
- When you are using a development endpoint, check your security group for an outbound rule that is self-referencing. For more information, see Setting up network access to data stores.

Error: Job run failed because the role passed should be given assume role permissions for the AWS Glue service

The user who defines a job must have permission for `iam:PassRole` for AWS Glue.

- When a user creates an AWS Glue job, confirm that the user’s role contains a policy that contains `iam:PassRole` for AWS Glue. For more information, see Step 3: Attach a policy to users or groups that access AWS Glue.

Error: DescribeVpcEndpoints action is unauthorized. unable to validate VPC ID vpc-id

- Check the policy passed to AWS Glue for the `ec2:DescribeVpcEndpoints` permission.

Error: DescribeRouteTables action is unauthorized. unable to validate subnet id: Subnet-id in VPC id: vpc-id

- Check the policy passed to AWS Glue for the `ec2:DescribeRouteTables` permission.

Error: Failed to call ec2:DescribeSubnets

- Check the policy passed to AWS Glue for the `ec2:DescribeSubnets` permission.
Error: Failed to call ec2:DescribeSecurityGroups

- Check the policy passed to AWS Glue for the ec2:DescribeSecurityGroups permission.

Error: Could not find subnet for AZ

- The Availability Zone might not be available to AWS Glue. Create and use a new subnet in a different Availability Zone from the one specified in the message.

Error: Job run exception when writing to a JDBC target

When you are running a job that writes to a JDBC target, the job might encounter errors in the following scenarios:

- If your job writes to a Microsoft SQL Server table, and the table has columns defined as type Boolean, then the table must be predefined in the SQL Server database. When you define the job on the AWS Glue console using a SQL Server target with the option Create tables in your data target, don't map any source columns to a target column with data type Boolean. You might encounter an error when the job runs.

  You can avoid the error by doing the following:
  
  - Choose an existing table with the Boolean column.
  - Edit the ApplyMapping transform and map the Boolean column in the source to a number or string in the target.
  - Edit the ApplyMapping transform to remove the Boolean column from the source.

- If your job writes to an Oracle table, you might need to adjust the length of names of Oracle objects. In some versions of Oracle, the maximum identifier length is limited to 30 bytes or 128 bytes. This limit affects the table names and column names of Oracle target data stores.

  You can avoid the error by doing the following:
  
  - Name Oracle target tables within the limit for your version.
  - The default column names are generated from the field names in the data. To handle the case when the column names are longer than the limit, use ApplyMapping or RenameField transforms to change the name of the column to be within the limit.
Error: Amazon S3 timeout

If AWS Glue returns a connect timed out error, it might be because it is trying to access an Amazon S3 bucket in another AWS Region.

- An Amazon S3 VPC endpoint can only route traffic to buckets within an AWS Region. If you need to connect to buckets in other Regions, a possible workaround is to use a NAT gateway. For more information, see [NAT Gateways](#).

Error: Amazon S3 access denied

If AWS Glue returns an access denied error to an Amazon S3 bucket or object, it might be because the IAM role provided does not have a policy with permission to your data store.

- An ETL job must have access to an Amazon S3 data store used as a source or target. A crawler must have access to an Amazon S3 data store that it crawls. For more information, see [Step 2: Create an IAM role for AWS Glue](#).

Error: Amazon S3 access key ID does not exist

If AWS Glue returns an access key ID does not exist error when running a job, it might be because of one of the following reasons:

- An ETL job uses an IAM role to access data stores, confirm that the IAM role for your job was not deleted before the job started.
- An IAM role contains permissions to access your data stores, confirm that any attached Amazon S3 policy containing `s3:ListBucket` is correct.

Error: Job run fails when accessing Amazon S3 with an `s3a://` URI

If a job run returns an error like `Failed to parse XML document with handler class`, it might be because of a failure trying to list hundreds of files using an `s3a://` URI. Access your data store using an `s3://` URI instead. The following exception trace highlights the errors to look for:

```
1. com.amazonaws.SdkClientException: Failed to parse XML document with handler class com.amazonaws.services.s3.model.transform.XmlResponsesSaxParser$ListBucketHandler
```
Error: Job run fails when accessing Amazon S3 with an s3a:// URI
Error: Amazon S3 service token expired

When moving data to and from Amazon Redshift, temporary Amazon S3 credentials, which expire after 1 hour, are used. If you have a long running job, it might fail. For information about how to set up your long running jobs to move data to and from Amazon Redshift, see [aws-glue-programming-etl-connect-redshift-home](https://aws.amazon.com/documentation/glue-programming-etl-connect-redshift-home).

Error: No private DNS for network interface found

If a job fails or a development endpoint fails to provision, it might be because of a problem in the network setup.
• If you are using the Amazon provided DNS, the value of enableDnsHostnames must be set to true. For more information, see DNS.

Error: Development endpoint provisioning failed

If AWS Glue fails to successfully provision a development endpoint, it might be because of a problem in the network setup.

• When you define a development endpoint, the VPC, subnet, and security groups are validated to confirm that they meet certain requirements.

• If you provided the optional SSH public key, check that it is a valid SSH public key.

• Check in the VPC console that your VPC uses a valid DHCP option set. For more information, see DHCP option sets.

• If the cluster remains in the PROVISIONING state, contact AWS Support.

Error: Notebook server CREATE_FAILED

If AWS Glue fails to create the notebook server for a development endpoint, it might be because of one of the following problems:

• AWS Glue passes an IAM role to Amazon EC2 when it is setting up the notebook server. The IAM role must have a trust relationship to Amazon EC2.

• The IAM role must have an instance profile of the same name. When you create the role for Amazon EC2 with the IAM console, the instance profile with the same name is automatically created. Check for an error in the log regarding the instance profile name iamInstanceProfile.name that is not valid. For more information, see Using Instance Profiles.

• Check that your role has permission to access aws-glue* buckets in the policy that you pass to create the notebook server.

Error: Local notebook fails to start

If your local notebook fails to start and reports errors that a directory or folder cannot be found, it might be because of one of the following problems:
If you are running on Microsoft Windows, make sure that the JAVA_HOME environment variable points to the correct Java directory. It's possible to update Java without updating this variable, and if it points to a folder that no longer exists, Jupyter notebooks fail to start.

**Error: Running crawler failed**

If AWS Glue fails to successfully run a crawler to catalog your data, it might be because of one of the following reasons. First check if an error is listed in the AWS Glue console crawlers list. Check if there is an exclamation icon next to the crawler name and hover over the icon to see any associated messages.

- Check the logs for the crawler run in CloudWatch Logs under /aws-glue/crawlers.

**Error: Partitions were not updated**

In case your partitions were not updated in the Data Catalog when you ran an ETL job, these log statements from the DataSink class in the CloudWatch logs may be helpful:

- "Attempting to fast-forward updates to the Catalog - nameSpace:" — Shows which database, table, and catalogId are attempted to be modified by this job. If this statement is not here, check if enableUpdateCatalog is set to true and properly passed as a getSink() parameter or in additional_options.
- "Schema change policy behavior:" — Shows which schema updateBehavior value you passed in.
- "Schemas qualify (schema compare):" — Will be true or false.
- "Schemas qualify (case-insensitive compare):" — Will be true or false.
- If both are false and your updateBehavior is not set to UPDATE_IN_DATABASE, then your DynamicFrame schema needs to be identical or contain a subset of the columns seen in the Data Catalog table schema.

For more information on updating partitions, see [Creating tables, updating the schema, and adding new partitions in the Data Catalog from AWS Glue ETL jobs.](#)
**Error: Upgrading Athena Data Catalog**

If you encounter errors while upgrading your Athena Data Catalog to the AWS Glue Data Catalog, see [Upgrading to the AWS Glue Data Catalog Step-by-Step](#).

**Error: Job bookmark update failed due to version mismatch**

You may be trying to parametrize AWS Glue jobs to apply the same transformation/logic on different datasets in Amazon S3. You want to track processed files on the locations provided. When you run the same job on the same source bucket and write to the same/different destination concurrently (concurrency > 1) the job fails with this error:

```
```

Solution: set concurrency to 1 or don't run the job concurrently.

Currently AWS Glue bookmarks don't support concurrent job runs and commits will fail.

**Error: A job is reprocessing data when job bookmarks are enabled**

There might be cases when you have enabled AWS Glue job bookmarks, but your ETL job is reprocessing data that was already processed in an earlier run. Check for these common causes of this error:

**Max Concurrency**

Ensure that the maximum number of concurrent runs for the job is 1. For more information, see the discussion of max concurrency in [Adding jobs in AWS Glue](#). When you have multiple concurrent jobs with job bookmarks and the maximum concurrency is set to 1, the job bookmark doesn't work correctly.

**Missing Job Object**

Ensure that your job run script ends with the following commit:

```
job.commit()
```
When you include this object, AWS Glue records the timestamp and path of the job run. If you run the job again with the same path, AWS Glue processes only the new files. If you don't include this object and job bookmarks are enabled, the job reprocesses the already processed files along with the new files and creates redundancy in the job's target data store.

**Missing Transformation Context Parameter**

Transformation context is an optional parameter in the `GlueContext` class, but job bookmarks don't work if you don't include it. To resolve this error, add the transformation context parameter when you create the `DynamicFrame`, as shown following:

```python
sample_dynF=create_dynamic_frame_from_catalog(database, table_name,transformation_ctx="sample_dynF")
```

**Input Source**

If you are using a relational database (a JDBC connection) for the input source, job bookmarks work only if the table's primary keys are in sequential order. Job bookmarks work for new rows, but not for updated rows. That is because job bookmarks look for the primary keys, which already exist. This does not apply if your input source is Amazon Simple Storage Service (Amazon S3).

**Last Modified Time**

For Amazon S3 input sources, job bookmarks check the last modified time of the objects, rather than the file names, to verify which objects need to be reprocessed. If your input source data has been modified since your last job run, the files are reprocessed when you run the job again.

**Error: Failover behavior between VPCs in AWS Glue**

The following process is used for failover for jobs in AWS Glue 4.0 and previous versions.

Summary: an AWS Glue connection is selected at the time a job run is submitted. If the job run encounters some issues, (lack of IP addresses, connectivity to source, routing problem), the job run will fail. If retries are configured, AWS Glue will retry with the same connection.

1. At the time of job run submission, AWS Glue picks the connection based on the order they are listed in the job configuration. It runs a validation, and if the validation succeeds AWS Glue will use that connection. AWS Glue tries the next connection if any of the validations fail.

2. AWS Glue validates the connection with the following:
   - checks for valid Amazon VPC id and subnet.
• checks that a NAT gateway or Amazon VPC endpoint exists.
• checks that the subnet has more than 0 allocated IP addresses.
• checks that the AZ is healthy.

AWS Glue cannot verify connectivity at the time of job run submission.

3. For jobs using Amazon VPC, all drivers and executors will be created in the same AZ with the connection selected at the time of job run submission.

4. If retries are configured, AWS Glue will retry with the same connection. This is because we cannot guarantee problems with this connection are long-running. If an AZ fails, existing job runs (depending on the stage of the job run) in that AZ can fail. A retry should detect an AZ failure and choose another AZ for the new run.

**Troubleshoot crawler errors when the crawler is using Lake Formation credentials**

Use the information below to diagnose and fix various issues while configuring the crawler using Lake Formation credentials.

**Error: The S3 location: s3://examplepath is not registered**

For a crawler to run using Lake Formation credentials, you need to first set up Lake Formation permissions. To resolve this error, please register the target Amazon S3 location with Lake Formation. For more information, see [Registering an Amazon S3 location](#).

**Error: User/Role is not authorized to perform: lakeformation:GetDataAccess on resource**

Please add the `lakeformation:GetDataAccess` permission to the crawler role using the IAM console or AWS CLI. With this permission, Lake Formation grants the request for temporary credentials to access the data. See the policy below:

```json
{
    "Version": "2012-10-17",
    "Statement": {
        "Effect": "Allow",
        "Action": [
            "lakeformation:GetDataAccess"
        ]
    }
}
```
Error: Insufficient Lake Formation permission(s) on (Database name: exampleDatabase, Table Name: exampleTable)

In the Lake Formation console (https://console.aws.amazon.com/lakeformation/), grant the crawler role access permissions (Create, Describe, Alter) on the database, which is specified as the output database. You can grant permissions on the table as well. For more information, see Granting database permissions using the named resource method.

Error: Insufficient Lake Formation permission(s) on s3://examplepath

1. Cross-account crawling
   a. Log in to the Lake Formation console (https://console.aws.amazon.com/lakeformation/) using the account where Amazon S3 bucket is registred (account B). Grant data location permissions to the account where the crawler will be run. This will allow the crawler to read data from the target Amazon S3 location.
   b. In the account where the crawler is created (account A), grant data location permissions on the target Amazon S3 location to the IAM role used for the crawler run so that the crawler can read the data from the destination in Lake Formation. For more information, see Granting data location permissions (external account).

2. In-account (crawler and registered Amazon S3 location are in the same account) crawling
   - Grant data location permissions to the IAM role used for the crawler run on the Amazon S3 location so that the crawler can read the data from the target in Lake Formation. For more information, see Granting data location permissions (same account).

Frequently asked questions about crawler configuration using Lake Formation credentials

1. How do I configure a crawler to run using Lake Formation credentials using the AWS console?

   In the AWS Glue console (https://console.aws.amazon.com/glue/), while configuring the crawler, select the option Use Lake Formation credentials for crawling Amazon S3 data source. For cross-account crawling, specify the AWS account ID where the target Amazon S3 location is registered with Lake Formation. For in-account crawling, the accountId field is optional.
2. **How do I configure a crawler to run using Lake Formation credentials using AWS CLI?**

   During `CreateCrawler` API call, add `LakeFormationConfiguration`:

   ```json
   "LakeFormationConfiguration": {
     "UseLakeFormationCredentials": true,
     "AccountId": "111111111111" (AWS account ID where the target Amazon S3 location is registered with Lake Formation)
   }
   ```

3. **What are the supported targets for a crawler using Lake Formation credentials?**

   A crawler using Lake Formation credentials is only supported for Amazon S3 (in-account and cross-account crawling), in-account Data Catalog targets (where the underlying location is Amazon S3), and Apache Iceberg targets.

4. **Can I crawl multiple Amazon S3 buckets as part of a single crawler using Lake Formation credentials?**

   No, for crawling targets using Lake Formation credential vending, the underlying Amazon S3 locations must belong to the same bucket. For example, customers can use multiple target locations (s3://bucket1/folder1, s3://bucket1/folder2) if they are under the same bucket (bucket1). Specifying different buckets (s3://bucket1/folder1, s3://bucket2/folder2) is not supported.

---

**Troubleshooting AWS Glue for Ray errors from logs**

AWS Glue provides access to logs that are emitted by Ray processes during the job run. If you encounter errors or unexpected behavior in Ray jobs, first gather information from the logs to determine the cause of failure. We also provide similar logs for interactive sessions. Sessions logs are provided with the `/aws-glue/ray/sessions` prefix.

Log lines are sent to CloudWatch in real time, as your job is run. Print statements are appended to the CloudWatch logs after the run completes. Logs are retained for two weeks after a job is run.

**Inspecting Ray job logs**

When a job fails, gather your job name and job run ID. You can find these in the AWS Glue console. Navigate to the job page, and then navigate to the **Runs** tab. Ray job logs are stored in the following dedicated CloudWatch log groups.
• /aws-glue/ray/jobs/script-log/ – Stores logs emitted by your main Ray script.
• /aws-glue/ray/jobs/ray-monitor-log/ – Stores logs emitted by the Ray autoscaler process. These logs are generated for the head node and not for other worker nodes.
• /aws-glue/ray/jobs/ray-gcs-logs/ – Stores logs emitted by the GCS (global control store) process. These logs are generated for the head node and not for other worker nodes.
• /aws-glue/ray/jobs/ray-process-logs/ – Stores logs emitted by other Ray processes (primarily the dashboard agent) running on the head node. These logs are generated for the head node and not for other worker nodes.
• /aws-glue/ray/jobs/ray-raylet-logs/ – Stores logs emitted by each raylet process. These logs are collected in a single stream for each worker node, including the head node.
• /aws-glue/ray/jobs/ray-worker-out-logs/ – Stores stdout logs for each worker in the cluster. These logs are generated for each worker node, including the head node.
• /aws-glue/ray/jobs/ray-worker-err-logs/ – Stores stderr logs for each worker in the cluster. These logs are generated for each worker node, including the head node.
• /aws-glue/ray/jobs/ray-runtime-env-log/ – Stores logs about the Ray setup process. These logs are generated for each worker node, including the head node.

**Troubleshooting Ray job errors**

To understand the organization of Ray log groups, and to find the log groups that will help you troubleshoot your errors, it helps to have background information about Ray architecture.

In AWS Glue ETL, a worker corresponds to an instance. When you configure workers for an AWS Glue job, you're setting the type and quantity of instances that are dedicated to the job. Ray uses the term *worker* in different ways.

Ray uses *head node* and *worker node* to distinguish the responsibilities of an instance within a Ray cluster. A Ray worker node can host multiple *actor* processes that perform computations to achieve the result of your distributed computation. Actors that run a replica of a function are called *replicas*. Replica actors can also be called worker processes. Replicas can also run on the head node, which is known as the head because it runs additional processes to coordinate the cluster.

Each actor that contributes to your computation generates its own log stream. This provides us with some insights:

• The number of processes that emit logs might be larger than the number of workers that are allocated to the job. Often, each core on each instance has an actor.
• Ray head nodes emit cluster management and startup logs. In contrast, Ray worker nodes only emit logs for the work performed on them.

For more information about Ray architecture, see Architecture Whitepapers in the Ray documentation.

**Problem area: Amazon S3 access**

Check the failure message of the job run. If that doesn't provide enough information, check `/aws-glue/ray/jobs/script-log/`.

**Problem area: PIP dependency management**

Check `/aws-glue/ray/jobs/ray-runtime-env-log/`.

**Problem area: Inspecting intermediate values in main process**

Write to stderr or stdout from your main script, and retrieve logs from `/aws-glue/ray/jobs/script-log/`.

**Problem area: Inspecting intermediate values in a child process**

Write to stderr or stdout from your remote function. Then, retrieve logs from `/aws-glue/ray/jobs/ray-worker-out-logs/` or `/aws-glue/ray/jobs/ray-worker-err-logs/`. Your function might have run on any replica, so you might have to examine multiple logs to find your intended output.

**Problem area: Interpreting IP addresses in error messages**

In certain error situations, your job might emit an error message that contains an IP address. These IP addresses are ephemeral, and are used by the cluster to identify and communicate between nodes. Logs for a node will be published to a log stream with a unique suffix based on the IP address.

In CloudWatch, you can filter down your logs to inspect those specific to this IP address by identifying this suffix. For example, given `FAILED_IP` and `JOB_RUN_ID`, you can identify the suffix with:

```
filter @logStream like /JOB_RUN_ID/
```
AWS Glue machine learning exceptions

This topic describes HTTP error codes and strings for AWS Glue exceptions related to machine learning. The error codes and error strings are provided for each machine learning activity that may occur when you perform an operation. Also, you can see whether it is possible to retry the operation that resulted in the error.

CancelMLTaskRunActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”
  - “No ML Task Run found for [taskRunId]: in account [accountId] for transform [transformName].”

  OK to retry: No.

CreateMLTaskRunActivity

This activity has the following exceptions:

- InvalidInputException (400)
  - “Internal service failure due to unexpected input.”
  - “An AWS Glue Table input source should be specified in transform.”
  - “Input source column [columnName] has an invalid data type defined in the catalog.”
  - “Exactly one input record table must be provided.”
  - “Should specify database name.”
  - “Should specify table name.”
• “Schema is not defined on the transform.”
• “Schema should contain given primary key: [primaryKey].”
• “Problem fetching the data catalog schema: [message].”
• “Cannot set Max Capacity and Worker Num/Type at the same time.”
• “Both WorkerType and NumberOfWorkers should be set.”
• “MaxCapacity should be >= [maxCapacity].”
• “NumberOfWorkers should be >= [maxCapacity].”
• “Max retries should be non-negative.”
• “Find Matches parameters have not been set.”
• “A primary key must be specified in Find Matches parameters.”

OK to retry: No.

• AlreadyExistsException (400)
  • “Transform with name [transformName] already exists.”

OK to retry: No.

• IdempotentParameterMismatchException (400)
  • “Idempotent create request for transform [transformName] had mismatching parameters.”

OK to retry: No.

• InternalServiceException (500)
  • “Dependency failure.”

OK to retry: Yes.

• ResourceNumberLimitExceeded Exception (400)
  • “ML Transforms count ([count]) has exceeded the limit of [limit] transforms.”

OK to retry: Yes, once you've deleted a transform to make room for this new one.

**DeleteMLTransformActivity**

This activity has the following exceptions:

• EntityNotFoundException (400)
• “Cannot find MLTransform in account [accountId] with handle [transformName]”

OK to retry: No.

GetMLTaskRunActivity

This activity has the following exceptions:

• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”
  • “No ML Task Run found for [taskRunId]: in account [accountId] for transform [transformName].”

OK to retry: No.

GetMLTaskRunsActivity

This activity has the following exceptions:

• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”
  • “No ML Task Run found for [taskRunId]: in account [accountId] for transform [transformName].”

OK to retry: No.

GetMLTransformActivity

This activity has the following exceptions:

• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”

OK to retry: No.
GetMLTransformsActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.

- InvalidInputException (400)
  - “Account ID can't be blank.”
  - “Sorting not supported for column [column].”
  - “[column] can't be blank.”
  - “Internal service failure due to unexpected input.”

  OK to retry: No.

GetSaveLocationForTransformArtifactActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.

- InvalidInputException (400)
  - “Unsupported artifact type [artifactType].”
  - “Internal service failure due to unexpected input.”

  OK to retry: No.

GetTaskRunArtifactActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.
• “No ML Task Run found for [taskRunId]: in account [accountId] for transform [transformName].”

OK to retry: No.

• InvalidInputException (400)
  • “File name ‘[fileName]’ is invalid for publish.”
  • “Cannot retrieve artifact for [taskType] task type.”
  • “Cannot retrieve artifact for [artifactType].”
  • “Internal service failure due to unexpected input.”

OK to retry: No.

PublishMLTransformModelActivity

This activity has the following exceptions:

• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”
  • “An existing model with version - [version] cannot be found for account id - [accountId] - and transform id - [transformId].”

OK to retry: No.

• InvalidInputException (400)
  • “File name ‘[fileName]’ is invalid for publish.”
  • “Illegal leading minus sign on unsigned string [string].”
  • “Bad digit at end of [string].”
  • “String value [string] exceeds range of unsigned long.”
  • “Internal service failure due to unexpected input.”

OK to retry: No.

PullLatestMLTransformModelActivity

This activity has the following exceptions:
- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.

- InvalidInputException (400)
  - “Internal service failure due to unexpected input.”

  OK to retry: No.

- ConcurrentModificationException (400)
  - “Cannot create model version to train due to racing inserts with mismatching parameters.”
  - “The ML Transform model for transform id [transformId] is stale or being updated by another process; Please retry.”

  OK to retry: Yes.

**PutJobMetadataForMLTransformActivity**

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”
  - “No ML Task Run found for [taskRunId]: in account [accountId] for transform [transformName].”

  OK to retry: No.

- InvalidInputException (400)
  - “Internal service failure due to unexpected input.”
  - “Unknown job metadata type [jobType].”
  - “Must provide a task run ID to update.”

  OK to retry: No.

**StartExportLabelsTaskRunActivity**

This activity has the following exceptions:
• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”
  • “No labelset exists for transformId [transformId] in account id [accountId].”

  OK to retry: No.

• InvalidInputException (400)
  • “[message].”
  • “S3 path provided is not in the same region as transform. Expecting region - [region], but got - [region].”

  OK to retry: No.

**StartImportLabelsTaskRunActivity**

This activity has the following exceptions:

• EntityNotFoundException (400)
  • “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.

• InvalidInputException (400)
  • “[message].”
  • “Invalid label file path.”
  • “Cannot access the label file at [labelPath]. [message].”
  • “Cannot use IAM role provided in the transform. Role: [role].”
  • “Invalid label file of size 0.”
  • “S3 path provided is not in the same region as transform. Expecting region - [region], but got - [region].”

  OK to retry: No.

• ResourceNumberLimitExceededException (400)
  • “Label file has exceeded the limit of [limit] MB.”

  OK to retry: No. Consider breaking your label file into several smaller files.
StartMLEvaluationTaskRunActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

  OK to retry: No.

- InvalidInputException (400)
  - “Exactly one input record table must be provided.”
  - “Should specify database name.”
  - “Should specify table name.”
  - “Find Matches parameters have not been set.”
  - “A primary key must be specified in Find Matches parameters.”

  OK to retry: No.

- MLTransformNotReadyException (400)
  - “This operation can only be applied to a transform that is in a READY state.”

  OK to retry: No.

- InternalServiceException (500)
  - “Dependency failure.”

  OK to retry: Yes.

- ConcurrentRunsExceededException (400)
  - “ML Task Runs count [count] has exceeded the transform limit of [limit] task runs.”
  - “ML Task Runs count [count] has exceeded the limit of [limit] task runs.”

  OK to retry: Yes, after waiting for task runs to finish.

StartMLLabelingSetGenerationTaskRunActivity

This activity has the following exceptions:

- EntityNotFoundException (400)
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”
OK to retry: No.

- **InvalidInputException (400)**
  - “Exactly one input record table must be provided.”
  - “Should specify database name.”
  - “Should specify table name.”
  - “Find Matches parameters have not been set.”
  - “A primary key must be specified in Find Matches parameters.”

OK to retry: No.

- **InternalServiceException (500)**
  - “Dependency failure.”

OK to retry: Yes.

- **ConcurrentRunsExceededException (400)**
  - “ML Task Runs count [count] has exceeded the transform limit of [limit] task runs.”

OK to retry: Yes, after task runs have completed.

**UpdateMLTransformActivity**

This activity has the following exceptions:

- **EntityNotFoundException (400)**
  - “Cannot find MLTransform in account [accountId] with handle [transformName].”

OK to retry: No.

- **InvalidInputException (400)**
  - “Another transform with name [transformName] already exists.”
  - “[message].”
  - “Transform name cannot be blank.”
  - “Cannot set Max Capacity and Worker Num/Type at the same time.”
  - “Both WorkerType and NumberOfWorkers should be set.”
  - “MaxCapacity should be >= [minMaxCapacity].”
• “NumberOfWorkers should be >= [minNumWorkers].”
• “Max retries should be non-negative.”
• “Internal service failure due to unexpected input.”
• “Find Matches parameters have not been set.”
• “A primary key must be specified in Find Matches parameters.”

OK to retry: No.

• AlreadyExistsException (400)
  • “Transform with name [transformName] already exists.”

OK to retry: No.

• IdempotentParameterMismatchException (400)
  • “Idempotent create request for transform [transformName] had mismatching parameters.”

OK to retry: No.

AWS Glue quotas

You can contact AWS Support to request a quota increase for the service quotas listed in the AWS General Reference. Unless otherwise noted, each quota is Region-specific. For more information, see AWS Glue Endpoints and Quotas.
Known issues for AWS Glue

Note the following known issues for AWS Glue.

Topics

- Preventing cross-job data access

Preventing cross-job data access

Consider the situation where you have two AWS Glue Spark jobs in a single AWS Account, each running in a separate AWS Glue Spark cluster. The jobs are using AWS Glue connections to access resources in the same virtual private cloud (VPC). In this situation, a job running in one cluster might be able to access the data from the job running in the other cluster.

The following diagram illustrates an example of this situation.
In the diagram, AWS Glue Job-1 is running in Cluster-1, and Job-2 is running in Cluster-2. Both jobs are working with the same instance of Amazon Redshift, which resides in Subnet-1 of a VPC. Subnet-1 could be a public or private subnet.

Job-1 is transforming data from Amazon Simple Storage Service (Amazon S3) Bucket-1 and writing the data to Amazon Redshift. Job-2 is doing the same with data in Bucket-2. Job-1 uses the AWS Identity and Access Management (IAM) role Role-1 (not shown), which gives access to Bucket-1. Job-2 uses Role-2 (not shown), which gives access to Bucket-2.

These jobs have network paths that enable them to communicate with each other's clusters and thus access each other's data. For example, Job-2 could access data in Bucket-1. In the diagram, this is shown as the path in red.

Preventing cross-job data access
To prevent this situation, we recommend that you attach different security configurations to Job-1 and Job-2. By attaching the security configurations, cross-job access to data is blocked by virtue of certificates that AWS Glue creates. The security configurations can be dummy configurations. That is, you can create the security configurations without enabling encryption of Amazon S3 data, Amazon CloudWatch data, or job bookmarks. All three encryption options can be disabled.

For information about security configurations, see the section called “Encrypting data written by AWS Glue”.

**To attach a security configuration to a job**

2. On the **Configure the job properties** page for the job, expand the **Security configuration, script libraries, and job parameters** section.
3. Select a security configuration in the list.
## Documentation history for AWS Glue

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support for using fine-grained sensitive data detection</strong></td>
<td>The Detect Sensitive Data transform provides the ability to detect, mask, or remove entities that you define, or are pre-defined by AWS Glue. Fine-grained actions further allows you to apply a specific action per entity. For more information, see <a href="#">Using fine-grained sensitive data detection</a>.</td>
<td>November 26, 2023</td>
</tr>
<tr>
<td><strong>Support for monitoring jobs with AWS Glue Observability metrics</strong></td>
<td>Use AWS Glue Observability metrics to generate insights into what is happening inside your AWS Glue for Apache Spark jobs to improve triaging and analysis of issues. For more information, see <a href="#">Monitoring with AWS Glue Observability metrics</a>.</td>
<td>November 26, 2023</td>
</tr>
<tr>
<td><strong>Support for anomaly detection in AWS Glue Data Quality</strong></td>
<td>AWS Glue Data Quality anomaly detection applies machine learning (ML) algorithms on data statistics over time to detect abnormal patterns and hidden data quality issues that are hard to detect through rules. For more information, see</td>
<td>November 26, 2023</td>
</tr>
</tbody>
</table>
Anomaly detection in AWS Glue Data Quality.

Update to default Spark UI logging behavior

Spark jobs generating Spark UI logs will now write with a different filename pattern to support Spark UI in the AWS Glue console. This does not change CloudWatch log behavior. You can revert to the legacy behavior by updating your job configuration. For more information, see Monitoring jobs using the Apache Spark web UI.

Support for new data sources in AWS Glue for Spark

Connections to Amazon OpenSearch Service, Azure SQL, Azure Cosmos for NoSQL, SAP HANA Teradata Vantage and Vertica are now supported natively within AWS Glue. Additionally, connections to these data sources, along with MongoDB, are now available for use in the AWS Glue Studio visual editor. For more information, see Connection types and options for ETL in AWS Glue for Spark for information about AWS Glue for Spark support and Adding an AWS Glue connection for information about use in the AWS Glue Studio visual editor.
<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for generating column statistics</td>
<td>You can compute column-level statistics for AWS Glue Data Catalog tables in data formats such as Parquet, ORC, JSON, ION, CSV, and XML without setting up additional data pipelines. For more information, see Working with column statistics.</td>
<td>November 16, 2023</td>
</tr>
<tr>
<td>Support for data compaction for Iceberg tables</td>
<td>For better read performance by AWS analytics services such as Amazon Athena and Amazon EMR, and AWS Glue ETL jobs, Data Catalog provides managed compaction (a process that compacts small Amazon S3 objects into larger objects) for Iceberg tables in Data Catalog. For more information, see Optimizing Iceberg tables.</td>
<td>November 13, 2023</td>
</tr>
<tr>
<td>Update to job run wait behavior</td>
<td>Standard Spark and Python shell job runs will now transition to WAITING in certain situations, rather than immediately transitioning to FAILED. For more information, see AWS Glue job run statuses.</td>
<td>November 8, 2023</td>
</tr>
<tr>
<td>AWS Glue Studio user guide consolidated into AWS Glue developer guide</td>
<td>The AWS Glue Studio user guide has been moved into the developer guide to create a single unified user guide for AWS Glue Studio, the AWS Glue console, and AWS Glue Studio programmatic access.</td>
<td>October 25, 2023</td>
</tr>
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</tr>
<tr>
<td>Update to the AWSGlueServiceNotebookRole AWS managed policy</td>
<td>Added information about a minor update to the AWSGlueServiceNotebookRole AWS managed policy. For more information, see <a href="#">AWS Glue Updates to AWS Managed Policies</a>.</td>
<td>October 9, 2023</td>
</tr>
<tr>
<td>AWS Glue Studio supports five new built-in transforms</td>
<td>AWS Glue Studio supports the following five new built-in transforms: Record matching, Remove null rows, Parse JSON column, Extract JSON path, and Regex extractor. For more information, see <a href="#">Editing AWS Glue managed data transform nodes</a>.</td>
<td>August 11, 2023</td>
</tr>
<tr>
<td>Update to the AWSGlueServiceRole AWS managed policy</td>
<td>Added information about a minor update to the AWSGlueServiceRole AWS managed policy. For more information, see <a href="#">AWS Glue Updates to AWS Managed Policies</a>.</td>
<td>August 4, 2023</td>
</tr>
</tbody>
</table>
**Support for crawling Apache Hudi tables**

Added information about using AWS Glue to crawl Hudi tables in Amazon S3 buckets and registering the Hudi tables to the AWS Glue Data Catalog. For more information, see [Which data stores can I crawl?](#) and [Crawler properties](#).

**Update to the AWSGlueConsoleFullAccess AWS managed policy**

Added information about a minor update to the AWSGlueConsoleFullAccess AWS managed policy. For more information, see [AWS Glue Updates to AWS Managed Policies](#).

**Support for crawling Apache Iceberg tables**

Added information about using AWS Glue to crawl Iceberg tables in Amazon S3 buckets and registering the Iceberg tables to the AWS Glue Data Catalog. For more information, see [Which data stores can I crawl?](#) and [Crawler properties](#).

**Support for AWS Glue with Ray**

Added information about AWS Glue with Ray, a new engine that can back AWS Glue jobs. Reorganized existing AWS Glue with Spark content to disambiguate.

July 21, 2023

July 14, 2023

July 7, 2023

May 30, 2023
| **Support for AWS Glue Data Quality (GA)** | AWS Glue Data Quality is now generally available. AWS Glue Data Quality helps you evaluate and monitor the quality of your data. For information about how to use AWS Glue Data Quality with Data Catalog, see [AWS Glue Data Quality](https://docs.aws.amazon.com/glue/latest/dg/data-quality.html). To learn about AWS Glue Data Quality for AWS Glue Studio, see [Evaluating data quality with AWS Glue Studio](https://docs.aws.amazon.com/glue/latest/dg/evaluate-data-quality.html). | May 24, 2023 |
| **Support for larger worker types for Apache Spark jobs** | Support is now available for use of the G.4X and G.8X worker types for Apache Spark jobs. These worker types are appropriate for jobs whose workloads contain your most demanding transforms, aggregations, joins, and queries. For more information, see [Adding jobs in AWS Glue](https://docs.aws.amazon.com/glue/latest/dg/adding-jobs.html). | May 8, 2023 |
| **Support for creating partition indexes when crawling tables** | Added information about how crawlers support the creation of partition indexes for tables that the crawler detects. For more information, see [Setting the partition index crawler configuration option](https://docs.aws.amazon.com/glue/latest/dg/crawler-configuration-options-partition-index.html). | April 24, 2023 |
Support for resource usage metrics

Added information about viewing the service's resource usage and configuring alarms in Amazon CloudWatch. For more information, see AWS Glue resource monitoring.

Update to the AWSGlueConsoleFullAccess AWS managed policy

Added information about a minor update to the AWSGlueConsoleFullAccess AWS managed policy. For more information, see AWS Glue Updates to AWS Managed Policies.

Added guidance for using AWS Glue with an AWS SDK with examples

The AWS Glue Developer Guide has two new sections that provide information to help you use AWS Glue with an AWS SDK. For more information, see Using AWS Glue with an AWS SDK and Code examples for AWS Glue using AWS SDKs.

Update to the documentation for IAM with AWS Glue

Reorganized and added information on using IAM with AWS Glue. For more information, see Identity and access management for AWS Glue.
<table>
<thead>
<tr>
<th>Feature</th>
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<tbody>
<tr>
<td><strong>Support for running streaming ETL jobs in AWS Glue version 4.0</strong></td>
<td>Added information about support for running streaming ETL jobs in Glue version 4.0, and new options for connecting to a Kafka cluster or an Amazon Managed Streaming for Apache Kafka cluster, and Amazon Kinesis Data Streams. For more information, see <a href="#">Adding Streaming ETL Jobs in AWS Glue</a> and <a href="#">Connection types and options for ETL in AWS Glue</a>.</td>
<td>February 8, 2023</td>
</tr>
<tr>
<td><strong>Support for crawling MongoDB Atlas data sources</strong></td>
<td>Added information about using AWS Glue to crawl MongoDB Atlas data sources. For more information, see <a href="#">Which data stores can I crawl?</a>, <a href="#">MongoDB and MongoDB Atlas connection properties</a>, and <a href="#">Using a MongoDB or MongoDB Atlas connection</a>.</td>
<td>February 6, 2023</td>
</tr>
<tr>
<td>Support for crawling Delta Lake tables using a native Delta Lake connector</td>
<td>Added information about using AWS Glue to crawl Delta Lake tables using a native Delta Lake connector. This feature allows you to use AWS query engines to query the Delta transaction log directly and use features such as time travel and ACID guarantees, and to sync your Delta Lake metadata from Amazon S3 transaction files into the Data Catalog to enable column permissions on your queries in Lake Formation. For more information, see <a href="#">How to specify configuration options for a Delta Lake data store</a> and <a href="#">Querying Delta Lake tables</a>.</td>
<td>December 15, 2022</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Support for AWS Glue Data Quality (preview)</td>
<td>Support is now available for AWS Glue Data Quality (preview). AWS Glue Data Quality helps you evaluate and monitor the quality of your data when you use AWS Glue 3.0. For information about how to use AWS Glue Data Quality with Data Catalog, see <a href="#">AWS Glue Data Quality (preview)</a>. To learn about AWS Glue Data Quality for AWS Glue Studio, see <a href="#">Evaluating data quality with AWS Glue Studio</a>.</td>
<td>November 30, 2022</td>
</tr>
</tbody>
</table>
Support for a new Amazon Redshift Spark connector with new features and performance improvements

Support is now available for a new Amazon Redshift Spark connector with a new JDBC driver for use with AWS Glue ETL jobs to build Apache Spark applications that read from and write to data in Amazon Redshift as part of your data ingestion and transformation pipelines. For more information, see Moving data to and from Amazon Redshift.

Support for AWS Glue version 4.0.

Added information about support for AWS Glue version 4.0. Features include native support for open-data lake frameworks with Apache Hudi, Delta Lake, and Apache Iceberg, and native support for the Amazon S3-based Cloud Shuffle Storage Plugin (an Apache Spark plugin) to use Amazon S3 for shuffling and elastic storage capacity. For more information, see AWS Glue Release Notes and Migrating AWS Glue jobs to AWS Glue version 4.0.
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</thead>
<tbody>
<tr>
<td><strong>AWS Glue Studio now offers custom visual transforms</strong></td>
<td>Custom visual transforms let customers define, reuse, and share business-specific ETL logic among their teams. For more information, see <a href="#">Custom visual transforms</a>.</td>
<td>November 28, 2022</td>
</tr>
<tr>
<td><strong>Support for using the AWS Glue crawler to publish metadata for JDBC data stores</strong></td>
<td>Support is now available for using the AWS Glue crawler to publish metadata such as comments and rawtypes to the Data Catalog for JDBC data stores. For more information, see <a href="#">Parameters set on Data Catalog tables by crawler</a>, <a href="#">Crawler properties</a>, and <a href="#">JdbcTarget structure</a>.</td>
<td>November 18, 2022</td>
</tr>
<tr>
<td><strong>Support for crawling Snowflake data stores</strong></td>
<td>Support is now available for using AWS Glue to crawl Snowflake tables and views, and to publish the metadata to the Data Catalog as a table entry. For Snowflake external tables in Amazon S3, the crawler also crawls the Amazon S3 location and the file format type of the external table and populates as Table parameters. For more information, see <a href="#">Which data stores can I crawl?</a>, <a href="#">AWS Glue connection properties</a>, and <a href="#">Parameters set on Data Catalog tables by crawler</a>.</td>
<td>November 18, 2022</td>
</tr>
<tr>
<td>Feature</td>
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<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>Support for improved shuffle management of your Spark applications</strong></td>
<td>Support is now available for a new Cloud Shuffle Storage Plugin for Apache Spark. For more information, see <a href="https://aws.amazon.com">AWS Glue Spark shuffle plugin with Amazon S3 and Cloud Shuffle Storage Plugin for Apache Spark</a>.</td>
<td>November 15, 2022</td>
</tr>
<tr>
<td>Added support for Data Catalog targets when accelerating crawls Amazon S3 event notifications</td>
<td>In addition to the existing support for Amazon S3 targets, support is now available for accelerating crawls for Data Catalog targets using Amazon S3 event notifications. For more information, see <a href="https://aws.amazon.com">Accelerating Crawls Using Amazon S3 Event Notifications</a>.</td>
<td>October 13, 2022</td>
</tr>
<tr>
<td><strong>Support for specifying the maximum number of tables a crawler can create</strong></td>
<td>Support is now available for specifying the maximum number of tables the crawler is allowed to create. For more information, see <a href="https://aws.amazon.com">How to specify the maximum number of tables the crawler is allowed to create</a>.</td>
<td>September 6, 2022</td>
</tr>
<tr>
<td><strong>Support for Python 3.9 in Python shell jobs in AWS Glue</strong></td>
<td>Support is now available for running scripts compatible with Python 3.9 in Python shell jobs in AWS Glue, and for choosing to use pre-packaged library sets. For more information, see <a href="https://aws.amazon.com">Python shell jobs in AWS Glue</a>.</td>
<td>August 11, 2022</td>
</tr>
<tr>
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</tr>
<tr>
<td>Support for running non-urgent or non-time sensitive AWS Glue jobs on spare capacity</td>
<td>Support is now available for the configuration of flexible job runs for non-urgent jobs such as pre-production jobs, testing, and one-time data loads. For more information, see <a href="#">Adding jobs in AWS Glue</a>.</td>
<td>August 9, 2022</td>
</tr>
<tr>
<td>Support for a new worker type for streaming jobs</td>
<td>Support is now available for use of the G.025X worker type for low volume streaming jobs. For more information, see <a href="#">Adding jobs in AWS Glue</a>.</td>
<td>July 14, 2022</td>
</tr>
<tr>
<td>Support for the use of Kafka SASL in AWS Glue connections</td>
<td>Support is now available for use of Kafka SASL in AWS Glue connections. For more information, see <a href="#">AWS Glue Kafka connection properties for client authentication</a>.</td>
<td>July 5, 2022</td>
</tr>
<tr>
<td>Support for Apache kafka connector for protobuf schemas</td>
<td>Support is now available for Apache Kafka Connector for Protobuf schemas. For more information, see <a href="#">AWS Glue Schema Registry</a>.</td>
<td>June 9, 2022</td>
</tr>
<tr>
<td>Support for Auto Scaling for AWS Glue jobs (GA)</td>
<td>Added information on using Auto Scaling for jobs in AWS Glue version 3.0 to dynamically scale compute resources. For more information, see <a href="#">Using Auto Scaling for AWS Glue</a>.</td>
<td>April 14, 2022</td>
</tr>
<tr>
<td>Update to the documentation for AWS Glue developing and testing AWS Glue job scripts</td>
<td>Reorganized and added information on the available development and testing methods for AWS Glue, including instructions for developing with Docker. For more information, see Developing and testing AWS Glue job scripts.</td>
<td>March 14, 2022</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Addition of protocol buffers (protobuf) as a supported data format for the AWS Glue schema registry</td>
<td>Added information about Protobuf as a supported data format (in addition to AVRO and JSON). For more information, see AWS Glue Schema Registry.</td>
<td>February 25, 2022</td>
</tr>
<tr>
<td>Support for crawling Delta Lake tables</td>
<td>Added information about using AWS Glue to crawl Delta Lake tables. For more information, see How to specify configuration options for a Delta Lake data store.</td>
<td>February 24, 2022</td>
</tr>
<tr>
<td>Support for AWS Glue job insights</td>
<td>Added information about using AWS Glue job insights to simplify job debugging and optimization for your AWS Glue jobs. For more information, see Monitoring with AWS Glue job insights.</td>
<td>February 8, 2022</td>
</tr>
<tr>
<td>Support for crawling Amazon S3 backed Data Catalog tables using a VPC endpoint</td>
<td>In addition to Amazon S3 data stores, you can configure your Amazon S3 backed Data Catalog tables to be accessed only by an Amazon Virtual Private Cloud environment (Amazon VPC), for security, auditing, or control purposes. For more information, see <a href="#">Crawling an Amazon S3 Data Store or Amazon S3 backed Data Catalog tables using a VPC Endpoint</a>.</td>
<td>February 3, 2022</td>
</tr>
<tr>
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</tr>
<tr>
<td>Support for Lake Formation governed tables</td>
<td>Added information about AWS Glue support for Lake Formation governed tables, which support ACID transactions, automatic data compaction, and time-travel queries. For more information, see <a href="#">AWS Glue API</a> and the <a href="#">AWS Lake Formation developer guide</a>.</td>
<td>November 30, 2021</td>
</tr>
<tr>
<td>New AWS managed policies added for interactive sessions and notebooks</td>
<td>New managed policies for IAM provided enhanced security for using AWS Glue with interactive sessions and notebooks. For more information, see <a href="#">AWS Managed Policies for AWS Glue</a>.</td>
<td>November 30, 2021</td>
</tr>
<tr>
<td>Feature Description</td>
<td>Details</td>
<td>Date</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Documentation for public preview features</td>
<td>Described features available in preview release for AWS Glue and AWS Glue Studio. For more information, see <a href="#">AWS Glue and AWS Glue Studio preview features</a>.</td>
<td>November 23, 2021</td>
</tr>
<tr>
<td>Glue schema registry now supported with streaming jobs</td>
<td>You can create streaming jobs that access tables that are part of the Glue Schema Registry. For more information see <a href="#">AWS Glue Schema Registry</a> and <a href="#">Adding Streaming ETL Jobs in AWS Glue</a>.</td>
<td>November 15, 2021</td>
</tr>
<tr>
<td>Support for new machine learning features</td>
<td>Added information about new features for the Find matches machine learning transform, including incremental matching and match scoring. For more information, see <a href="#">Finding Incremental Matches</a> and <a href="#">Estimating the Quality of Matches using Match Confidence Scores</a>.</td>
<td>October 31, 2021</td>
</tr>
<tr>
<td>(Private preview) Support for AWS Glue flex jobs</td>
<td>Added information about configuring AWS Glue Spark jobs with a flexible execution class, appropriate for time-insensitive jobs whose start and completion times may vary. For more information, see <a href="#">Adding Jobs in AWS Glue</a>.</td>
<td>October 29, 2021</td>
</tr>
<tr>
<td>Change</td>
<td>Description</td>
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</tr>
<tr>
<td><strong>Support for accelerating crawls using Amazon S3 event notifications</strong></td>
<td>Added information about accelerating crawls using Amazon S3 event notifications. For more information, see <a href="#">Accelerating Crawls Using Amazon S3 Event Notifications</a>. <strong>October 15, 2021</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Additional security configuration options related to access-control and VPCs</strong></td>
<td>Added information about how you can configure new access control permissions on AWS Glue and configuration of VPCs. For more information, see <a href="#">AWS Tags in AWS Glue</a>, <a href="#">Identity-Based Policies (IAM Policies) that Control Settings Using Condition Keys or Context Keys</a>, and <a href="#">Configuring all AWS calls to go through your VPC</a>. <strong>October 13, 2021</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Support for VPC endpoint policies</strong></td>
<td>Added information about support for Virtual Private Cloud (VPC) endpoint policies in AWS Glue. For more information, see <a href="#">AWS Glue and interface VPC endpoints (AWS PrivateLink)</a>. <strong>October 11, 2021</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Glue Studio is now available in China</strong></td>
<td>AWS Glue Studio is now available in the China Beijing and Ningxia regions. <strong>October 11, 2021</strong></td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>AWS Glue Studio offers notebook authoring, for interactive job editing</strong></td>
<td>Notebooks help you to write and execute code, visualize the results, and share insights. Typically, data scientists use notebooks for experiments and data exploration tasks. For more information, see <a href="#">Using Notebooks</a>.</td>
<td>October 1, 2021</td>
</tr>
<tr>
<td><strong>Direct access to streaming sources now available</strong></td>
<td>When adding data sources to your ETL job in the visual editor, you can supply information to access the data stream instead of having to use a Data Catalog database and table.</td>
<td>September 30, 2021</td>
</tr>
<tr>
<td><strong>Documented the AWS Glue version support policy</strong></td>
<td>Added information about the AWS Glue version support policy and the end of life phases for certain AWS Glue versions. For more information, see <a href="#">AWS Glue version support policy</a>.</td>
<td>September 24, 2021</td>
</tr>
<tr>
<td><strong>Custom connectors can now be used with data previews</strong></td>
<td>When editing data source node using a custom connector, you can preview the dataset by choosing the Data preview tab. For more information, see <a href="#">Custom Connectors</a>.</td>
<td>September 24, 2021</td>
</tr>
</tbody>
</table>
Support for AWS Glue interactive sessions (private preview)

(Private preview) Added information about using AWS Glue interactive sessions to run Spark workloads in the cloud from any Jupyter Notebook. Interactive sessions are the preferred method for developing your AWS Glue extract, transform, and load (ETL) code when you use AWS Glue 2.0 or later. For more information, see Setting Up and Running AWS Glue interactive sessions for Jupyter Notebook.

Support for creating workflows from blueprints (GA)

Added information about coding common extract, transform, and load (ETL) use cases in blueprints and then creating workflows from blueprints. Enables data analysts to easily create and run complex ETL processes. For more information, see Performing Complex ETL Activities Using blueprints and Workflows in AWS Glue.

August 24, 2021

August 23, 2021
Support for AWS Glue version 3.0.

Added information about support for AWS Glue version 3.0 which supports the Apache Spark 3.0 engine upgrade for running Apache Spark ETL jobs, and other optimizations and upgrades. For more information, see AWS Glue Release Notes and Migrating AWS Glue jobs to AWS Glue version 3.0. Other features in this release include the AWS Glue shuffle manager, a SIMD vectorized CSV reader, and catalog partition predicates. For more information see AWS Glue Spark shuffle manager with Amazon S3, Format Options for ETL Inputs and Outputs in AWS Glue, and Server-side filtering using catalog partition predicates.

AWS GovCloud (US) Region

AWS Glue Studio is now available in the AWS GovCloud (US) Region.

Python shell authoring available in AWS Glue Studio

When creating a new job, you can now choose to create a Python shell job. For more information, see Start the job creation process and Editing Python shell jobs in AWS Glue Studio.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support for starting a workflow with an Amazon EventBridge event</strong></td>
<td>Added information about how AWS Glue can be an event consumer in an event-driven architecture. For more information, see <a href="#">Starting an AWS Glue Workflow with an Amazon EventBridge Event</a> and <a href="#">Viewing the EventBridge Events That Started a Workflow</a>.</td>
<td>July 14, 2021</td>
</tr>
<tr>
<td><strong>Addition of JSON as a supported data format for the AWS Glue schema registry</strong></td>
<td>Added information about JSON as a supported data format (in addition to AVRO). For more information, see <a href="#">AWS Glue Schema Registry</a>.</td>
<td>June 30, 2021</td>
</tr>
<tr>
<td><strong>Create AWS Glue streaming jobs without a Data Catalog table</strong></td>
<td>The <code>create_data_frame_from_options</code> Python function or <code>getSource</code> for Scala scripts support creating streaming ETL jobs that reference the data streams directly instead of requiring a Data Catalog table.</td>
<td>June 15, 2021</td>
</tr>
<tr>
<td><strong>AWS Glue machine learning transforms now support AWS Key Management Service keys</strong></td>
<td>You can specify a security configuration or AWS KMS key when configuring AWS Glue Machine Learning transforms with the console, the CLI, or the AWS Glue APIs. For more information, see <a href="#">Using Data Encryption with Machine Learning Transformations</a> and <a href="#">AWS Glue Machine Learning API</a>.</td>
<td>June 15, 2021</td>
</tr>
<tr>
<td>Update to the AWSGlueConsoleFullAccess AWS managed policy</td>
<td>Added information about a minor update to the AWSGlueConsoleFullAccess AWS managed policy. For more information, see <a href="#">AWS Glue Updates to AWS Managed Policies</a>.</td>
<td>June 10, 2021</td>
</tr>
<tr>
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</tr>
<tr>
<td>View your job's dataset while creating and editing jobs</td>
<td>You can use the new <strong>Data preview</strong> tab for a node in your job diagram to see a sample of the data processed by that node. For more information, see <a href="#">Using data previews in the visual job editor</a>.</td>
<td>June 7, 2021</td>
</tr>
<tr>
<td>Support for specifying a value that indicates the table location for the crawler output.</td>
<td>Added information about specifying a value that indicates the table location when configuring the crawler's output. For more information, see <a href="#">How to specify the table location</a>.</td>
<td>June 4, 2021</td>
</tr>
<tr>
<td>Support for crawling a sample of files in a dataset when crawling an Amazon S3 data store</td>
<td>Added information about how to crawl a sample of files when crawling Amazon S3. For more information, see <a href="#">Crawler Properties</a>.</td>
<td>May 10, 2021</td>
</tr>
</tbody>
</table>
Support for the AWS Glue optimized parquet writer

Added information about using the AWS Glue optimized parquet writer for DynamicFrames to create or update tables with the parquet classification. For more information, see Creating Tables, Updating Schema, and Adding New Partitions in the Data Catalog from AWS Glue ETL Jobs and Format Options for ETL Inputs and Outputs in AWS Glue.

Support for kafka client authentication passwords

Added information about how streaming ETL jobs in AWS Glue support SSL client certificate authentication with Apache Kafka stream producers. You can now provide a custom certificate while defining an AWS Glue connection to an Apache Kafka cluster, which AWS Glue will use when authenticating with it. For more information, see AWS Glue Connection Properties and Connection API.

May 4, 2021

April 28, 2021
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support for consuming data from Amazon Kinesis Data Streams in another account in streaming ETL jobs</strong></td>
<td>Added information about to create a streaming ETL job to consume data from Amazon Kinesis Data Streams in another account. For more information, see <a href="#">Adding Streaming ETL Jobs in AWS Glue</a>.</td>
<td>March 30, 2021</td>
</tr>
<tr>
<td><strong>SQL transform available</strong></td>
<td>You can use a SQL transform node to write your own transform in the form of a SQL query. For more information, see <a href="#">Using a SQL query to transform data</a>.</td>
<td>March 23, 2021</td>
</tr>
<tr>
<td><strong>Support for creating workflows from blueprints (public preview)</strong></td>
<td>(Public preview) Added information about coding common extract, transform, and load (ETL) use cases in blueprints and then creating workflows from blueprints. Enables data analysts to easily create and run complex ETL processes. For more information, see <a href="#">Performing Complex ETL Activities Using blueprints and Workflows in AWS Glue</a>.</td>
<td>March 22, 2021</td>
</tr>
<tr>
<td><strong>Connectors can be used for data targets</strong></td>
<td>Using a custom or AWS Marketplace connector for your data target is now supported. For more information, see <a href="#">Authoring jobs with custom connectors</a>.</td>
<td>March 15, 2021</td>
</tr>
<tr>
<td>Feature Description</td>
<td>Details</td>
<td>Date</td>
</tr>
<tr>
<td>---------------------</td>
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</tr>
<tr>
<td><strong>Support for column importance metrics for AWS Glue machine learning transforms</strong></td>
<td>Added information about viewing column importance metrics when working with AWS Glue machine learning transforms. For more information see <a href="#">Working with Machine Learning Transforms on the AWS Glue Console</a>.</td>
<td>February 5, 2021</td>
</tr>
<tr>
<td><strong>Job scheduling now available in AWS Glue Studio</strong></td>
<td>You can define a time-based schedule for your job runs in AWS Glue Studio. You can use the console to create a basic schedule, or define a more complex schedule using the Unix-like cron syntax. For more information, see <a href="#">Schedule job runs</a>.</td>
<td>December 21, 2020</td>
</tr>
<tr>
<td><strong>AWS Glue Custom Connectors released</strong></td>
<td>AWS Glue Custom Connectors allow you to discover and subscribe to connectors in AWS Marketplace. We also released AWS Glue Spark runtime interfaces to plug in connectors built for Apache Spark Datasource, Athena federated query, and JDBC APIs. For more information, see <a href="#">Using Connectors and connections with AWS Glue Studio</a>.</td>
<td>December 21, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Added information</td>
<td>Date</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Support for running streaming ETL jobs in AWS Glue version 2.0</strong></td>
<td>Added information about support for running streaming ETL jobs in Glue version 2.0. For more information, see <a href="#">Adding Streaming ETL Jobs in AWS Glue</a>.</td>
<td>December 18, 2020</td>
</tr>
<tr>
<td><strong>Support for workload partitioning with bounded execution</strong></td>
<td>Added information about enabling workload partitioning to configure the upper bounds on the dataset size, or the number of files processed on ETL job runs. For more information, see <a href="#">Workload Partitioning with Bounded Execution</a>.</td>
<td>November 23, 2020</td>
</tr>
<tr>
<td><strong>Support for enhanced partition management</strong></td>
<td>Added information about how to use new APIs to add or delete a partition index to/from an existing table. For more information, see <a href="#">Working with Partition Indexes</a>.</td>
<td>November 23, 2020</td>
</tr>
<tr>
<td><strong>Support for the AWS Glue schema registry</strong></td>
<td>Added information about using the AWS Glue Schema Registry to centrally discover, control, and evolve schemas. For more information, see <a href="#">AWS Glue Schema Registry</a>.</td>
<td>November 19, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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</tr>
<tr>
<td><strong>Support for the grok input format in streaming ETL jobs</strong></td>
<td>Added information about applying Grok patterns to streaming sources such as log files. For more information, see <a href="#">Applying Grok Patterns to Streaming Sources</a>.</td>
<td>November 17, 2020</td>
</tr>
<tr>
<td><strong>Support for adding tags to workflows on the AWS Glue console</strong></td>
<td>Added information about adding tags when creating a workflow using the AWS Glue console. For more information, see <a href="#">Creating and Building Out a Workflow Using the AWS Glue Console</a>.</td>
<td>October 27, 2020</td>
</tr>
<tr>
<td><strong>Support for incremental crawler runs</strong></td>
<td>Added information about support for incremental crawler runs, which crawl only Amazon S3 folders added since the last run. For more information, see <a href="#">Incremental Crawls</a>.</td>
<td>October 21, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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</tr>
<tr>
<td>Support for schema detection for streaming ETL data sources, support for Avro streaming ETL data sources and self-managed kafka</td>
<td>Streaming extract, transform, and load (ETL) jobs in AWS Glue can now automatically detect the schema of incoming records and handle schema changes on a per-record basis. Self-managed Kafka data sources are now supported. Streaming ETL jobs now support the Avro format in data sources. For more information, see Streaming ETL in AWS Glue, Defining Job Properties for a Streaming ETL Job, and Notes and Restrictions for Avro Streaming Sources.</td>
<td>October 7, 2020</td>
</tr>
<tr>
<td>Support for crawling MongoDB and DocumentDB data sources</td>
<td>Added information about support for crawling MongoDB and Amazon DocumentDB (with MongoDB compatibility) data sources. For more information, see Defining Crawlers.</td>
<td>October 5, 2020</td>
</tr>
<tr>
<td>Support for FIPS compliance</td>
<td>Added information about FIPS endpoints for customers who require FIPS 140-2 validated cryptographic modules when accessing data using AWS Glue. For more information, see FIPS Compliance.</td>
<td>September 23, 2020</td>
</tr>
</tbody>
</table>
**AWS Glue Studio provides an easy to use visual interface for creating and monitoring jobs**

You can now use a simple graph-based interface to compose jobs that move and transform data and run them on AWS Glue. You can then use the job run dashboard in AWS Glue Studio to monitor ETL execution and ensure that your jobs are operating as intended. For more information, see [AWS Glue Studio User Guide](#).

**September 23, 2020**

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**Support for creating table indexes to improve query performance**

Added information about creating table indexes to allow you to retrieve a subset of the partitions from a table. For more information, see [Working with Partition Indexes](#).

**September 9, 2020**

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**Support for reduced startup times when running Apache Spark ETL jobs in AWS Glue version 2.0.**

Added information about support for AWS Glue version 2.0 which provides an upgraded infrastructure for running Apache Spark ETL jobs with reduced startup times, changes in logging, and support for specifying additional Python modules at the job level. For more information, see [AWS Glue Release Notes](#) and [Running Spark ETL Jobs with Reduced Startup Times](#).

**August 10, 2020**
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for limiting the number of concurrent workflow runs.</td>
<td>Added information about how to limit the number of concurrent workflow runs for a particular workflow. For more information, see <a href="#">Creating and Building Out a Workflow Using the AWS Glue Console</a>.</td>
<td>August 10, 2020</td>
</tr>
<tr>
<td>Support for crawling an Amazon S3 data store using a VPC endpoint</td>
<td>Added information about configuring your Amazon S3 data store to be accessed only by an Amazon Virtual Private Cloud environment (Amazon VPC), for security, auditing, or control purposes. For more information, see <a href="#">Crawling an Amazon S3 Data Store using a VPC Endpoint</a>.</td>
<td>August 7, 2020</td>
</tr>
<tr>
<td>Support for resuming workflow runs</td>
<td>Added information about how to resume workflow runs that only partially completed because one or more nodes (jobs or crawlers) did not complete successfully. For more information, see <a href="#">Repairing and Resuming a Workflow Run</a>.</td>
<td>July 27, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Added information</td>
<td>Date</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Support for enabling private CA certificates in Kafka connections in AWS Glue.</td>
<td>Added information about new connection options that support enabling private CA certificates for Kafka connections in AWS Glue. For more information, see Connection Types and Options for ETL in AWS Glue.</td>
<td>July 20, 2020</td>
</tr>
<tr>
<td>Support for reading DynamoDB data in another account</td>
<td>Added information about AWS Glue support for reading data from another AWS account's DynamoDB table For more information, see Reading from DynamoDB Data in Another Account.</td>
<td>July 17, 2020</td>
</tr>
<tr>
<td>Support for a DynamoDB writer connection in AWS Glue version 1.0 or later</td>
<td>Added information about support for DynamoDB writer, and new or updated connection options for DynamoDB to read or write. For more information, see Connection Types and Options for ETL in AWS Glue.</td>
<td>July 17, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>Support for resource links and for cross-account access control using both AWS Glue and Lake Formation</strong></td>
<td>Added content about new Data Catalog objects called resource links, and about how to manage sharing Data Catalog resources across accounts with both AWS Glue and AWS Lake Formation. For more information, see <a href="#">Granting Cross-Account Access</a> and <a href="#">Table Resource Links</a>.</td>
<td>July 7, 2020</td>
</tr>
<tr>
<td><strong>Support for sampling records when crawling DynamoDB data stores</strong></td>
<td>Added information about new properties that you can configure when crawling a DynamoDB data store. For more information, see <a href="#">Crawler Properties</a>.</td>
<td>June 12, 2020</td>
</tr>
<tr>
<td><strong>Support for stopping a workflow run.</strong></td>
<td>Added information about how to stop a workflow run for a particular workflow. For more information, see <a href="#">Stopping a Workflow Run</a>.</td>
<td>May 14, 2020</td>
</tr>
<tr>
<td><strong>Support for Spark streaming ETL jobs</strong></td>
<td>Added information about creating extract, transform, and load (ETL) jobs with streaming data sources. For more information, see <a href="#">Adding Streaming ETL Jobs in AWS Glue</a>.</td>
<td>April 27, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Support for creating tables, updating the schema, and adding new partitions in the Data Catalog after running an ETL job</td>
<td>Added information about how you can enable creating tables, updating the schema, and adding new partitions to see the results of your ETL job in the Data Catalog. For more information, see <a href="#">Creating Tables, Updating Schema, and Adding New Partitions in the Data Catalog from AWS Glue ETL Jobs</a>.</td>
<td>April 2, 2020</td>
</tr>
<tr>
<td>Support for specifying a version for the Apache Avro data format as an ETL input and output in AWS Glue</td>
<td>Added information about specifying a version for the Apache Avro data format as an ETL input and output in AWS Glue. The default version 1.7. You can use the version format option to specify Avro version 1.8 to enable logical reading/writing. For more information, see <a href="#">Format Options for ETL Inputs and Outputs in AWS Glue</a>.</td>
<td>March 31, 2020</td>
</tr>
<tr>
<td>Support for the EMRFS S3-optimized committer for writing Parquet data into Amazon S3</td>
<td>Added information about how to set a new flag to enable the EMRFS S3-optimized committer for writing Parquet data into Amazon S3 when creating or updating an AWS Glue job. For more information, see <a href="#">Special Parameters Used by AWS Glue</a>.</td>
<td>March 30, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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</tr>
<tr>
<td>Support for machine learning transforms as a resource managed by AWS resource tags</td>
<td>Added information about using AWS resource tags to manage and control access to your machine learning transforms in AWS Glue. You can assign AWS resource tags to jobs, triggers, endpoints, crawlers, and machine learning transforms in AWS Glue. For more information, see AWS Tags in AWS Glue.</td>
<td>March 2, 2020</td>
</tr>
<tr>
<td>Support for non-overrideable job arguments</td>
<td>Added information about support for special job parameters that cannot be overridden in triggers or when you run the job. For more information see Adding Jobs in AWS Glue.</td>
<td>February 12, 2020</td>
</tr>
<tr>
<td>Support for new transforms to work with datasets in Amazon S3</td>
<td>Added information about new transforms (Merge, Purge, and Transition) and Amazon S3 storage class exclusions for Apache Spark applications to work with datasets in Amazon S3. For more information on support for these transforms for Python, see mergeDynamicFrame and Working with Datasets in Amazon S3. For Scala, see mergeDynamicFrames and AWS Glue Scala GlueContext APIs.</td>
<td>January 16, 2020</td>
</tr>
<tr>
<td>Feature</td>
<td>Added Information</td>
<td>Date</td>
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<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Support for updating the Data Catalog with new partition information from an ETL job</td>
<td>Added information about how to code an extract, transform, and load (ETL) script to update the AWS Glue Data Catalog with new partition information. With this capability, you no longer have to rerun the crawler after job completion to view the new partitions. For more information see <a href="#">Updating the Data Catalog with New Partitions</a>.</td>
<td>January 15, 2020</td>
</tr>
<tr>
<td>New tutorial: Using an SageMaker notebook</td>
<td>Added a tutorial that demonstrates how to use an Amazon SageMaker notebook to help develop your ETL and machine learning scripts. See <a href="#">Tutorial: Use an Amazon SageMaker Notebook with Your Development Endpoint</a>.</td>
<td>January 3, 2020</td>
</tr>
<tr>
<td>Support for reading from MongoDB and Amazon DocumentDB (with MongoDB compatibility)</td>
<td>Added information about new connection types and connection options for reading from and writing to MongoDB and Amazon DocumentDB (with MongoDB Compatibility). For more information, see <a href="#">Connection Types and Options for ETL in AWS Glue</a>.</td>
<td>December 17, 2019</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Date</td>
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<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Various corrections and</td>
<td>Added corrections and clarifications throughout. Removed entries from the Known Issues chapter. Added warnings that AWS Glue supports only symmetrical customer master keys (CMKs) when specifying Data Catalog encryption settings and creating security configurations. Added a note that AWS Glue does not support writing to Amazon DynamoDB.</td>
<td>December 9, 2019</td>
</tr>
<tr>
<td>clarifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support for custom JDBC</td>
<td>Added information about connecting to data sources and targets with JDBC drivers that AWS Glue does not natively support, such as MySQL version 8 and Oracle Database version 18. For more information see <a href="#">JDBC connectionType Values</a>.</td>
<td>November 25, 2019</td>
</tr>
</tbody>
</table>
Support for connecting SageMaker notebooks to different development endpoints

Added information about how you can connect an SageMaker notebook to different development endpoints. Updates to describe the new console action for switching to a new development endpoint, and the new SageMaker IAM policy. For more information, see [Working with Notebooks on the AWS Glue Console](https://docs.aws.amazon.com/glue/latest/dg/working-with-notebooks.html) and [Create an IAM Policy for Amazon SageMaker Notebooks](https://docs.aws.amazon.com/glue/latest/dg/notebooks-iam-policy.html).

November 21, 2019

Support for AWS Glue version in machine learning transforms

Added information about defining the AWS Glue version in a machine learning transform to indicate the which version of AWS Glue a machine learning transform is compatible with. For more information see [Working with Machine Learning Transforms on the AWS Glue Console](https://docs.aws.amazon.com/glue/latest/dg/machine-learning-transforms.html).

November 21, 2019
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support for rewinding your job bookmarks</strong></td>
<td>Added information about rewinding your job bookmarks to any previous job run, resulting in the subsequent job run reprocessing data only from the bookmarked job run. Described two new sub-options for the job-bookmark-pause option that allow you to run a job between two bookmarks. For more information, see <a href="#">Tracking Processed Data Using Job Bookmarks</a> and <a href="#">Special Parameters Used by AWS Glue</a>.</td>
<td>October 22, 2019</td>
</tr>
<tr>
<td><strong>Support for custom JDBC certificates for connecting to a data store</strong></td>
<td>Added information about AWS Glue support of custom JDBC certificates for SSL connections to AWS Glue data sources or targets. For more information, see <a href="#">Working with Connections on the AWS Glue Console</a>.</td>
<td>October 10, 2019</td>
</tr>
<tr>
<td><strong>Support for Python wheel</strong></td>
<td>Added information about AWS Glue support of wheel files (along with egg files) as dependencies for Python shell jobs. For more information, see <a href="#">Providing Your Own Python Library</a>.</td>
<td>September 26, 2019</td>
</tr>
</tbody>
</table>
Support for versioning of development endpoints in AWS Glue

Added information about defining the Glue version in development endpoints. Glue version determines the versions of Apache Spark and Python that AWS Glue supports. For more information, see Adding a Development Endpoint.

September 19, 2019

Support for monitoring AWS Glue using Spark UI

Added information about using Apache Spark UI to monitor and debug AWS Glue ETL jobs running on the AWS Glue job system, and Spark applications on AWS Glue development endpoints. For more information, see Monitoring AWS Glue Using Spark UI.

September 19, 2019

Enhancement of support for local ETL script development using the public AWS Glue ETL library

Updated the AWS Glue ETL library content to reflect that AWS Glue version 1.0 is now supported. For more information, see Developing and Testing ETL Scripts Locally Using the AWS Glue ETL Library.

September 18, 2019
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Support for excluding Amazon S3 storage classes when running jobs</strong></td>
<td>Added information about excluding Amazon S3 storage classes when running AWS Glue ETL jobs that read files or partitions from Amazon S3. For more information, see <a href="#">Excluding Amazon S3 Storage Classes</a>.</td>
<td>August 29, 2019</td>
</tr>
<tr>
<td><strong>Support for local ETL script development using the public AWS Glue ETL library</strong></td>
<td>Added information about how to develop and test Python and Scala ETL scripts locally without the need for a network connection. For more information, see <a href="#">Developing and Testing ETL Scripts Locally Using the AWS Glue ETL Library</a>.</td>
<td>August 28, 2019</td>
</tr>
<tr>
<td><strong>Known issues</strong></td>
<td>Added information about known issues in AWS Glue. For more information, see <a href="#">Known Issues for AWS Glue</a>.</td>
<td>August 28, 2019</td>
</tr>
<tr>
<td><strong>Support for machine learning transforms in AWS Glue</strong></td>
<td>Added information about machine learning capabilities provided by AWS Glue to create custom transforms. You can create these transforms when you create a job. For more information, see <a href="#">Machine Learning Transforms in AWS Glue</a>.</td>
<td>August 8, 2019</td>
</tr>
<tr>
<td>Feature</td>
<td>Details</td>
<td>Date</td>
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<td>------------------------------------------------------------------------</td>
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<tr>
<td><strong>Support for shared Amazon Virtual Private Cloud</strong></td>
<td>Added information about AWS Glue support for shared Amazon Virtual Private Cloud. For more information, see <a href="#">Shared Amazon VPCs</a>.</td>
<td>August 6, 2019</td>
</tr>
<tr>
<td><strong>Support for versioning in AWS Glue</strong></td>
<td>Added information about defining the Glue version in job properties. AWS Glue version determines the versions of Apache Spark and Python that AWS Glue supports. For more information, see <a href="#">Adding Jobs in AWS Glue</a>.</td>
<td>July 24, 2019</td>
</tr>
<tr>
<td><strong>Support for additional configuration options for development endpoints</strong></td>
<td>Added information about configuration options for development endpoints that have memory-intensive workloads. You can choose from two new configurations that provide more memory per executor. For more information, see <a href="#">Working with Development Endpoints on the AWS Glue Console</a>.</td>
<td>July 24, 2019</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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</tr>
<tr>
<td>Support for performing extract, transfer, and load (ETL) activities using workflows</td>
<td>Added information about using a new construct called a workflow to design a complex multi-job extract, transform, and load (ETL) activity that AWS Glue can run and track as a single entity. For more information, see <a href="#">Performing Complex ETL Activities Using Workflows in AWS Glue</a>.</td>
<td>June 20, 2019</td>
</tr>
<tr>
<td>Support for Python 3.6 in Python shell jobs</td>
<td>Added information about support for Python 3.6 in Python shell jobs. You can specify either Python 2.7 or Python 3.6 as a job property. For more information, see <a href="#">Adding Python Shell Jobs in AWS Glue</a>.</td>
<td>June 5, 2019</td>
</tr>
<tr>
<td>Support for virtual private cloud (VPC) endpoints</td>
<td>Added information about connecting directly to AWS Glue through an interface endpoint in your VPC. When you use a VPC interface endpoint, communication between your VPC and AWS Glue is conducted entirely and securely within the AWS network. For more information, see <a href="#">Using AWS Glue with VPC Endpoints</a>.</td>
<td>June 4, 2019</td>
</tr>
<tr>
<td>Feature Description</td>
<td>Details</td>
<td>Date</td>
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</tr>
<tr>
<td><strong>Support for real-time, continuous logging for AWS Glue jobs.</strong></td>
<td>Added information about enabling and viewing real-time Apache Spark job logs in CloudWatch including the driver logs, each of the executor logs, and a Spark job progress bar. For more information, see <a href="#">Continuous Logging for AWS Glue Jobs</a>.</td>
<td>May 28, 2019</td>
</tr>
<tr>
<td><strong>Support for existing Data Catalog tables as crawler sources</strong></td>
<td>Added information about specifying a list of existing Data Catalog tables as crawler sources. Crawlers can then detect changes to table schemas, update table definitions, and register new partitions as new data becomes available. For more information, see <a href="#">Crawler Properties</a>.</td>
<td>May 10, 2019</td>
</tr>
<tr>
<td><strong>Support for additional configuration options for memory-intensive jobs</strong></td>
<td>Added information about configuration options for Apache Spark jobs with memory-intensive workloads. You can choose from two new configurations that provide more memory per executor. For more information, see <a href="#">Adding Jobs in AWS Glue</a>.</td>
<td>April 5, 2019</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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<tr>
<td><strong>Support for CSV custom classifiers</strong></td>
<td>Added information about using a custom CSV classifier to infer the schema of various types of CSV data. For more information, see <a href="#">Writing Custom Classifiers</a>.</td>
<td>March 26, 2019</td>
</tr>
<tr>
<td><strong>Support for AWS resource tags</strong></td>
<td>Added information about using AWS resource tags to help you manage and control access to your AWS Glue resources. You can assign AWS resource tags to jobs, triggers, endpoints, and crawlers in AWS Glue. For more information, see <a href="#">AWS Tags in AWS Glue</a>.</td>
<td>March 20, 2019</td>
</tr>
<tr>
<td><strong>Support of Data Catalog for Spark SQL jobs</strong></td>
<td>Added information about configuring your AWS Glue jobs and development endpoints to use the AWS Glue Data Catalog as an external Apache Hive Metastore. This allows jobs and development endpoints to directly run Apache Spark SQL queries against the tables stored in the AWS Glue Data Catalog. For more information, see <a href="#">AWS Glue Data Catalog Support for Spark SQL Jobs</a>.</td>
<td>March 14, 2019</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Date</td>
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<td>----------------------------------------------</td>
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<tr>
<td><strong>Support for Python shell jobs</strong></td>
<td>Added information about Python shell jobs and the new field <strong>Maximum capacity</strong>. For more information, see <a href="https://aws.amazon.com/">Adding Python Shell Jobs in AWS Glue</a>.</td>
<td>January 18, 2019</td>
</tr>
<tr>
<td><strong>Support for notifications when there are changes to databases and tables</strong></td>
<td>Added information about events that are generated for changes to database, table, and partition API calls. You can configure actions in CloudWatch Events to respond to these events. For more information, see <a href="https://aws.amazon.com/">Automating AWS Glue with CloudWatch Events</a>.</td>
<td>January 16, 2019</td>
</tr>
<tr>
<td><strong>Support for encrypting connection passwords</strong></td>
<td>Added information about encrypting passwords used in connection objects. For more information, see <a href="https://aws.amazon.com/">Encrypting Connection Passwords</a>.</td>
<td>December 11, 2018</td>
</tr>
<tr>
<td><strong>Support for resource-level permission and resource-based policies</strong></td>
<td>Added information about using resource-level permissions and resource-based policies with AWS Glue. For more information, see the topics within <a href="https://aws.amazon.com/">Security in AWS Glue</a>.</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td><strong>Support for SageMaker notebooks</strong></td>
<td>Added information about using SageMaker notebooks with AWS Glue development endpoints. For more information, see <a href="https://aws.amazon.com/">Managing Notebooks</a>.</td>
<td>October 5, 2018</td>
</tr>
<tr>
<td>Feature</td>
<td>Added information</td>
<td>Date</td>
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<tr>
<td><strong>Support for encryption</strong></td>
<td>Added information about using encryption with AWS Glue. For more information, see Encryption at Rest, Encryption in Transit, and Setting Up Encryption in AWS Glue.</td>
<td>August 24, 2018</td>
</tr>
<tr>
<td><strong>Support for Apache Spark job metrics</strong></td>
<td>Added information about the use of Apache Spark metrics for better debugging and profiling of ETL jobs. You can easily track runtime metrics such as bytes read and written, memory usage and CPU load of the driver and executors, and data shuffles among executors from the AWS Glue console. For more information, see Monitoring AWS Glue Using CloudWatch Metrics, Job Monitoring and Debugging, and Working with Jobs on the AWS Glue Console.</td>
<td>July 13, 2018</td>
</tr>
<tr>
<td><strong>Support of DynamoDB as a data source</strong></td>
<td>Added information about crawling DynamoDB and using it as a data source of ETL jobs. For more information, see Cataloging Tables with a Crawler and Connection Parameters.</td>
<td>July 10, 2018</td>
</tr>
<tr>
<td>Updates to create notebook server procedure</td>
<td>Updated information about how to create a notebook server on an Amazon EC2 instance associated with a development endpoint. For more information, see <a href="#">Creating a Notebook Server Associated with a Development Endpoint</a>.</td>
<td>July 9, 2018</td>
</tr>
<tr>
<td>Updates now available over RSS</td>
<td>You can now subscribe to an RSS feed to receive notifications about updates to the <a href="#">AWS Glue Developer Guide</a>.</td>
<td>June 25, 2018</td>
</tr>
<tr>
<td>Support delay notifications for jobs</td>
<td>Added information about configuring a delay threshold when a job runs. For more information, see <a href="#">Adding Jobs in AWS Glue</a>.</td>
<td>May 25, 2018</td>
</tr>
<tr>
<td>Configure a crawler to append new columns</td>
<td>Added information about new configuration option for crawlers, MergeNewColumns. For more information, see <a href="#">Configuring a Crawler</a>.</td>
<td>May 7, 2018</td>
</tr>
<tr>
<td>Support timeout of jobs</td>
<td>Added information about setting a timeout threshold when a job runs. For more information, see <a href="#">Adding Jobs in AWS Glue</a>.</td>
<td>April 10, 2018</td>
</tr>
</tbody>
</table>
Support Scala ETL script and trigger jobs based on additional run states

Added information about using Scala as the ETL programming language. In addition, the trigger API now supports firing when any conditions are met (in addition to all conditions). Also, jobs can be triggered based on a "failed" or "stopped" job run (in addition to a "succeeded" job run).

January 12, 2018

Earlier updates

The following table describes the important changes in each release of the *AWS Glue Developer Guide* before January 2018.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support XML data sources and new crawler configuration option</td>
<td>Added information about classifying XML data sources and new crawler option for partition changes.</td>
<td>November 16, 2017</td>
</tr>
<tr>
<td>New transforms, support for additional Amazon RDS database engines, and development endpoint enhancements</td>
<td>Added information about the map and filter transforms, support for Amazon RDS Microsoft SQL Server, and Amazon RDS Oracle, and new features for development endpoints.</td>
<td>September 29, 2017</td>
</tr>
<tr>
<td>AWS Glue initial release</td>
<td>This is the initial release of the <em>AWS Glue Developer Guide</em>.</td>
<td>August 14, 2017</td>
</tr>
</tbody>
</table>
AWS Glossary

For the latest AWS terminology, see the AWS glossary in the AWS Glossary Reference.